PRINCIPLES OF HUMAN ECOLOGY

Peter J. Richerson

Department of Environmental Science and Policy

University of California, Davis

Monique Borgerhoff Mulder

Department of Anthropology

University of California, Davis

Bryan J. Vila

Department of Sociology

University of Wyoming

Acknowledgments

Human Ecology is a nascent field for which there is no satisfactory textbook. We have essentially written our own by exanding our lecture notes during the past several years. The book has been evolving, mainly with the help of our students and teaching assistants at Irvine and Davis. We very much appreciate their patience with past imperfect versions and their generous help with constructive criticism.

The book is still imperfect. We beg your indulgence and invite your comments and critiques. We are especially interested in ferreting out presentations that are dull, incorrect, or confusing, expanding those features and sections that you find exciting and enlightening, and discoving major gap in our coverage. Let us know!

Jennifer Pollock, Elaine Fang, and Jane Foster helped immensely in scanning in figures, entering and proofing text, and in other chores which greatly improved the quality of the text.

Much of Chapters 11-14 and 23 derives from Richerson's collaborative work with Robert Boyd, without whose contribution they would not exist. One of the early intructors in this course, Davis anthropologist William G. Davis, helped establish the basic form of the course over about a decade of co-teaching it with Richerson. His stamp is still strong on Chapters 2-7. We especially thank them, but also absolve them from any resposiblity for the use to which their ideas have been put here.

Many colleagues over the years have improved our ideas about himan ecology in spritited discussions and helpful pointers to the literature. Most of them are recognized our citations to their work here.Barbara Sherry of Simon and Schuster Custom Publishing and her coworkers are responsible for the very professional appearance of this version of the material.

Peter Richerson, Monique Borgerhoff Mulder, and Bryan Vila

Give comments to any of the authors or send to:

Peter Richerson, Professor

Division of Environmental Studies

University of California Davis

Davis, CA 95616

pjricherson@ucdavis.edu

Table of Contents

Chapter 1. **What Is Human Ecology?** Relationship between human ecology, biological ecology, and the social sciences. A synthetic or open discipline. Coping with complexity and diversity. Classical "discoveries," "concepts," and "models." Hypotheses and plausibility arguments. Virtues of general models.

Chapter 2. **Environment, Technology, and Culture**. Discovery of human diversity in time and space. Concepts of culture and the "culture core." The discovery of regularities in the relationship between technology, environment, and evolutionary level in human societies.

Part II. Human Natural History

Chapter 3. **Hunting and Gathering Societies**. Implications of dependence on wild plants and animals for demographic variables, settlement patterns, and social organization.

Chapter 4. **Horticultural Societies**. Implications of plant and animal domestication for demographic variables, settlement patterns, and social organization.

Chapter 5. **Pastoral Societies**. Implications of an emphasis on livestock herding on demographic variables, settlement patterns, and social organization.

Chapter 6. **Agrarian Societies**. Implications of advances in agricultural technology for demographic variables, settlement patterns and social organization.

Chapter 7. **Commercial/Industrial Societies**. Implications of an emphasis on trade and manufacturing for demographic variables, settlement patterns, and social organization.

Part III. Processes of Human Evolution

Chapter 8. **Basic Demographic Concepts**. Models of population growth and regulation. Concept of age structure. The population concept.

Chapter 9. **Natural Selection and Biological Evolution**. The discovery of biotic diversity and evolution. Basic models of biotic evolutionary processes.

Chapter 10. **The Sociobiology Hypothesis**. Relevance of natural selection to human behavior. Evolutionary theory of behavior. Some human examples.

Chapter 11. **Mechanisms of Cultural Evolution**. The population concept applied to culture. Basic models of the mechanisms of cultural change. The similarities and differences between organic and cultural evolution.

Chapter 12. **Natural Selection on Cultural Variation**. Discovery that human decision-making powers are weak. Model of the consequences of selection on cultural variation. Costly information hypothesis; an amended proposal for the relationship between genes and culture.

Chapter 13.**Evolution of Social Organization**. The evolutionist's concept of altruism (or the economist's of public goods). Models of kin and group selection. Discovery that cooperation rare in nature. A model of the adaptive advantages of conformist transmission. A model of group selection on cultural variation, a hypothesis to explain the large scale of human cooperation.

Chapter 14. **Evolution of Symbolic Traits**. Concept of symbols. Discovery of human symbolic diversity. A model of the indirect bias mechanism. The runaway process, a hypothetical mechanism to underpin group-functional and functional theories of symbolic diversity.

Part IV. Systemic Interactions

1. Demographic Processes

Chapter 15. **Population Regulation in Human Societies.** Fundamental importance of demography to understanding human behavior. Demographic diversity in time and space. Malthusian, Ricardian, and Boserupian models. The European demographic transition.

Chapter 16.**Crime and Criminology.** Concepts of crime versus criminality. Ecological, micro-level and macro-level factors. Causes and correlates of crime.

2. Society/Society Interactions

Chapter 17. **Commerce and Trade**. The concept of division of labor. The "Law of comparative advantage" model of the benefits of the international division of labor. Monopoly and other coercive models of trade. Trade as a stimulus to technical evolution.

Chapter 18. **Warfare and Population Displacement**. A game-theoretic model of violent conflict. Varieties of warfare. Demographic effects. Role in technical progress. Other forms of inter-societal competition.

Chapter 19. **Diffusion of Innovations**. Patterns in the spread of ideas within and between societies. Empirical evidence for direct and indirect bias mechanisms. Hypothesis that diffusion of innovations between societies is responsible for rapid evolution.

Chapter 20. **Disease Exchanges**. Discovery of role of disease in human population interactions. Concept of endemic versus epidemic diseases. Epidemiological models. Disease patterns as a function of level of technical development. The evolution and exchange of new diseases.

3. Technology/Environment Interactions.

Chapter 21. **Technology and Environmental Deterioration: Preindustrial Societies.** Concepts of environmental deterioration and coevolution. Examples of positive and negative feedbacks of environmental alterations by preindustrial people. Overkill hypothesis for Terminal Pleistocene extinctions. Role of environmental "deterioration" in cultural evolution.

Chapter 22. **Technology and Environmental Deterioration: Industrial Societies.** Argument that industrial societies have as strong interactions with their environment as preindustrial ones. Concept of public choice. Concepts of risk and uncertainty. Role of value conflicts and limited information in limiting adaptive responses to environmental degradation. Voting paradox model.

Part V. Evolutionary Transformations of Human Ecological Patterns.

Chapter 23. **Macroevolution: Microevolutionary Processes and the History of the Human Species**. Concept of micro versus macroevolution (time scales). Concept of uniformitarianism. Punctuational versus gradual models. Externalist and internalist models of historical process.

Chapter 24. **Origin of the Human Adaptive Pattern**. The discoveries of the Pleistocene climatic pattern and of the mosaic pattern of hominid evolution. Externalist and internalist hypotheses of hominid evolution.

Chapter 25. **The Origin of Plant and Animal Domestication**. The discovery of the Neolithic. Externalist and Internalist hypotheses to explain the origins of agriculture.

Chapter 26. **The Origin of States and Stratification**. Historians' and archaeologists' discoveries regarding the development of complex societies. Functional (voluntaristic) versus coercive hypotheses for the origin of states.

Chapter 27. **The Development of Commercial and Industrial Societies**. The concept of modernity. Hypotheses regarding the failure of agrarian states to routinely modernize. Hypotheses to explain why the key breakthrough to modernity occurred in Europe.

Chapter 28. **Summary and Review**. A summary of the ecological perspective on human behavior.

Part I. Introduction

Chapter 1. What is Human Ecology?

Chapter 2. Environment, Technology, and Culture

Chapter 1. WHAT IS HUMAN ECOLOGY?

Another Unique Species

(Title of Robert Foley's 1987 book on evolutionary human ecology)

I. Introduction

What is human ecology? Human ecology is an approach to the study of human behavior marked by two committments. First, human ecologists think that humans should be studied living *systems operating in complex environments.* The human sciences are balkanized into several social science, humanistic, and human biological disciplines. Ecologists are used to thinking that systemic nature of individual organisms and populations of organisms mean that we typically have to understand how diverse parts of the system operate together to produce behavior. The traditional human science disciplines take people apart; human ecologists endeavor to put us back together. Breaking complex problems down to operationally tractable parts is a great strategy, but only so long as some are comitted to puting them back together in the end! Second, human ecologists think that humans are subject to very similar ecological and evolutionary processes as any other species. Of course, humans are unique, and this fact has important consequences. However, we think that the deep rifts between human biologists and social scientists (and between scientists and humanists for that matter) are a deeply embarassing scandal that honest scholars are obligated to repair as expeditiously as possible.

Why study human ecology? As Dr. Vila puts it: "I regard the study of human ecology as much more than an enjoyable intellectual challenge. I've spent the majority of my adult life dealing with human aggression and violence: as a young Marine in Viet Nam; as a street cop in Los Angeles; as a police chief in the emerging island nations of Micronesia; and as one of the people responsible for planning for the continuity of our national government in the event of a nuclear war. These experiences have led me to believe that it is imperative that we gain a fundamental understanding of why humans sometimes cooperate and behave altruistically—and why they sometimes act in the opposite fashion."

The lack of good, well-verified answers to the big questions in human ecology, and in the human sciences more generally, is a bit scary. Our high level of ignorance of the causes of human behavior is not reassuring. Several of the ideas we will introduce are positively chilling. For example, we will discuss the idea that arms races and the dangerous game of war are virtually a natural phenomenon and thus extremely difficult to control. We will also discuss evidence that there is no guarantee that human collectivities can act according to simple norms of rationality, and how absurd cultural norms can arise through simple systematic processes involving positive feedback (i.e., vicious cycles). Sleepless nights can result from the realization that we share the planet with a large, dangerous, unpredictable animal—each other. Writing some lectures in this course sometimes feels a bit like writing the script for a horror movie, except that it really happens! Perhaps the most important practical message of this course is this:

THE PRACTICAL MESSAGE:

We do not yet know enough about humans to reliably control our more dangerous and destructive behaviors. Until we do, the human adventure is liable to be often a little more exciting than one would like. No need to panic right here right now, but, as you know from the newspaper things can get hairy!

Of course, people are often beautiful, charming and certainly always interesting. For scientists, there is the challenge of the unknown. If people were well understood they'd also be boring. Let us not overdo the misanthropy!

Welcome to the frontier! Human ecology is an area of science where the frontier problems of the discipline can be presented to an upper division class. We'll try to expose you to this frontier as the quarter progresses. You will see that we have more interesting hypotheses than firm answers, and no little amount of plain confusion.

We hope that you will enjoy this aspect of the course. The frontier is where the *real* problems are at for a practicing scientist. Most of them learn to enjoy operating on the edge of the known, trying to convert ignorance and confusion into tolerably reliable knowledge. Actually *working* on the scientific frontier to reduce chaos, error, and confusion to orderly knowledge is apt to be confusing, boring, and hard work—like life on a real frontier. Scientists suffer all this for the occasional thrill that comes from discovering an important bit of new knowledge for oneself. Most science is a poor spectator sport; you need a couple of years of post-graduate education just to work your way up to the frontier. Human ecology, because it deals with relatively neglected problems, has a more approachable frontier. We hope you'll enjoy like on the frontier

II. Basic Concepts of Human Ecology

A. Basic Definition

Human ecology is the study of the interactions of humans with their environments, or the study of the distribution and abundance of humans. This definition is based directly on conventional definitions of biological ecology. Ecology is usually defined as the study of interactions of organisms with their environments[1] and each other. More pointedly, it can be defined as the study of the distribution and abundance of organisms. This definition is deceptive. It implies much more than it says explicitly because virtually everything that humans are or do (and the same goes for any species) affects their distribution and abundance. Thus, using the *term "human ecology" actually expresses a broad ambition to understand human behavior*.

B. Borrowing Concepts from Biology

The basic rationale for human ecology is that concepts and methods shared with the biological sciences ought to be useful to understand human behavior. Our behavior is taken to be just a special case of general ecological processes (as any particular species is a special case). This idea has a long history—in demography, for example. Malthus' pioneering ideas about human population explosions played a large role in Darwin's thinking about all populations. Darwin's ideas about natural selection in turn have had a large influence on how we think about humans. As Foley's title in the epigraph indicates, humans may be a peculiar beast, but then so is every other species. We agree with Foley that humans can't stand in some splendid isolation from the rest of nature.

It the next lecture we introduce the classic "culture core" model of how we're necessarily connected to the environment. To preview, people have to make a living by extracting resources from the environment. So do all organisms. Typical organisms use organic structures directly to moke a living; lions kill prey with their teeth and monkeys grind hard seeds with their teeth. People do a little of the same, but most of our adaptations revolve around complex traditional skills we have learned from others. Human populations have a given basic set of tools (technology), whatever their evolving cultural tradition has developed to that point. The details of the toolkit will vary adaptively in the context of the given type. For example, hunting societies that live in environments rich in aquatic resources will

---

[1] Environment is defined as the circumstances, objects, or conditions by which one is surrounded. These usually include the complex of physical, chemical, and biotic factors (e.g., climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival. When discussing humans, "environment" often includes the aggregate of social and cultural conditions that influence the life of an individual or community. The definition leaves it up to the analyst what to put inside the population and what outside in the environment. Always watch this move closely!

use harpoons, whereas desert dwellers will lack such devices. Our technological traditions are so variable from place to place and time to time that ecologically we function as if we were many different species. The application of a given technology in a given environment will strongly influence (or at least strongly constrain) the density of people that can be supported and the effort that must be devoted to subsistence. Population density (and the possibilities for aggregation into large settlements versus the need to stay dispersed to exploit extensive resources) will determine (strongly constrain) social organization. Complex social interactions require many people, which is impossible in a dispersed, low density society. The extreme specialists (e.g. college professors and students) require that food production be efficient per producer, so that a few producers can support us "parasites" [ever hear a farmer grumble about city-dwelling parasites? If not, we'll bet you don't know many farmers.]. At the same time, societies must mobilize the same basic technology in different ways, depending upon the resources the environment offers. At least environment, technology, demography, and social and political organization ought to *highly systemic* with the primary causal arrows leading from environment and technology to demography to social and political organization. Perhaps even some symbolic features of culture like religion may have some systematic relationship to ecology (see Figure 1-1) As we'll see in more detail in Lecture 2, technology, social institutions (the cultural rules that organize society and politics) and any other elements of culture that impact technology and demography, are important parts of the human ecological system. Julian Steward, a pioneering human ecologist, called these parts of culture the "culture core." He meant to distinguish this ecologically relevant core from many aspects of culture that may not be closely related to ecological processes. What language one speaks is not a core feature for example because all languages are functionally equivalent, at least to a first approximation..

C. What Will We Use From Biology?

The basic common core of ecology and evolution is sometimes called ***population biology***. Human ecology borrows a complex of ideas from population biologists. The most basic of these are the ideas of *population growth and regulation* in a single population, as developed by demographers. If we add *heritable variation*, such as genetic variation to the population, then different types will compete. Some will survive and reproduce better than others, and the more fit types will replace the less fit. This is Darwin's idea of *natural selection*. Since the effect of natural selection depends upon the environment--a variant that fails in one environment may succeed in another--natural selection tends to produce diversity. We often say that it *adapts* organisms to the environment that they live in. Then, we need to think about individuals of a population interacting with each other as well as the outside environment. The evolution and ecology of social interactions is often called *socio-*

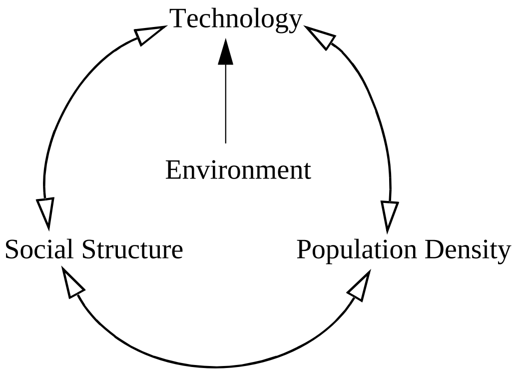


Figure 1-1. Diagrammatic representation of Culture Core concept (see Fig. 2-3 for another representation).

biology. Next, we can try to use *community ecology,* the study of how individuals and populations interact with each other via, competition, predation, parasitism, and mutualism. For example, if competitors are too similar in their resource use, the more efficient user of resources drives out the less. This is called *competitive exclusion,* and is rather like natural selection at the level of species instead of genes. Ecological communities tend to be composed of specialized species, each occupying a unique ecological *niche*. It is often useful to think of the community of organisms plus the interacting abiotic factors on a give site as a system of interacting parts, and *ecosystem*. We also need to recall that the organisms have effects on environments as well as vice versa. The important early 20th Century evolutionist R.A. Fisher called this *environmental deterioration*. Often, when one population evolves, say cheetahs become leaner and faster, the environment deteriorates as far as prey like impala are concerned. Now, selection will start to favor faster, more alert impala too, which then deteriorates the environment for cheetah. This cyclical round of deterioration and evolutionary response is termed *coevolution*.

All of you undoubtedly have a passing familiarity with at least some of these concepts. If your knowledge is rusty, not to worry. We'll review these them in some detail before we apply them to humans.

D. Borrowing by Homology

We can apply ecology and evolution to humans as just another animal. This is making use of *homology*. Humans really are a species of ape after all. We share many basic anatomical features with other apes, as well as subtler things. For example, all apes have a very long juvenile dependent period compared to most mammals, and there is likely to be some common evolutionary ecological reason why we share this feature and common consequences for the rest of our behavior and relations to the environment. Apes have very rudimentary abilities to learn language. Many people are studying ape protolanguage with the idea that the brain structures that permit apes to have a little language served as the basis for our much expanded capacities. We have a lot in common with all of the mammals and have some interesting parallels to the social insects.

Comparative evolutionary ecologists often cast a wide net in animal comparisons, under the assumption that all ecologically similar creatures will follow a similar logic. Wolves, lions, porpoises, tuna, and army ants are not very closely related, but they are all social predators. Some human populations are also social predators. Perhaps, ultimately because of the imperatives of natural selection, they follow the same basic rules of *optimal foraging* as other social predators. Perhaps even rarified types like fly fishermen follow some of the patterns expected of solitary foragers. Human sociobiologists have derived a variety of predictions from general evolutionary optimal behavior models to apply to humans, often with good success.

E. Borrowing by Analogy

Some of the unique attributes of the human species are only loosely ***analogous*** *to commonly studied biological phenomena*. We may still wish to borrow ideas from biology because the human phenomenon is similar enough to the non-human to get a good inspiration for theory or method from the borrowing. There is actually a long history of borrowing analogies back and forth between biology and social science. “Natural selection” is derived from an analogy with plant and animal breeding--artificial selection. The ecologists’ term “community” is derived from an analogy with human communities. Analogies are a dangerous form of borrowing if the similarities are too superficial, and especially if the borrower is unaware of where the two phenomena being compared part company. Perfect analogies are rare. On the positive side, if theory or method happen to be better developed in one discipline than another, then intelligent borrowing using analogy saves a lot of time. It turns out that social scientists have tended to neglect population phenomena compared to population biologists. In the key area of Darwinian evolutionary theory, by the 1970s social scientists had fallen perhaps 40 years behind. As biologists and biologically inspired social scientists discovered this neglect, the current generation of cultural evolutionists embarked on a number of controversial, but on the whole successful, analogical projects.

Several analogies have attracted attention:

Culture is like genes: Humans are unusual in the degree to which we get our behavior by imitation from our parents and others. Getting ideas by imitation is somewhat analogous to genetic transmission. What difference does it make if you learn how to make a pot from mom versus inheriting a gene for potmaking from her? Either way, if you make good pots, your survival and your kids survival may be enhanced relative to people who make bad pots. Of course, we have to be careful. Culture is also unlike genes in a number of respects. We explore this analogy in detail in lectures 12-15.

Human societies are like species: In most species, all populations have the same basic adaptation. Human adaptations are much more diverse. Some populations are mainly plant eaters, others are mainly predators. Some predatory populations emphasize fish, others once hunted mammoths. We want to understand how this diversity can arise, and why specific humans have the adaptations they do. Of course, humans are a single biological species; different populations interbreed freely and successfully. Much of the human ecology that we explore in the next 5 lectures and in Part III of the course is based on the analogy of ecologically specialized human societies to species.

Human societies are like ecological communities: Within any one human society, there are a few to many subgroups specialized to do different things. Minimally, human societies usually specialize tasks by age and gender. Human gender roles are often as different as typical species adaptations in natural communities. In complex societies like ours, there are often hundreds or thousands of differentiated occupations requiring very substantially different skills to be successful, and specialized intergating organizations linking all the occupational specialists into a rather tightly integrated social system. A big city with its massive flows of matter and energy in and out together with its complex human community is a large ecosystem unto itself.

Human societies are like bee, ant, and termite colonies: Only a few species live together in large numbers and cooperate extensively. Biologists call these species *ultra-social.* Many of the more social of the social insects have hundreds of thousands of individuals each the colony, all cooperating, dividing tasks, and the like. Humans are also counted among the ultra-social animals, although the means we use to achieve ultra-sociality are apparently quite different. The workers in insect colonies are close relatives, usually sisters, or brothers and sisters in the case of termites. How humans achieve a similar result by other mechanisms than family solidarity is an important topic.

Humans are like peacocks, bowerbirds, song-sparrows, flowers, and tropical fish: We are a gaudy, noisy lot. Biologists suppose that the beautiful plumage of birds, their singing, and even the colorful displays of flowers, are analogous to advertizing. Male peacocks may be signalling the quality of their genes to mates. Singing birds are often warning neighbors to stay off their territories. Flowers are advertising the quality of their nectar reward to insect pollinators. Darwin was so struck by the analogy between animal and human signalling that he put his main discussion of humans and his main discussion of signalling in the same book, *The Descent of Man and Selection in Relation to Sex* (1871). Human language is the most spectacular of our signalling capabilities, and in important respects goes beyond anything animals do. Nonetheless, we do all the things that animals do with signals, right down to “borrowing” feathers and fur from the animals themselves!

F. Testing Human Ecology

Ecology and evolutionary biology are sources of hypotheses to test. Students of human behavior have commonly made use of theory from these more general sciences, but they have used a lot of other sources of inspiration as well. It is always an open question how much the uniqueness of any species requires adjustment and amendment to account for its specific behavior.

We will thus entertain hypotheses and arguments from a number of areas of study with varying degrees of skepticism about the possibility of using the ecological approach to study to humans. Many anthropologists, for instance, attribute causal priority to patterns of meaning embedded in symbolic processes (e.g. culture-specific systems of belief in the supernatural). They feel that symbolic processes allow us to invent the world we live in largely independently of influence by the practical, real-world problems of survival, reproduction, and competition that fascinate ecologists. Similarly, historians often invoke common sense causal explanations for particular events, but are quite skeptical about the possibility of constructing more general explanations that have the character of the "laws" of ordinary sciences like ecology. As usual in science, when the dust settles there are only two real tests of a hypothesis, its logical coherence and its ability to account for the data. We begin with the big claim that humans are just "another unique species" and try to see if we can knock some holes in it.

The ecological perspective has been responsible for some of the greatest successes in the social sciences, and it is really the only perspective to offer a plausible scheme for understanding human behavior synthetically. We think that population biology (biological ecology plus evolution) offers the best source of theoretical inspiration for the social sciences. On the ecological side, humans *do* have to win a living from variable and sometimes hostile environments, just like any other organism. On the evolutionary side, humans are the products of organic evolution, and the cultural evolution that supplements organic evolution in our case has many analogies to the evolution of genes. However, it is clear that the peculiarities of humans are very important, and thus that we have to keep an open mind about modifications and amendments as we borrow from biology. Just how unique we are is an interesting question.

Humans are a problem for modern Darwinism mainly because of the complexities caused by culture. Social scientists too (e.g., Durkheim 1933:266-268) have long noted adaptive patterns of human behavior. But for the most part, these adaptations are cultural, not genetic. Humans make extremely elaborate use of learned traditions rather than genetic specializations to cope with environmental variations. Compare, for example, the highly specialized clothing, shelters, and boats that permit the Eskimo to subsist as hunters in the high arctic with the mostly anatomical adaptations of polar bears to almost the same suite of resources. The Eskimo do have a few biological adaptations to the arctic (their short, stout stature helps conserve heat), but they are obviously still basically a tropical animal many degrees of latitude out of their "natural" range. A really sophisticated set of tools has allowed them to finesse the biological limits imposed by humans' tropical ancestry. The whole of the 20th Century refinement of the theory of adaptation, based on a synthesis of Darwin's ideas about the nature of evolutionary forces and Mendel's ideas about the mechanism of organic inheritance, is not directly relevant to the main means of human adaptation, culture, as exemplified by Eskimo adaptations to the arctic.

Given culture, how much can we borrow from biology? Several interesting questions arise: Can we borrow the biologist's ideas about adaptation and apply them to humans? How exactly shall we make a place for cultural mechanisms within a Darwinian framework? or Are social scientists best off to largely ignore biology and start afresh with a cultural theory of adaptation at the outset? Opinion on these points varies very widely, as was already noted. Many social scientists and other scholars, such as symbolic anthropologists, argue that humans are such an extreme special case because of their ability to think, use symbols like language, and so forth, and that very little of the variation we observe in human behavior is adaptive. Humans, the story goes, are able to transcend the environmental limitations that impose natural selection on other organisms. Darwin's co-discoverer of the theory of natural selection, Alfred Russel Wallace, held this opinion.

G. Summary

Thus, the big questions in the course are:

(1) How should we deal with the unique properties of humans?
(2) How large a role do the unique properties of humans leave for the ecological approach and the concept of adaptation?
(3) How should we modify ecological and evolutionary theory to account for those unique properties?

Darwin and Huxley shattered the easy assumption that humans are utterly divorced from the rest of nature in the 1870s, and more than a century later we are still struggling to work out the implications of this challenge: Are humans really anything very special? If so, special in what way? What are the evolutionary origins of the differences?

The extreme opinions sketched above are merely the end points of a continuum of possible hypotheses. Various degrees of applicability of the biological concepts and various amounts of amendment are quite possible. In our opinion, the sensible middle ground in this debate is too little explored. Many scholars, rather childishly, would rather argue and agree to disagree than think hard about the problem.

III. Objectives of the Book

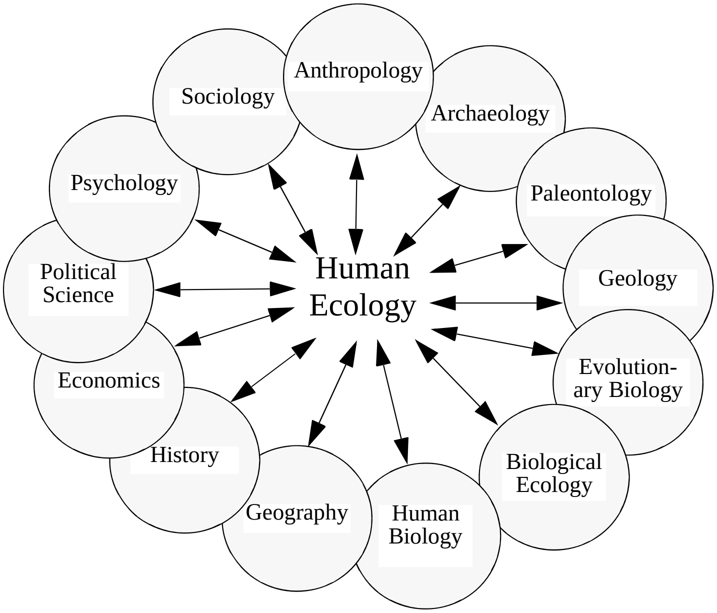
A. Convey a Broad, General Understanding of Human Behavior

Human ecology is a synthetic cross-discipline. The ecological approach is attractive to many scientists because it provides a broad view, congenial to the synthesis of the contributions of the many disciplines that are required to understand human behavior. Much as the whole field of biology is united by the neo-Darwinian synthetic theory of evolution, so human ecologists seek to develop an "umbrella theory" to unite and make sense out of the specialized contributions of the narrower disciplines. The basic concepts mentioned above, genes, culture, and environment, cover immense ground in terms of disciplines involved as well as phenomena on the ground. And all of these can interact in various ways to affect human behavior. Human ecology is the only intellectual tradition to take this truism wholly into account. Figure 1-1 is a diagrammatic representation of this view of human ecology as a sort of synthetic super-disciplinary approach.

Many disciplines contribute to human ecology because our behavior is ***complex*** *and* ***diverse***. Individuals who have taken the ecological/evolutionary approach to humans include biologists, anthropologists, psychologists, sociologists, demographers, historians, geographers, geophysicists, and economists. The justification for having so many disciplines is the complexity and diversity of human behavior. We are affected by the laws of physics, by our biological capabilities, and by the skills and knowledge available to us. We are diverse in the sense that human behavior is very different in different places and at different times, even when environments are very similar. The various simple societies of the past were as different in their adaptations as most animal species (compare the! Kung of the Kalahari Desert with the Eskimo), not even to mention the differences between simpler and more complex societies. Complexity and diversity obviously offer a severe challenge to understanding humans. A complex web of causal processes and historical constraints influence the least thing we do. No one person can hope to understand all of them in any detail.

This kind of synthesis is important to meet the criterion of the "seamlessness of nature." In the scientific enterprise, disciplines cannot legitimately exist in isolation because all the phenomena of the natural world actually do interact. Disciplines are useful human artifacts, but their boundaries are artificial. At the minimum, this furnishes an important check on theories in any one discipline (imagine a theory of the flight of birds that ignores or contradicts the physical principles of gravity, drag and lift, or a theory of aerodynamics

Figure 1-1. Relationship of Human Ecology to the traditional academic disciplines.



that predicts that birds should not be able to fly). In the case of human behavior these consistency checks also need to be applied. For example, humans do have genes, and must have been subject to natural selection on them. A social science theory that asserts that this fact is unimportant (as some seem to do) must be suspect. Unless there is a careful justification for such a claim, it looks like a rejection of the doctrine of the seamlessness of nature. For most of the history of human ecology, synthesis was more pious hope than achieved reality. Progress at the present time is very rapid, however, and the main lines of a successful synthesis are visible.

General understanding is important and everyone has a world view. The trouble is that our world views normally tend to be tacit and unexamined. It is the role of a general education course to open our broad views of the world to the daylight. General understanding is not pedantic nonsense but a most useful kind of information. We believe that the best way to find, understand and solve many theoretical and applied problems is to begin by articulating that problem to a general scheme. Many people, even people highly sophisticated about their specialty, often have only vague and ill structured general schemes. In this case, conventional prejudices and untutored intuition have to be substituted for knowledge. A little knowledge is dangerous, the saying goes, but it is perhaps less dangerous than no knowledge! In the broad areas of human knowledge most related to your specific interests and activities, you will be better off with as sound a general understanding as you can manage. Areas in which you are not an expert are sure to impinge on those where you are. A sound, general, synthetic[2] understanding sometimes alerts one to dangers and opportunities from other areas, and suggests when someone else ought to be consulted. Most of all, it allows you to consider approaches and ideas drawn from outside your specialty and helps you communicate your ideas to others in their terms. *These are tools for you to think with.*

The trick is to mix general and specific approaches: No perfect solution to the diversity and complexity problems exists. One trick ecologists and evolutionary biologists use to advantage is to mix general and specific approaches to problems. In this course we will sacrifice much detail, but we will try to cover most of the important processes that affect human behavior in order to get a synthetic general understanding.

Sacrificing details is necessary to cover enough ground to obtain a general view, but it is potentially catastrophic because the details always turn out to be important. For example, our examination of inter-society interactions will be very far from sufficiently detailed to form the basis for formulating a foreign policy for the U.S. Such tasks require considering a multitude of details, such as how much military power the U.S. can exert, at what cost, with carrier task forces in a crisis in the Persian Gulf.

On the other hand, we hold that attending only to a detailed level of analysis in human affairs (or scholarship) is as bad as depending only on generalities. There are far too many potentially crucial details of far too many kinds for any individual to grasp more than a tiny fraction of them. At the level of generality we adopt here, a sort of overall view of the problem of interest can be maintained. This gives the student, statesman, professional, or ordinary citizen a basis for organizing and questioning the requisite squads of experts. It gives the scholar, technical expert and manager an outline of the explanatory tools of disciplines other than his own, and a basis for appropriate choices of supplementary education and cross-disciplinary colleagues for the problem at hand. In the complex questions surrounding human behavior, whether applied or academic, the “big picture” matters as well as the details. At any rate, a belief in the utility of a simplified, but general and integrated, understanding underlies the organization of the course.

Use your own expertise to calibrate the errors made by a too general analysis. Most of you already have considerable expertise in some field we touch on in this course. You have all accumulated some significant life experiences. We hope you will think about the

---

[2] By synthetic, we mean that it is composed from pieces drawn from many different intellectual and academic sources.

relationship of your own discipline and experiences to this general picture, and thus supply the other half of the trick of mixing general and specific approaches to the same problem. As we touch on your expertise, you'll get a feeling for the costs of simplifying to get the general view. At the same time, we hope that you will be able to see how a general understanding might make your own expertise more broadly applicable, and suggest from where you might usefully borrow ideas.

The attempt at completeness of coverage also forces us to think about gaps in our understanding of ourselves. What we don't know about humans is at least as important and interesting as what we do know. Nothing is more practical than knowing when you are on soft ground! By "don't know" we mean both what nobody knows because science hasn't gotten that far, and what one personally doesn't know. For basic scientists, gaps in knowledge are interesting because that is where the action is. (We love the gaps that practical people hate because filling them is our calling!) Thus, in addition to classical ideas, the course will also cover a number of controversial and speculative areas, where concepts are ill-formulated, multiple conflicting hypotheses remain unresolved, and spirited controversy abounds. For example, we will examine the controversial hypotheses of human sociobiologists, and the muddy conceptual waters surrounding the relationship between historical and scientific forms of explanation.

B. Convey Classical Ideas and Contemporary Controversies

You can view this course as a sort of "Best of the Disciplines" collection of classical ideas, together with an account of the most interesting contemporary controversies, using evolutionary ecology to provide structure. Whatever you end up thinking about the ecological approach, we hope you'll agree at the end of the course that there were a lot of interesting ideas discussed. There are four rather different kinds of ideas we will deal with, *discoveries, concepts, models,* and *hypotheses.* This four-part classification of the main ideas is intended to help you break the course material down into digestible chunks. We urge you concentrate on formulating in your own words a thumbnail sketch of each of the discoveries, concepts, models, and hypotheses presented in the lectures. The Lecture Outline in the Preface is meant to be used as a key to the basic concepts we use in the course**.** If you've got 25-50 accurate words on most of them you will do fine in the course. The synthetic linkages between the various ideas will come pretty easily once your fund of well understood pieces is large enough because the ecological approach is naturally systemic.

Discoveries are knowledge about the world in which we have high confidence."Scientific facts" might be another word for discoveries. Copernicus and his fellow Enlightenment astronomers discovered that the Earth moves around the Sun, Darwin discovered some interesting finches on the Galapagos, Salk discovered a polio vaccine, etc. The disciplines that study complex/diverse subject matters tend to have many small discoveries but fewer really big ones by comparison to the reductionistic disciplines like physics. Nevertheless, there are a few really big ones, particularly the very discoveries of the immense *biotic and cultural diversity* in the contemporary world, and of the complex evolutionary history that generated this diversity. We will devote a fair fraction of this class to sketching an outline of human diversity.

Analyzed closely, scientific discoveries are composed of concepts and models, and are one extreme type of hypothesis—an empirically well-verified one.

Concepts are essentially definitions. We have been discussing the concept of human ecology by starting with a definition and tracing out some of its ramifications. Concepts do not seem very scientific perhaps, since definitions are arbitrary. However, some concepts are very productive of scientific discoveries. They “cut nature at her joints” as philosophers say.

For example, in this course we will devote a lot of attention to the *concept of a population*. A population is a set of variable individuals that routinely interbreed with each other, and which typically have many ecological factors in common. Darwin, and his contemporaries and followers, developed this concept to replace the typological concept of species used by the earlier generation of taxonomists like Linneaus. This concept forms the foundation for modern ecology and evolutionary biology (sometimes collectively called population biology). Similarly, the *concept of culture* was formulated in the mid-19th Century by Edward Tylor and his contemporaries and followers in anthropology, and was eventually used to replace the highly ethnocentric concept of a graded scale of human sophistication. The accurate study of human diversity derives from the use of this concept. In later lectures, you will see how much contemporary debates can be understood in terms of how to relate humans as biological populations to humans as bearers of culture. “Population” and “culture” are examples of classic scientific concepts that are still doing “work” for us.

Hypotheses are candidate explanations of some interesting body of empirical data. Typically, a hypothesis is assembled out of several component models. Current usage does not really make a rigid distinction between models and hypotheses. However, using the term “model” often implies an intent to investigate logical structure, while hypothesis implies an intent to investigate the match between an idea and the real world. A hypothesis should suggest measurements or experiments where a model might not.

As an increasing body of evidence suggests that a particular hypothesis is sound, it begins to look more and more like a discovery. Since no scientific idea is ever immune from further empirical and theoretical challenge, no well-tested hypothesis ever becomes an absolutely incontestable fact. When a well-tested hypothesis attains the status of a discovery is a judgment call. For example, Darwin's hypothesis that natural selection is the single most important evolutionary force can probably now be rated a discovery, but as late as about 1940 it would surely have to be judge still a hypothesis only. Ditto for Tylor's cultural hypothesis for human diversity.

Models are outlines of how important processes might work. We will consider several different kinds of models: simple, complex, general and specific. Prototypical examples are the computer simulations or actual mechanical models that engineers build of bridges, aircraft, and the like, and use to try test design ideas on a small scale. Likewise, economists build complex models to try to predict how the economy will behave. Econometric models are notoriously unreliable, especially by comparison with engineering models. They are defeated by the complexity and diversity of economic systems.

Oddly enough, it turns out that simple models are one of the most useful tools for studying complex\diverse problems. They are part of a three-step method for studying these problems.

First, we try to decompose complex problems into modules that are simple enough so that the resulting pieces are easily modelled. The proper concepts are most useful for this purpose. We want pieces that we can really understand and think about[3].

Second, we try to build two kinds of models of the pieces. The first type are good *simple, general* models. General models need not accurately represent any particular manifestation of a process, such as natural selection or rational choice, but they ought to give the general flavor of the whole class. As it were, we are here trying to cope with the problem of complexity by largely neglecting diversity. It is with models of this type that we will be mostly concerned in this class. The second type are *specific models* that usually do try to accurately mimic a specific example of a process. In diverse fields, the number of these is potentially very large (every individual species or society is going to require its own model for some purposes), although it is often fairly easy to understand them once you understand the simple general model that typifies the class.

Third, we start putting the pieces back together to understand how systems work in

---

[3] And ones that have been "cut at the joints". That is, concepts that separate a complicated problem into meaningful pieces.

something like their full complexity. Usually, we still try to keep things as simple as possible, as this step can get out of hand. It is easy to throw a few component submodels together and get something that is too complex to understand. In a computer simulation this often happens with shockingly few pieces. It is easy to do what economists and ecologists sometimes do--build a model that is *both* very difficult to understand and which is a lousy predictor. People trained in the physical sciences, where complexity is serious enough, but diversity is much less, often find biology and the social sciences puzzling and frustrating because it is so hard to get models that are both precise and general. Physical scientists speak of the "laws of nature" (e.g. the 1st and 2nd laws of thermodynamics). Evolutionary biologists and social scientists gave up this terminology 30 or 40 years ago when we realized that every simple law we formulated had significant exceptions, and attempts to make more complex laws broke down because no tolerable amount of complexity reduced the number of exceptions much.

Models come in several flavors. There are mathematical models, and their relatives the computer simulation. These have the advantage of being formally precise, and are especially good for making sure that the model is at least logically correct. There are verbal models. These are prose descriptions of a process. Their virtue is that they capture intuitions well. Their fault is that they are very hard to specify precisely enough that their logic can be thoroughly checked. There are actual physical models like the engineers build. These are not much used in ecology and social science, but their close relative, the experimental model, is widely employed. The real world in all its glory cannot be brought into the lab, but significant hunks of it can, or experiments can be conducted in the field. Essentially, we use experimental controls to force only one or a few processes to contribute to variation in our experimental system in order to understand this process in isolation. Thus, there is a striking similarity between the simple models theorists use and an experiment. Often, experiments to test general models use a convenient experimental organism to represent the empirical world in a general way. Thus, *Drosophila* is very commonly employed as a convenient proxy for all animals in evolutionary studies. Undergraduates are the organism of choice as models of all people in social psychological studies. Actually, undergraduates make excellent experimental organisms; you are reasonably tractable, follow instructions, and take care of your own housing and food. You are much cheaper and easier to use than chimpanzees for example. However, there are strict limits, enforced by the Human Subjects Committee, on what sort of experiments you can be subjected to!

Ecology, evolutionary biology, and the social sciences are roughly speaking about half way through the project of having a decent toolkit of models for most interesting prob-

lems you can name. The disaggregation of concepts is well advanced (not to say that useful new concepts do not turn up from time to time), and we have many nice models of the basic elements of biotic and social systems. However, we often can't put back together what we've torn apart! The best one can do at the present time is have a sort of toolkit of simple models with which to approach a problem. Given a reasonable good toolkit, one can often piece together a pretty good idea of what is happening. This course aims to build up your toolkit of models, if you want to look at it that way.

IV. Bibliographic Notes

This is just a list of the papers that proved useful for writing up these lectures in case you might want to get deeper into the topic some day:

Literature cited:

Durkheim, Emile. 1933. *The Division of Labor in Society*. Translated by George Simpson. New York: The Free Press.

Key books and papers that provide useful general introductions to human ecology:

1. Papers by anthropologists emphasizing cultural ecology:

Harris, M. 1979. *Cultural Materialism: The struggle for a science of culture.* New York: Random House. Interesting, but rather polemical and hence to be read skeptically.

Johnson, A.W. and T. Earle. 1987. *The Evolution of Human Societies: From Foraging Group to Agrarian State.* Stanford: Stanford University Press.

Moran, E.F. 1979. *Human Adaptability: An introduction to ecological anthropology*. North Scituate, Mass.: Duxbury Press. Emphasizes the ecosystem concept as an organizing principle. Early historical chapters excellent.

Orlove, B.S. 1980. Ecological anthropology. *Ann. Rev. Anthropol*. 9:235-73. Good modern review.

Vayda, A.P., and B.J. McCay. 1975. New directions in ecology and ecological anthropology. *Ann. Rev. Anthropol*. 4:293-306.

2. Archaeologists have made much use of ecological ideas:

Foley, Robert. 1987. *Another Unique Species: Patterns in human evolutionary ecology.* Essex, England: Longman.

Klein, R.G. 1989. *The Human Career: Human Biological and Cultural Origins*. Chicago: University of Chicago Press.

3. Sociologists have not written much lately to my knowledge:

Duncan, O.D. 1964. Social organization and the ecosystem. In, R.E.L. Ferris (ed.), *Handbook of Modern Sociology*. Chicago: Rand McNally.

Lenski, G. and J. Lenski. 1982. *Human Societies: An Introduction to Macrosociology*. New York: McGraw Hill.

Young, G. 1974. Human ecology as an interdisciplinary concept: a critical inquiry. *Advances in Ecological Research* 8: 8-105.

4. There is a thriving literature in cross-cultural psychology with an ecological flavor:

Berry, J.W. 1976. *Human Ecology and Cognitive Style: Comparative Studies in Cultural and Psychological Style*. New York: John Wiley. See also the Journal of Cross-cultural Psychology.

E.E. Werner. 1979. *Cross-cultural Child Development*. Monterey, CA: Brooks/Cole.

5. Reviews of the use of evolutionary ideas in the social sciences can be found in:

Campbell, D.T. 1975. On the conflicts between biological and social evolution and between psychology and moral tradition. *Am. Psychol*. 30: 1103-1126. Campbell's own work on cultural evolution is extensive, but this is a good starting point for that as well.

Smith, E.A. and B. Winterhalter. 1992. *Evolutionary Ecology and Human Behavior*. New York: Aldine. This edited volume contains many additional references to the human sociobiology literature.

Ingold, T. 1986. *Evolution and Social Life*. Cambridge: Cambridge University Press. This book is by a social scientist critical of biology-based approaches to human behavior.

6. Introductions to Evolutionary Biology and Ecology in general:

Begon, M., J.L. Harper, and C.R. Townsend. 1990. *Ecology: Individuals, Populations, and Communities*. Cambridge Mass.: Blackwell.

Dawkins, R. 1986. *The Blind Watchmaker*. New York: Norton. An excellent non-technical introduction.

Ridley, M., 1993. *Evolution*. Boston: Basil Blackwell.

7. Additional reading:

There is a fairly good scientific journal, *Human Ecology*, which has a good selection of empirical and theoretical papers, and book reviews. If you have a taste for the classics, Darwin's *Descent of Man and Selection in Relation to Sex* is worth reading. A. Alland (1985) has edited up a selection *Human Nature: Darwin's View* (Columbia Univ. Press) which is pretty good. However, the introductory essay is badly flawed in my humble opinion. Read Richerson and Boyd's review in *BioScience*(1988:430-434) for reasons for disagreeing with Alland.

Several good general collections of papers have been put together over the years, although none are very recent:

Cohen, Y.I. (ed.) 1968. *Man in Adaptation*. (Two Volumes). Chicago: Aldine.

Richerson, P.J. and J. McEvoy III (eds.). 1976. *Human Ecology*. North Scituate, Mass.: Duxbury.

Vayda, A.P. (ed.) 1969. *Environment and Cultural Behavior*. Garden City NY: The Natural History Press.

Chapter 2. ENVIRONMENT, TECHNOLOGY AND CULTURE

> [The] fundamental procedures of cultural ecology are as follows: First, the interrelationship of exploitative or productive technology and the environment must be analyzed.
>
> Julian H. Steward, 1955

I. Introduction

A. Technology as Cultural Adaptation

Julian Steward argued that technology was the window between the natural world and human society and culture. As we saw in the last lecture people are unlike other animals in the extent of their culture. We cannot safely use the ordinary theory of ecology and evolution from biology without taking culture into account. However, culture is a huge mass of socially transmitted preferences, attitudes, knowledge, concepts and so forth. Language, religion, political opinions, dress customs, and many other things are learned. Among all these parts of culture, technology is, according to Steward, the obvious place for the human ecologist to start, because it is the way that we make our living in the world that couples us directly to the rest of nature. Like any other organism, we have to acquire resources from the environment to survive and reproduce. Using technology we learn from others rather than anatomical adaptations does not alter the fundamental need to make a living. Steward was perfectly willing to imagine that other parts of culture were important, and could have ecological explanations, but he insisted that if this was so, it would be because they somehow affected technology. For example, a cultural system of gender rules deriving from religion has obvious ecological consequences if it restricts the use of important forms of technology to half of the population, as is often the case.

Steward was one of the pioneers of the field of cultural ecology. One of the great contributions of cultural ecologists was to furnish us with a taxonomy of human cultures based on subsistence relations. We will use this taxonomy in this course. It turns out to be a great scheme to systematically organize the great mass of things we know about human behavior. Ask Steward's first question *How do they make a living?* and much else falls into place. Human ecology has gone a long way since the pioneering work of the original cultural ecologists, but there is still no better first question. The success of the cultural anthropologists' classification scheme is evidence that they got the importance of the process of adaptation via technology roughly right. Cultural ecologists were thus key pioneer contributors to human ecology.

The purpose of this lecture is to use the history of cultural ecology as means to introduce you to some of the main issues in applying ecological and evolutionary ideas to humans.

B. An Example—Alkali Cooking of Maize

The humble example of corn cooking techniques nicely illustrates how ecological and evolutionary ideas apply to cultural patterns. Corn (maize) is an important part of the diet of many subsistence cultivators in the world. In the early 1970s Solomon Katz, a biological anthropologist interested in cultural ecology, studied the common, but not universal, practice of boiling corn in alkaline solutions such as wood ash, to make *masa harina*, hominy, or similar products. (Tortillas are made of masa harina, not plain corn meal.) It turns out that boiling corn in this way makes more of the amino acid lysine available. Lysine is the amino acid that is least abundant in corn, relative to human nutritional needs. Alkali treatment in the New World is strongly correlated with dependence on corn; societies that are heavily dependent on corn treat it, but those that have access to ample game or other sources of proteins rich in lysine do not. Given that alkali treatment is troublesome but effective in increasing lysine, this looks like a highly adaptive process. Score one point for the ecological approach.

Some sort of evolutionary process must have produced the ecological correlation. Corn is also a widely used staple in the Old World, (especially in Africa) but alkali treatment is absent. Africans have depended on corn for only a few hundred years, while the crop is indigenous to America and has been cultivated for thousands of years. People may be smart, but the small, statistical effects of alkali treatment on health and welfare must be hard to discover. Some complex process operating over long spans of time must act to "create" cultural adaptations much like natural selection "creates" organic adaptations. Score a point for the need for an evolutionary theory of cultural adaptation.

Alkali treatment is a typical Stewardian technological adaptation, not an organic one. Alkali treatment is an item of traditional culture among many American cultivators. It is a technological adaptation, not a genetic one. As we have noted, very many human "adaptations" are of this sort. *One might go so far as to say that the main human genetic adaptation is the neural and anatomical machinery to use culturally acquired technology as an adaptive device.* We have big brains to acquire the requisite ideas by culture, and our upright posture frees our hands to implement them.

A limitation of the cultural ecologists' explanations was that they lacked much of a theory of the processes of cultural adaptation and evolution. While the patterns of correlation between practices and environment, and the long time needed for them to arise, exemplified by alkali cooking, are compelling at one level, a convincing, detailed account of how such things happen was lacking. Compared to the great attention population biologists have given to the processes of organic evolution, social scientists' accounts of cultural evolution are quite underdeveloped. Rectifying this incompleteness is currently one of the most important frontiers of human ecology, and some major problems are still unsolved. .

Keep in mind that skepticism is the main engine of scientific progress, the scientist's rule is to try to doubt every explanation with the proviso that the least dubious one is provisionally accepted.

C. Cultural Anthropologists' Critique

A second important issue is that many cultural behaviors ***don't*** *look very adaptive.* For example, folk medicine is often based on the idea that treatments of diseases should bear some relationship to the diseases that they are supposed to cure. Under this theory, European folk medicine used liverworts (small, primitive terrestrial plants) to cure liver disease because liverworts look like livers, and fox lungs to cure respiratory ailments because of the purported respiratory prowess of foxes. This idea became accepted medical theory in the l8th century under the label "doctrine of signs." A Benevolent Creator would have given such hints to his favorite species. God would advertise His remedies, like painkiller and laxative makers, so to speak. Today, it is clear that such a theory is useless. Score one for the skeptics of the ecological approach.

The doctrine of signs was more than just an elementary mistake, it was part of a much larger Western supernatural belief system. The most spectacular of these possible examples of maladaptation are bound up with complex systems of supernatural beliefs. The doctrine of signs was an adjunct to the peculiarly rationalized theology of medieval and modern European Christianity. Religion and other ideological, extra-rational belief systems are common motivations for apparently debilitating and dangerous beliefs ranging from lavish expenditures of resources for propitiating gods to suicidal sacrifices in holy wars. At the very least, justifying the doctrine of signs with a religious argument based on the assumption of a Benevolent Creator who would leave signs inhibited a more rational approach to medicine. Even worse, some empiricists like Galileo were actively harassed by the Church as heretics; not a few scientists were killed by the Inquisition. Religions of course do often promote quite adaptive behavior; for example, belonging to conservative Christian faiths seems to protect people from substance abuse.

Quite aside from religion, much more mundane symbolic rituals consume vast quantities of human time and resources to no obvious benefit. This Fall many of us wasted 3 hours most Sundays watching our favorite football team. Perhaps we even enjoyed it, at least when they won. How could such behavior conceivably be adaptive? Most of you can probably invent an adaptive hypothesis for sports fans' behavior, but how much confidence do you have in it?

Many social scientists argue that non-adaptive processes are much more important than adaptive ones in determining human behavior. For cultural ecologists, following Steward, technology is a large, open window through which the natural world lights up a large fraction of culture. The critics of ecology think the window is small and opaque, and that culture is largely insulated from nature by thick walls. Technology may be a window on the natural world all right, but the size of the window, the color of the glass, the direction it faces, and every other thing about it are determined by our language, political and social system, supernatural belief system and the like. If the ecological/evolutionary approach is to be wholly successful, it must make a place for symbolic behavior and consider they hypothesis that culture sometimes produces non-adaptive or maladaptive behavior.

II. Discoveries of Human Diversity and Uniqueness

A. Introduction

Social scientists of the 19th and 20th Centuries documented the immense variety of human behavior in time and space and some striking differences between contemporary behavior and that of other animals. We call these discoveries, because the broad outlines of the data don't change much as new information comes available. We will constantly draw upon the general results on diversity and uniqueness in the rest of the course to outline (1) just what it is human ecology (and/or the rest of the social sciences) has to explain, and (2) sources of data to test hypotheses. Aside from these uses, some familiarity with both is an important part of a general education!

B. Human Diversity

The discovery of human diversity is the great contribution of classical anthropology, archaeology and history. Human behavior is very different from place to place and time to time. *The* discovery is really a set of many small discoveries linked together in a sensible framework. The main outlines of human diversity were sketched in the 19th Century. This body of knowledge developed more or less in parallel with the discovery of organic diversity and the existence of adaptive patterns mentioned in lecture 1. Indeed, several important figures, such as Charles Darwin and John Wesley Powell, the explorer of the Grand Canyon

Country, made significant contributions to both ethnography and natural history.

The proper discovery of human diversity was surprisingly recent. The diversity of peoples had, of course impressed people from time immemorial, but generally one society was only really familiar with its immediate neighbors, who in turn tended to be relatively alike. To the extent that distant people were known at all the knowledge was partial, distorted, and unsystematic. The advent of the voyages of discovery late in the 15th Century greatly increased contact with more distant societies, but appreciation of the nature of human diversity was quite poor until a more scientific approach to exploration was begun in the latter part of the 18th Century.

When Darwin wrote his *Descent of Man* in 1871, he devoted the seventh chapter to racial differences. A certain amount of his data came from his own observations on the voyage of the Beagle, where he got a chance to observe Hispanic Americans, Indians, and Blacks in South America, and a few peoples elsewhere. His most famous observations were of the Fuegans who lived at the tip of South America. Several Fuegans had been taken by Captain Fitzroy of the Beagle to England on a previous voyage. They had been instructed in the rudiments of Christianity and Civilization and were being returned to help bring the “benefits” of Christianity and civilization to their fellows. However, by the 1870's Darwin could depend upon much more than his own observations; a host of similar scientific travellers accounts were available, and the science of anthropology was emerging.

Darwin's analysis of the differences between the races is a good example of how scientists eventually made progress in the face of popular ethnocentrism. His methods were those of careful observation, and broad comparison. For example, he formulated detailed questionnaires on human behavior to a large number of correspondents. He could check their answers against his own broad base of personal observations. Then he reasoned very carefully about the assembled data. For example, the people of Tierra Del Fuego that he observed on the Beagle voyage struck him as the most “primitive” group known to him. However, they were obviously close in race and language to much more “advance” Native Americans living in temperate Argentina. The environment of Tierra del Fuego was exceedingly difficult and that of Argentina relatively benign. Darwin argued that the “primitiveness” of the Fuegans was an adaptation to their environment, not a biological characteristic. He considered that a mass of comparative evidence supported a similar interpretation. Regarding the English tendency to ethnocentrism, he observed that his own people had been “hideous savages” themselves not so very long ago!

Darwin allowed that at first observation a trained naturalist is inclined to classify the different races as distinct species because of the differences in “bodily constitution,” "mental disposition," and adaptation to differing climates. Indeed in terms of phenotype (especially behavior, but also physiognomy), humans are extremely variable, and, of course, we are an extremely widely distributed species. However, Darwin argued, the interfertility of all human populations, especially of the massive cases of genetic mixing he observed in South America and elsewhere, and the impossibility of producing a clean racial classification without a mass of intergrading populations, made the separated species idea untenable. The different-species argument required that mixed blood people do more poorly than pure types. Its proponents argued that mulattos, for example, were sickly and disease prone. But Darwin had visited places largely populated by mulattos and mestizos, and as far as he could see they did just fine! On the issue of mental differences Darwin was "incessantly struck... with the many little traits of character showing how similar their [Indians and Blacks with whom he had been intimate on the *Beagle* voyage] minds were to ours." He considered that sexual selection (fad and fashion in standards of human beauty) was chiefly responsible for biological differences like skin color. Darwin didn't use the concept of culture, which was just in the process of being developed by Edward Tylor in the 1870s. But he did attribute human differences to "civilization," a rather parallel concept, and began to demolish the ethnocentric interpretation of races as species. All things considered, Darwin's view is quite modern for his time, and ideas like separate species for the separate races were widely touted despite his argument. Unfortunately few of Darwin's contemporaries in the 19th Century followed his lead. Getting rid of ethnocentrism in the human sciences was a 20th Century struggle, and some vigilance is still warranted, even in scientific circles.

Even today much is left to understand about human diversity, but the main outlines of what has varied and where seem safely in hand. You can form an impression of the ethnographic data available on humans by studying the maps of figure 2-1, from Jorgensen (1980). He and his collaborators summarized the known information for 172 Western American Indian tribes. They combed the literature for information on each tribe, and used statistical techniques to extract patterns which are displayed in maps. We have selected three maps. Figure 2-1a shows environmental areas, based on a statistical summary of 132 variables., including the physical environment (temperature and rainfall), and dominant plants and animals (the many blank areas indicate insufficient data for the analysis). Figure 2-1b maps language as conventionally classified by linguists based on similarities of language structure, sounds, and words. Figure 2-1c shows a statistical summary of 46 variables related to subsistence technology. Note the reasonable correlation between technology and economy in many areas, but the weak relationship between language and the other two patterns. Roughly similar data is available for the whole world. In the 1950's G.P. Murdock and his collaborators began to assemble world-wide samples of ethnographic data for analysis. By now, their working base of ethnographic (and some historical) accounts numbers over 1,000. We will refer to this compendium repeatedly in Part II of the course.

C. Human Uniqueness

What are we to make of the differences between humans and other animals? Are they significant enough to require fundamentally different theories, or will small amendments to biology suffice? It all depends on how different we are, and in what ways. After all every species is unique, or it isn't really a separate species! Recall from the last chapter that there are several candidates for features that are unique to humans, or at least exaggerated in our species relative to most other animals, including our ape relatives. The possession of cultural transmission, complex societies with division of labor, and symbolic communication capacities, especially language are the most important examples.

Folk traditions are quite inconsistent in their views of the resemblance between humans and other animals. Some traditions, for example the Judeo-Christian, give "Man" a very special place in the cosmos, next to God. Other traditions endow animals with human-like characteristics. We are prone to think of these latter as primitive "animism." (In "animistic" religious traditions, animals, plants, streams, rock formations, and the like are believed to have human-like motives and abilities.) However, modern children's stories make rich use of animals with human characteristics, pet owners give personal names to their favorite animals, and TV nature programs exaggerate the human-like traits of animals. An example is given in Figure 2-2 (from Bodecker, 1974; in the story humans destroy a mushroom village inhabited by insects. The other small animals gather to help them put it right, each according to its own special skills).

Like human diversity, the proper discovery of human uniqueness is rather recent. Just what the differences between humans and other animals are is mostly a discovery of the 20th century. K. Frisch, N. Tinbergen, and K. Lorenz won the Nobel Prize in the early 1970s for the development of the careful field observational methods that were necessary to describe and dissect animal behavior accurately. With this work, and with the publication of Edward O. Wilson's (1975), the famous Harvard student of ants, magisterial summary of animal behavior in a comparative evolutionary framework, that the main outlines of how animal and human behavior differ had been discovered. The problem has been to describe as accurately as possible the similarities and differences between animal and human behavior.

Like the discovery of human diversity, a proper account of human uniqueness was a result of the application of scientific methods. Let us take the example of culture or imitative learning. 19th Century naturalists were pretty sophisticated in many respects, but as

Figure 2-1a. Conventional mapping of environmental areas. After Jorgensen (1980).

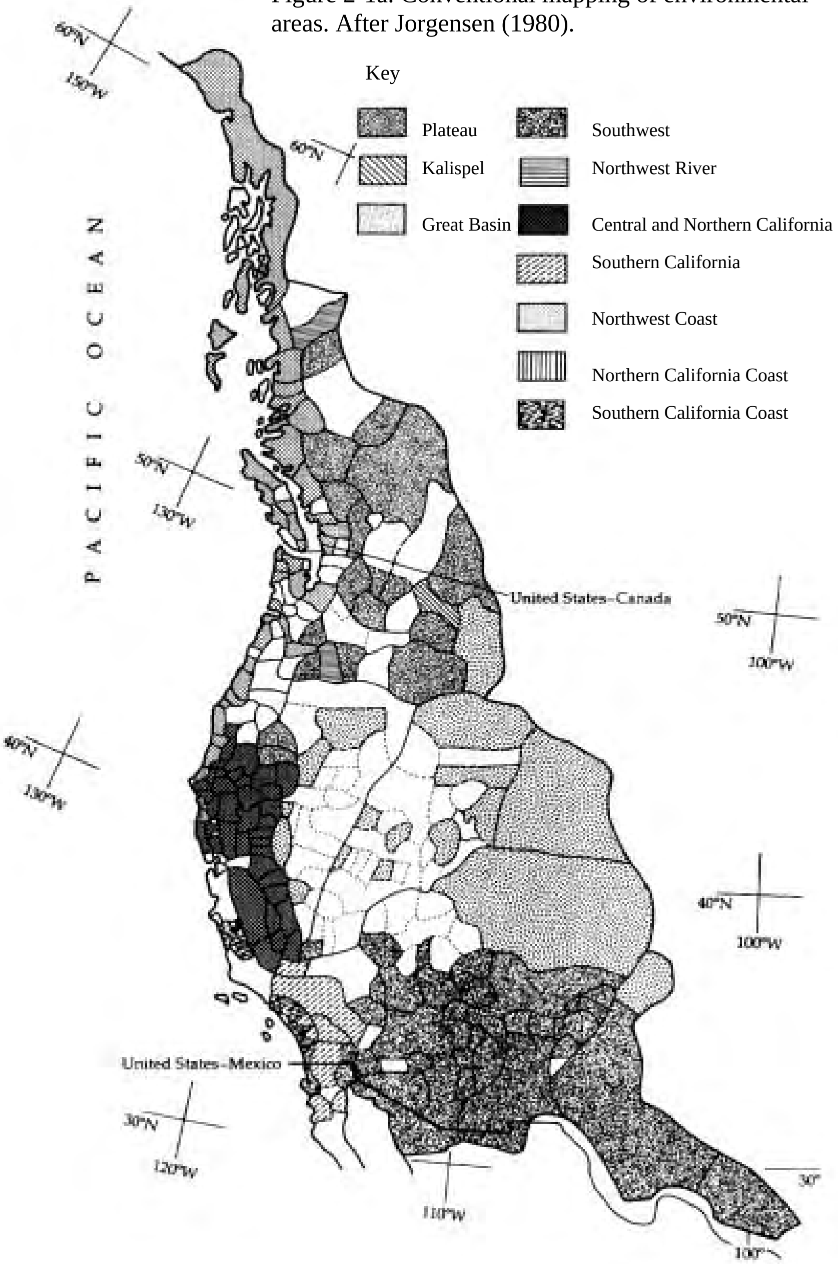


Figure 2-1b. Distribution of languages in western North America, by phylum and family. After Jorgensen (1980).

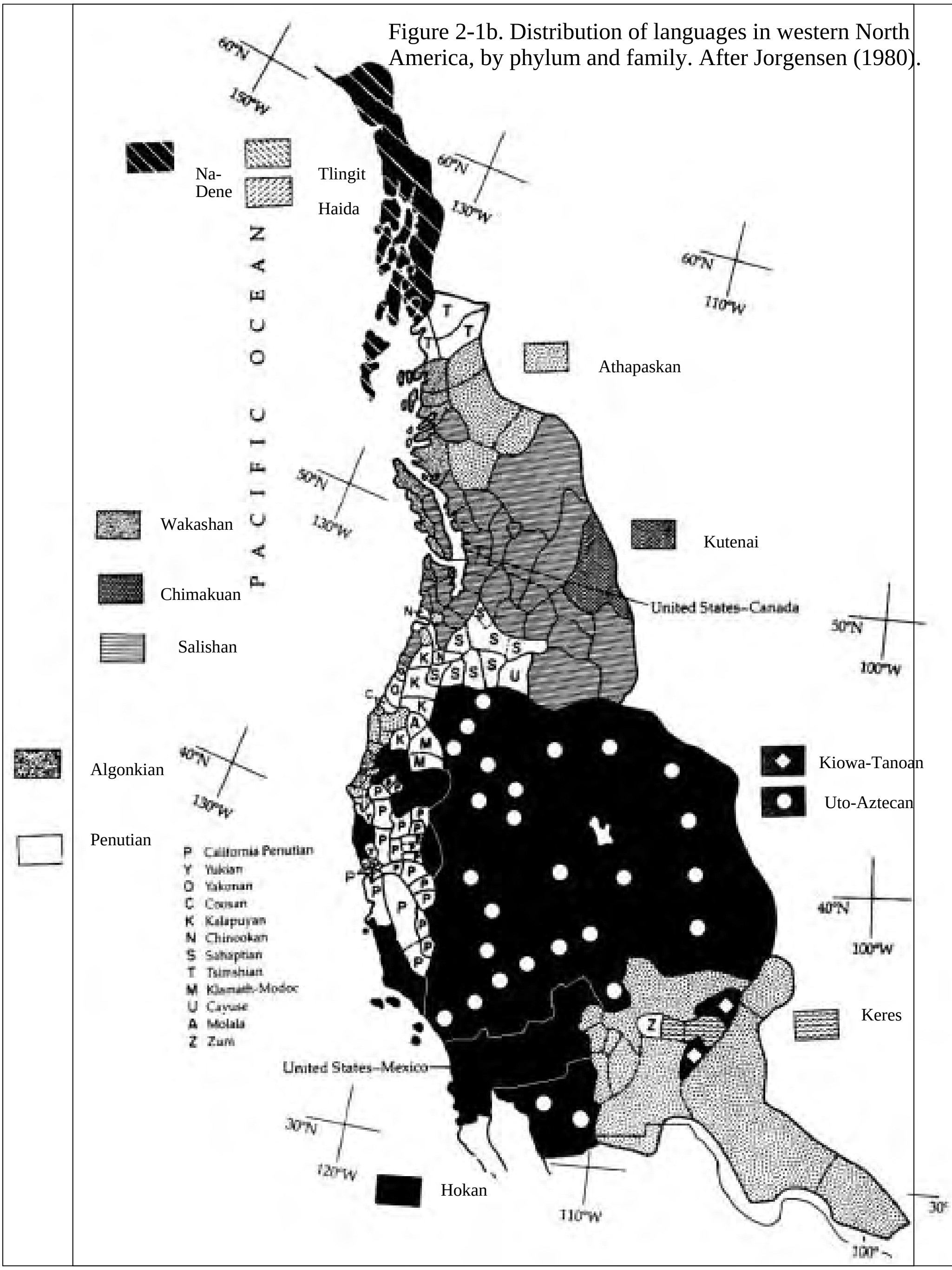


Figure 2-1c. Conventional mapping of economic organization areas. After Jorgensen (1980).

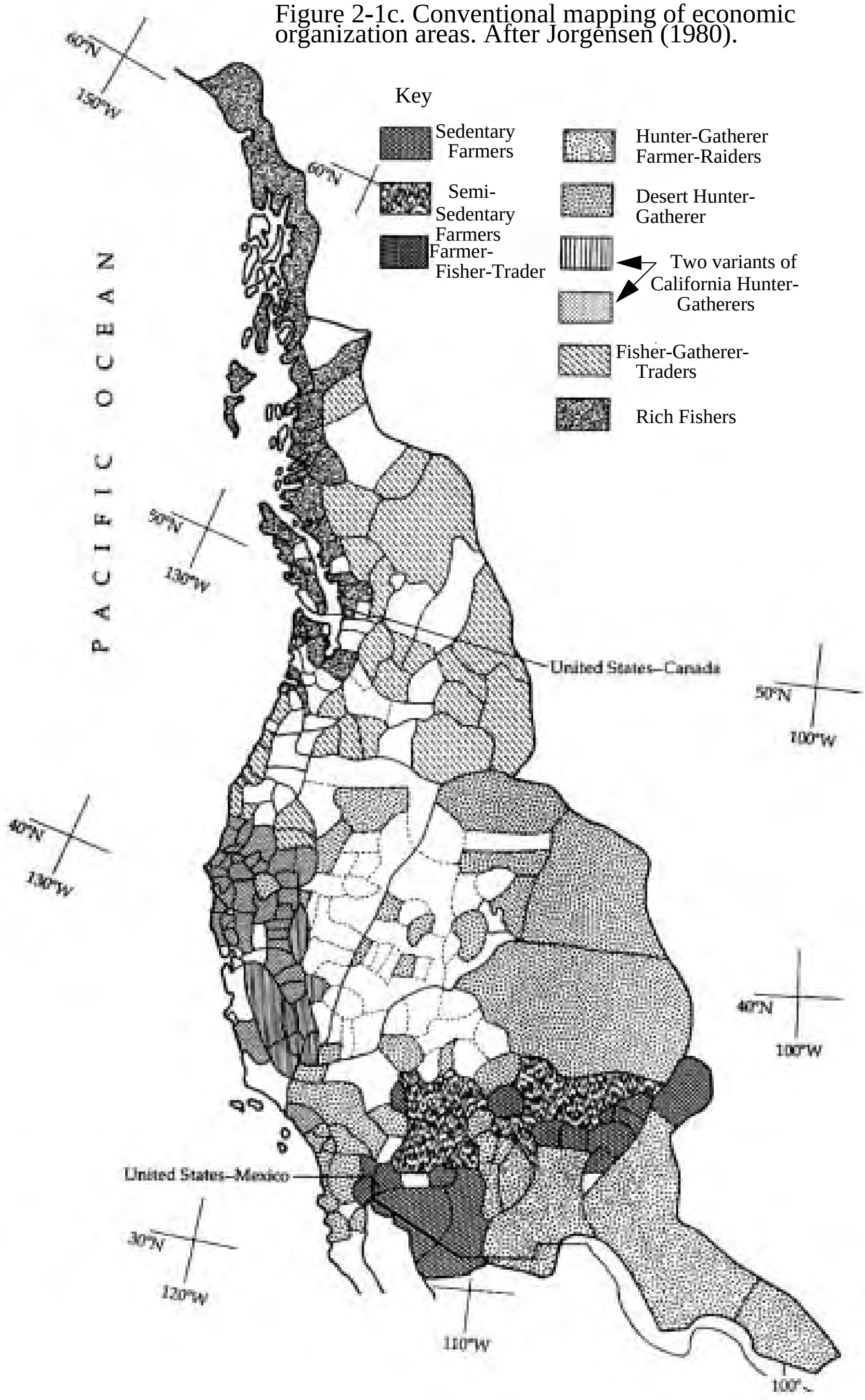
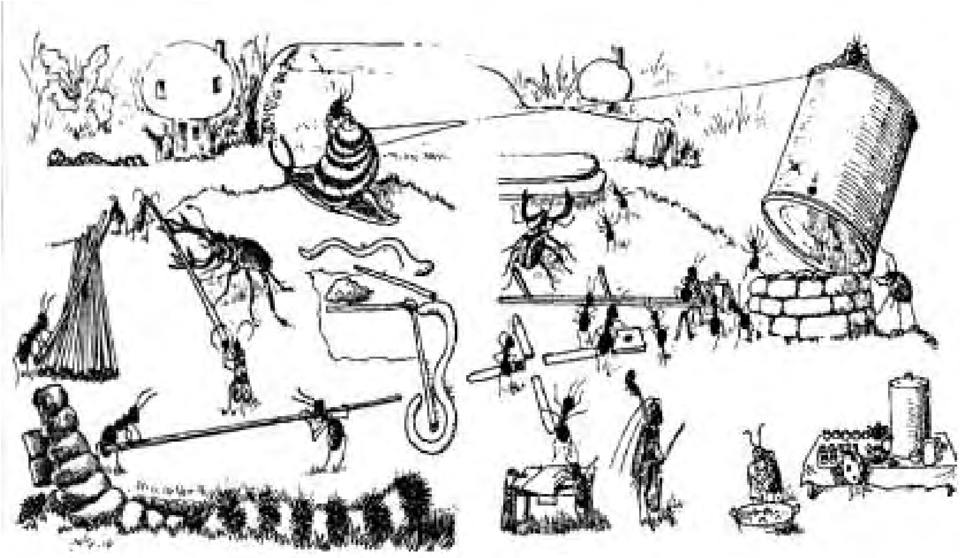


Figure 2-2. Fanciful portrayal of human-like cooperation among invertebrates from a children's book (Bodecker, 1974:42-43).



"When work began the following day, some enterprising earthworms offered to do the plumbing. A firm of carpenter ants undertook construction and shingling. Caterpillars, fitted with little scoops, did earth removal. Spider spun ropes for hoisting. Snail -- slow but dependable -- did the hoisting. Moth carried shingles to the ants. Firefly and her two younger brothers worked in the greenhouse. Ladybug produced tea, toast, and strawberry jam for everybody. And while they all worked, Cricket played encouraging music for them."

late as 1884 George Romanes, a follower of Darwin, wrote an influential book in which he attributed to all sorts of animals the ability to learn from other animals. For example, he and Darwin both believed that honeybees could learn techniques for extracting nectar from difficult flowers by observing bumblebees. They were led to this conclusion by a case Darwin observed in which first bumblebees, and later on the same morning, then honeybees did come to obtain nectar by biting open difficult flowers. (Independent individual learning by the honey bees was almost certainly the cause of this pattern rather than observational learning from bumblebees.)

Experimental methods demolished conclusions based on loose anthropocentric interpretations of animal behavior. Experimental studies, especially by the influential psychologist Thorndike (1911), led to extreme skepticism about *any* claims for social learning (protoculture) in animals based on uncontrolled observations. Thorndike and his colleagues tested animals for imitative learning by exposing untrained animals like cats to trained demonstrators, such as cats that had learned to press a bar to avoid a painful shock. In such experiments, exposure to a trained conspecific does not measurably speed up the learning process compared to control conditions where no demonstrator is present. Such psychologists made "anthropomorphizing" (reasoning about animal behavior by analogies to human behavior) an accusatory term.

Only in the last decade have comparative psychologists come to have a reasonably clear picture of how much social learning takes place in animals. The general answer is clearly that many examples can be cited in birds and mammals, but certainly the capacities of culture in animals are much more modest than in humans (Zentall and Galef, 1988). This may surprise some of you, but there is no evidence that the whales and dolphins have a particularly high order of intelligence, capacities for culture, or any other mental characteristics that are out of the mammalian norm in the direction of humans, many interesting TV programs notwithstanding. The Swiss primatologist Hans Kummer tells an anecdote to illustrate the limitations of monkey imitation, drawn from his long-term observation of macaques at the Zurich Zoo. It seems that one year the monkeys were housed in a cage next to an apple tree. A few apples fell inside the cage and were much relished by the 15 or so animals housed there. One animal discovered how to use a stick to reach under the bottom bar of the cage and scrape apples that landed outside into the cage. This caused a tremendous excitement, and other animals began staring at the outside apples, playing with the stick, and otherwise acting as if they were trying to imitate the scraping behavior. None succeeded. Imitative tasks that humans find quite easy, even our relatively big-brained primate cousins find virtually impossible! The authors in the Zentall and Galef volume describe a number of animal protoculture systems, but humans appear to unique in both the amount of information acquired by imitation, and speed and flexibility of our imitative capacity.

D. Methods to avoid ethnocentrism, mythologizing, and anthropocentrism

We emphasize: The advantage that 19th Century ethnographers and historians had over previous observers was more scientific methods. Lacking formal methods, people are prone to corrupt their observations with ethnocentrism, mythology, and anthropocentrism.

People have a very strong tendency to place negative value judgments on the strange behavior of aliens, something we call ***ethnocentrism***. We still sometimes use the Greeks' old term "barbarians". Foreigners are speakers of harsh, unpleasant crude languages, yammering like animals, thought the Greeks: "bar bar bar bar...," hence "barbarians." They are immoral and dirty, uptight and cunning, and other bad things. Their supposed evil behavior is often used to frighten children; Latin American parents tell their kids if they are bad El Draco (the English pirate/patriot Francis Drake) will come and take them away to an unmentionably horrible fate. Drake was actually quite chivalrous, not a wanton killer at all, (at least according to his English biographers!). Worse, intellectuals often use "primitive" people as role players in ethical writings without any regard for the true facts. For example, to Thomas Hobbes primitives were people whose lives had to be nasty brutish and short in order to clearly display the virtues of the orderly civilization regulated by the state he favored. These value judgments, folk or scholarly, very seriously interfere with accurate observation and sound evaluation of unfamiliar cultures. Your authors have worked in Africa, Micronesia, and Latin America. We have often been struck by how even professional people and scientists slip into the habit of dealing with cultural diversity by invidious distinctions. Only professional anthropologists and a few people who “go native” avoid this tendency. It is not that anthropologists are saints or that anyone is ever completely objective. But in anthropology if anyone can show that your observations or interpretations are ethnocentric, it is a serious professional embarrassment. Anthropologists try hard to avoid, and criticize people who don’t avoid, ethnocentrism. It doesn’t always work perfectly, but it is *much better than not trying at all* (Nettler, 1984: 138-140). The norm against ethnocentrism is like the Ten Commandments. Many rules ore good ones, even if we can’t really expect anyone to obey them perfectly. We certainly hope that you will learn enough about the realities of human diversity in this course to be able yourself to mainly avoid ethnocentrism (and feel guilty when you lapse!). This doesn’t mean that you aren’t perfectly free, in good conscience, to draw ethical conclusions about foreigner’s practices in the end. Few would go so far as to say that avoiding ethnocentrism means that you have to accept the Nazis’ behavior 1933-45 as quaint German customs! It is just that it is wise to understand before leaping to condemnation (see epigraph to Chapter 19...

An illustrative excerpt from George Bernard Shaw’s *Cæsar and Cleopatra* (1900; 1957):

(*Cæsar, Cleopatra, Theodotus, & Britannus (a native of Britain) are discussing Cleo’s upcoming marriage to her brother Ptolemy:*)

THEODOTUS. Cæsar: you are a stranger here, and not conversant with our laws. The kings and queens of Egypt may not marry except with their own royal blood. Ptolemy and Cleopatra are born king and consort just as they are born brother and sister.

BRITANNUS [*shocked*] Cæsar: this is not proper.

THEODOTUS [*outraged*[1]] How!

CÆSAR [*recovering his self-possession*] Pardon him, Theodotus: he is a barbarian, and thinks that the customs of his tribe and island are the laws of nature.

---

[1] (at Britannus’ breach of protocol)

Ethnocentrism is not only a Western hang-up. It is not quite universal; pairs of groups have a wide range of attitudes toward each other. However, invidious distinctions are quite common. In simple societies, the society's name for itself often translates as "Human Beings," and their names for neighbors often gloss as something disparaging, like "Rotten Fish Eaters."

***Mythologizing** history is a related problem to ethnocentrism.* People most commonly use history of their own group for present-day purposes. For example, a story about a people's past may be part of its definition as a Culture. That is how we use the Mayflower settlers in American history. We are all mythical descendants of people fleeing persecution to seek a new life in the New World free of the irrational prejudices of the old. Actually, even the Quakers, who later in America did become models of tolerance, caused much difficulty for Oliver Cromwell, the leader of the 17th Century English arch Protestants against the near-Catholic practices of Charles I and his supporters. Massachusetts Puritans were utterly intolerant of Quakers and other dissenting Protestants, whipping them savagely and ejecting them from the Colony. We try to help ourselves assimilate new settlers by tying their experiences to the myth that the original Founders established principles of tolerance. If you can be portrayed as fleeing persecution you are already half American when you step off the boat (or airplane these days). Of course, tolerance, after we discovered it and when we remember to apply it, has been a principle that has served us well! Myths may serve important social functions, even if not the truth, as the great world historian William McNeill has observed. Brown (1988) has an interesting hypothesis about why history is so commonly mythologized, but written with more critical objectivity by some people in some societies.

Often, the early scholarly historians tried to make history tell moral lessons for contemporary political struggles. The tendency of certain liberal 19th Century British historians to use history to buttress their political predilections (History is on *our* side!) has given the name "whig history" to this sort of exercise. Of course, people in the past were fighting their own battles, not ours. It interferes with accurately assessing the past if we have to look over our shoulders to see if the answers we get will help or hinder our political preferences in the present.

***Anthropocentrism** is the mistake of making humans the measure of all things.* This is an extremely misleading way to view the relationship between humans and the rest of nature. In this course, we will make a lot of comparisons between humans and other organisms. It is the working assumption of human ecology that humans are *basically* similar to other organisms! Once we allow for similarities, it opens the possibility of smuggling folk anthropocentric notions into our views of natural processes. Perhaps we also need to worry about "zoocentrism," importing too much from ecology and evolutionary biology. Many of the pioneering students of the application of biological ideas to humans were entomologists (Edward Wilson and Richard Alexander are examples). Anyone who actually likes bugs has to be watched carefully! (Richerson is an entomologist, by the way.) The pitfall of anthropocentrism (and entomocentrism) is an ever-present danger, which we can avoid only by calibrating human uniqueness as carefully as we can.

III. The First Ecological/Evolutionary Synthesis

Julian Steward's 1955 book Theory of Cultral Change *was important because it was the first synthesis of the discoveries of human diversity and uniqueness using ecological and evolutionary ideas*. The development of classical anthropology between Darwin's and Steward's time is a fascinating and complex story that we have to compress in the interests of time. Suffice it to say, the main conceptual development in the late 19th and early 20th Century was the development of the concept of culture. Using this concept, descriptive anthropologists collected the huge corpus of ethnographic data we referred to above. Steward's project was to make theoretical sense of this mass of data using ideas of ecology and evolution *borrowed* from biology and *adapted* to account for the uniquely cultural and social aspects of human adaptation. He gave us a simple, workable *model of adaptation* to environment via culture. Understanding the successes and failures in his argument cuts to the most basic issues in human ecology.

A.Method of Cultural Ecology

The basic method Steward advocated was to trace the effects of environment, acting through technology, as deep into a culture as the effects actually went. Recall from the first part of the lecture the key role of technology for Steward's method.

He was reacting to two other views he considered oversimplified. The first was environmental determinism, championed by a geographer, Ellsworth Huntington. Huntington's views were rather ethnocentric. For example, he thought that Europeans were culturally superior, and that this superiority came from the favorable climate of Europe. His views required a one-to-one mapping of environment onto culture. This clearly goes too far. For example, it is hard to account for the recent history of California in these terms. 200 years ago, it was inhabited by Native Americans whose behaved very differently from Mediterranean peoples living under the same climate. Spanish settlement did change everything in the direction of Mediterranean customs (much modified by passage through Mexico), but the Anglo conquest turned behavior in still another direction. Rigid environmetal determinism cannot account for the diversity of customs that can exist in the same environment. In reaction to environmental determinism, the famous Berkeley anthropologist Alfred Kroeber introduced the idea of "environmental possibilism." His favorite example was maize growing. Maize requires summers of a certain warmth to mature. Inside the zone that met these requirements, maize production was possible, but whether or not a culture took up maize production inside the zone had nothing to do with ecology. This clear went too far in the opposite direction. Maize growing people had tended to expand in the New World to the limits of maize cultivation, because in favorable environments maize production supported larger populations than any other economy, and large populations can generally outcompete smaller ones. Environmental determinism went too far, but environmental possibilism equally plainly gave up too much.

Steward's second procedure was to trace the effects of technology to patterns of social behavior, especially the organization of work. In humans, making a living is a social activity. There is almost always a division of labor between the sexes, with a cooperative household economy involving both men's and women's work. The organization of work is highly variable between different societies. Steward argued that much of this variation was a result of ecological imperatives. Given a certain environment and a certain type of technology, there will be more and less effective ways to organize society to accomplish work. The more effective ways will generally prevail.

Steward's most famous example is the way the organization of hunting and gathering work varied as a function of environment in North America. Consider the application of this technology in three kinds of environments. (l) A very sparse environment with dispersed resources of plants and small game (rabbits), such as the American Great Basin. The best social organization to exploit such an environment is likely to be the smallest functional human society. And, indeed, a type of social unit Steward called the *family band* is indeed characteristic in such habitats. People live most of the time in a roving household consisting of a husband, wife, children and a few related hangers-on. (2) A habitat in which small groups of large game animals (deer) are an important resource. Here very large packages of meat are available, but several hunters can advantageously collaborate to track, kill, and butcher the animal. Here the main social unit is usually organized around several males who trace their ancestry through a common male ancestor. Steward called this the *patrilineal band* form of social organization. (3) An environment in which large groups of migratory big game (bison) are common. Here, the optimal social group may be many more than are available in any one lineage. The large, but dispersed, herds must be found, and many people can collaborate to attack and process them. Here, Steward called the association of many patrilineal groups into a single residential group of up to a few hundred people the *composite band.*

The third procedure was to trace the effects of technology and work organization as they affect other parts of culture. For example, the demography of a society, including such things as its total size and the size of individual settlements, is a function of economic productivity. The amount of resources a society can obtain depends upon the environment, the technology, and how effectively work is organized. Total size and settlement size in turn affect the economic division of labor. Large societies can support craft specialists, like weavers and potters who make tools for everyone else and trade for food. In small societies, craft specialization is curtailed; everyone has to make tools for themselves because the number of potential customers is too small to support a specialist. The big composite bands of the Plains bison hunters included war chiefs, ordinary chiefs, shaman, police societies, and a number of other specialists and complex institutions lacking in the family bands of the societies of the Great Basin.

For Steward, the excitement was to find out exactly how far these threads would go toward parts of culture remote from the technological window. Clearly, some features of culture are quite free to vary independently of technology and environment. Language is an extreme example. Basques, English, and Japanese work in very similar industrial societies today in very similar environments. Not long ago, they all worked in similar agrarian economies. Long ago, speakers of the ancestors these very distantly related languages were hunters and gatherers somewhere in temperate Eurasia. Aside from a few loan words perhaps, this long history of living in similar environments and using similar technology has not caused their languages to become similar. In figure 2-1, look carefully at the patterns for language families like Penutian and Athapaskan. Migrations of ancient North Americans apparently carried speakers of any given language from one environment to another. As they moved into new environments they tended to acquire new, appropriate technology, but retain their old language. Athapaskans are believed to be latecomers to North America from Asia. In comparatively recent times, some Athapaskan groups moved from Western Canada to Coastal California and to the Southwest.

What about things like ritual and religion? On the one hand, exactly what supernatural beliefs might be seem like language; people are free to believe in whatever God(s) they want. On the other, religious support for social norms may be important to social organization, and sometimes things like the Jewish/Moslem pork prohibition seem to have direct ecological consequences. Since Steward, this has indeed been the “hot topic” of cultural ecology. We will review the results in subsequent lectures.

B. The Culture Core

Steward's main ideas are summarized in his concept of the ***culture core***. The culture core is those features of culture that really are illuminated by the technological window. They are those features that are related to the work of making a living in a particular environment. As we have seen, aspects of social organization related to work are certainly part of the culture core. Most of the variations of language were out, according to Steward. In between was a vast grey area to be filled in. Figure 2-3 illustrates the concept of the culture core in contrast to environmental determinism and environmental possibilism. One way of reading the history of cultural ecology since 1955 is that we have been trying to determine what does and doesn't belong in the culture core.

STEWARD'S KEY IDEA:

Technology is the "window" through which people look at their environment. Our adaptations are mainly technological, and how we interact with any given environment depends first of all on the tools we bring to that environment.

.

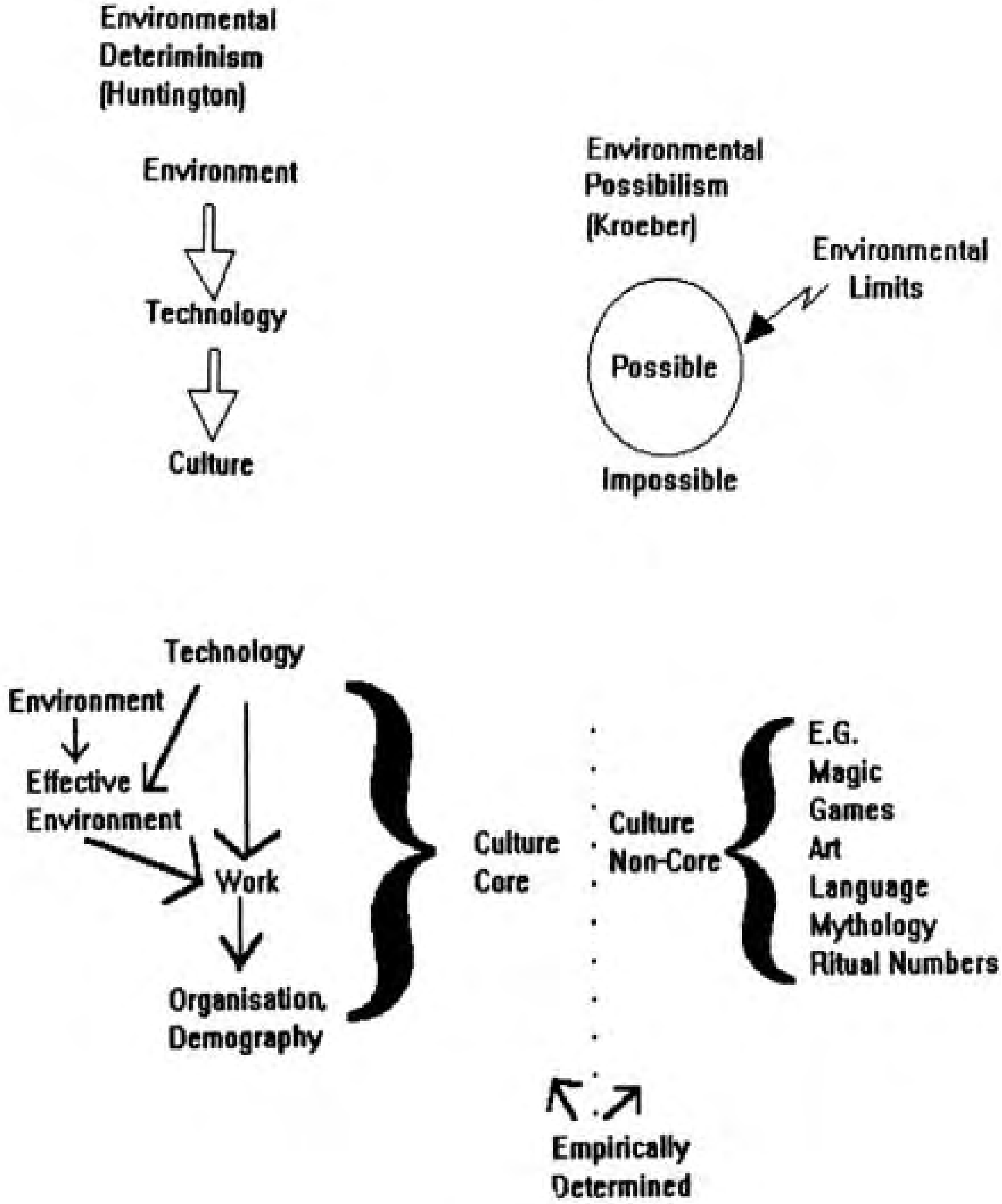
C. Problems with mechanism

The idea of technological adaptations sounded much easier than it turned out to be, more for theoretical than empirical reasons. The problem is that the idea of cultural adaptation was very vague. As we'll see in part III of the course, the concept of adaptation in biology has a rather exact basis in the process of natural selection, which is rather better worked out for genes than for culture. In the 1970s a yawning gap opened between what biology-based students of behavior thought natural selection could do, and what cultural ecologists supposed it could do. When evolutionary biologists G.C Williams (1966), E.O. Wilson (1975) and R.D. Alexander (1979) made a point of this, all hell broke loose in what is called the *sociobiology debate*. Your instructors are among those who have been working to clean up the intellectual blood spilled by the sociobiology debate.

D. Problems with long-term history

Human technology has been making rapid "progress" for the last 10,000 years, independently of local adaptation. You can see this pattern in Figure 2-1 in the Southwest. Beginning about 200BC, the Pueblo groups, derived from several different linguistic stocks, had adopted maize farming and village life, based on ancient traditions of Central

Figure 2-3. Diagram of the culture core concept in comparison to environmental determinism and possibilism. Thanks to R. Bettinger.



Mexico. The recently intrusive Athapaskans (Apache and Navaho) engaged in a simpler system of maize growing, with a much stronger hunting and gathering component, in the same general environment. If the history of other regions, like Europe, is any guide, eventually corn farming would have spread into all of the temperate moist to semi-arid West. California was an especially prime area for irrigated agriculture, as later developments showed, but corn farming was only just knocking at our door along the Colorado River as late as 1750.

Ecologists prefer to work with equilibrium adaptations, rather than fold in the vagarities of historical chance. Usually evolutionary ecologists find that many animal behaviors are close to the long run adaptive optimum; most animals are not in the midst of a fundamental historical transformation of their adaptations as we watch. Humans are an exception. During the last 2 million years our abilities to use culture to acquire adaptations have expanded dramatically. During just the last 100,000 years or so we acquired a fully modern physique and intellect, probably including language and similar "fancy" culture capacities. During the last 10,000 years we have developed farming and "civilization." Humans are a speedily moving target for adaptive analysis! Steward and his contemporaries solved this problem to a first approximation by separating their evolutionary and ecological theories. The evolutionary "theory" was completely descriptive. People had been progressing from simpler to more complex technology, and we could roughly categorize the phenomenon into stages. The famous stages of "savagery," "barbarism," and "civilization" (due to L.H. Morgan in the 19th Century) were replaced by the finer and less ethnocentric technological distinctions we'll use in lectures 3-7. These don't solve the problem that there is not even a hint of a mechanism telling us how societies "progress" from one stage to another. Progressive stage theories were long ago passe in evolutionary biology, but a completely adequate Darwinian theory of long-term change was also lacking. In the late 1970s Stephen Gould and some colleagues pointed this out, and ignited another very messy controversy know as the *macroevolution debate.* We return to questions raised by this debate in lectures in Part V at the end of the course.

In the meantime, realize that Steward and other cultural ecologists held their noses and used the assumption of equilibrium adaptations, taking history as given. The working method was: (1) take the basic technology of a group as given by history, and fixed. It does change fairl slowly normally. Say they are hunter-gatherers. (2) Analyze the marginal adaptive adjustments people make in their culture core to adapt the historically given technology to their environment. That is what Steward did with his band structure analysis described above. He didn't ask why hunters didn't settle down and farm corn instead, only how they organized their societies given the best hunting strategy differed depending upon the kind and density of prey hunted. There is no problem with this approach, so long as we realize that it sets aside the huge variation that exists across spans time and space measured in thousands of years and thousands of kilometers.. As we'll see, a modernized version of it is applied to good effect by human sociobiologists (Borgerhoff Mulder has applied it to calculating how many co-wives a woman should tolerate, given that a society has a history of permitting polygyny.) However, it is a shame to leave the most important things to atheoretical descriptive stages. In biology, Darwinism is supposed to be a complete theory of evolutionary change. We want an evolutionary theory that has a causal motor and wheels to run on! Natural selection and genes are the main motor and wheels of organic evolution. The wheels of cultural evolution are information transfer by teaching and imitation clearly enough, but what are the motors? Steward had no answer, but we will introduce some good candidates in later chapters.

Human macroevolution is important for both social science and biology. Cultural macroevolution is occurring rapidly, and we happen to have caught our species in the act of revolutionary changes. We may have important lessons for the general theory of macroevolution.

V. Summary

Ecological and evolutionary ideas borrowed from biology are promising methodological tools to investigate the great diversity of human behavior. We are animals and have to garner resources to survive and reproduce. If we don't do so fairly effectively we'll disappear, probably with the assistance of a shove from a human group that is more effectively adapted. We do some cute things with culture, but even these often look suspiciously like adaptive means to make a living. It is hard to see how human populations can be exempt from the "laws" of nature in the form of the need to work to make a living.

Humans are unique. Our cultural mode of adaptation is largely missing even in our close primate relatives that lack not only fancy things like language, but simple "monkey see, monkey do" imitation. The highly social nature of humans is unusual. Most animals are more like bears than humans--solitary and hostile. large-scale cooperation with non-relatives is especially unusual.

Our unique features cause theoretical trouble. Some of the cute things we do don't look very adaptive. Some that do appear adaptive, like live in large, cooperative, communicating groups seem to make us the earth's dominant animal. However, sociobiologists inspired by evolutionary biology and more classical social scientists have disagreed vociferously about how this can work.

Environmental interactions focussed on technology, social organization, and the rest *of the culture core are a good place to start on these complex problems*. The cultural ecologists' simple model of cultural adaptation via technology and work, and aspects of culture closely related to work gets us a long way on diversity problem and on the problem of adjusting ecology and evolution for human peculiarities. Its problems have required new models to buttress its vagueness and oversimplification, but it is a good model for all of that!

VI. Bibliographic notes

References:

Alexander, R.D. 1979. *Darwinism and Human Affairs*. Seattle: Univ. Washington Press.

Bernard Shaw, George. 1900; 1957. *Cæsar and Cleopatra*. New York: Penguin Books.

Bodecker, N.M. 1974. *The Mushroom Center Disaster*. Atheneum.

Brown, D.E. 1988. *Hierarchy, History, and Human Nature: The Social Origins of Historical Consciousness*. Tuscon: Univ. of Arizona Press.

Darwin, C. 1874. *The Descent of Man and Selection in Relation to Sex.* 2nd Edition. London: Murray.

Jorgensen, J.G. 1980. *Western Indians*. San Francisco: Freeman.

Katz, S.H., M.L. Hediger, and L.A. Valleroy. 1974. Traditional maize processing techniques in the New World. *Science* 184: 765-773.

Kroeber, A.L. 1939. *Cultural and Natural Areas of Native North America*. Univ. Calif. Publ. Amer. Arch. Ethnol. 38:1-242.

Morgan, L.H. 1910. *Ancient Society.* Chicago: C.H. Kerr.

Murdock, J.P. 1949. *Social Structure.* New York: Macmillan.

______. 1967. *The Ethnographic Atlas.* Pittsburgh: Univ. of Pittsburgh Press.

Nettler, Gwynn. 1984. *Explaining Crime, 3rd Ed.* New York: McGraw-Hill.

Romanes, G.J. 1884. *Mental Evolution in Animals.* New York: AMS Press.

Steward, J.H. 1955. *The Theory of Culture Change: the methodology of multilinear evolution.* Urbana: Univ. of Illinois Press.

Thorndike, E.L. 1911. *Animal Intelligence*. New York: Macmillan.

Tylor, E.B. 1958 [1871]. *Primitive Culture*. New York: Harper.

Wilson, E.O. 1975. *Sociobiology: The New Synthesis*. Cambridge: Harvard.

Williams, G.C. 1966. *Adaptation and Natural Selection: A Critique of Some Current Evolutionary Thought.* Princeton: Princeton Univ. Press.

Zentall, T. and B.G.F. Galef. 1988. *Social Learning: A Biopsychological Approach.* Lawrence Erlbaum.

Part II. HUMAN NATURAL HISTORY

Chapter 3. Hunting and Gathering Societies

Chapter 4. Horticultural Societies

Chapter 5. Pastoral Societies

Chapter 6. Agrarian Societies

Chapter 7. Commercial/Industrial Societies

Chapter 3. HUNTING AND GATHERING SOCIETIES

Life before civilization was “nasty, brutish, and short!”

Thomas Hobbes 1650

Hunters and gatherers are the “original affluent society!”

Marshall Sahlins 1969

Introduction to Part II

A. Plan for next five chapters:

The chapters in Part II will follow closely the traditional division of societies into technological types. We will emphasize the effects of environmental variation on the adaptations of human cultures, following Steward. For present purposes, we will take the basic types of societies as historical givens. The last series of chapters in the course will return to the problems of the evolutionary transformation of one kind of society into another after we have considered evolutionary mechanisms and the nature of systemic interactions with environments in more detail.

The discussion will focus on five basic types of societies, defined initially in terms of their basic subsistence technology (mode of production):

(a) Hunting and Gathering Societies. Those peoples whose technology is designed to use primarily wild game and plant resources.

(b) Horticultural Societies. Societies that depend primarily on cultivated plants for subsistence, but that lack the use of draft animals and the plow.

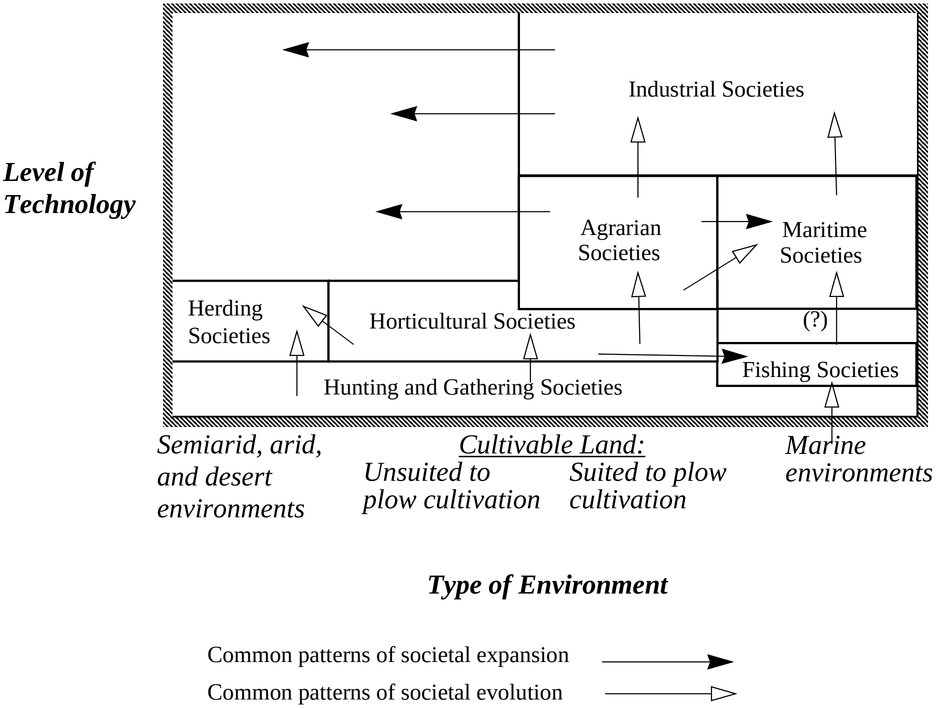
(c) Pastoral Societies. People who emphasize the raising of livestock.

(d) Agrarian Societies. Societies that depend mainly on plant cultivation, and that use draft animals and plows.

(e) Commercial/Industrial Societies. Societies with a majority of the population engaged in trade and manufacturing.

There are several more specialized types; e.g., Lenski and Lenski (1987) also list fishing, and maritime societies. These are of minor importance generally, although maritime societies such as the Greek city-states of ancient times and Venice at the beginning of the modern period do play an important role in theoretical discussions because they precociously resemble modern societies. Figure 3-1 reproduces a diagram from Lenski and Lenski’s (1987:82) that summarizes the *most common*, but not the only, evolutionary pathways among these types:

Figure 3-1. Lenski and Lenski's (1987:82) ecological-evolutionary taxonomy of societies.



The Big Question is: does human ecology provide a useful taxonomy? To the extent that Steward's concept of the culture core is useful, we expect to find a complex of associated traits that surround the technology and vary as technology and environment vary. In essence, we are testing the utility of the ecological/evolutionary approach to human behavior by organizing the grand sweep of the data on human diversity into a few categories using the culture core concept. If this exercise results in a compact, informative taxonomy, there must be something to the idea.

With regard to cultural traits, aside from the toolkit itself, that are candidates for inclusion in the cultural core, we will focus on the following:

(a) Demographic variables, including average human density, settlement size, and degree of mobility.

(b) Social and political organization, including patterns of relations between individuals, degree of stratification, degree of occupational specialization, patterns of leadership, institutions of social control and collective decision-mak-

ing, etc.
(c) Symbolic culture, natural and supernatural belief systems, political ideology, art, public ritual, and the like.

Taxonomy is always a difficult business, and ecological (functional rather than lineage-based) taxonomies are always very messy in detail. Let us agree to take our classification system a bit lightly. There is no nice neat branching pattern such as is furnished by organic evolution as it makes species. Humans are all the same species; races and cultures fairly freely exchange ideas and genes. Mixed types, borderline cases, and the like are bound to be common. The analogy between the historical and contemporary variants is especially likely to be rather imperfect. Ancient Rome and modern India are not exactly comparable, even if they are agrarian societies in our scheme. We will often have trouble finding the best criterion to classify given examples at any level of a functional classification scheme. To take a concrete example, how do we classify the African forest Pygmies? They gain about half their subsistence hunting and gathering in the forest and about half from horticultural crops obtained by working for Bantu horticulturalists. We can avoid endless terminological hassles here only by agreeing to use the classification as a means to an end, not as an end in itself.

Does a culture core exist that varies as a function of environment, given technology? If the Stewardian hypothesis is correct, and especially if the enlarged culture core of modern ecological anthropologists is correct, we expect to find strong statistical associations with these variables and technology especially when the environmental variation within basic technical categories is taken into account. We also expect to be able to interpret much of the variation in the culture core in adaptive terms. In the last lecture we did see that the associations in Western North America were fairly strong.

At a given level of technology, culture core variables should be a strong function of environment; environmental determinism should work well enough within sets of societies deploying a similar technology. To test the Stewardian hypothesis, we will look for situations where there is a strong environmental gradient being exploited by people using the same basic technology. If the people are neighbors, technology can be borrowed back and forth, so that we can largely control for the effects of historical differences in technological level. If Steward was right, we should see the effects of environmental variation quite clearly on such gradients.

*Demography is a key variable relating environment to many culture core features.*Technology and environment determine how much food can be produced by a society. Food production per unit land determines overall population size and density. Food production per human producer (labor efficiency) determines how many people can be released from food production for specialized occupations, like potters, priests, and policemen. Transport technology determines how easily food can be moved from the countryside to support city folk, hence population concentration.

I. Hunting and Gathering: Background

A. History

This form of technology is the oldest and most widely distributed in time and space. The ancient hominids were probably hunters and gatherers in some sense from about 2.5 million years ago, when stone tools first appear in the archaeological record. Thus, humans were hunters and gatherers for by far the largest fraction of human evolutionary history. However, the development of the technology was relatively slow until about an acceleration in evolutionary developments began about 100,000 years ago. During the early Pleistocene (ca. 2 million to 1 million years ago) hominids were restricted to Africa. After about 1 million years ago *Homo erectus* type hominids with a kit of stone tools called the Achuelean industry, spread to most of warm and temperate Eurasia. About 100,000 years ago more sophisticated industries appeared, along with Neanderthal hominids and their relatives. These people penetrated into quite cold environments. Although ancient hominids hunted or scavenged animals and gathered plant resources, we do not know very precisely what their lifeways were like. Neanderthals, and other relatively recent but archaic hominids, had brains as big as ours but very robust skeletons and a considerably different stone tool technology than later anatomically modern humans. Neanderthals had many healed injuries to their skeletons resembling those seen in rodeo cowboys, suggesting some very rough activities, perhaps killing large animals with hand-held weapons instead of projectiles like hurled spears or arrows. Fully modern humans evolved between about 100,000 and 50,000 years ago, but the toolkit of Late Pleistocene peoples suggests a somewhat different style of life than among contemporary hunters and gatherers. Late Pleistocene peoples (50,000-10,000 BP-Before Present) had a relatively greater emphasis on big game relative to fish, shellfish and plants (especially plants that require heavy investment in grinding, leaching and other processing) than is common in the Holocene (the last 10,000 years) among the hunters and gatherers we know from the present and recent past.

Anatomically modern humans spread to Australia and America, the last major habitable land areas of the Earth. The world was full of people, if rather thinly populated, by the eve of the evolution of horticulture 10,000 years ago. The relatively recent shift from technologies that emphasize animals as the major caloric resource to those that make major use of plant resources is termed the *broad spectrum revolution* by archaeologists. Some of the most sophisticated hunter gatherer technologies, such as those of the high arctic Eskimo, also developed during the last few thousand years. We will enlarge upon this evolutionary pattern in Chapter 25. The tremendous environmental and temporal range of hunting and gathering societies led to a wide range of subsistence technologies and other cultural features. Steward developed his culture core concept to explain both this range of variation within subsistence types, as well as the differences between subsistence types.

B. Ethnographic Knowledge

The food foragers known from contemporary ethnographies (i.e., those that survived long enough to receive reasonable description by professional anthropologists) are a poorish sample of this variation. Most of the cases are peoples who live in, or recently lived in environments so marginal the expanding farmers had not evicted them. The best known studies of relatively unacculturated peoples are from desert dwellers like the Australian Aborigines, the African Bushmen, and tropical forest hunters from South America, Africa, and SE Asia. North America had a great variety of hunters and gatherers until the mid 19th century, many living in quite productive environments, but professional anthropology arrived a little too late to observe them in a pristine state. The societies of aboriginal California are an example. By judiciously combining explorers' accounts, and the ethnographic and archaeological evidence, we can obtain some idea of earlier hunter-gatherer societies and those from richer environments. But the story of late Pleistocene hunters in their full glory, hunting Mammoths and Cave Bears, will always have a bit of the imaginative reconstruction about it! That style of life mostly disappeared with the climatic changes and waves of big game extinctions about 10,000 years BP which we will discuss more in Chapters 22 & 23.

C. Mythologizing Hunters

Because hunting and gathering subsistence characterized humans as we evolved, and because we have practiced this form of subsistence for more of our history than any other, hunting and gathering peoples are prime candidates for mythologizing. This is Original Man, wild and free, just as evolution fashioned him (sic). For a sweeping critique of contemporary society, what more effective technique than to portray hunters and gatherers as happy, healthy, peaceable, moral, wise, etc., and moderns as pale, corrupt shadows of Natural Man and Woman? For a sweeping defense of modern society with its many petty frustrations, what is more effective than to portray hunters and gatherers as ignorant, superstitious, violent, dirty, miserable wretches, barely more than animals? Neither portrayal necessarily has much to do with the nature and variety of hunting and gathering subsistence as it was actually practiced in so many places over such a span of time. But as you can see from our epigraphs, quite respectable thinkers have succumbed to the tendency to mythologize hunters and gatherers in the quest for a theory of human nature that supported their whiggish purposes.

II. Technology

The toolkit of most hunter-gatherer peoples is quite simple. Light killing weapons, spears, atlatls, bows and arrows, and simple choppers and knives for processing the carcasses are all that many groups use. Food collection equipment is often no more than a digging stick and a slab of bark or a simple wooden bowl (Figure 3-2). Food preparation is likely to be quite rudimentary, as simple as roasting a small animal by throwing it skin and all into an open fire. Shelters are often very simple windbreaks or huts. Some toolkits were considerably more elaborate than this minimum. For example, the Eskimo had sophisticated winter clothing, kayaks, dog sleds, igloos, barbed harpoons, and other advanced items. California Indians had basketry tight enough to hold and boil water (using red-hot stones dropped into the basket). The more sophisticated toolkits were restricted to extreme environments on the one hand, where nothing less would do (the arctic), or to more provident environments for reasons we will see below (California).

Simple tools are used in sophisticated ways. To hunt and gather successful requires considerable knowledge of natural history, and a good level of physical hardihood. Think backpacking and living in a tent 365 days/year with no storebought food. Ethnoecologists (students of the ecological knowledge of hunters and gatherers) have shown that they recognize a huge variety of plant and animal species and have an intimate understanding of animal behavior and patterns of plant growth, flowering and fruiting. The tracking ability of hunters is legendary. A human or animal can be followed on the basis of the most obscure signs. Such skills are quite useful to people whose weapons are so weak that an outright kill is much less probable than a debilitating wound that may take hours or even days to kill a large animal. Hunters will follow an injured large animal for days until it weakens enough to be finished off.

In the most recent hunting and gathering societies, plant products supply the bulk of the calories, while fish and game supply a major share of the protein. This is well demonstrated in the case of the well-studied !Kung Bushmen[1], where plant foods supply 60-80% of calories (Tanaka, in Lee and DeVore, 1976). Plant collecting also requires fairly sophisticated technical and natural-historical skill to find and process. For example, the acorn-processing equipment of the California peoples, and the fine-seed gathering and processing equipment of Great Basin peoples were quite elaborate.

The diversity of hunting and gathering strategies is great. For example, the production of fruits, nuts, and starch storage organs--the parts of plants that people can readily eat--is relatively high in tropical environments, but declines toward the poles. On the other hand, higher latitude environments often produce a seasonal flush of rough forage that is efficiently processed by ungulates (cows, sheep, antelope etc.) and other large herbivores (elephants, horses, girraffe). These animals have sophisticated guts that harbor microbes that help them digest cellulose and the chewing appartus to reduce roughages to small particles so that the microbes can attack them efficiently. Temperate and polar seas similarly often have huge seasonal plankton blooms that sustain high production of fish, shellfish and marine mammals and birds. Higher latitude people usually eat more meat and animal fat than lower latitude people. At the extreme, the Eskimo and other polar people lived almost entirely on fish, meat, and blubber. Kelly (1995) and Binford (2001) treat hunter-gather variability with sophistication.

The effort required to gain a subsistence by hunting and gathering is a point of contention. Lee (1979) reported quite low work effort for the !Kung, on the order of 3-4 hours per day. Hill et al (1985) report that the Ache of Paraguay work essentially full 8 hour days routinely. Hill et al argue that Lee’s widely cited figures are anomalously low. The sample size is still rather small and the variation rather high. Truswell and Hansen (in Lee and DeVore, 1976) present evidence that !Kung Bushmen have a quite slender margin of calories, especially during the hard dry season. Even in the best of times, Bushmen are very lean. Their low work effort may be a function of the low quality of plant foods available, and the long distances between high-quality patches. Humans can only process so much roughage, and Bushmen have distended bellies from eating so much cellulose-rich plant food. When it is a long, hot walk to collect some poorish chow, one may be better off to go a little hungry. How hungry would you have to be to walk 10 miles for a bowl of boiled whole oats, no milk and no sugar?

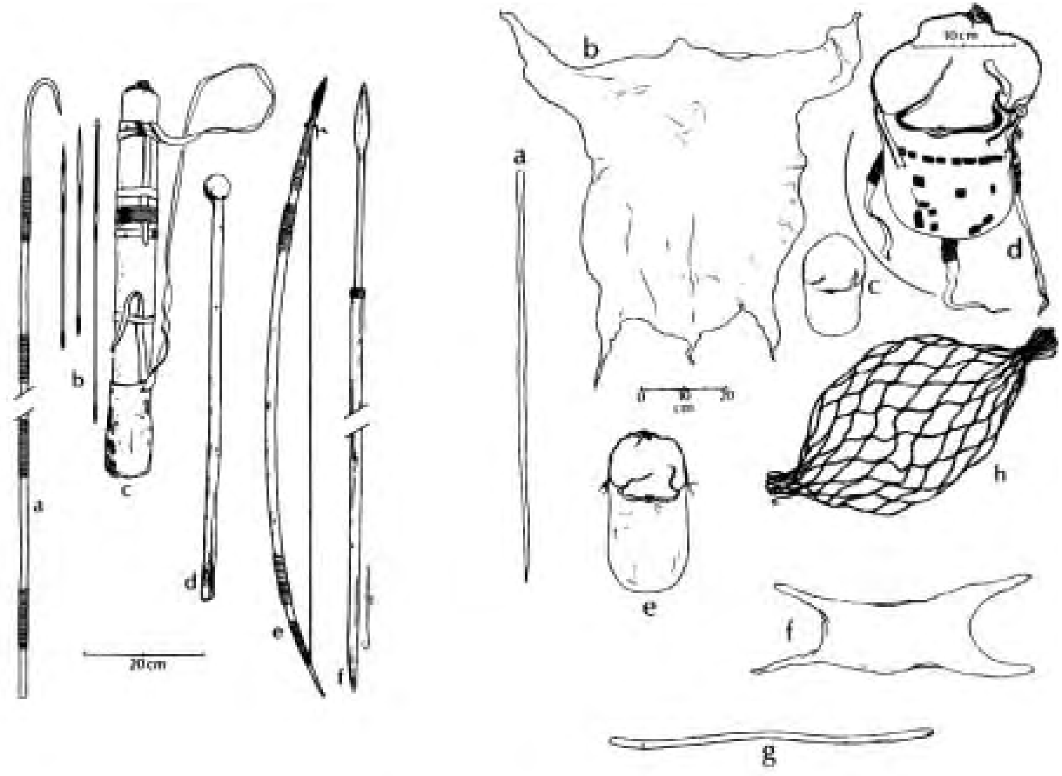
II. Demography

The single most important consequence of hunter-gatherer technology is that it ordinarily supports very low human population densities. It is not a very efficient system of

---

1. If you’re wondering what on earth !Kung represents, here’s the answer: the exclamation point is used to represent the tongue click with which the !Kung San precede the word! Some languages use several such unusual sounds.

Figure 3-1.A basic hunter-gatherer toolkit. These are the implements used by Dobe !Kung men and women. (Source: R. B. Lee 1979:38 & 46.)



subsistence on a *per hectare* basis even when it is as efficient on a *per capita* basis as in the !Kung case. On the hunting side, being at the top of the food chain results in relatively small flows of energy to hunting. On the gathering side, humans are not biologically adapted to do well on the bulk of plant materials. We cannot digest cellulose like ruminants nor detoxify many plant poisons. Plants, for the most part, are well adapted to deal with much more effective herbivores. Thus humans are restricted to fruits, large seeds, tubers, and other relatively scarce high energy plant resources. More sophisticated processing can improve yields rather substantially (e.g. the leaching[2] of acorns to make palatable meal free of tannin by California peoples), but such technologies are rare and late in time.

Thus, human population densities under hunting and gathering technology range from the order of one person/30 km^2 in deserts, unproductive forests and the arctic to perhaps three people/km^2 in the relatively provident oak forests of aboriginal Central California. Yolo County, Central California, is roughly 2,000 km^2. Under desert conditions it would support roughly 65 people—two or three small bands. As it was, Yolo County probably supported a few thousand people (Heizer and Elsasser, 1980, quote a figure of 79,000 for the whole Sacramento Valley). Under modern circumstances this small rural county has a population of 141,000. In a few highly unusual cases, local densities were much higher, such as among the North-western Coastal peoples of North America, where river runs of salmon and other marine resources were locally very rich, and canoe transport allowed transport of food resources to large villages. The pre-agricultural peoples who exploited dense stands of wild grains in the Old and New Worlds may have had similarly high densities. Again, these adaptations are generally quite late in prehistory.

Not only were the densities of most hunters and gatherers low, but typical settlement sizes are also small. We reviewed the data in the last chapter for several types of bands. The low average productivity per unit are of hunting and gathering technology means that settlements must be small and highly dispersed, excepting again special cases like the salmon fishermen, where fairly large settlements could collect around an especially concentrated, transportable resource.

The typical hunting and gathering band must move frequently, often as frequently as every few days. Mobility is another consequence of low productivity per unit of land. A given area is hunted and gathered out to such a distance that it is easier to move camp than to forage at greater distances and return daily to the same home base. The usual situation

---

[2] In this process, mashed acorns are soaked in water and rinsed to remove the tannin. Tannin tastes bitter and binds proteins, inhibityng their digestion, thus serving to discourage herbivores by making acorns a less attractive food source.

seems to have been a seasonal round of movement to exploit the variable resources of a large area. Some groups could occupy particularly rich resources for variable lengths of time and be more sedentary.

Yellen (in Lee and DeVore, 1976) gives a travel diary for the Dobe group of !Kung, showing 38 moves in a five and a half month period. The longest continuous stay in one place was 26 days. However, about 2/5 of the total time was spent at their base camp (in 6 periods). The basic pattern was one of more or less brief excursions to distant areas followed by a return to the base camp. The !Kung are in some ways less mobile than many hunter-gatherers because, especially during the dry season, they are tied to the relatively few permanent waterholes in the Kalahari.

Any substantial movement at all puts severe limits on the sophistication of toolkits if all one's belongings must be hand carried from place to place every few days. Imagine what a Shoshone woman in the Great Basin, who might have had to walk several km. to a new camp every few days, would do with a ceramic pot. Throw the fragile, heavy monster away! It also means that food storage is difficult. Once a group has to move much at all, long-term food storage is impossible. Food is heavy and bulky in quantity and left unguarded it is vulnerable to pests and pilferage. Thus most lower latitude hunter-gatherers do not even use simple food storage techniques such as making dried meat to any extent (Figure 3-3). Groups like the North-Western salmon fishermen and the Central California acorn leachers who were sedentary enough to make accumulating stores worthwhile. Arctic people can freeze meat, though the incidence of botulism fatalities from consuming putrid meat is said to have been one of the hazards of their subsistence system.

The need to move frequently also puts a direct damper on population growth rates. Movement on foot limits each woman to one dependent child at a time. !Kung San space children deliberately so that they only have to carry one at a time, using infanticide or abortion, if necessary, to space children about 4 years apart. N. Blurton-Jones at UCLA (cites are in Chapter 9) has calculated from !Kung San data just how limiting it is to have to deal with small children while moving camp and foraging. Anyone who has traveled with small children under the best of modern conditions will have the dimmest inkling of what hiking 10 km with a toddler, a 5 year old, and all your worldly possessions would be like. Analysis of the time budgets of Ache forest hunters show similar constraints (see, for example, Hill et al. 1985). Thus, such constraints are probably common in mobile groups. Hunter-gathers also probably tended to nurse children to the age of 4 or so, and lactation tends to suppress ovulation. Hunter-gathers, at least tropical ones, lack the highly concentrated calories fats and processed carbohydrates) that young children need to thrive.

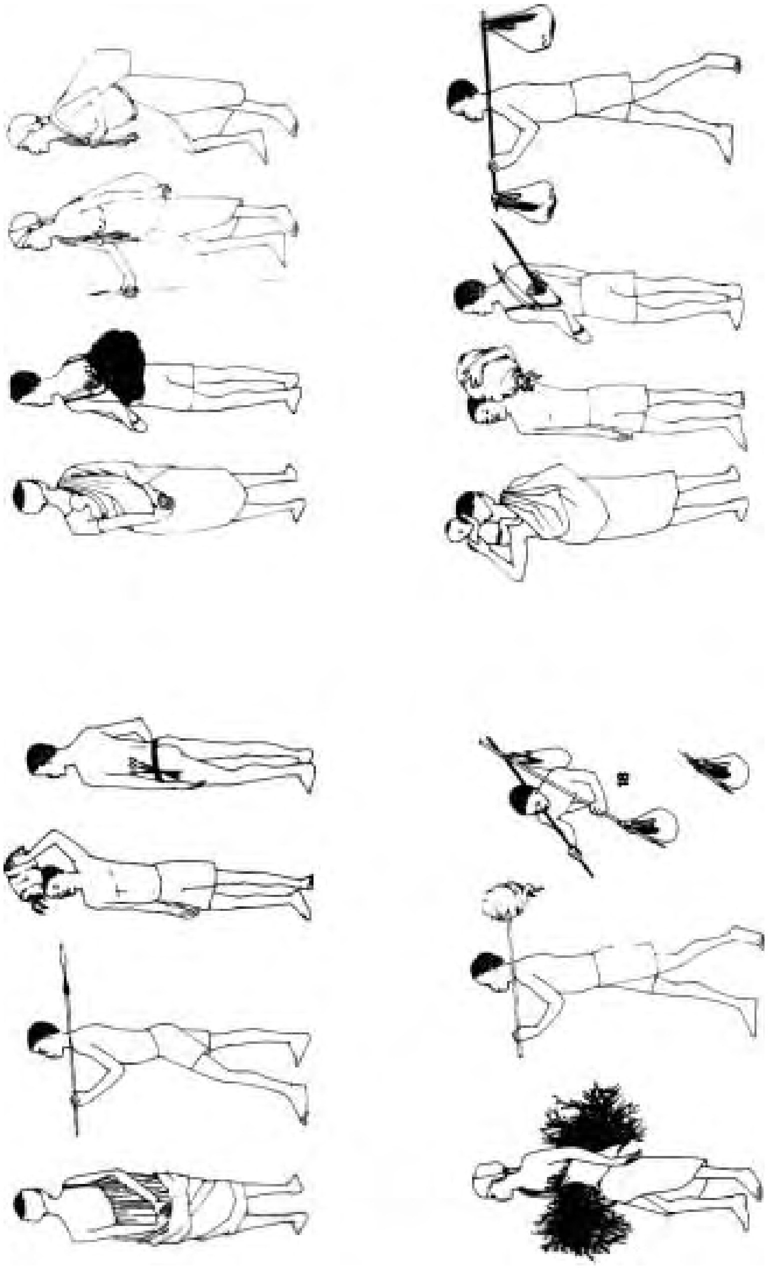


Figure 3-2. Since foodstuffs, tools, and young children must be carried, the need of most hunter-gatherers for mobility is reflected in the many ways in which they utilize their limited toolkit. (Source: R. B. Lee 1979:42-43.)

Despite rather low birth rates and fairly high infant mortality rates, hunter-gathering seems to be a fairly dependable mode of subsistence. Many low-quality wild foods remain to be exploited during droughts and bad winters. It doesn't seem as if sedentary agricultural or "rich" food foragers do much, if any, better in this respect in spite of their ability to store food much more effectively. The greater densities and narrower specialization of richer peoples increase risks even while storage reduces them. As we will see in Chapter 26, some scholars have hypothesized that human diets *deteriorated* after agriculture was developed. The evidence is ambiguous; most ancient peoples seem to have suffered at least seasonal or irregular bouts of poor nutrition during the worst time of year, and/or in bad years.

III. Social and Political Organization

Hunting and gathering technology typically results in very simple social systems. Most bands, except the very largest, are organized largely on the basis of kinship, usually reckoned through the male line, but usually not rigidly so. Kinship is the single most important means of social organization by far, and the simplest societies have little more than extended kinship as a basis for cooperative activities. Specialized, permanent roles are normally absent. A few individuals are recognized as shamen, arrowmakers and the like, but none can earn a living from such activities; all able-bodied individuals must hunt or gather. Only the very richest hunting and gathering societies exhibit occupational role specialization (canoe builders, chiefs, etc.) The exception is a strong division of labor by sex. Men hunt and women gather although there is some flexibility in this. Hunting is not compatible with the care of small children to the extent that gathering is, and as is perhaps required by the need to nurse young as well, so men play a limited role in child care but a big role in hunting larger and more distant game resources. Women, usually with kids in tow, forage for plant resources, easily caught small game, shellfish, and other things that can be exploited while looking after kids. Frank Marlowe's (2001) survey of the literature suggests that in the tropics women provide around 75% of calories in the family diet and men about 25%, wheres in the Arctic men's contribution rises to 100%. Arctic women's work is critical nevertheless. For example the time consuming and skilled labor of women is needed to produce the sophisticated tailored clothing without which men could not hunt for most months of the year. Men in tropical societies often produce most of the protien and fat in the diet. All known hunter-gather subsistence systems require the cotribution of men and women to succeed.

The extensive sharing of food and other resources is usually organized around kin-

ship and friendship lines. Every band takes care to have a web of kinship bonds linking to its neighbors, most often through arranged marriages of the patrilineage's women into other bands. These webs of alliance and sharing are usually interpreted as adaptations to the uncertainty of hunting and gathering subsistence (Kaplan, et al., 1984). On any given day, a hunter is likely to return home empty-handed, but someone is likely to have gotten enough to give everyone a share. If times are tough at home, kin in other groups will generally permit another band to seek resources in their territory, or perhaps a nuclear family or two will go off to live with the luckier in-laws in a different band. This sort of movement of nuclear families from band to band characterizes the !Kung, and probably many other less well studied societies. The !Kung and the desert people of the Australian interior had elaborate institutions to link people together beyong the bounds of normal kinship. The !Kung, according to Polly Wiessner, used a gift exchange system to cultivate friendships with people in distant bands. Women exchanged fancy beadwork and men arrows. The Central Australians had elaborate "section" systems of extended kinship that classified marriage with all but a few women as incestuous. Men might have travel hundreds of kilometers to find an eligible mate. According to Aram Yengoyan and Wiessner the effect of these institutions-was to ensure that every family had friends and inlaws scattered everywhere. When subsistence or political problems occurred, people could seek aid from any of a number of kin or friends in a number of different environments. Yengoyan argues that the odd fact that section systems were more complex in the arid interior of Australia and less so along the more productive coasts owes to the fact that subsistence was more precarious in the interior. In better environments one was less likely to need distant allies, but in the desert much effort had to be invested in developing the widest network possible. In a sense, hunter-gatherers in unpredictable environments were investing in a kind of social insurance. By cultivating friends and distant relatives and helping them when they got in trouble, one could seek help in turn. As we shall see in Chapter 25, in the last ice age ('125,000-10,000 years ago), all environments on earth were highly variable, and the success of modern humans during that period and the eclipse of earlier human species like Neanderthals likely owed a lot to our ability to organize such social insurance instititions.

Political organization is extremely rudimentary in most hunting and gathering societies. A headman may be recognized, usually because he is the senior male of the band lineage or because of outstanding personal qualities (hunting ability, general good sense). Usually such a "leader" can only cajole and persuade, not command. This style of leadership is familiar to us faculty through the typical University committee; you have probably had similar experiences. The chairman typically has slightly more power than the average member, usually because the appointer of the committee tries to get respected individuals as chairs. But formally everything is quite egalitarian, and the chair usually tries to engineer a harmonious consensus (formal votes are divisive in small groups). Everybody's opinion is politely heard, even those boorish loudmouths whose nutty opinions no one is likely to take seriously. Woe be unto the chair who tries to dictate to his committee.

Some hunting and gathering societies are exceptions to the generalization about the simplicity of social and political organization. The Northwest Coast salmon fishing peoples are the best known ethnographically. The Kwakiutl are a famous example. As we have already noted, these people lived at higher densities because of the huge salmon resources available in the big rivers of Puget Sound and similar areas. These groups were semi-sedentary, and stored dried salmon and other food products. They accumulated non-portable possessions and lived in plank houses. Their political system was based on powerful "chiefs," actually "bigmen," full time political specialists. Because this system is characteristic of horticultural societies, we will investigate it in more detail in the next chapter. Bigmen played a ritual role, redistributed surplus goods, conducted warfare, and the like. Although dependent upon popular support, bigmen had quite a lot of formal authority.

Control of within-group conflict is not easy in the absence of real authority. Single deviant individuals are ostracized, and being outside the sharing network will be fatal unless the culprit reforms. Larger scale disputes between families can often be solved by the disaffected splitting to form their own band, if the party is large enough, or moving to a related group if small. Petty disputes are a serious problem; violence is typically not all that uncommon at the level of feuds between families.

Knauft (1988) has recently emphasized that the murder rate is remarkably high in all the well-known politically very simple societies due to the use of self-help violence. (This category includes some tropical horticulturalists, and most contemporary hunter-gatherer groups, that are characterized by very small settlements, low population density, and strongly egalitarian social systems.) These groups tend to have strongly peaceful norms, but a statistically high rate of individual murder. He cites rates of ca. 300 to 800 murders/100,000 population/yr. in several such groups. This compares to 142/100,000/yr. for Cleveland Black Males 1969-74 and 0.5/100,000/yr for Great Britain in 1959, to place such numbers in context. This picture contrasts very sharply with the conventional wisdom about such societies. Anthropologists have apparently been mislead by the peaceful norms of such groups, and by the fact that even high rates of murder do not result in very many dead bodies per year per small group. However, in the group Knauft studied, the Gebusi of New Guinea, these deaths added up. In a very unhealthful environment, homicide accounted for 1/3 of all adult deaths. His interpretation of this pattern is that in politically very simple societies there is no authority to settle disputes. If you've got a beef with someone, it is up to you to settle it. The danger of unrestrained violence favors norms of good fellowship and peaceableness. But, ultimately, the norms are an imperfect substitute for some form of political authority, and murder is the only solution to disagreements that a chief or headman might mediate in even slightly more complex societies.

Between-band or between-culture relations can also cause serious "foreign affairs" problems. Probably, the high degree of kin connections with most immediate neighbors keeps between-band feuds in bounds most of the time, but feuding on this scale seems to be a frequent problem. With no formal authority, each band must depend on its own ability to defend itself or to threaten and carry out violence to enforce conformance with rules. With distantly related groups a generalized hostility or suspicion seems to have been common, but alliances between ethnically distinct groups were also common. Warfare among hunting and gathering peoples seems seldom to have been nearly as well developed as among more "sophisticated" folk. Once again, we must beware of mythologizing. Conflicts over resources seem to have been endemic. The distribution of language groups in North America, where the situation is well studied, clearly shows that groups expanded and contracted over time. For example, Bettinger and Baumhoff (1982) in the Anthropology Department at U.C. Davis have shown how the present inhabitants of the Great Basin must have spread into that region in the last few hundred years as their improved seed processing technology allowed them to out-compete earlier big game hunting specialists. One wonders if this competition would have been completely pacific. The reports of the first commentators to reach hunting and gathering often describe a fair amount of inter-ethnic warfare (anthropologists typically arrived after such people were pacified). Most hunting and gathering societies lived at suspicious peace with their unrelated neighbors most of the time, but that incursions on recognized boundaries likely would bring a violent response.

The scale and duration of warfare would, however, tend to be limited by the lack of effective political institutions (a war chief with the power to command, or even lead by the example of his prestige), and the logistical limitations of conducting war in the face of a daily need to forage. Also, the lack of much stored food or material possessions among hunters means that the one motivation for predatory raiding, booty, is greatly reduced. It is notable that richer and more sedentary peoples seemed to have warred more. The Northwest Coast peoples had quite well organized warfare in contact times, and possibly before, over resources and trade routes, and to acquire slaves.

In spite of hostile relations, trade was often moderately important to hunter-gatherers. Some of it was luxury trade. In California, for example, shell moved from the coast inland, while things like colorful bird feathers moved coastward in return. Some foodstuffs also moved in trade in California, and good stone, such as obsidian, moved considerable distances. The Northwest coast slave trade reached as far south as the Northeastern part of California.

IV. Socialization Practices and Cultural Dynamics

The socialization practices of hunter-gatherers are notable for being fairly relaxed, light on corporal punishment, and encouraging of individual self-reliance. Cross-cultural psychologists believe that the relatively high demands on individual initiative in hunting and gathering activities, and the lack of a need to socialize children to respect powerful arbitrary authorities favors this style of socialization and related independent personality type. (See the work of Berry, cited in Chapter 1.)

Small societies without role specialists and writing may be limited in the number of cultural traits they can keep in a culture. Those things that only a few happen to learn are likely to be lost by accident. There is some evidence from Tasmania to suggest that the small, isolated population there lost a number of traits they brought over from Australia due to this process (Diamond, 1978). If this line of argument is correct, the sheer size of a culture will have important effects on its sophistication.

V. Ideology

Typical mobile food foragers have relatively simple ritual practices and religious beliefs. Formalization is relatively weak. More sedentary groups, like the California people, seem to have had more elaborate and formal ones. However, the Australians are noted for their very elaborate ritual and spiritual beliefs, while Bushmen, living in relatively similar environments, seem more “secular”. The Bushmen do have a series of dance disciplines that induce mystical experiences (Katz in Lee and DeVore, 1976). A case might be made on the basis of this contrast that ideological variables are outside the culture core. All foragers for the last 35,000 years have had some art objects, often quite elegant ones. Clearly, sedentarism at least allows these to be multiplied (e.g. Bushmen don’t make totem poles, but sedentary fishermen of the Northwest Coast did). Score a point for Kroeber’s possibilism here.

VI. Conclusion: The Gradient Test

The culture core idea works for hunter-gatherer societies. Since we have just begun a comparative exercise, it is too early to reach any definitive conclusions about the adequacy of the neo-Stewardian argument. Notice, however, that within the variation of hunting-gathering technology itself, it seems possible to generalize Steward's argument about the effect of environmental variation to several more variables besides band structure. Hunting and gathering societies that live in typical environments (recently at least) are limited to very small, usually migratory residential units. These small units in turn enforce a simple culture in respect to toolkit, social organization, and political relations. However, in those cases of denser resources, especially those that allow a measure of sedentarism, these constraints (determinants?) are relaxed and more complex culture cores tend to emerge (Price and Brown, 1985). Even if average densities remain low, the ability to aggregate even temporarily, as in the case of composite bands, has important effects.

Consider the gradient in Western North America starting in the arid inland Great Basin, moving to the semi-arid California coast, and the up the coast to the Puget Sound area. Refer back to figure 2-1. On this gradient the productivity of the environment for hunting and gathering increases. The interior Great Basin peoples were highly mobile and were Steward's primary example of societies organized by family bands that could associate with other bands only for limited periods of time because of the very low density of food resources. There was virtually no political organization beyond the leaders of the family bands. The Californians of the coast and valley lived in a much more provident environment, and were semi-sedentary. Villages of 100 or more people were established as headquarters, from which people radiated on hunting and collecting trips. Senior members of lineages provided leadership of the villages, and sometimes, as in the Pomo, access to leadership was formalized and leaders had some real powers to coerce. In California, there were typically extra-kinship organizations called "sodalities" that drew people from many villages in the same ethnic unit for ceremonial purposes. Sodalities are roughly akin to American lodges and service fraternities like the Masons, Moose Lodge, and Rotary Club. Often they have a religious cast too. Sodality functionaries are often political leaders. We have seen that the Northwest Coast groups of North America are an example of hunting and gathering peoples achieving densities more typical of simple horticultural groups. Some but not all of these groups also had quite highly organized political systems led by Big Men (chiefs whose role was more achieved by reputation for generosity, wisdom, coercive power and oratory prowess than by a strict rule of descent) who organized quite complex economic enterprises. Many of the generalizations that apply to simple horticulturalists also apply the Northwest Coast as far south as Northwestern California (Johnson and Earle, 1987). Semi-sedentary, relatively dense populations, such as those that characterized California, were in between "typical" hunter-gatherers like the !Kung we know from the poor ethnographic recordand the Northwest Coast people. These societies also had populations of intermediate density, of intermediate complexity, toolkits, and social organization, and the like to match. Thus, as Steward argued, there does seem to be a pretty good relationship between environment and many culture core aspects of society, as long as we focus, as in this case, on a given technological type. The main intervening variable seems to be demography. Hunting and gathering in many environments allows only low human densities and small, mobile bands. In environments where greater average densities are possible, and where larger and more permanent settlements are possible, social and political complexity also increase. As we shall see in the next chapters, this pattern holds for other technological types.

Jorgensen (1980) notes that correlation between environment and social organization is imperfect for Western North American hunters and gatherers, the gross fit with Stewardian expectations notwithstanding. Part of the failure to fit is due to the relatively rapid ongoing evolution in this region. In the Northwest, politically more centralized groups seemed to have been spreading at the expense of less centralized ones. The ongoing intensification of production using harder-to-process foods like acorns and grass seed was ongoing at contact. The spread of intensive plant using strategies into the Great Basin occurred only about 500-700 years ago according to Bettinger and Baumhoff. Maize agriculture was on the move in the Southwest. Thus, a significant element of historical variation overlays the environment-technology-culture core pattern.

Whether the hunting and gathering way of life is as rosy as some students of this type of society have sometimes thought is debatable. Just in the last 20 years, opinion has fluctuated between the “nasty brutish, and short” and “civilization was the big mistake” schools of thought. We used to champion the latter, but Knauft’s paper and other neo-Hobbesian observations have shaken our faith. It is good to beware of mythologizing! Keep you hypotheses multiple and don’t get overly fond of any one!

V. Bibliographic Notes

References:

Bettinger, R.L. and M.A. Baumhoff. 1982. The Numic spread. Great Basin cultures in competition. *Amer. Antiquity*. 47: 485-503.

Binford, L.R. 2001. Constructing frames of reference : an analytical method for archaeological theory building using hunter-gatherer and environmental data sets. Berkeley : University of California Press

Diamond, J. 1978. The Tasmanians: The longest isolation, the simplest technology. *Nature* 273: 185-6.

Heizer, R.F. and A.B. Elsasser. 1980. *The Natural World of the California Indians*. Berkeley: UC Press.

Hill, K., H. Kaplan, K. Hawkes, A.M. Hurtado. 1985. Men's time allocation to subsistence work among the Ache of Eastern Paraguay. *Human Ecology* 13: 29-47. (See other references to Hill et al.'s work in this paper. This is the methodologically and theoretically most sophisticated work presently being done on hunting and gathering.)

Johnson, A.W. and T. Earle. 1987. *Evolution of Human Societies*. Stanford: Stanford University Press. This is an excellent new book treating many of the same issues as Lenski and Lenski. Unfortunately, I think their taxonomy obscures Steward's main insight regarding the culture core and how it works.

Kaplan, H., K. Hill, K. Hawkes, A.M. Hurtado. 1984. Food sharing among the Ache hunter-gatherers of Eastern Paraguay. *Curr. Anthrop.* 25. 113-5.

Kelly, R.L. 1995. The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways. Washington: Smithsonian Institution Press.

Knauft, B. 1987. Reconsidering violence in simple human societies: homicide among the Gebusi of New Guinea. *Curr. Anthrop. 28(4):457-500.*

Lee, R.B. and I. DeVore (eds.). 1976. *Kalahari Hunter-Gatherers*. Cambridge: Harvard University Press. (The Harvard work reviewed here is the best-known modern work on hunter-gatherers. !Kung San are the most studied and most famous hunter-gatherers in the world I'm sure, although it is an open question how typical they are.)

Lee, R. B. 1979. *The Dobe !Kung*. New York: Holt, Reinhart and Winston.

Price, T.D. and J.A. Brown. 1985. *Prehistoric Hunter-Gatherers: The Emergence of Cultural Complexity*. Orlando: Academic Press. (This is a very interesting collection of papers, emphasizing the hunting and gathering societies that were more complex than those we know from the ethnographic record.)

Some useful general references:

Bicchieri, M.B. (ed). 1972. *Hunters and Gatherers Today*. New York: Holt, Rinehart, and Winston.

Kroeber, A.L. 1925. *Handbook of California Indians*. Bureau of American Ethnology, Bulletin 78. (Also a Dover reprint edition. Compendia of information of this type exists from the early salvage ethnography and reconstruction from early accounts for vanished societies in many parts of the world. They are pretty easy to dig out of a good library.)

Service, E.R. (see cite in last chapter.)

Chapter 4. HORTICULTURAL SOCIETIES

I. Introduction

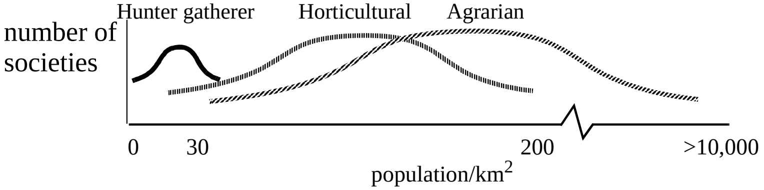
A. Basic Concepts

Horticultural societies are differentiated from hunting and gathering societies by the use of domesticated plants as the major basis for subsistence. Horticultural societies are technically differentiated from agrarian societies by their lack of plows and animal traction, and from pastoral societies because they do not make domesticated herd animals the main basis of subsistence.

Many more people can be supported per km^2 by investing effort in replacing relatively rare wild plant species that produce relatively few parts that humans can eat with masses of domesticated species that produce relatively great quantities of edible parts. People tend to have to work hard to plant, weed, harvest, and process food in horticultural systems. There is no assistance from animal or mechanical powered tools.

Horticultural societies have agricultural systems that are relatively unproductive per unit of human labor compared to plow agriculture, and more productive per unit land area than hunting and gathering., As figure 4-1 illustrates, this is a generalization about means; it does not tell us anything about the variance. Hunters and gatherers in the very best environments (e.g., the Northwest Coast) had local population densities that far exceed the very low densities of some horticulturalists of the tropical forests. Likewise, the best that horticulturalists can do in a favorable environment in this regard undoubtedly beats what the plowman can do in an unfavorable environment. When livestock becomes important enough that their herders become mobile, substantially different pastoral societies arise, although many horticulturalists keep some animals, and many pastoralists engage in some farming.

Figure 4-1. A rough comparison of population densities among three pre-industrial subsistence types.



Keep these two efficiencies, productivity per unit land and per unit labor, in mind. They have somewhat different effects on culture core variables.

B. History

Horticulture first developed in the Middle East beginning about 9,500 years ago and by about 5,000 years ago this technology had spread far eastward and to the Atlantic in the West (Times Historical Atlas[1]*, 1979: 42).* Cattle and sheep herding developed very early, in association with the plant domesticates, chiefly wheat and barley, plus a substantial number of minor crops. Hence, with the availability of draft animals, agrarian societies arose relatively early from horticultural ones in W. Asia and Europe. North China, Mexico, and Peru were also earlier centers of horticulture. The tropical lowlands of East Asia, Africa, and South America appear to have developed horticulture based on tropical crops rather later than the four semiarid city centers. We will discuss the evolution of horticulture in more detail in Chapter 26.

C. Ethnographic Sample

Unlike the case with hunting and gathering societies, we have a rather large sample of contemporary horticultural societies. However, our sample is still rather biased relative to the historical record. A special type of horticulture, swidden cultivation, has turned out to be a quite durable adaptation to the wet tropics. Elsewhere, plow agriculture has tended to replace horticulture. For example, the Spanish brought cattle to the New World, and ox-drawn plows replaced horticulture in most of the drier and more temperate parts of “Latin” America fairly soon after the Conquest. Chroniclers with the conquistadors give us some picture of these societies. We know something more of the horticulture of the Native American of the Eastern half of the US, most of whom were forest horticulturalists, and of the peoples of the Southwestern US and N. Mexico, who were horticulturalists in semi-arid country. These societies persisted in fairly unmodified state into the 19th Century.

Many people still depend upon horticulture in the wet tropics. You may have heard the somewhat old pejorative term “slash and burn” applied to swidden horticulture. After WWII views on swidden cultivation have changed substantially (Conklin, 1954). In many areas of the hot, wet tropics, high rainfall has developed soils that are very poor in nutrient holding capacity. An effective way to farm these poor soils is to burn off the forest and grow crops for a few years in the ash fertilized plot. As nutrients are depleted and weeds invade the field, it is allowed to return to forest. The period of forest fallow varies greatly, but 15-50 years. is perhaps the typical range. No more elaborate form of cultivation has yet proved practical on the worst of these soils, and many examples of quite simple horticulture are common in S.E. Asia, S. America, and Africa. In some tropical areas, especially Africa, there are also societies practicing more advanced forms of horticulture in the seasonally dry

---

[1] This is a very interesting reference work for leisurely perusal.

regions north and south of the Congo Basin. In Oceania, Melanesian and Polynesian societies still practice horticulture. A few hundred million people in the tropical parts of the world practice horticulture today.

II. Technology

A. Simplest Horticulture

The simplest toolkit of all is very simple indeed. The toolkit of horticulturalists varies immensely in complexity. Lenski and Lenski (1982) recognize this fact by subdividing the continuum into "simple" and "advanced" subtypes. The Amazonian Basin horticulturalists like the Yanomamo, Xavante, and Waorani made do with a simple stone axe to cut the forest, a means of making fire by friction to burn it, and simple wooden digging sticks and spades to plant their cuttings of manioc, sugar cane, maize seeds, etc. (Steel axes and machetes are much preferred to stone these days; steel is roughly 3 times as efficient in results per unit effort as stone.) South American simple horticulturalists typically keep no domesticated animals, and the men hunt and fish for protein. In Oceania, by contrast, pigs are a near-universal element of simple horticulture. In Sub-Sahara Africa, cattle are frequently kept whenever tetse flies, which transmit devastating diseases from native game to the relatively recent cattle, are absent. Residence is semi-permanent, so houses of modest sophistication are constructed. Villages may last on the same spot for a decade or longer, until it is convenient to move to find more game or to be closer to swidden plots.

Despite the relative simplicity of the technology, something like a 100 or more domesticated crops are kept, and plots are botanically complex. Conklin (1954) reported that an "ideal" Philippine Hunanoo swidden plot would contain 48 species of cultivars, including some 250 named varieties of the basic crops. A sharp division between domesticated and wild plants probably gives a misleading impression of tropical forest cultivation. Many wild plants are encouraged or planted. The complexity of swidden plots sometimes seems to mimic the forest, as plants with different stature and maturity schedules are interplanted. Forest succession seems to be managed to encourage species that will return the plot to cultivatable condition as rapidly and in as good a condition as possible. Altogether, tropical horticulturalists might be styled vegetation managers rather than farmers after the agrarian model (e.g., Conklin, 1961; Manner, 1981). Thus, as in the case of mobile hunters and gatherers, the simplicity of the toolkit belies the sophistication of its application.

B. Complex Horticulture

Many ancient horticultural societies had much more than the minimum tool kit. To get an impression of the range of technical sophistication of horticulture, we can compare the extremely simple Amazonian basin technology to much more sophisticated toolkit of the Andean Highlands. Andean peoples were a fair example of an advanced horticultural society in 1500. Cultivation implements included a "foot-plow", a sort of spade. Fields were permanent, often terraced and irrigated, and normally manured or cultivated with a short fallow. Inca and pre-Incan water control and irrigation works were quite impressive. Much of the system is still used today in the Highlands and Coastal Valleys of Peru, and ruined hydraulic structures are common as well. Domestic animals were kept, llamas, alpacas, and guinea pigs. Bronze was used for some utilitarian items and for weapons and ornaments (gold and silver for the last, too). Houses made of mud brick were designed to last a generation or two. Monumental architecture and fortifications of dressed stone are the visually most arresting accomplishments of the Andean peoples. You have all seen pictures of Cuzco and Machu Picchu. Textiles and pottery were in common use. Only a few societies we would call horticultural have a more sophisticated toolkit, although African horticultural societies have iron tools. This last is important. Bronze is a good metal for many purposes, but it is expensive because good copper and tin ores are hard to come by. Hence, bronze is an elite metal, not much used for common agricultural tools. Iron is a democratic metal, harder to manufacture, but relatively cheap once the technique is known because its ores are much more abundant. Perhaps significantly, Sub-Sahara Africa has little monumental architecture, which is a product of highly stratified societies. Iron and agriculture came together. Is it possible that the democratic metal (a good, sharp spear for Everyman) prevented the extremes of stratification in Africa?

III. Demographic Consequences

In the poor soil regions of the very wet tropics human densities under horticulture are often very low. In Amazonia and lowland New Guinea, densities are well within the range for hunters and gatherers, a fraction of a person per km^2. These people keep perhaps a hectare[2] of garden under cultivation per family, and do not return to the same plot for up to 100 years. Also unsuitable soils and areas too distant from rivers may not be worthwhile to cultivate at all. Even so, much seemingly suitable land seems to be lightly populated, and much suitable land left uncultivated. Students of Amazonia have debated several possible reasons for this, including depopulation by introduced diseases, the existence of intense warfare, and limited abundance of sources of protein (see papers in Hames and Vickers, 1983). In New Guinea, very high mortality rates from malaria may be a sufficient explanation for low population densities.

---

[2] A hectare is roughly the length of a football field on each side—100m X 100m.

Under more favorable circumstances, horticulture can support quite high human densities. On good soils, densities of up to 100 people per km^2 are possible, as in some parts of the highlands of New Guinea and tropical America, in Polynesia, in Africa, and in S.E. Asia. These densities are perhaps partly a function of recent developments like new crops during the last few hundred years, but in general horticulture is capable of supporting as many or more people per unit land as under the plow, just with more human labor per unit of yield. The maps and tables from Steward and Faron (1959) in figure 4-3 give an impression of the variation in South America during both pre-Columbian and contemporary times.

Settlements are of course much more likely to be permanent or semi-permanent than was the case with hunters and gatherers. Shifting cultivation in poorer tropical areas is the norm, and villages are moved every 5-25 years in some cases, but among advanced horticulturalists, permanent villages are the rule. In the least dense tropical systems, settlements may be no larger than hunters and gatherers' camps. The Gebusi of lowland New Guinea referred to in the last Chapter average 26.5 people per settlement. At the other extreme, fair-sized cities were maintained by the highly developed horticultural societies of Africa, Peru and Mexico. Cuzco, the Inca capital, must have several tens of thousands of inhabitants, for example. Common people lived in substantial permanent adobe houses, and huge monumental edifices were constructed of intricately dressed stone. But such large settlements are an indirect outgrowth of horticultural technology itself and make sense only in the context of the political situation we will consider in a moment.

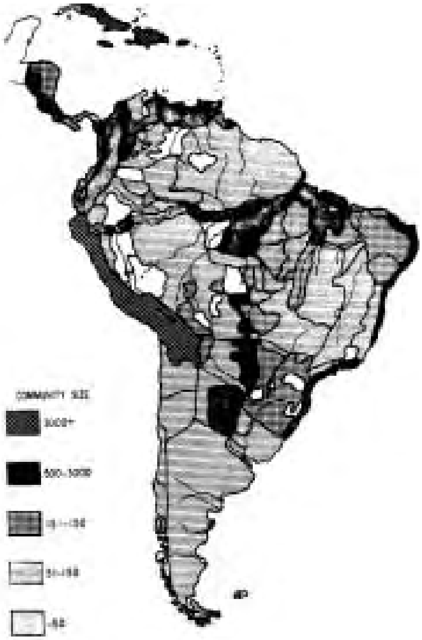
IV. Social and Political Organization

A. The Range of Sophistication is Large

The range of variation in political institutions is large under horticultural subsistence. Note in Steward and Faron's (1959) maps and tables that there is a pretty close correlation between ecology, population density, and political and social complexity. We looked briefly at the Gebusi in the last Chapter, who are as simple politically as the simplest hunting and gathering groups (Knauft, 1985). They lack any sort of formalized political roles. Kin relations and personal ties are all that order Gebusi society. The weak headman is also found among the simpler horticultural societies, such as those of the Amazon Basin, while full-fledged imperial states are found in the most advanced societies, such as the Inca Empire of Peru. More typically, horticultural societies are either organized around "Big-men" or Tribal Chiefs.

In the simpler horticultural societies, differences compared to hunters and gatherers are, to repeat, modest. Kinship remains the most important means of organizing social in-

Figure 4-3. Comparison of environment, subsistence type, community size and population density among contemporary native South American peoples. Compare with data for the same areas ca. 1500bp. Maps and table taken from Steward and Faron (1959:45, 52, 53, 57).



Population Densities per mi²

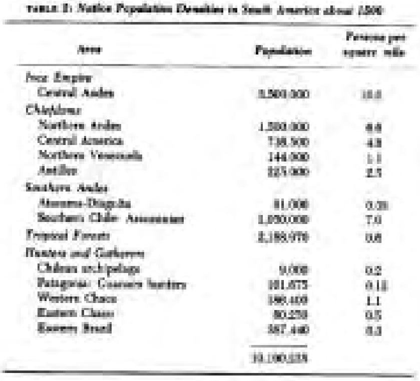


TABLE 2: *Native Population Densities in South America about 1500*

Area	Population	Persons per square mile
Inca Empire		
Central Andes	3,500,000	10.0
Chiefdoms		
Northern Andes	1,500,000	6.6
Central America	736,500	4.8
Northern Venezuela	144,000	1.1
Antilles	225,000	2.5
Southern Andes		
Atacama-Diaguita	81,000	0.39
Southern Chile: Araucanians	1,050,000	7.0
Tropical Forests	2,188,970	0.6
Hunters and Gatherers		
Chilean archipelago	9,000	0.2
Patagonia: Guanaco hunters	101,675	0.18
Western Chaco	198,400	1.1
Eastern Chaco	80,250	0.5
Eastern Brazil	387,440	0.3
	10,190,535	

teractions, and plays almost the same role as described for these societies. Interestingly enough, kinship emphasizes ties through the female line rather frequently in horticultural societies. Such societies are said to be matrilineal. In many horticultural societies, women contribute disproportionately to subsistence activities because they are responsible for most of the gardening work, and it seems to be useful to keep related sets of women together after marriage, rather than men as in the typically patrilineal hunter-gatherer case. However, many horticulturalists are patrilineal, so there is no strongly deterministic effect of subsistence type and environment on this variable. Polygyny[3] is also common in horticultural societies for the same reason. When women are the principle wealth producers, a man may get rich by having several wives. Men seem rather parasitical in horticultural societies, because they often do relatively little subsistence work but arrogate to themselves important political and military roles.

The norm for horticultural societies shifts radically in the direction already glimpsed among the richest of hunter-gatherer societies, toward the addition of new forms of social organization. Permanent villages of a few hundred people and much denser populations on the ground make interactions with non-kin commonplace. Coordination of non-kin often leads to political specialists, tradesmen, craftsmen, priests, soldiers, slaves and other occupational specialists, if population densities are high enough to permit sufficient people to be freed of the tasks of cultivation. Note that merely an increase in population density, even without any per capita increases in productivity, can allow some social complexity. If there are many people nearby, a small contribution from each will be sufficient to support a few leaders or craftsmen as full-time specialists. Simple markets may facilitate such specialization, but the role of political institutions in exchange is often large.

Political systems organized by political entreprenuers are common. These “Bigman” systems are characterized by a free competition for the main political role; these are “democratic” societies in which men rise to leadership through their merits and with the support of a body of followers. These systems have been well studied in New Guinea. Similar systems were probably the norm in much of horticultural America, for example in the biggish villages along the main stem of the Amazon. An aspiring bigman tries to talk his relatives into providing him with a share of their produce which he uses to create patterns of obligation among non-kinsmen. If he is successful he may come to be recognized as the main bigman in his village, responsible for the coordination of its affairs and redistributing food and

---

[3] *Polygyny* is the state or practice of having more than one wife or female mate at a time. *Polyandry* refers to having more than one husband or male mate. *Polygamy* refers to a marriage in which a spouse of either sex may have more than one mate at the same time

other necessities between kin groups through the webs obligations that surround him. Typically there remain lesser competing bigmen, who may displace or succeed the current main one. The big-man is a sort of cross between a businessman and a politician. Some of these societies look as if they had been designed by conservative economists, like Milton Freedman, who so emphasize free-market competition (Pospisil, 1978).

There seems to be a strict limit to the number of people that can be organized politically under the bigman system, only up to a few hundred people. Typically, a bigman is merely respected for his personal qualities, and perhaps feared because of his ability to mold a public consensus. His formal powers are generally weak. In this, the bigman system somewhat resembles modern democracies in the extent to which the political elite must respond to public opinion. We are not aware of any known cases of a formal electoral democracy developing directly out of such a system and permitting a state level of political organization to arise. It is interesting that formal democracy is so rare among human societies, and that open political systems based on free competition for popular support occur in relatively simple societies and then again in the industrial democracies. Other kinds of social institutions can operate to link people on a wide scale even with relatively weak leadership. Wiessner and Tumu (1998) reconstruct the way Enga collaborating bigmen in Highland New Guinea used systems ceremonial warfare and ceremonial gift exchange to bring many thousands of Enga across a considerable distance into a rather complex economic system.

Political systems based on hereditary politicians (Chiefs) organize fairly large-scale political units. Chieftainships have a hereditary principle of political power, and, as they are elaborated, evolve into the ascriptively stratified societies so common historically. Often, the senior males of a lineage have some authority over lineage members in hunting and gathering and simple horticultural groups. Chieftainship arises by extension of this principle to the ranking of lineages themselves as senior and junior, so that the senior male of the purportedly senior lineage (the man who can trace his ancestry back to a founding male through *eldest* sons) claims political authority over a large group. Genealogies may in fact be jiggered fairly substantially to fit political reality, but the ideology of inherited political power over a large “family” is important. The ranking of lineages can be quite deep in the more complex cases. There may be a level or two of sub-chiefs with the head of the most exalted senior lineage of all acting as the overall “paramount” tribal chieftain. Conquered or allied people may be incorporated under some paternalistic principle or simply by “rewriting” history to correspond to the ranked lineage principle.

Sometimes the number of people coordinated by such a system gets very large indeed, up to a few tens of thousands, rather than the few hundreds for the big-man system. However, the typical chief still has to mobilize kin obligations to make his will felt. The subchiefs and other members of the high-ranked lineages do his bidding because he is a kinsman, or because he and his kinsmen are strong enough to compel obedience. The chief typically has to be on site to make his will felt. For example, in war he calls out the warriors and leads them into battle. All of this is true despite the fact that the chief is usually also endowed with supernatural respect, as a chief priest of a local cult as well as a political leader.The supernatural powers (the *mana* of the Polynesian chiefs for example) is often so effective in preventing revolts by average citizens. However, in most cases, there are enough genealogical complexities so that chiefs always have to watch out for ambitious half-brothers, uncles, and neighboring chiefs. Members of lesser lineages may not often revolt on their own, but they can often easily rationalize a shift of loyalty if the existing chief is too overbearing. Thus the will of lesser folk plays a role, if a diminished one compared to big-man systems, in constraining leaders.

In a few cases, state-level political systems are based on horticultural subsistence. At some point, the size of a chiefdom becomes too large to managed by the paramount chief without a cadre of clerks, judges, policemen and soldiers directly answerable to the chief, and we judge that a state has arisen. However nepotistic the recruitment of this body of retainers may be, a new principle of social organization, bureaucracy, is said to have arisen when the chief’s subordinates are no longer sublineage leaders in their own right, but functional specialists of one sort or another who exercise authority only as agents of the state leader. Then the chief is called a king. As the state emerges, it is also typical for the senior lineages to be separated from lesser folk qualitatively as an aristocracy, rather than being only quantitatively higher-ranked. If you are familiar with medieval European history, there is no simple point at which this boundary was crossed. (Were Shakespeare’s MacBeth and Lear kings or chiefs?) States are usually, but not always, underpinned by agrarian technology, whereas horticulturalists more commonly get only as far as chiefdoms. Nevertheless, there are many examples of small states under horticultural technology in the New World, Africa, and S.E. Asia. The Inca’s very late, large, multiethnic conquest empire was a unique achievement under horticultural technology however. (See Patrick Kirch (1984) for a good example of the political evolution of chiefdoms from the simplest exemplars to borderline states in Polynesia.)

B. The Redistribution Function

The political organization of horticulturalists is important because of the redistributive aspect of political institutions. Crop production is not a particularly secure mode of life in many environments. Any given family can easily suffer from insufficient production in a given year. Political institutions often function to redistribute food to the unlucky, either as a loan or "gift" that creates obligation to the bigman or chief. Chiefs and bigmen are celebrated for their generosity and condemned for selfishness. A failure of generosity will result in substantial loss of popular support, and more or less severe risk or loss of power. Furthermore, given a modicum of political leadership with an interest in economic prosperity and efficiency, a considerably more complex economy can develop. This is because, similarly, craft specialists such as long-distance traders and blacksmiths require some guarantee of subsistence before they will abandon horticulture for a trade. Of course, the costs of maintaining a full blown chief in the rich style to which he easily becomes accustomed is not a negligible cost. We will return to consider the functional versus exploitative aspects of political institutions in Chapter 27.

C. Management of Violence

Warfare is typically much more important under horticultural than hunter-gatherer technology. This is true even among the groups like the Amazonian horticulturalists that do not otherwise depart from hunter-gatherer social and political organization much.

Terroristic practices such as headhunting, headshrinking, scalping, and cannibalism are commonly practiced by horticulturalists, and are vivid testimony to the high levels of intercommunity violence they commonly exhibit. Probably, the main impulse for such warlike behavior is that fixed property is much more available as booty, cultivated land is more worth seizing (or defending), slaves can be put to productive work in the fields, etc. Just the fact of higher densities mean that unrelated people are closer at hand to cause trouble (or offer opportunities to raid).

The very simplest societies seem to exhibit a lot of violence at the level of individual homicides, as we saw in the last chapter. As population density goes up, and political sophistication increases, organized authority gradually suppresses internal violence at a larger and larger scale. Politically organized communities forbid murder, as Thomas Hobbes hypothesis long ago suggested. Bigmen and chiefs in simpler chiefdoms do not monopolize legitimate violence (the right to punish transgressors) to anything like the degree of states. Rather they act as mediators, mobilizers of public opinion, and occasionally co-enforcers of customary rules. Often in such societies a kin group remains responsible for its own policing, say avenging a murder or demanding blood payment for one. The big-man or chief advises, and uses his good offices and prestige to ensure in-group peace, but does not wield a big stick. Still, this is sufficient to make a marked reduction in within-group violence.

However, politically organized and independent communities feud and war. With the problem of in-group violence substantially solved, people are freer to turn to their more distant neighbors. Horticultural societies are typically as highly and exuberantly aggressive as groups as typical hunters and gatherers are overtly peaceable but murderous as individuals. Clan vendetta, raids led by “fight chiefs” (actually a type of bigman), and chiefly wars of conquest are typical of horticultural societies.

Much of this warfare is highly ritualized, including on the one hand chivalrous arranged battles, and on the other the conspicuous exhibition of warrior virtues and the preparation of grisly trophies. We will consider why warfare might have such elaborate symbolic attributes in Chapter 19.

V. Other Features of Culture

Elite “high” culture emerges in chiefdoms and states. Lenski and Lenski note several interesting correlates of the development and elaboration of horticulture for the symbolic elements of culture. One is the development of “high” art, art for the elite made by specialists. Hunter-gatherer “folk” art was something people did for their own enjoyment and use in exchange. At the horticultural stage, art begins to be used also as a symbol of prestige, especially ascribed prestige of noble birth. Regalia like crowns, and ceremonies like coronation develop that mark elites as qualitatively distinct from commoners. Similarly, supernatural beliefs are elaborated. Witchcraft, for example seems to be correlated with sedentary life. Horticulturalists may not like their neighbors and kin, but they cannot move away the way hunter-gatherers usually can. Maybe this is the reason why witchcraft beliefs become particulers developed among horticulturalists (Edgerton, 1971).

In chiefdoms, we begin to see another phenomenon, the development of a close relationship between religion and political organization. Chiefs frequently claim supernatural powers or support, and supervise the construction of monumental buildings to celebrate the connection. The well known henge monuments[4] of the Atlantic coast of Europe are examples, as are the totemic mounds of the US Mid-West, and the statuary of Polynesia—that on Easter Island being the most spectacular.

VI. Environmental Gradients and Core Response

The ecological and humidity gradient from the Pacific across the Andes into the Amazon Basin is one of the most spectacular in the world. It provides an excellent example of how the same basic subsistence system can lead to very different outcomes in different en-

---

[4] Stonehenge, near Salisbury in England, is an example of this type of monument.

vironments by the Stewardian culture core mechanism. The Coastal Valleys are narrow oasis ribbons in an extremely dry desert, flowing from 6,000m peaks to the sea. On the east, the Andes plunge very sharply from a similar range of tall peaks to nearly sea level in perhaps 50 km, carving spectacular gorges in the eastern flanks of the mountains. The Eastern Lowlands are hot, wet tropical forest, with mostly poor, heavily leached soils. In the mountains are a series of high (3,000-4,000 m), cool, semiarid intermontane valleys covered with fresh alluvium from the eroding Andes.

The human ecological gradient was equally sharp. The wet Eastern lowlands were the home of simple horticulturalists and hunters and gatherers. The intermontane valleys and miniature Niles along the Peruvian Coast were host to sophisticated chiefdoms, city-states, and ultimately the Inca Empire. The Inca Empire developed very late, mostly in the 15th Century, and it was immensely long (ca 2,000 km) but very narrow, following the montane valleys and coastal rivers. The Andean and Amazonian societies were in long, direct and continuous contact along the Eastern side of the Andes at roughly 2,000 m elevation. Machu Picchu, the famous “lost city of the Incas” was a fortified border town on this frontier, only 50 km or so downriver toward Amazonia from the Inca capital at Cuzco. The toolkit of the lowlanders was relatively modest, and the scarcity of good soils kept population densities low, accounting for the relatively simple bigman-led political systems with little division of labor. The Inca Empire and precursor city-states had a much more productive agriculture centered on good alluvial soils. Terracing, irrigation, manuring and other advanced horticultural techniques allowed dense populations and sufficient labor efficiency to permit the emergence of urban centers with considerable craft specialization as well as bureaucracies and professional military forces.

The sharp differences in technology across this frontier cannot have had to do with evolutionary differences due to development in isolation. Trade, raiding, and other forms of contact gave ample opportunity for the lowland people to acquire highland technology, if they could use it. They didn’t apparently because they couldn’t. Thus, the extremely steep natural-ecological gradient on the East side of the Andes was (and still is) matched by an extremely steep human ecological gradient. As we shall see a broad culture core reflects the gradient as well. For Steward (1959), it must have been gratifying to see how well his culture core concept applied in South America.

Horticultural societies also furnish classic examples of differences determined by history rather than ecology. The most famous is the difference between the bigman systems of Melanesia and the ranked chiefdoms of Polynesia (Sahlins, 1963; see also Orlove cite in first chapter). Here, peoples with similar technology inhabiting similar islands differ substantially in their political organization because of different histories. It seems likely that the idea of ranked lineages only arose once as the Polynesians evolved from Melanesians three millennia ago. In most environments, this small difference had little impact on social organization, but on large islands Polynesians quickly developed large-scale chiefdoms and even states, while Melanesian societies remained relatively small-scale even on very large islands like New Guinea. We will return to this problem in Chapter 27 when we consider the evolution of states and stratification. For the present, just remember that the Andes/Amazon contrast, where a historical/evolutionary effect can be ruled out because of long, constant contact, is not entirely typical.

VII. Conclusion

The culture core concept works, but evolution is needed as well.

Horticultural societies cover an impressive range of variation within the type. Steward's culture core concept does an excellent job of accounting for much of that variation, but there are some quite puzzling anomalies, exemplified here by the contrast between Melanesia and Polynesia. In cases such as Melanesia and Polynesia, we need to invoke historical or evolutionary processes to explain the anomalies. In the case of political evolution in the Andes, the very late development of the Inca Empire is testimony to ongoing evolution.

VII. Bibliographic Notes

References:

Conklin, H.C. 1961. The study of shifting cultivation. *Curr. Anthrop.* 2: 27-61.

Conklin, H.C. 1954. An ethnoecological approach to shifting cultivation. *Trans. NY Acad. Sci.* 17: 133-42.

Hames, R.B. and W.T. Vickers (eds). 1983. *Adaptive Responses of Native Amazonians.* New York: Academic Press.

Harlan, J.R. 1971. Agricultural origins: centers and noncenters. *Science* 174: 468-474.

Kirch, Patrick. 1984. *The Evolution of Polynesian Chiefdoms.* CAmbridge: Cambridge Univ. Press.

Knauft, B.M. 1985. *Good Company and Violence.* Berkeley: Univ. of California Press.

Manner, H.I. 1981. Ecological succession in new and old swiddens of Montane Papua New Guinea. *Human Ecology* 9: 359-60.

Meggers, B.J. 1984. In, H. Sioli, ed. *The Amazon*. Hague: Junk.

Pospisil, L. 1978. *The Kapauku Papuans of West New Guinea*. New York: Holt, Rinehart, and Winston.

Sahlins, M. 1963. Poor man, rich man, big-man, chief: Political types in Melanesia and

Polynesia. *Comp. Stud. Soc. Hist.* 5: 285-303.

Steward, J.H., and L.C. Faron. 1959. *Native Peoples of South America*. NY: McGraw-Hill.

Times Atlas of World History. 1979. Maplewood NJ: Hammond. (This is a wonderful reference book. If you have any interest in history you'll love it. They have a companion one on archaeology. Only drawbacks: they get dated fast and have no referenes to follow up.)

Wiessner, P, and A. Tumu. 1998. Historical Vines: Enga Networks of Exchange, Ritual, and Warfare in Papua New Guinea. Washington: Smithsonian Institution Press

General:

The journal *Human Ecology* is a good place to start for descriptive articles on modern swidden cultivation. See especially Vol. 11 #1, March 1983.

Regional summaries and collections of papers from regions where horticulture is common are useful, e.g.:

Vayda, A.P. 1968. *Peoples and Cultures of the Pacific.* Garden City NY: The Natural History Press.

General readers in human ecology usually have some of the important classical papers on horticulture. The book-length descriptive works on particular horticultural societies are an important primary reference, as is the growing agronomic literature from the tropics.

Chapter 5. PASTORAL SOCIETIES

> Some outstanding traits in Nuer character may be said to be consistent with their low technology and scanty food supply. I emphasize again the crudity and discomfort of their lives. All who have lived with Nuer would, I believe, agree that though they are very poor in goods they are very proud in spirit. Schooled in hardship and hunger—for both they express contempt—they accept the direst calamities with resignation and endure them with courage. Content with few goods they despise all that lies outside them; their derisive pride amazes a stranger.
>
> E. E. Evans-Pritchard (1940: 90)[1]

I. Introduction

A. Pastoralism Defined

Pastoral societies are those that have a disproportionate subsistence emphasis on herding domesticated livestock. Many horticultural, agrarian, and industrial production systems incorporate livestock. The most important defining criterion perhaps is the organization of community life around the needs of the herds. Typical herding societies are "nomadic." People live in portable tents or temporary structures and move considerable distances from pasture to pasture according to the dictates of ecological circumstances and the needs of the beasts. Nomadism is a technological adaptation to scarce and ephemeral pasturage that has major ramifying effects on culture core features that are absent if animals are managed from a fixed home base, as in European dairying or Mexican/Anglo-American ranching.

B. Pastoralists Confound Progressivism

Pastoral societies are theoretically important because they exhibit non-progressive evolution. Although it is possible to portray pastoral societies as an "evolutionary bypath", (e.g. Lenski and Lenski, 1982), this is a mistake. Pastoral societies played an important role during the agrarian era and illustrate some important ecological/evolutionary processes.

Evolutionists of the progressivist (orthogenetic) type, who believe that evolution has some inevitable tendency in the direction of more complex and probably morally superior societies, are inclined to downplay pastoral societies because they tend to contradict with the inevitability-of-progress flavor of this "theory." Pastoralists developed relatively late in history, but have the air of primitive throwbacks and destroyers of "advanced" civilizations.

---

1. The Nuer are cattle pastoralists in the southern Sudan.

C. Environmentally Specialized Societies

Pastoralism was for a long time a very successful adaptation to grassland and desert. The existence of extensive tracts of temperate grassland (steppe), subtropical desert, or tropical savanna, combined with the technology of animal husbandry, lead to the development of pastoral societies that compete and very effectively with more "advanced" agrarian societies for these open country environments, despite being considerably more "primitive" in terms of complexity of social and political organization. For example, pastoral peoples routinely prevented farmers from occupying the rich steppes of South-eastern Europe that are now the main grain producing regions of Hungary, Russia and the Ukraine. The politics of the Old World agrarian civilizations was heavily influenced by pastoral raiding and conquest, as pastoral peoples used the mobility afforded by a wealth of riding animals to plunder civilized states and to impose themselves as elites upon conquered agrarian societies.

Imagine how the history of the Old World might have differed if the ratio of the grasslands favorable to pastoralism to those where the farmers could dominate had been, say, twice as great as it was. Given the trouble Central Asian nomads caused civilized states in the period from about 3,000 to 750 years ago, if the ratio of prime pastoral to farming environment were much more in favor of the pastoral adaptation, the Eurasian development of sophisticated states would have been severely retarded. Imagine if the Goths, Huns or Mongols had had a little more grassy country to work with! The "civilized" agrarian Eurasians, whose technical evolution gave them such great dominance in the last 5000 years, could easily still be the terrified, benighted clients of pastoral conquerors, much as the Russians were for a couple of centuries after the Mongol conquest. The south-eastern region of Europe became an agricultural frontier from the 16th to the 18th century (McNeill, 1964), as firearms finally tipped the balance of power in favor of agrarian states.

Trade and war are both favored by the efficient transportation technology that is in the hands of pastoralists. Pastoralists tend to engage quite freely in commercial trade and war. Carts, and caravans derive directly from the basic subsistence adaptations of pastoralists, and are easily adapted to commercial trade and/or raiding and conquest.

II. Pastoral Technology

A. Pastoralism as Horticulture/Agriculture Without Plants

The technology of pastoralism is largely just the animal husbandry component of the prevailing horticultural and agrarian technology, more or less thoroughly shorn of its plant cultivation component. On the level of subsistence, pastoralists are merely farmers who specialize in herding animals like sheep, goats, cattle, horses, llamas, yaks, and so forth. Normally, this specialization includes a good deal of specialized knowledge about animal husbandry, pasture, and land transportation technology, exceeding that of their farming neighbors, but not dramatically. Contrariwise, although many pastoralists also farm, they are generally not the experts their neighbors are.

Few pastoral people subsist entirely on animal products. Most probably derive half or more of their calories from plant products. These may derive from growing crops, from trade in animal products with settled agricultural foreigners, by extending services such as caravan operation for pay, by having agricultural slaves or clients, and by raid or threat of raids. The human diet is greatly enriched by eating relatively small amounts of meat and animal fats. Leather, horn, wool, and animals for traction are also valuable. Thus animal specialists are often motivated to trade much of their valuable animal production for grains, crafts and manufactures, luxuries and so forth. Settled peoples often pay tribute to pastoralists to avoid raids, or pay some pastoralists to protect them from other pastoralists. The role of pastoralists as traders best developed in those places and periods when caravan routes were important. The Silk Road to and from Europe and Western Asia to China is a famous example. It was open in the Roman period and again under the Mongol Khans. This route was only open when a dominating power controlled Central Asia sufficiently to keep it reasonably policed.

The key to the culture core of pastoralism is the mobility made possible by herders. In agriculturally productive areas, farmers may keep many animals, and sometimes even specialize in dairy or meat production. However, as long as these animal farmers maintain a settled residence they generally remain part of the surrounding agrarian society. In poorer environments, the reason for mobility is much the same as in the case of hunting and gathering. By emphasizing animal products, the focus of subsistence is moved up the food chain a step, and several animals must be kept to support a family. Typically, any given area is grazed out in a few days to weeks and herds must be moved. In dry tropical and subtropical areas, such as Arabia and much of Africa, herds are moved in response to water availability. In temperate Eurasia, seasonal migrations are common. For example, groups may move animals quite some distance from lowland winter pastures to highland summer pastures. This pattern is common in the American West even today. As we will see, in richer environments, mobility is as much a socio-political as an environmental adaptation to exploit scattered pastures.

B. Culture core consequences

Once a whole society is committed to living in tents and temporary huts as they fol-

low their herds, social organization can change dramatically. As we discuss in more detail section IV, mobile herders are highly independent. They can move to avoid trouble, and move to make it by raiding their neighbors for livestock if they are other pastoralists and for other forms of booty if they are settled peoples. Quite small groups, usually a patrilineal extended family that collaborates to manage one herd, is the basic social unit. It can operate as a nearly autonomous social system with tenuous ties to other families. However, mobility means that many such units can potentially assemble in one place. Thus tribes and confederations of tribes can also arise. Historically, the scale of pastoral societies tended to fluctuate unpredictably. More often than not, pastoral societies were small and independent, with much conflict between tribal segments within ethnic groups. In the great waves of conquest in the Old World, multi-ethnic confederations arose. The Mongols organized an imperial state on the basis of nomad conquest.

C. Is it adaptive to maximize standing stock?

Wealth and status in pastoral societies are typically dependent on the size of one's herd. Attempts are made to maximize herd size in the face of a rather uncertain environment. Dairying is also especially well developed among pastoralists, because it allows them to exploit animals without killing them and thus reducing herds. Some specialized animal product technologies are virtually unique to pastoralists, for example the widespread use of blood extracted from living animals, which has a similar motivation as dairying.

The stress on large herd *size* rather than *productivity* has itself been interpreted as a kind of "bank account" adaptation to uncertainty in rainfall, disease, and raid losses (Mace and Houston, 1989). Productivity is reduced at high herd size because ranges tend to be "overstocked," reducing milk yields, increasing calf mortality, etc. However, maximizing the standing biomass of livestock rather than the short-term yield provides a substantial reserve in case of problems. Semi-arid and arid areas are notoriously variable in terms of rainfall, even without the political uncertainties of pastoral life, and the maximum-standing-stock technique perhaps makes sense as an adaptation to highly variable environments, although it has seemed irrational to range management experts schooled in maximizing the flow of meat, milk, and fiber production into a market economy. This difference in outlook has caused much misunderstanding over the years when international aid experts recommend reducing livestock populations in traditionally pastoral areas. Due to the ideological importance of livestock to many pastoralists, they seem to the experts to be merely irrational cow lovers. Only quite recently have they come grasp the risk management function of large herds.

C. Variability--Plains Indians, Eurasians and Africans:

Pastoral societies are tremendously variable in terms of the details of their technology. Perhaps the most important distinctions are those based on sophistication of transport methods. The pastoralists of the Eurasian Steppe, including Indo-Europeans in the early days, Turks and Mongols later, made extensive use of wheeled transportation, as well as riding horses. The Camel nomads of the Eurasian and North African deserts rode but seldom used cartage. The late, specialized North and South American equestrian hunters were similar to the Arab Bedouin in this respect. Finally, the Eastern and Southern African cattle herding pastoralists used neither carts nor riding animals. Their toolkit and social organization is more horticultural than agrarian, as is developed in Section VI. Carts allowed Eurasians to carry a larger fraction of the agrarian toolkit around with them, and to assemble and supply larger collections of people in one place.without having a very complex political system. As Johnson and Earle (1987, cite in Chapter 1) point out, social complexity among pastoralists ranges from societies like the Nuer to Eurasian examples of Kahnates with many economic, religious, and political specialists, and a strong, though commonly achieved, status hierarchy. Still, even Eurasian pastoralists were generally very unsophisticated by the standards of their “civilized” neighbors. For example, even the Mongols at the height of their power were an illiterate society, in spite of having literate neighbors for millennia. As we saw with the Andean ecological gradient, the grassland—farmland technical gradient remained sharp over long periods of intimate contact. Section VI elaborates on the reasons for the variability in pastoral systems.

III. Origins: Several Centers

In the Old World, the main region of pastoralism was the broad band of steppe (semi-arid temperate grassland), mountainous country, and temperate desert stretching from the Hungarian Plain eastward to Manchuria, bounded on the north by the forest belt and on the south by the line running from Black Sea through the Caucasus Mountains, through Tibet and the skirting around the headwaters of the great river systems of China (Figure 5-1). Here pastoralism was first developed, probably in the Western part of the region about 5,000 years ago, just as the first agrarian states were emerging to the south in Mesopotamia. These people were Indo-European in speech. We all speak a tongue (English) derived from Indo-European, a result of the far reaching impact of the first waves of pastoral conquest (Mallory, 1989). The terms for horse gear are among those that the Indo-European languages have in common and are among the Proto-Indo-European terms that can confidently be reconstructed. (PIE was the ancestral language, spoken in the Caspian region about 7,000 BP. Linguists believe they have a fair reconstruction of the language from the commonalities of all the derived tongues.) The steppe and desert pastoralists of Eurasia herded cattle, sheep, and horses for the most part (yaks in Tibet, bactrian camels in the drier parts). This zone was extensively occupied by pastoral societies until the late 19th and early 20th centuries. *The second important locus developed about 3,000 BP in Arabia*, based on the domestication of the one-humped camel to exploit the hotter, drier pastures of the subtropical deserts, supplemented by sheep, goats, and horses in the better areas. These people were Semitic language family speakers (includes Arabic and Hebrew among others), and the wide distribution of Arabic speakers from Mesopotamia to Northern Africa (and the even wider distribution of the Moslem religion) testifies to their activities. Camel pastoralists are still an important part of the Middle Eastern scene; Saudi Arabia is ruled by a dynasty with direct pastoral ancestry.

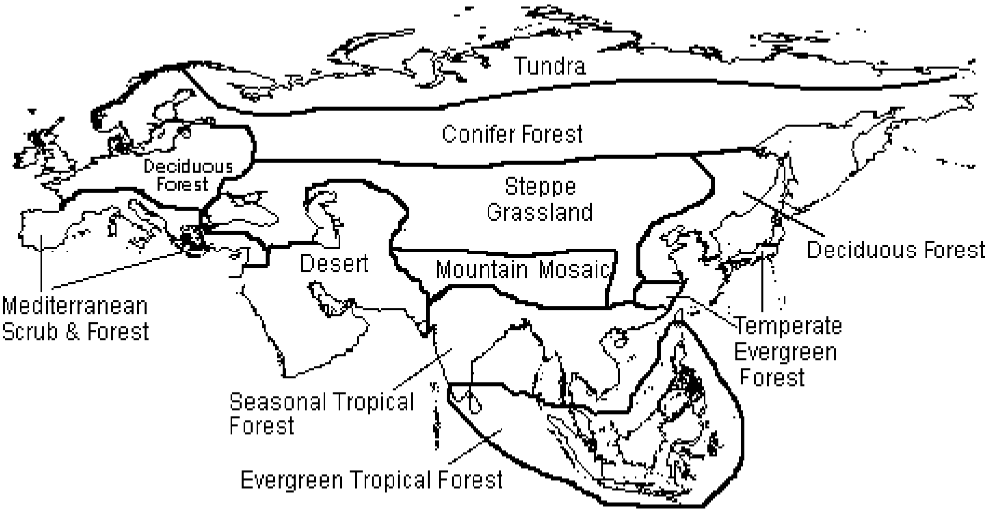


Figure 5-1. The main ecological zones of Eurasia. Pastoral peoples dominated the steppe, and desert zones, and were important in the dry parts of the mountain regions.

The third important locus of Old-World pastoralism is the belt of African societies that sweep across the Sahel south of the Sahara, down through the drier parts of East Africa, and back across to the Atlantic south of the tropical forests. These peoples herd cattle in tropical savanna areas arid enough to be fairly free of tsetse (which transmit a series of trypanosome diseases to which most cattle are not resistant). This development was fairly late-3,000 BP. People speaking Nilotic and Bantu languages expanded substantially after the development of cattle pastoralism in Africa. Goats are a relatively important secondary animal in this region. Sheep, horses, and camels are herded by many pastoralists from Somalia west to the Atlantic and north to the Mediterranean, but not in Eastern or Southern Africa for reasons discussed in Section VI.

There was a fourth minor locus of pastoralism in the northern forest and tundra in the Old World beyond the limits of farming, diffused to the Canadian Arctic in this century, based on reindeer herding (e.g., the Chukchi of Siberia and the Lapps of Norway and Finland).

Pastoral societies were absent in the New World. Although Andean peoples herded camelids extensively in conjunction with agriculture, but it is doubtful if independent societies were involved. Small foci of pastoralism exist in many places where farming is difficult, for example in India (Gadgil and Melhotra, 1982), and something on that scale could have occurred in the Andes. The American peoples domesticated few animals compared to the Old World, and the opportunities for pastoralism were correspondingly reduced. In Chapter 22 we discuss a possible reason for this difference.

However, when Europeans introduced horses back into the New World, a sort of pastoral society developed very rapidly in the Great Plains of North America, and on the Patagonian steppe in South America. These people were horse mounted hunters rather than pastoralists in the usual sense, but the parallels in terms of ecological zone and trading and raiding activities are striking (Ingold 1980). It is also striking that the Plains and Patagonian quasi-pastoralist societies evolved very rapidly once the key innovations (horses, guns, and trade) were acquired by diffusion, a testimony to potent evolutionary potential in pastoralism. It seems likely that full-scale pastoralism would have rapidly developed, had not Generals Sherman (USA), and Rosas (Argentina), and the other European Indian fighters brought overwhelming modern military force to bear. The firearms, cannon, improved wagons, riverboats, and similar industrial products that 19th Century states could deploy in abundance, were too much for the Indians in the end. The Russians and Chinese used the same technology to pacify pastoral societies in steppe belt Eurasia in the same period.

IV. Social Organization

A. The Importance of Patrilineal Kin Groups

Virtually all pastoral societies are built around patrilineal kinship groups. Typically, the genealogy of each patrilineage is reckoned, either actually or fictitiously, back many generations. The minimal functional unit of such societies is usually a co-residential patrilineal unit of varying dimensions dependent on ecological variables and political history. Large segments are generally favored for defense, but sparse pasturage causes fairly minimal units to be the rule. Thus, typically a unit of 50-200 persons organized around a few fairly closely related males is the unit that herds and lives together. These units are usually webbed together by patrilineal kinship ties that gradually weaken with genealogical distance to a tribal section, to the whole tribe, and on up to a supra-tribal ethnic group. In the case of the Bedouin, Turkomen, and African groups that are fairly well known from the ethnographic record, the whole society for some purposes can number in the tens of thousands in some cases, though normally these links would be thought quite remote and mobilized to accomplish something only under extraordinary circumstances. As the famous study of the Nuer, an African pastoral group, by E.E. Evans-Pritchard (1940) showed, this "segmentary" principle can be fairly effective in organizing collective action among pastoralists. The Nuer lack chiefs and other complex political institutions, but can cooperate very effectively on an ad hoc and informal basis, reinforced by a lively ethnocentric sense, to raid or resist domination by non-Nuer. Kelly (1985) describes how the Nuer were able to conquer their neighbors, the Dinka without a sophisticated political system.

B. Sexual Division of Labor

The sexual division of labor is sharply marked in pastoralist societies. First of all, men are often largely responsible for herding larger stock such as cattle, whereas women engage in handicrafts, food production and processing, small-stock herding (goats, sheep) and the milking of livestock at camps. The division of labor is underlined by the grossly disproportionate emphasis on masculinity in these societies. Herding large animals is rough, dangerous, and uncomfortable and a cult of masculinity is perhaps functional even without considering warfare. The Maasai herders of Kenya and Datoga of Tanzania are good examples of the type (Borgerhoff Mulder, 1991). A man ought to have killed a lion with a spear as one of the many stressful tests of his manhood. He exhibits a good deal of contempt for anyone who is not an owner of cattle and a warrior, anyone who is not a true human being in other words. Even today, these people are quite contemptuous, not only of their farming neighbors, but also of Europeans. (As our epigraph shows, the Nuer have the same attitude.) They might have some respect for hard-bitten old fashioned American cowboys, but otherwise they are unimpressed by anybody else. Real humans own cattle, others are just low-grade farming scum.

This is not to say that the status of women is particularly low in such societies; it often seems to be fairly reasonable by comparison with some agrarian societies. For example, Mongol women played an important political role, often acting as regents for sons too young to directly rule as tribal chiefs after the death of their fathers. Some pastoral societies have a socially sanctioned role for males that desire to opt out of the hypermasculine system (e.g., the berdache transvestite role among the Plains Indians). The Chukchi reindeer herders of Siberia had a special role for women inclined and tough enough to perform as men. Both of these institutions included homosexual (biologically but not socially speaking) marriage (Leeds, 1965).

C. Significant Occupational Specialization

The more complex pastoral societies support a certain variety of specialized roles besides the basic male herdsman and female craft/food processing ones. Despite the emphasis on animals, most herders are dependent on crop staples for much of their caloric intake, as noted above. In the more complex herding societies, where the core families do not farm, client agricultural families are often part of the society. If not, or in addition, specialized tradesmen organize the exchange of agricultural products for animal products. Specialized craftsmen, such as blacksmiths were common. Political specialists (chiefs and their retinue) were often important, especially in the great conquest bands, religious men (especially after the spread of Islam and Buddhism), and slaves were present in the more "advanced" groups.

The Mongols created the most complex pastoral societies based on a long Eurasian tradition of pastoral near-states (Allsen, 1987). Even when in their most bloodthirsty moods, the great khans spared useful specialists among defeated city-dwellers and incorporated them into the mobile bands in great numbers. Military specialists (e.g., engineers to construct fortifications and manage their destruction) were especially favored, but literate administrators and the like were included as well. The ruthless rationalism of the Mongols impressed everyone, and was undoubtedly the reason for their unprecedented political and military successes (Saunders, 1971).

V. Political Origin and Consequences of Pastoralism

A. Lattimore's Hypothesis

The most famous hypothesis about the origin of pastoralism focuses on the political-military consequences of pastoralism combined with nomadic movement. Owen Lattimore argued in 1940, on the basis of the history of Chinese relations with the Eastern nomads, that pastoralism grew out of mixed farming on the margins of the main centers of agrarian states (see also classics by Grousset, 1970, and Khazanov, 1983). As the size and power of early states developed, their rulers came to heavily exploit peasants. In most habitats, the state fastened an almost unbreakable yoke on the rural producer. A revolt *might* displace the existing elite, but seldom get rid of them altogether. In the next chapter, we'll see that in mountainous country tribal independence could sometimes be defended from states. In the grassland belt, pastoralism turned out to be an even more effective strategy for resisting state domination. By abandoning or deemphasizing crops, pastoralists could move with their animals when the prince's army marched, use the mobility of chariots and later riding animals to harass the army, and move back when the army got tired. By discovering the fundamental tactical advantages of movement, concentration, surprise, and offensive violence, pastoralists could defend themselves from numerically and technically superior armies of states. William Irons (1975) has given good evidence that the Turkomen of the Eastern shores of the Caspian used just such a mechanism to resist Persian and Russian domination down into the early years of this century.

Custer discovered just how effective these tactics could be at the Battle of the Little Big Horn as the Sioux and the Cheyenne tried to resist Euro-American domination[2]. The Americans were not exactly surprised by this band of Indians; they had gone looking for them. What was a surprise was how many warriors were concentrated on the Little Big Horn so distant from their reservations. The US Army's intelligence failed to take into account how quickly—and how far—horse nomads could move. Custer's 200 odd cavalrymen rashly tried to attack an encampment containing perhaps 2,000 warriors, who made short work of them (Connell, 1984).

B. Positive Feedback and the Evolution of Culture

The evolution of pastoral military institutions tends to snowball. In the first place, herd animals are relatively easy to rustle, and pastoralists everywhere are in the habit of stealing from each other. Rustling keeps fighting skills tuned to a high pitch. Furthermore, the pastoralists' skills are quite suited to general banditry and raiding on the agricultural fringe. The Plains Indians of North America were essentially forced to adopt pure pastoralism or be driven from the grasslands. People, like the Apache, who tried to mix maize farming and horse hunting were highly vulnerable to the mounted hunter's surprise attacks because they were tied to their fields. They left the Plains, but certainly not because they soft touches in the fighting line. The horse hunters of the southern Plains sometimes raided deep into Northern Mexico in search of horses and other booty.

The temptations of booty could be supplemented by dreams of conquest; examples of pastoral nomads furnishing ruling elites for states have already been noted. Normally, the main deterrent to pastoral conquest of states is the relatively small size and mutual hostility of the pastoral tribes. However, as the Sioux-Cheyenne confederation at the Battle of the Little Bighorn illustrates, sometimes the tribes can unite, and the inherent power of pastoral

---

[2] "The best light cavalry in the world" said General Crook, Custer's boss, in rueful admiration. His column had been defeated by the same group of Indians on Rosebud Creek a few days before Custer's command was annihilated.

mobility can be increased sharply, both because of less need to protect the grassland rear, and more warriors for the raid or assault. Once a few tribes unite, they are in a position to use the carrot and stick on still other tribes. The choice is: join the confederation for a great raid, or die! What began, according to Lattimore's hypothesis, as a defensive tactic to avoid the state's excessive taxes became an offensive weapon of terrifying potential.

Under normal circumstances, a well organized state can keep all this under reasonable control. Tribute can be paid, punitive expeditions organized, great walls built, and clever diplomacy exercised to keep nomads fighting each other as much as possible. States readily grasped the danger, even if the ruling dynasty hadn't pastoral roots.

Occasionally state defenses collapsed in spectacular fashion in the face of pastoral onslaught.The reasons are not clearly understood. Weakness in the surrounding states, demographic events among the pastoralists, environmental changes on the steppe, and the appearance of charismatic leaders capable of uniting nomad supra-tribal confederations have been suggested as causes. When a good erruption got started, just the refugees seeking to escape could cause havoc with civilized states, as when the Hunnish raiding drove the Germanic tribes into the Roman frontier (ca. 370 AD). In all, civilized Eurasian suffered 4 major invasions, the Indo-Europeans (ca 5,000 BP), the Hun and German invasions just mentioned, the Arabic expansion in the 7th Century, and the Mongol invasions of the 13th Century. The Mongol invasions were the most spectacular example of a pastoral irruption. Ghengis Khan built a supra-ethnic nomad army of tremendous size and sophistication; he had more Turks than Mongols in his armies of conquest (Saunders, 1971, Morgan, 1986, Grousset, 1970). Under his successors the Mongols came to control the whole of the Steppe from Eastern Europe to Manchuria, plus most of the bordering states, including China and Russia. (Figure 5-2). Events in Africa were also dramatic after the advent of pastoralism, if not as well understood. In each of these cases, the nomad wave eventually receded after considerable destruction of civilized states. Often, the nomads remained as the aristocracy of a reconstructed state (frequently in China, the Mogul empire in India, the German Kingdoms in the Middle Ages, African Kingdoms of West Africa, etc.). These new aristocrats more or less rapidly lost their pastoral roots and became civilized or were expelled. In the meantime, attempts to maintain domination from the steppes themselves failed as the great confederacies gradually broke back down to their relatively harmless feuding tribes and sections. The Mongol Khanates of Central Asia were the most sophisticated and durable of these state-like confederacies in the grassland proper. The last of these peoples lost their independence to Russia in the 19th Century. (The Moslem Southerners of what used to be the USSR are lately in the news again as they assert their independence once more.) The positive contribution of these attacks, if such a judgment is possible, is that the military eruptions of the nomads put stresses on everyone for technical innovations in military hardware and software, improvements in state craft among the civilized folk, the long distance trade they made possible stimulated commercial innovation, and just the movement of peoples was an effective agent of diffusion of new ideas and new diseases (see chapters 20 and 21). The conflicts between nomads and states illustrates the role conflict can play as an evolutionary engine, at least if McNeill's hypothesis is correct.

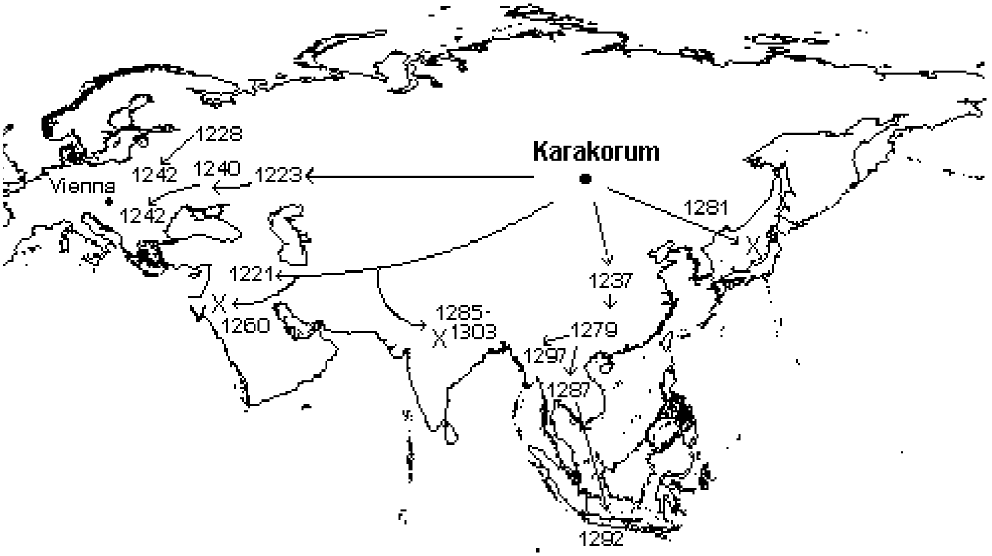


Figure 5-2. The course of Mongol conquest in Eurasia. X's mark major defeats the conquest was stopped. Based on McNeill, 1963, and Dyer, 1985.

VI. Gradients and Core Response

A. Pastoral Diversity in Africa

The broad African pastoral belt that surrounds the human tropical forest of Central Africa has many examples that illustrate Steward's claim that the same technology deployed in different environments can generate far-reaching differences between societies. In West Africa, pastoralists such as the Fulani (Stenning, 1959) much resemble the pastoralists of Central Asia. They maintained caravan routes between the gold fields of tropical West Africa, the date oases of the interior, and the Mediterranean. The West African pastoral tribes had complex relations with a series of powerful states based on advanced horticulture along the forest fringe, Ghana, Mali, Songhai, Hausaland, Kanem-Bornu, etc.

Timbuctu is perhaps the most famous city of this region. Islam became the dominant religion in the region, spreading down the pastoralist's trade routes from North Africa.

In addition to trade, pastoralists raided and often conquered and dominated states on both the tropical and Mediterranean edges of their territories in the style of Central Asian pastoralists. The famous medieval geographer, Ibn Khaldun (d. 1406), described what he saw as a cycle of pastoral conquest and decay in North Africa. In the desert, great warriors arose with a disciplined cadre of followers from the general tumult of pastoral politics, dominated by raiding and warfare. Conquest of an agrarian state enabled such great warriors and their tribe's leading figures to install themselves as the state's elite. Such elites were at first energetic, competent, and often puritanical as a by-product of the rigorous virtues instilled by the demands of a pastoral life-style. Then, inevitably, the decadent pleasures of city life weakened the moral fiber of the elite, and after a few generations the elite's corruption weakened the state, inviting another conquest from the desert.

The pastoral societies of eastern and southern Africa contrast sharply with those of the west. These societies are generally pedestrian herders specializing in cattle. The Nuer, Maasai and Datoga are members of a great group of such pastoralists that reached from the southern Sudan down through Kenya and Tanzania and then spread across the southern part of the African continent. The political organization of these societies, and of the farming societies they interacted with, was generally much simpler than that typical of West Africa. A few marginally state level politicies existed in historic times in the vicinity of Lake Victoria and at Zimbabwe, but chiefdoms and acephalous societies were much more common. Trade routes were shorter, although quite sophisticated Arab trading cities existed all along the coast of East Africa for many centuries. Islam did not spread inland here with anything like the success that it spread southward into West Africa from the north.

B. Environmental Gradients

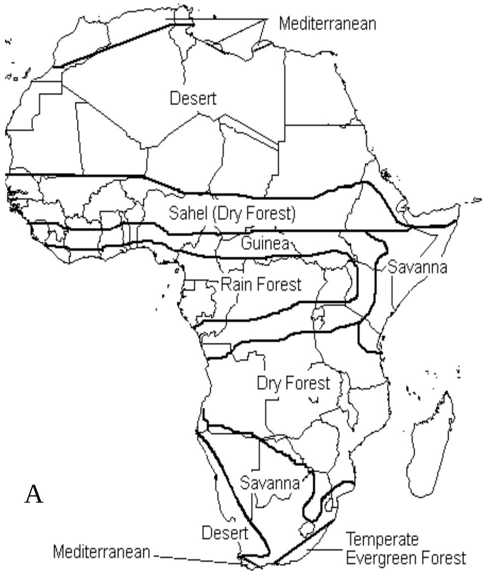
The most important environmental gradients in Africa are those of rainfall (Ellis and Galvin, 1994). In the west, there is a dramatic change in rainfall from the Mediterranean to the Equator. The Mediterranean fringe is well watered in winter, the Sahara itself is virtually rainless, the Sahel south of the desert has about 250 mm (10 in) of rain in the summer, and the Guinea zone (in which the main state-level societies were historically located) has about 750 mm (30 in) in summer. Still further south, the tropical evergreen forest zone has an aseasonal pattern of rainfall ranging up to more than 2,000 mm (80 in.) per year. This relatively simple north-south gradient does not exist in East Africa. Rather, there is a mosaic of high and low rainfall areas dictated by the complex topography of East Africa. In the east, the rainfall seasonality also differs from the west. There are two rainy seasons, one in spring and the other in fall, rather than one in summer. Finally, the interannual variability is much higher in East Africa that in West Africa.

The rainfall regime is obviously important to crop production, but it produces another important gradient that is important to pastoralists, gradients of diseases. The wetter zones have many more diseases of both humans and livestock than the drier ones. (On human diseases see Chapter 21.) The sheep, goats, cattle, horses, camels and donkeys herded in Africa are all introductions from Western Asia, and have reached the tropical zones relatively recently, about 4,000 years ago. Hence, for the most part, they are ill adapted to the diseases of the wet tropical zone.

The best known diseases affecting domestic livestock and humans are trypanosome (a group of protozoan parasites) transmitted by a group of biting flies, the infamous tsetse. Ford's (1971) account of the relationship between flies, trypanosomes, people, and their livestock is a human ecological classic. In humans, trypanosomes cause sleeping sickness, outbreaks of which sometimes depopulated whole districts. The effects of trypanosome diseases in livestock are similarly devastating. Trypanosomes have reservoirs in the wild animals of Africa, and these species are relatively resistant to their effects. Figures 5.3 a and b show the distribution of tsetse and cattle in relation to vegetation zone (reflective of rainfallpatterns in Africa. Notice that there is considerable overlap of cattle and fly distributions, despite the susceptibility of cattle to fly-borne trypanosomes.

C. Technological Adaptations

In West Africa, the main adaptations of nomadic pastoralists involve a close articulation via trade with farming peoples, who sometimes also keep livestock (see Grayzel, 1990, for an example of a typical West African system). The relatively predictable rains and the simple nature of the gradients encourages pastoralists to move north into the Sahel and Desert during the rainy season. Pasture is available, and the herders can move out of the tsetse zone. As the rains diminish the pastoralists move south and pasture their cattle on crop residues in the Guinea zone after farmers there have harvested the fields. Tsetse require relatively cool, moist, and shady conditions to thrive, and their activity is restricted during the dry season. Farmers are willing to pasture the cattle of pastoralists because of the value of dung as fertilizer. Interactions between farmers, pastoralists, other specialists such as smiths and fishermen, and state elites is very well developed. During the dry season period of contact, trade of animal products and caravan goods for grain foods and articles produced by local and even quite distant craft industries is lively. There is considerable economic symbiosis between pastoralists and the wider complex agrarian community. According to Ellis and Galvin, the size of the pastoral sector fluctuates with the comings and goings of long term droughts, which can last for decades, as the most recent one has. If the brief rains typical of the Sahelian and Desert zones are seriously short great losses of livestock can occur over large areas.s.



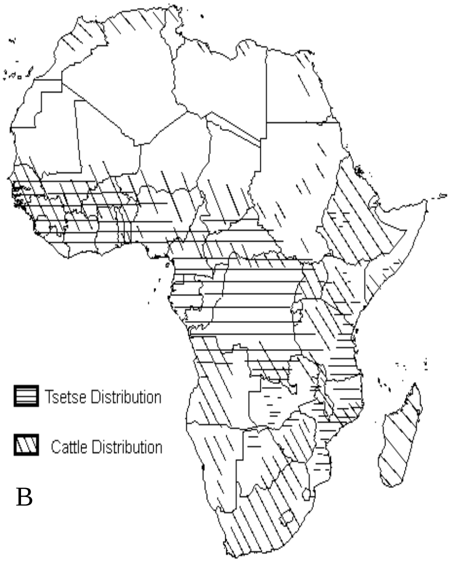


Figure 5.3a. The main ecological zones of Africa.

Figure 5.3b. Cattle and Tsetse distribution in Africa. Note the complex geography of cattle and flies in East Africa.

The East African system is quite different. Galaty (1991) discusses the Maasi in some detail. According to Ellis and Galvin, the crucial role is played by the two-peaked, unreliable rainy seasons. Because of the division of the rainy season, crop production is only possible at considerably higher mean rainfall compared to West Africa. Furthermore, the two-peaked rainy season, by spreading out the rains and favoring perennial rather than annual grasses, actually favors pastoralism relative to farming. The high interannual variability means that pasture and crop failure is common, but so are years of great abundance. Environmental variability forces the farming and herding sectors of East Africa to operate far from equilibrium in a chaotic succession of booms and busts for each. Both sectors will expand and contract drastically in response to climate and climate-induced changes of disease vectors. The East African pastoralists are thus less able to develop large-scale, routine trade relationships with settled farmers and are economically more self-sufficient.

In addition, Ford argued that farming occupation, by clearing brush that shelters tsetse on hot dry days and reducing trypanosome-carrying wild game, creates its own favorable disease climate for humans and cattle. On the other hand, human depopulation leads to brush encroachment, favor tsetse, requiring a long period of pioneering for recovery. Pastoralists can move away from tsetse, but often at the risk of conflict with other pastoral groups, or farmers. Farmers were less able to move, and depopulation due to disease, warfare or other causes would favor the invasion of tsetse, and keep both farmers and herders out of the area for substantial periods. Substantial portions of East Africa thus remained wilderness, guarded by tsetse, and later by European colonists, who created protected game parks where wildlife was abundant. Contrariwise, a continent wide epidemic of rinderpest in the 1890s, a disastrously virulent epidemic of cattle and the wild game fed upon by tsetse, tipped the balance in favor of horticultural expansion because the flies declined with their game and cattle victims. Former pastoralists took up horticulture during the rinderpest disaster, and had difficulty expanding cattle herds in the aftermath, as game parks were created in some of the most favorable cattle country.

The presence of a complex environmental mosaic with tsetse makes it impossible to maintain riding animals, especially horses and camels in East Africa, except in the Ethiopian highlands and the deserts of Northern Kenya. These animals are more susceptible to trypanosomes, and perhaps other diseases than cattle and goats. Thus the trading specialization common among herders is not well developed in East Africa. The movement of goods out of the interior toward the Arab port towns on the East Coast was much less well developed than the caravan trade across the Sahara, despite the great distances and extreme environment of the latter. Likewise the lack of mounted mobility and suitably wealthy agrarian neighbors limited the role of raiding and conquest.

The pastoralists who reached Southern Africa after traversing the East African fly belt came without horses and camels, so that mounted pastoralism never developed in the otherwise favorable southern sector. European colonists who possessed the advantages of mounts were able to colonize the region up to the tsetse limit where the Dutch Boers were stopped by the death of their draft oxen on the Limpopo, the southern border of present-day Zimbabwe, though Cecil Rhodes was later able to establish a British colony centered on the fly-free highland north of the Limpopo (Southern Rhodesia).

D. Socio-political and Ideological Responses

West Africa exhibits the sociopolitical outcomes of pastoralism that were common in Eurasia in historical times. Pastoral societies of the Western Sahel had a close economic symbiosis with state level polities. Pastoralists were politically important, and often made themselves the elites of such states by right of conquest. The caravan trade across the Sahara was for a long while Western Eurasia’s most important source of gold, while salt, dates, and manufactures came south. Trade became an avenue for ideas, and Islam spread to the West African states. The required pilgrimage expected of pious Muslims could take place by travel along caravan routes to Mecca.

East Africa, by contrast, was largely a complex of tribal societies. Advanced chiefdoms, simple states (Buganda) and even pastoral conquest states (Rwanda, Burundi) did occur in the Lakes Region, but these systems never reached the complexity of the states of West Africa. Trade with the coast was never on a large enough scale or over long enough distances to effectively connect these societies to global currents of thought, such as Islam, despite relatively close proximity to the Arab trade ports on the Indian Ocean coast.

VII. Conclusion

The development of pastoral societies illustrates well the role of environment, even after the advent of "civilization." Climate and tsetse combined to give pedestrian pastoralists of East Africa a distinctively different character from the mounted pastoralists of West Africa. It also illustrates the possibility of "regressive" evolution when the rise of pastoralists in classical times often pushed back the frontiers of agrarian "civilization." This trend lends support to the view that evolution is not fundamentally an onward and upward process. Paradoxically, it also seems that these relatively simple societies can play an important role in long-run technical advance by their stimulus to and competition with the conservative agrarian states. They also illustrate in dramatic form how the prevailing scale of social organization is a complex balance of centrifugal and centripetal forces. Nomad empires arose out of nowhere with the speed and force of the wrath of God Himself (an analogy not lost on the victims) and then almost as swiftly collapsed back to a collection of feuding tribal sections.

"Advanced" maritime societies seldom competed unsuccessfully with agrarian states and empires. Maritime societies are those that specialize in fishing and trade using watercraft. Some such societies become sufficiently specialized variants on the agrarian theme to count as a separate type in some taxonomies, such as that of Lenski and Lenski. Maritime societies have a certain parallel to pastoral societies but tend to be a counterpoint on the issue of the inevitability of progress. Like pastoral societies they are dependent on adapting specialized technology derived from the general agrarian toolkit to a specialized environment, the sea. Like pastoralists the mobility derived from having efficient watercraft is easily turned from subsistence pursuits like fishing to trading and raiding.

It is historian William McNeill's hypothesis that trade and war are most powerful stimuli of evolutionary change (both "progressive" and "regressive" developments) basically because they are intrinsically competitive, favoring ever more efficient innovations, and ruthlessly weeding out those who fail to adopt the best techniques. Pastoral warriors played an important role in destroying Rome, and Viking pirates limited N. European progress for several centuries. Then, a millennium after the fall of Rome, pastoral tradesmen and Indian Ocean seamen transported crucial Chinese innovations back to Europe that set off the "rise" of the Western peoples (a five-hundred-year-long binge of piracy, conquest, and exploitative commercial activity on the one hand; the most dramatic, sustained, episode of technical advance in the history of the species on the other).

Confounding progressivism again, some maritime societies like the Greeks, were very "advanced" judged by modern standards yet had little staying power against the more "primitive" typical agrarian states. Agrarian states were typically very conservative compared to maritime states on the Greek model, but the maritime state was inevitably very small in an era when both agriculture and maritime transportation were relatively inefficient. In only a few favored circumstances and in small numbers could societies exist in which the mass of citizens escape being peasant producers. As a consequence of small size, the political independence of maritime societies from agrarian ones was tenuous and short-lived. The relative conservatism of the agrarian state was thus punctuated only by brief bursts of creativity by the Phonicians, Greeks, etc. In Chapter 24 we will return to the general question of what regulates the rate of innovation in societies. If the maritime Mediterranean societies had not been overwhelmed by the continental agrarian states and the agrarian states in turn frequently set back by nomad conquests, perhaps the rate of technical advance of the Classical Greek period would have started earlier and been sustained without interruption, and the Industrial Revolution might have occurred 2,000 years ago.

VII. Bibliographic Notes

References:

Allsen, T.T. 1987. *Mongol Imperialism: The Policies of the Grand Qan Monke in China, Russia and the Islamic Islands 1251-1259*. Berkeley: University of California Press.

Barraclough, Geoffrey, ed. 1982. *The Times Concise Atlas of world History*. Maplewood, NJ, Hammond.

Borgerhoff Mulder, M. 1991. Datoga pastoralists of Tanzania. National Geographic Research and Exploration 7:166-187.

Connell, E. S. 1984. *Son of the Morning Star*. San Francisco: North Point Press.

Dyer, Gwynne. 1985. *WAR*. New York: Crown.

Ellis, J and K.A. Galvin. 1994. Climate patterns and land-use practices in the dry zones of Africa. *BioScience* 44: 340-349.

Evans-Pritchard, E. E. 1940. *The Nuer*. The University Press, Oxford.

Ford, J. 1971. *The Role of Trypanosomiases in African Ecology: A Study of the Tsetse Fly Problem*. Oxford: Clarendon.

Gadgil, M. and K.C. Mulhotra. 1982. Ecology of a pastoral caste: Gavli Dhangars of peninsular India. *Human Ecology* 10: 107-143.

Grazel, J.A. 1990. Markets and migration: a Fulbe pastoral system in Mali. In: J.G. Galaty and D.L. Johnson, eds. *The World of Pastoralism: Herding Systems in Comparative Perspective*. New York: Guilford.

Grousset, R. 1970. *The Empire of the Steppes: A History of Central Asia*.New Brunswick: Rutgers University Press.

Galaty, J.G. 1991. Pastoral orbits and deadly jousts: factors in the Maasi expansion. In J.G. Galaty and P. Bronte, *Herders, Warriors, and Traders: Pastoralism in Africa*. Boulder: Westview Press. pp. 171-198.

Ingold, T. 1980. *Hunters, Pastoralists and Ranchers.* Cambridge: Cambridge University Press.

Irons, W. 1974. Nomadism as a political adaptation: the case of the Yomut Turkmen. *Amer. Ethnol.* 1: 635-658

Kelly, R.C. 1985. *The Nuer Conquest: The Structure And Development of an Expansionist System.* Ann Arbor: University of Michigan Press.

Khazanov, A.M. 1983. *Nomads and the Outside World.* Madison: University of Wisconsin Press.

Lattimore, O. 1951. *Inner Asian Frontiers of China*. New York: Amer. Geogr. Society.

Leeds, A. 1965. Reindeer herding and Chukchi social institutions. In: A. Leeds and A.P. Vayda. *Man, Culture and Animals*, pp 87-128. Washington: Amer. Assoc. Adv. Sci. Publ. #78. (This collection has a number of other useful papers on pastoralism.)

Mace, R. and A. Houston. 1989. Pastoral Strategies for Survival in Unpredictable Environments: a model of herd composition that maximise household viability. *Agricultural Systems 31:185-204.*

Mallory, J. P. 1989. *In Search of the Indo-Europeans: Language, archaeology, and myth.* New York: Thames and Hudson.

McNeill, W. H. 1964. *Europe's Steppe Frontier, 1500-1800*. Chicago: University of Chicago Press.

McNeill, W. H. 1963. *The Rise of the West: A History of Human Community*. Chicago: University of Chicago.

McNeill, W. H. 1976. *Plagues and Peoples.* Garden City, NY:Anchor Doubleday.

Morgan, D. 1986. *The Mongols*. Cambridge, Mass.: Blackwell.

Saunders, J.J. 1971. *The History of the Mongol Conquests*. London: Routledge & Kegan Paul.

Stenning, D. J. 1959. *Savannah Nomads: A Study of the Wodaabe Pastoral Fulani of Western Bornu Province Norther Region, Nigeria*. London: Oxford University Press

CHAPTER 6. AGRARIAN SOCIETIES

I. Introduction

A. Linking Technology and Social Structure

The story of agrarian societies continues the themes of the last two Chapters on horticulture and pastoralism. *With the continued development of agricultural technology came associated trends in the development of other aspects of culture*. Recall that the chief results of plant domestication were (1) greater production per of unit land, (2) higher population densities and sedentary settlements, (3) and increases in material wealth, including stored food and luxury items. Associated with these technical and demographic changes was a substantial increase in the social and political complexity of societies. Large scale military defense and redistribution became more important as wealth increased, the local reliability of subsistence declined, and some specialists removed themselves from personal participation in food production.

As agrarian technology developed, the potential for substantial gains in per capita production arose as more sophisticated technology was put into farmers' and artisans' hands. Gains in *production per unit of land* and *per unit of human labor* have somewhat different implications for culture core traits, as we have already noted.

*The tragedy of agrarian societies is that this potential was not generally realize*d. A combination of exploitation by elites and population growth tended to erase any gains in well-being for most cultivators. This is essentially the argument of T.R. Malthus, whose famous ideas we will examine in detail, especially in Chapters 9 & 15. Many have gone so far as to argue that civilization is a big mistake, that people were happier on average in pre-state level societies. This hypothesis is hard to test, but it is clear that the average person did not make spectacular gains in personal well-being from the growth of agrarian societies. Agrarian states do permit larger numbers of people to live, and some would count that as a gain itself.

Have agrarian societies really removed environmental constraints? Another important theme developed by Lenski and Lenski (1982) and others is that the variations among agrarian societies seems to have had less and less to do with environmental variation and more and more to do with technical and sociopolitical evolution. Humans seem to be winning more and more independence from direct environmental controls over human behavior through the culture core. You should be skeptical of this claim. It is true that some of the variation between societies living in different environments is reduced, but perhaps environmental effects are only being made internal to these larger and more complex societies rather than being eliminated. Agrarian societies are typically large in size and internal redistribution and external trade tend to reduce the society-wide impact of local environmental differences. Thus the neat geographical correlation between sociopolitical form, demography, and the like, nicely showing how culture core traits are connected to environment, is lost. However, the structure of economic life and even of political structure still strongly reflects environment, albeit through more complex causal pathways. The famous French historian, Fernand Braudel (1972), made this point in his weighty tome "*The Mediterranean and the Mediterranean World in the Age of Philip II*." Braudel takes almost infinite pains to show how the details of Mediterranean geography, climate, soils, and so forth affected things beginning with everyday life and working up to the policies and fates of empires like Philip II's. (Philip II was the Hapsburg heir to Spain and the Low Countries (etc.), ruling from 1556 to 1598. He ordered the Spanish Armada to attack England in 1588 in his most famous defeat.)

B. Some Examples of Agrarian Societies

Our sample of agrarian societies is quite large, because so many of them have maintained written records, and have persisted until quite recently. Even today, poorer nations typically categorized as "Third World" or "Less Developed Countries" (LDCs) are generally agrarian societies, albeit with variable admixtures of industrial technology. Geertz (1965) gives a classic account of one such society, Indonesia. China, India, Peru, and many others retain much of the technology and other culture core features of agrarian societies. The description of such societies comes largely from historians, although anthropologists, sociologists, economic historians, and others have made major contributions to understanding such systems. What we mainly lack is adequate samples of the very early agrarian societies in Western and Eastern Asia. We suppose that the better-known advanced horticultural societies, such as the American advanced chiefdoms, city-states (e.g. Aztecs) and one conquest empire (the Incas), are reasonable rough models. Of course, the archaeology of agrarian societies in Western and Eastern Asia is very good, and written records start only a few centuries after the transition from simpler societies to states (the Homeric tales and the Old Testament are good examples).

While the amount of data on agrarian societies is quite impressive, one can overestimate its quality. Brown (1988) notes that even most literate societies write very little critical history or commentary on contemporary affairs. Most of what is written down, even in quite literate societies, is so mythologized as to be nearly useless. Europe and China are exceptions, but even in these cases it depends upon the time period. Reliable documentary sources for India, to mention a classical agrarian civilization, are almost absent, for example. You've all heard the maxim that "Those who forget history are condemned to repeat it." The trouble is, even relatively well documented "lessons" of history, such as the decline and fall of Rome, are rather poorly understood and offer only rather dim and unreliable lessons (see Bowersock in Yoffee and Cowgill, 1988).

II. Technology

A. Plows and Non-Human Energy

The defining trait of agrarian technology is the presence of plows and draft animals. Without forgetting the fact that some advanced horticultural societies, such as the Inca Empire, became fairly sophisticated without the plow, there is a basic innovation involved in the plow. For the first time tools could be operated with non-human labor. Thus, the returns to the labor of a human worker could be substantially multiplied by substituting the relatively great power of the beast for the relatively puny powers of people. Other technological sophistications increase human output (compare working with a badly designed versus a well designed hammer), but no single technical principle has proven quite as important as the idea of substituting non-human power for human labor. Extending this principle to ever more subsistence tasks ultimately produced the industrial revolution.

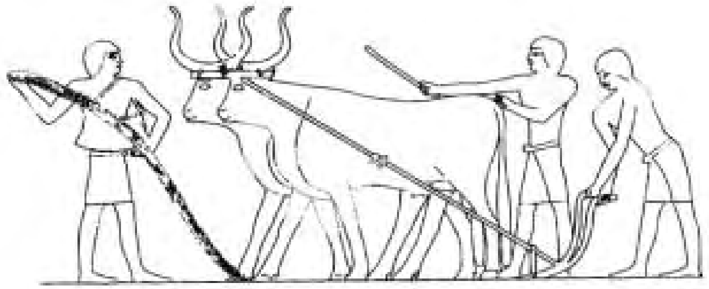
B. Variety and Improvement

Plows were first used in the Middle East around 5,000 years ago (5,000 bp). The first plows were simple "scratch plows" whose physical effect on the soil was just to stir the top 10-15 cm of soil to prepare a seedbed. These plows were pulled by a very simple yoke arrangement as illustrated in Figure 6-1. In light dry soils, these plows are quite sufficient (the modern disc harrows so commonly used in California operate on the same principle) to aerate the soil, provide a barrier to the evaporation of soil moisture, and destroy weeds. Permanent fields can be maintained much more easily as a result of plowing. In semi-arid country, such as South-Western Asia, California, or the Peruvian Highlands, scratch plowing is all that is required to maintain permanent fields.

A second revolutionary technical development along the same lines was the development of wheeled, animal-drawn cartage. Now products could be moved much greater distances, and the redistributive functions of political authorities and private trade expanded. Military uses of the new animal mobility were noticed early on. First, there were carts to haul supplies and booty, later chariots enabled development of a cavalry arm in military organizations.

Societies based on scratch plow technology still exist, for example in the Peruvian

Figure 6-1. Early Egyptian ox-drawn plow (about 2700 B.C.). Note the primitive method of harnessing the animals - a simple bar attached to the horns. (Lenski and Lenski 1982:170)



highlands. People there adopted the ox-drawn scratch plow from the Spanish, and still use it to cultivate the bulk of Peru's arable land. The pre-Columbian horticultural foot plow is still used extensively as well. It would be interesting to compare this technology in terms of labor productivity with the horticultural technology that is still used there as well. We suspect that simple plow cultivation perhaps doubles labor productivity.

C. The Moldboard Plow, an Example Of Continuing Technological Evolution

The continued technological development of agrarian societies can be illustrated by the evolution of the plow. The main subsequent innovation in the West (before industrialization) was the heavy moldboard plow. These are the tools we think of as plows proper, with a share and coulter[1] to cut sod and moldboards[2] to turn the cut slice of earth rather precisely upside down. Such plows help return downward-leaching nutrients to the surface, and are better at keeping heavy soils free of weeds in damp climates, where the mere stirring of the scratch plow does insufficient damage to root systems. Anyone who has hand-pulled weeds in a cool, damp climate knows how liable plants are to reroot themselves. Moldboard plows require greater power to drag and improved harness and livestock were developed for them. The horse collar and the proper ox yoke are relatively late developments in this tradition. The horse collar and the ox yoke transfer the drag of the implement to the shoulders and neck of the animals in such a way that they can exert great effort with-

---

[1] A cutting tool (as a knife or sharp disc) that is attached to the beam of a plow. It makes a vertical cut in the surface and permits clean separation and effective covering of the soil and materials being turned under.

[2] A curved iron plate attached above a plowshare to lift and turn the soil.

out choking or injury. The Peruvian Highlanders still use the inefficient horn yoke (the drawbar of the plow is attached to a stick tied across the horns of a pair of bullocks), which transmits the drag of the plow to the animal through the neck, substantially cutting the maximum force the animals can exert. This is sufficient for the light plow; perhaps full force would tend to damage these relatively delicate tools.

Heavy plows were responsible for the medieval economic and socio-political revolution of Europe. Heavy plows were known in Roman times, but only came into widespread use in the Medieval period in Europe, where they allowed the cultivation for the first time of the heavier, wetter, inherently more productive soils common north of the Alps. Prior to the extensive use of moldboard plows, Northern European settlement was mostly confined to belts of lighter soils that could be farmed with the scratch plow. As late as 1000 AD 80% of Europe was still covered by dense forest and was only opened to the plow by a wave of pioneering that lasted until 1300 or so. The adoption of the heavy plow required some very basic social-organizational innovations. Heavy plows required several families to pool their oxen to form a team large and strong enough to pull the heavy plow. The resulting "ox-gangs" became an important social group.

This was not the end, however, to the evolution of plow technology. A recent article by Hugh Sidney (1992) in *Time* describes how contemporary U.S. farmers are now abandoning the moldboard plow in favor of new techniques that better protect the land from erosion and increase crop yields—a change that Bill Richards, head of the U.S. Soil Conservation Service, called "a cultural revolution." As Sidney recounts:

> Instead [of using traditional plow technology], farmers leave residue from the previous year's crops in place to hold soil and moisture, then scratch or chisel in seeds, which sprout through the decomposing residue. Crop rotation is used to break insect cycles. Weeds are targeted, controlled by new herbicides that quickly break down and vanish.…
>
> The techniques were known a half-century ago but not widely adopted because of stubbornness and no economic urgency. Now environmental concerns, politics and economic necessity have fortuitously converged to drive this farm revolution.

One indicator of how drastic the change has been is reflected in domestic sales of moldboard plows. 60,000 of them were manufactured in 1970; only 6,300 were sold in 1991!

D. Other Technological Developments (metal, cloth, ships, etc.)

Similar trajectories of development occurred for many other items of the expanding agrarian tool kit. Metallurgy, weaving, marine vessels, pottery, military equipment, and many other classes of items improved substantially during the agrarian era. But it is a mistake to think that developments were steady. Rather, many scholars have suggested that innovations tended to come in irregular bursts, and that long periods of near stasis were the rule. The average rate of technical innovation was very slow by modern standards, and probably slowed after about 5,000 bp, when the basic agrarian toolkit was completed. It also seems that many important innovations were made by peripheral peoples, not the powerful, central societies of the day. For example, iron metallurgy was developed by the marginal Hittites of Anatolia (modern Turkey) (about 3,400 bp), not the central societies of Mesopotamia and Egypt. It is also notable that developments were more rapid in Eurasia than in America or Africa, to which agrarian technology diffused at a quite late date from Eurasia. Lenski and Lenski introduce some of the major hypotheses to account for this effect, and we will return to this problem in Chapters 24-28.

III. Demographic Effects

A. The Trend Toward Higher Population Density Continues

The main demographic consequences of agrarian technology were simply a continuation of the trend toward higher population densities and larger settlements. The latter is probably a more secure consequence of agrarian technology than the former. In principle livestock compete with humans for food and in some environments, advanced horticultural techniques can probably support more people per km^2 than agrarian techniques. On the other hand, the moldboard plow opened vast new tracts of land in Europe and greatly increased population densities. (One wonders why horticultural technology was not applied to these heavy European soils at a much earlier period. Perhaps it was, but the long-fallow forest horticulture was too minor a mode of subsistence compared to permanent cultivation of light soils to make much of an impact.)

Aside from average density, agrarian technology permitted urbanization of population to a greater extent than was possible under horticulture. The reasons were two. First, settlement sizes grew with agrarian technology because more productive farmers (per unit of labor) freed more people for urban specialty occupations. Second, land and maritime transportation improvements made it possible to supply great cities of 10^5 or even 10^6 inhabitants, such as Rome, Baghdad, and the Chinese capital cities. Rome, for example, could draw grain and other bulk raw materials Sicily, North Africa, Egypt, and Southern France to sustain large populations, even by modern standards, using maritime transport on the Mediterranean. It is productivity per unit of labor and transport efficiency improvements of agrarian technology, operating through the rise of large urban agglomerations of craftsmen, priests, and administrators, that had the widest impact on the more peripheral culture core features of agrarian societies.

The populations of agrarian societies also fluctuated substantially around the slowly rising trend line, due to famines, disease epidemics and political breakdowns (civil wars, conquest by foreigners, etc.). At least at the high points, population densities often seem to have exceeded the level at which everyone could be productively employed at current levels of technology. Malthusian deterioration, under-employment and a decline in rural and lower-class urban standards of living, ensued.

IV. Social Organization

A. New Forms of Social Organization

The trend is for kinship to continue to decline relatively in importance as a means of regulating social life. As agrarian societies developed, an increasing proportion of the population withdrew from primary production in favor of other occupations. (When this proportion reaches 50% we will rather arbitrarily say that the society is no longer agrarian, but passes over the boundary of the commercial/industrial type.) As occupational specialization increases, new organizational principles are developed, such as guilds to regulate craft specializations, and markets for the exchange of the specialists' products. The ancestors of the modern business corporations and banks grew up around markets and long-distance trade. The development of large-scale political and religious institutions, covered in the next section, is part of this increase in social complexity.

Nevertheless, it will not do to discount the importance of kinship even in the more complex agrarian states. In the Chapter on trade and commerce (Chapter 18) we will see how large a role kinship played in early long-distance trade systems. Suffice it to say here that the role of kinship remained quite large in agrarian societies by comparison with modern ones.

B. Altered Sexual Division of Labor

The sexual division of labor remains fundamental to the economics of agrarian societies, but tends to change in form compared to typical horticultural systems. Recall, that women tend to put in a disproportionate share of the agricultural work in horticultural societies. Under agrarian technology men's labor becomes relatively much more important, chiefly because managing large animals is almost always, like hunting, men's work. Arguably, this is a functional division of labor because the strength of males is better adapted to handling large animals and because they demand full-time attention that women, who must mix work and child care, cannot afford. In any case men go back to substantial work after a long vacation during horticultural times, so to speak.

However, the renewed economic importance of males is perhaps reflected in lower status for women. This is because in excluding women from agricultural work and marketing, women's labor becomes devalued. In addition, agrarian societies generally have a strong patrilineal bias to the inheritence and hence ownership of valuable property. These changed conditions in labor and ownership are reflected in marriage customs. Marriage among horticulturalists is frequently accompanied by bride-price payments to the bride's family to compensate for their loss of a valuable laborer. Dowry is more frequent in agrarian societies, payments by the bride's family to the groom's; men in agrarian societies have to be compensated for taking on a wife. On average, agrarian societies have perhaps the lowest levels of women's prestige and influence of any technological type.

C. Social Stratification

Agrarian societies are especially noted for their extremes of social stratification. The high-ranked lineages of tribal horticultural societies become (typically) a much more exalted ruling class, still typically combining religious and military institutions to justify and enforce their domination, and support elaborate patterns of consumption. Slavery, serfdom, or peonage is commonly the lot of the primary producer. The emphasis in the modern West on personal liberties and freedoms (and in the Marxist countries on economic equality for that matter) was in large part a reaction to the steep and rigid stratification of agrarian societies.

Increasing social stratification is linked to a more developed division of labor. Less onerous but strongly customary bonds between non-agricultural occupational specialists were common, contributing to the emergence of middle and lower middle classes of merchants and craftsmen. In agrarian societies we see elaboration of domestic relations within the household, the "upstairs, downstairs" syndrome. India carries this sort of thing to the logical extreme in the caste system (Srinivas, 1962). In the caste system, each occupational specialty is an endogamous group, a *jati*, with local custom dictating the relationships between castes in quite some detail.

Because of the sharp and rigid social stratification of agrarian societies, you might think them poor subjects for mythologizing by moderns. If so, you are too quick to dismiss the power of imagination over reason. Many "Neo-feudalist" romantics hark back to these days of oneness and wholeness and pleasant outdoor work under the benevolent guidance of Lord and Prelate. Not everyone is really comfortable with the freedom, flexibility, and anonymity of modern life. The tight social structure of agrarian societies seems attractive, especially, perhaps, to those who imagine ascribed elite roles for themselves. One of us (PJR) suspect some professional academics of this, such as the creators of Middle Earth student housing. They named their streets after characters and places in Tolkien's ring trilogy, one of the smarmiest[3] romanticizations of feudalism. And they seem to exalt the small-scale communalism of the medieval manor. Of course, no one makes a big point of social stratification in these romanticizations (or if they do it is made to seem colorfully harmless; remember the Kennedy era being tagged with the Camelot label). Are there modern politicos who dream of being Princes, Dukes, Lords and Bishops? Perhaps we're too skeptical?

V. Political Institutions

A. States are Characteristic of Agrarian Societies

The main institutional innovation of agrarian societies is the state. As we saw in an earlier Chapter, some advanced horticultural societies developed state-level political organization, but the earliest, and until recent times, by far the most powerful and elaborate states were based on agrarian technology.

On the one hand the state is an effective institution to manage the immense redistribution required if productive farmers are to be linked to specialist producers of metal tools, cartwheels, cloth, and the like. The invention of writing and mathematics are important technical contributions of such societies, and were born of the needs of the bureaucrats of the early states to keep track of the immense flows of products the state handled. The earliest documents, for example the great troves of cuneiform clay tablets discovered in Mesopotamia were records for royal storehouses. It is interesting that the modern analog, the automated database system, was among the very first and still most popular applications of computer technology. It seems that in their redistributive function the earliest (and latest) states were just larger-scale versions of the tribal chiefdom, if a hard line of any kind can be drawn on the continuum.

On the other hand, the productive division of labor of agrarian societies is a strong temptation to the guileful priest and the greedy warrior. These two classes often combine to extract a scandalously disproportionate share of the farmers', artisans' and traders' efforts (by modern standards; we must take care to understand before we condemn). The sharp social stratification we noted above is closely related to large differences in political power buttressed by an impressive ideological superstructure, typically an official state religion. This development is presaged in the high consumption standard and sacred person-

---

[3] Smarmy \'sma¨r-me¯\ smarm (to gush, slobber). Revealing or marked by a smug, ingratiating, or false earnestness (e.g., "a tone of smarmy self-satisfaction").

age of the tribal chief in the more elaborate cases of chiefdoms. Still, as the historian William McNeill notes, it is dangerous to press things too far. Too great an extraction of the surplus makes the peasants restive, and weakens the society's ability to resist foreign invaders. An uneasy balance is often the result, and the theoretical puzzle of the relative contributions of group-beneficial and purely exploitative processes to explaining stratified societies is even more acute than in the ranked tribal case.

States begin to control internal violence by enforcing a rule of law. Political leaders provide a formal legal system and claim a monopoly on the legitimate use of violence. Hammurabi's code from ancient Mesopotamia, around the time when proper states first emerged, is an early and famous example of the emergence of this state function. Self-help violence is no longer the only way to enforce social rules.

The ability to ensure within-group peace for extended periods of time, combined with the greater managerial scope and transportation improvements, made large scale warfare possible among states. In many areas, classically in Mesopotamia a few hundred years after city-states/advanced chiefdoms appeared, this increased military scope led campaigns of permanent imperialism to replace the basically plundering campaigns of the tribal period. The reading for Chapter 19 gives some insight into this period, and to the history of warfare in agrarian states more generally.

B. Instability

One apparent consequence of the political complexity of states is that they tend to be unstable. Dynastic changes, foreign occupation, and the collapse of imperial states into smaller constituent city states, even the regression of states to the tribal scale of organization are common. Further, it is common for large states and empires to co-exist in similar environments, using similar technologies, with small city states or even tribal societies. For example, during the European burst of state-building that occurred in Europe in recent centuries, Germany and Italy were dominated by city states and principalities long after England, France, Spain, and Russia had large states. Similarly, the Greek city-states coexisted for centuries alongside Asian empires. Then, suddenly, under Philip and Alexander, the Greeks went on an empire-building binge of their own.

An hypothesis that such events are independent of ecology has been developed by Colin Renfrew (1973) and William McNeill (1982). They imagine that tribal chiefdoms, states, and empires are inherently prone to instabilities. Some of you may have heard or read about chaos theory, which describes how even relatively simple systems can exhibit large irregular fluctuations. This is the sort of thing Renfrew and McNeill have in mind.

Ecological processes of one kind or another may rather easily promote the evolution of more complex states only to have other processes, such as population growth causing declines of economic well-being and consequently revolt, shatter them. At any rate, recorded history can easily be read as a most bewildering pattern of political expansions, contractions, and fragmentations (have a look at the intricate maps that are needed to portray these changes in any good historical atlas). Almost all of the systemic processes we will examine later in the course have been invoked in these cases, demographic events, disease, inter- and intra-society conflict, environmental deterioration, climate change, and technical innovation. We do not want to give up on the evolutionary ecological approach too soon! Authors in Yoffee and Cowgill (1988) have recently reviewed several examples of collapse in ancient agrarian states without coming to any firm conclusions.

VI. Environmental Gradients and Core Response

A. Introduction

Once again, our question in this section is whether the same basic technology applied in different environments leads to adaptive variation of culture core variables. Such features as rainfall, length of growing season, availability of irrigation water and the like influence the productivity of agriculture. Topography greatly affects transportation costs. Flat open topography, navigable rivers, and proximity to seacoasts make access to markets easy, but also expose farmers to offensive military action. Rough topography isolates farmers from both. It is easy to imagine that these sorts of environmental variables should affect the whole suit of culture core variables. Our example is the variation in ecological variables and cultural responses in the Indus River drainage of present-day Western India, Northern Pakistan, and Eastern Afganistan.

B. Environmental Variation

Since agrarian technology was applied historically from Spain and North Africa in a more or less broad swath right across temperate and subtropical Asia to the Pacific, a very wide variety of climates, soils, and topography were (and still are) exploited by agrarian producers. Western Eurasia has temperature and rainfall gradients running from the warm, dry, winter-rain Mediterranean region, to the cool ever-moist Northwest. Climates become more continental (hotter summers, colder winters) inland. Central Asia is a complex of arid and semi-arid lands, dominated on the east by the Himalayan massif. The Indian subcontinent is strongly affected by the Monsoon (the flow of warm wet air from the Indian Ocean and Western Pacific onto the continent). In the Far East there is an aridity and temperature gradient from the dry regions of central Asia, and the cold of Siberia, toward temperate, subtropical and tropical moist regions to the southeast. Figure 5.1 in the previous chapter (from fig 21-22, Walter, 1985, with modifications) shows how these environmental gradients are expressed in the natural vegetation and agricultural potential.

Strong gradients give us the best test of the culture core concept because they tend to control for the effects of history by permitting long-continued contact and diffusion of culture between neighboring peoples, as we saw in our previous example of culture core variations in horticultural societies on the Andean gradient and the pastoral comparison of West and East Africa. The Himalayan mountains and there surrounding lowlands provide many similar a test cases for agrarian technology. The Indus River drainage has headwaters in the Hindu Kush and Karakoram ranges of the Western Himalaya, and its mouth on the Indian Ocean at Karachi (Figure 6-2). The Indus region is mostly arid to semi-arid, with much of the river's flow generated by rainfall and snowfall in the high mountains (the peak K-2, 8,611 m, second only to Everest, is on the divide between the Upper Indus and the drainages of Western China). In upstream sections, the river and its tributaries flow in dozens of relatively narrow canyons from 1,000 m elevation up into the very rugged mountains. At middle elevations, 1,800-3,500 m, mountain slopes are covered with conifer forests, above which mountain meadows are the highest territory of interest to agrarian producers. From 1,000 m to sea level, the river and its 4 major tributaries flow 1,100 km across a broad, flat alluvial floodplain, much like the Tigris-Euphrates, Nile, and Sacramento-San Joaquin Valleys. Norwegian Anthropologist Fredrik Barth (1981) conducted classic human ecological studies of the Pathan peoples of the middle Indus and their neighbors which well demonstrates the impact of this gradient on culture core variables. (See also Eglar, 1958; Keiser, 1991, Nyrop, 1984, Galaty and Johnson, 1990; for a great “good read” account from the British Imperial perspective see Hopkirk, 1990.)

C. Technological Variation

The classic ox drawn scratch plow agrarian technology has been applied for several thousand years in the Indus Basin (Bharadwaj, 1961). Because of limited and seasonal rainfall, irrigation is practiced everywhere from sea level to the limits of cultivation at around 2,000 m elevation

As elevation increases, the land available for cultivation shrinks relative to pastureland. In the arid lowlands, livestock must be mainly fed from irrigated lands on wastes from food crops, and a minimum of livestock are kept, although this minimum is necessary for traction, dairy products, and dung for fertilizer and fuel. The average is something like 1 cow per 4 people. The province of Punjab, now divided between India and Pakistan, is the most productive of the lowland districts. A number of tributaries of the Indus cross the Punjab providing irrigation for a substantial area, and level areas between the rivers can be irrigated from shallow wells..)

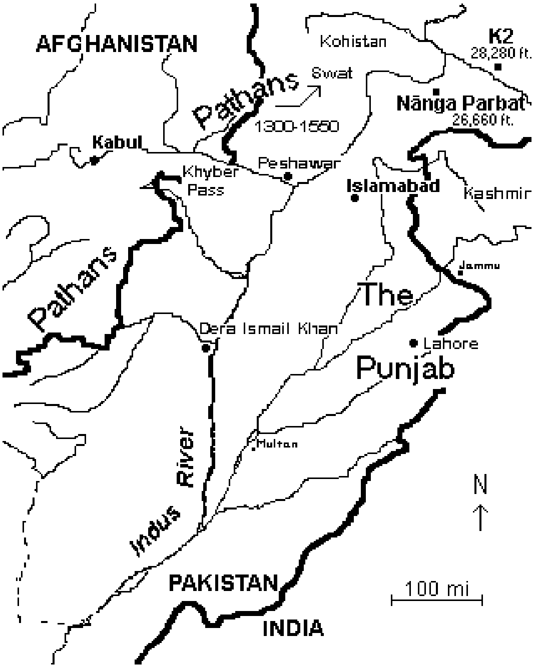


Figure 6-2. The Indus River Basin. The Pathan region along the Pakistan-Afganistan is hilly. As indicated by the locations of K-2 and Nanga Parabat, the country where Pathans and Kohistanis interact becomes very rugged. The Punjab, especially lower on the rivers (Multan) becomes quite flat.

Above 2,000 m land is only useful for pasture, and the highest elevations are exploited by pastoral nomads, owning perhaps 3 head of cattle (or cattle equivalents counting sheep and goats), per person. A variety of mixed farming strategies are pursued at middle elevations depending upon the ratio of irrigated to grazing lands, and their proximity. In Swat, where Barth worked, Pathan farmers engage in a relatively productive double-cropping agricultural system that includes rice and other subtropical plants. Pathan farms are relatively distant from mountain pastures, and Pathan landlords have a symbiotic relationship with Gujar herders who use the summer pasture owned by Pathans in exchange for livestock products. Above about 1,500 m elevation in Swat, Pathan villages are replaced by another ethnic group, Kohistanis. Kohistani farmers irrigate small, narrow, terraced fields with ingenious irrigation works, and herd substantial numbers of animals in the mountains above their villages. Because of the smaller fields and cooler temperatures only one crop is possible per year, and the variety of crops is restricted.

Ease of communication is also a function of elevation. The Punjab lowlands are easily traversed by wheeled vehicles, and trading (and raiding) are practical. Highland villages, by contrast, can be reached only with considerable difficulty by rough trails up narrow gorges and across formidable passes; trading is difficult, but defense is easy.

D. Demography and Social Organization

Punjab urban societies are good examples of the Agrarian States. Lowland Punjab is densely settled. Villages of a few hundred to a few thousand are thickly scattered on the plain a 2 or 3 kilometers apart. There is a considerable hierarchy of settlements, with market towns every 15 or 20 kilometers. At the top of the pyramid are large cities, like Lahore. The Indus region has a long history of urban centers. The ruins of Mohenjo-Daro on the lower Indus and Harrapa in Punjab are the oldest cities on the Indian subcontinent, and date to 2,500 BC, only a little later than the very earliest cities in Mesopotamia. For most the period since the Harrapa culture, large Empires held sway in the Punjab. Before the independence of India and Pakistan, the Mughal Empire dominated most of the India subcontinent. Before the Mughal conquest in 1526, Punjab was ruled by Turko-Afghan dynasties, introducing Islam. Even in Islamic Pakistan, the caste system developed in pre-Islamic Hindu India is a major mechanism of social organization. Occupation is fixed by birth, individual mobility from one caste to another is extremely limited, and economic relations between castes are subject to complex customary regulation. Since Islam has an egalitarian ideology, there is no religious underpinning to caste as there is in Hindu India, but nevertheless the institution is very strong. Village life is typically dominated by a landowning elite caste, which may or may not be a majority. A fair number of villagers will belong to one of a number of separate crafts castes, such as barber, blacksmith, carpenter, cobbler, sweeper, potter, and so forth. These terms are misleading in the sense that each caste tends to have a complex array of tasks, for example the barber may also be the cook for large village ceremonies.

The high-caste ruling elite is predominantly urban, historically often of foreign derivation, and the villages are ruled indirectly, through the local landholding citizenry, a prominent member of which is the village headman. The headman arranges for the collection of taxes, but also attempts to obtain favors for the village from central authorities. The worst urban regimes are greedy, brutal and incompetent. The best are enlightened authoritarians that take an active interest in the administration of justice and in advancing economic prosperity. Overt expressions of local or regional independence are suppressed with great energy by urban elites, and local villagers are without arms. Many additional caste specialists, such as soldiers, jewelers, scribes, merchants, and long-distance traders are concentrated in the urban centers.

In traditional Punjab, there was a complex mosaic of cross-cutting ties of varying strength between people--village, district, caste, religion and sect within major religion. Partition in 1947 simplified the PakistaniPunjab social system to the extent that almost all Hindus and Sikhs left for India, but otherwise the principle remains the same. A unified sense of nation, such as we are familiar, was virtually absent. Political boundaries were drawn and redrawn without much affecting village life, although warfare among elites and between elites and conquerors and raiders was sometimes devastating.

The Pathan tribes are the largest ethnic group in Afghanistan as well as dominating the middle elevation regions of Northwest Pakistan. The Pathans of the hill regions are organized tribally rather than as states. Barth describes the social and political system as feudal. At the village level, an Islamicized caste system operates similar to that in Punjab, with domination by the landholding elite. More than 20 castes are participants in the system, with Pathan landowners at the top. The difference is that Pathan landlords are skilled and dedicated warriors, much like the knights of the European early Middle Ages. Pathans subscribe to a complex tribal code of ethics, *paktunwali*, that includes patrilineal descent, Islam, male honor, seclusion of women, standards of hospitality, and social equality of all male Pathans. Public ceremonies celebrate and promulgate this value system. The larger and more successful landowners attract a body of low caste clients and are recognized as chiefs among the local Pathans as well. The “chiefly” role is not formally hereditary, but is based a family maintaining wealth and influence. The chiefly role resembles what we have called bigmen in connection with horticulturalists in its relatively informal and achieved rather than ascribed nature. To be a Pathan proper, a man must own land. There is downward mobility from the elite Pathan group if a family looses its land but no upward mobility. All village landowners participate in the affairs of the community. Much as in common situation among pastoralists, a segmentary lineage system links villages together.

For temporary purposes, chiefs can negotiate alliances with other chiefs and assemble as many as 10 or 15 thousand warriors, usually either for predatory raiding, conquest of new territory, or defense (Note some parallels between the Pathans and tribal societies with horticultural and pastoral subsistence). Pathans have been exposed to the idea of a state for a long time, and have organized some states (the Afghan state centered on Kabul and the Swat state organized in the early 20th Century are examples) and imposed themselves as elites elsewhere (including the Punjab). However, the independent, egalitarian tribal ethos is distinctly hostile to state formation, especially to the rigid, arbitrary, deeply hierarchical, authoritarian state typical of the region. That is, Pathans are willing to serve as conquerors and feudal nobility with a personally sworn loyalty to a conqueror; every Pathan warrior is a potential king or nobleman if the opportunity for conquest arises, much the case with pastoral nomad conquests. Pathans, however, vigorously resist attempts to make them subordinates in a state system. A Pathan landholding warrior may swear personal allegiance to his local chief, but is not comfortable as a citizen of a state several steps down in the hierarchy.

Due to the difficult nature of the mountainous territory the Pathan tribes have long controlled a large block of country west of the Indus. Although in some regions, isolation nearly completely defeats attempts to control the tribes (Barth believes that Pathans in the Swat area have never paid taxes to an external state), in other areas, Pathans control the major routes from the Indus to Central and Western Asia, the legendary Khyber Pass for example. Rulers with imperial ambitions have exerted great effort to control the passes. Sometimes states have controlled the routes for varying periods of time, although some of the greatest, Alexander of Macedon, for example have been defeated there. The British attempt to control Kabul west of the Khyber was defeated in the winter of 1842 with the massacre of the entire garrison as it attempted to evacuate through the mountains to India. The recent defeat of the USSR in its attempt to control Afghanistan is the latest in a long list of imperial defeats at the hands of the Pathans.

In the Swat region of Pakistan, Pathan expansion has reach an equilibrium with the original Kohistani inhabitants dominating the higher elevations. Barth argues that the Kohistani--Pathan boundary is imposed by an ecological barrier, low agricultural productivity. The Pathan feudal life-style requires a productive, double-cropped farm to support the cadre of low-caste retainers that make the warrior elite’s investment in hospitality, arms and military activity possible. Pathans have expanded at the expense of Kohistanis in the past, but the boundary has been stable for many generations. The single-cropping system of the Kohistani region, only a few specialists of any kind can be supported, and no man can aspire to have enough low caste retainers to live a life of leisure at their expense. Village councils of elders and lineage headmen meet to decide important matters, and some coordination between local villages of 400-2000 inhabitants was possible. However, neither the chiefly role nor the large-scale collective tribal identity are as well developed as among the Pathans. Invading Pathans were thus able to evict Kohistanis from the lower double-crop region because their political system generated sufficient armed pressure to overcome Kohistani resistance. It must not be thought that Kohistanis are pushovers. Keiser (1991) describes how in the mid 1970s Kohistani communities united to fight Pakistani government attempts to control timber resources. After using tanks and air strikes to attempt to suppress the insurrection, the central government eventually settled the issue by substantially increasing timber royalties!

Our special case of the Indus gradient generalizes well to the general relationship between tribally and state organize agrarian societies in other parts of the world. The guerilla tactics inherent in the heroic, individualistic, segmental tribal system is quite effective in rugged, sparsely settled terrain, but in open, densely populated country, fortifications and large, coordinated armies generally get the best of tribesmen. Pathan tribal farmer-warriors are not unique. Scotland, Wales, and Western Europe north and east of the Rhine resisted Roman domination in the Classical period, and the Highland Scots retained ther rough tribal ways until Cromwell's time (17th Century). Swiss mountaineers maintain their cantonal independence right down to this day. The Swiss still have universal military training, and every able-bodied Swiss male has his assault rifle in his closet. That the Germans left them alone in WWII is some testimony to the military reputation they still have. Bronson (1988, in Yoffee and Cowgill) argues that agrarian and horticultural tribesmen on the frontier were responsible for the relatively late and uncertain emergence of the state in India. He argues that other places, such as Luzon Island in the Philippines, would certainly have seen states emerge except that the ratio of rough mountain country to open plains was too high. Raids from the mountains seem to have kept the fertile but indefensible plains virtually unpopulated.

VII. Other Aspects of Culture

An example: Child rearing practices are harsh. One interesting correlate of agrarian societies is authoritarian patterns of child rearing. Among modern members of tribal and agrarian state societies, child rearing is much more rigid than among hunter-gatherers and the modern industrial middle class. Rigid, arbitrary rules are stressed and corporal punishment is well used. The resulting individuals seem to be much less independent, but much more cooperative. This might be interpreted as an adaptive result of the need for greater cooperation between individuals in agrarian as opposed to hunting production. Also, one might imagine that independent, individualistic peasants would have trouble coping with the arbitrary rules and stiff exactions of their overlords. The Robin Hoods of most agrarian states were no doubt fairly promptly caught and killed, usually in some rather unpleasant way, like crucifixion.

As already noted in passing in discussing the Indus gradient, religious belief systems are part of the ideology of Pakistani Punjabis, Pathans, and Kohistanis. Although all are today Islamic, local custom and belief is richly variable. Religious leaders and scholars are generally respected and play significant political roles. As in the very well developed case of *paktunwali* , the local variant of Islam typically underpins local and regional identities, and provides an ideological framework for the prevailing social organization. How necessary the more abstract parts of the ideology are for social organization is a debatable issue. On the one hand, *paktunwali* seems to be an important component of Pathan success in assembling larger military forces than other tribesmen. On the other hand, the customs of caste survive in Pakistan in the face of a religious system that seems quite hostile to its heavily hierarchial Hindu underpinnings in India. In fact, agrarian states and feudal societies often have a lot of quasi-hereditary economic specialization, so the existence of it despite the egalitarian ideology of Islam is not too surprising, especially given that Islam is a relatively late overlay of a formerly Hindu society. Still, the fit between religious ideology and social structure is not particularly close if such contrasting religions as Islam and Hinduism are both consistent with caste social structure. Caste itself may be a core variable but not religious ideology.

VIII. Conclusion

A. The Trends Continue

As technology becomes more sophisticated, and more people are supported per unit of labor, the complexity of social institutions increases.

In agrarian societies, some of the simple correlations between social complexity and environment begin to disappear, but we argue this is misleading. One view is that humans with this technology have moved a large step toward controlling their environments, are less dependent on them, and hence show fewer correlations between environment and technology-related traits. A rather different view is that as societies become larger and the movement of goods and people cheaper, they incorporate an increasing range of environmental variation within their borders and trade system. Then simple correlations between gross environmental variation and the gross form of society, such as hunter-gatherer and horticultural societies exhibit, is reduced. *But environmental factors may still play a strong role as variables that affect the internal structure and history of a society in complex ways*; i.e., they become “intrasystemic.” For example, the average size of agrarian states will depend on the ease of transportation, major cities will tend to be located at trade nodes, and the demographic history of a society may depend on disease episodes. In the modern age the location of resources (e.g. Middle Eastern oil) and the problems of environmental deterioration (e.g. the looming global warming problem) seem to suggest to us that even the most sophisticated industrial societies are far from independent of the environment. Let us keep the Lenski and Lenski hypothesis in mind during the Systemic Interactions part of the book, Chapters 17-23.

IX. Bibliographic Notes

References:

Barth, F. 1981. *Features of Person and Society in Swat: Collected Essays on Pathans*. London: Routledge & Kegan Paul.

Bharadwaj, O.P. 1961. The arid zone of India and Pakistan. In: L.D. Stamp, ed., *A History Land Use in Arid Regions*. Paris: UNESCO Pp 143-174.

Braudel, F. 1972 [original French ed. 1949]. *The Mediterranean and the Mediterranean World in the Age of Philip II*. New York: Harper and Row.

Brown, D.E. 1988. *Hierarchy, History, and Human Nature: The Social Origins of Historical Consciousness*. Tuscon: Univ. of Arizona Press.

Elgar, Z.S. 1958. *Vartan Bhanji: Institutionalized Reciprocity in a Changing Punjabi Village*. Columbia Univ. PhD Thesis, Anthropology. (Ann Arbor: University Microfilms).

Ferguson, R.B. 1984. *Warfare, Culture, and Environment*. New York: Academic Press.

Galaty, J.G. and D.L. Johnson. 1990. Introduction: Pastoral systems in global perspective. In J.G. Galaty and D.L Johnson, The World of Pastoralism.New York: Guilford. Pp-32.

Geertz. C. 1965. *A Social History of an Indonesian Town*. Cambridge: MIT press

Hopkirk, P. 1990. *The Great Game: On Secret Service in High Asia*. London: Murray.

Keiser, L. 1991. *Friend by Day, Enemy by Night: Organized Vengeance in a Kohistani Community*. Fort Worth: Holt Rinehart and Winston.

McNeill, W.H. 1982. *The Pursuit of Power*. Chicago: University of Chicago Press.

Nyrop, R.F (ed.) 1984. *Pakistan: A Country Study*. Washington DC: US Department of the Army.

Renfrew, C. (ed.) 1973. *The Explanation of Culture Change*. Pittsburgh: Univ. of Pittsburgh Press.

Sidney, Hugh. 1992. “Revolution on the Farm.” *Time* 6/29:54-56.

Srinivas, M.N. 1962. *Caste in Modern India*. Bombay: Asia Publishing House.

Werner, E.E. 1979. *Cross-Cultural Child Development*. Monterey Calif.: Brooks/Cole.

Yoffee, N. and G.L. Cowgill. 1988. *The Collapse of Ancient States and Civilizations*. Tuscon: University of Arizona Press.

General:

The literature on agrarian societies is immense since many of these societies kept written records and have been the subject of historical scholarship. Similarly, since many of them still exist, they have been studied by social scientists of all sorts. This means that the first task for a beginning student interested in general issues. Two books are particularly helpful:

W.H. McNeill. 1963. *The Rise of the West: A History of the Human Community*. Chicago:

Univ. of Chicago Press. (McNeill stresses technological and ecological processes, and hence fits our prejudices. We’ll be reading some bits of his work later on).

The Times Atlas of World History. 1979. London: Times Books Limited. (Beautiful maps and nice essays. Perhaps half the book is relevant to agrarian societies. A good reference that is sometimes offered as a come-on by book clubs and remainder shops, so you can get one cheap. One of our all-time favorite books, although it has the bad drawback of having no references.)

Many popular histories give a good sense of the late agrarian period in the West. Barbara Tuchman’s *A Distant Mirror*, mostly about 14th Century France, is a good example.

Chapter 7. COMMERCIAL/INDUSTRIAL SOCIETIES

I. Introduction

A. Background

We are presently in the midst of one of the major technical revolutions in human history. The rise of "modern" societies during the last few centuries is the capital fact of recent history. The last five hundred years have witnessed technical changes of unprecedented scope and rapidity emanating from a small and heretofore unremarkable part of the world, Western Europe. In this Chapter we will try to put our finger on just how these societies differ from non-modern ones. In Chapter 28, we will return to some of the evolutionary issues involved.

By one useful definition, commercial and industrial societies are those with less than half of their population engaged directly in agricultural production. As usual, this definition has an arbitrary element, but it marks out those societies with a mostly urban character for special attention. Perhaps the most important point is that these societies, in contrast to the agrarian or horticultural type, are not dominated quantitatively or qualitatively by people with a direct interest in food acquisition. In these societies merchants and manufacturers are typically the dominant class, as opposed to land-owning lineages, chieftains, or aristocrats with a direct interest in agriculture as is the case in horticultural, agrarian, and pastoral societies.

Should we separate or join commercial & industrial subtypes? Occasional societies in the classical period, such as some of the Greek city-states, subsisted mostly on maritime-trade rather than agricultural production. (Only a maritime location could permit this specialization because only ships could reach far enough economically for grain under classical technology to support a society with few farmers). As we briefly glimpsed in Chapter 6, these rare societies are interesting because of their very modern looking character in some domains of social and political organization, and in other aspects of culture. They are the "precocious" counterparts to the "backward" pastoralists. These were ancient complex societies with widespread literacy, a large class of politically active citizens, republican—even democratic—political institutions, a talent for rational philosophy and science, and so forth. Such societies disappeared after a few centuries as the classical agrarian empires conquered them. They had a brief and ephemeral existence until the rather sudden emergence of early modern societies and the age of European dominance beginning about 1500 AD. Why did these heretofore hothouse flowers of agrarian history suddenly muscle on stage to become the dominant technological type?

Why has progress to industry and science been smooth this time—but not before? Many authorities, Lenski and Lenski are typical, make the taxonomic break between agrarian/commercial and industrial societies, and stress the improvements in production technology associated with the Industrial Revolution, beginning around 1800. Others, typically historians like McNeill, make the main break between classical and modern societies at the time of the Renaissance, around 1500. After a lot of reflection, we've adopted the historian's division in preference to the sociologist's. It is a judgment call, but it seems to us that the "Rise of the West" is a smooth trajectory from 1500 onwards and that the Industrial Revolution, as impressive at it is in some ways, is a natural outgrowth of several centuries of development. This taxonomic decision, while quite arbitrary, does have the virtue of highlighting the puzzle of why a particular set of maritime commercial societies led to such advances after many Classical Period examples flashed so brilliantly and vanished. This is a genuine puzzle, and if a taxonomy prevents it from being swept under the progressivist rug, so much the better. Why did Venice spark the Modern Era when Athens didn't?

A compromise taxonomy, perhaps, would entail dividing the type into simple and complex sub-types, commercial/ industrial societies, much as we have done with horticultural and agrarian societies. This scheme permits a focus on both the similarities and differences between the subtypes. In this Chapter, we aim to lay out enough of the data for you to make your own choice.

B. History

The first glimmerings of the commercial and industrial revolution can be seen in the Mediterranean city-states of 1000-1500 AD. As European societies developed during the Middle Ages, classical knowledge was reacquired from scattered sources, especially the Arabs, and a new series of maritime commercial societies developed again in Europe. The initial developments were centered in Northern Italy, in the city-states of Venice, Florence, Milan, and Genoa and nearby Barcelona. Venice turned out to be the single most important of these in terms of economic developments (McNeill, 1974), while Florence was the intellectual leader. Venice and her sisters linked the whole Mediterranean world with trade routes. Long, tenuous trade routes linked these routes in turn to the Orient, over which a number of key innovations diffused from China (paper-making, printing, the compass, gunpowder, silk-worm raising). Other areas contributed innovations in ship-building and these cities were themselves the center of the Renaissance, whose early scientific advances and general rationalism led to innovations of their own.

By about 1500 a few of these city-states probably met our definition of having half of their populations engaged in non-agricultural pursuits and became commercial societies. (Exact estimates of the ratio of rural to urban population are lacking as far as we know, but it is certainly true that these small states were highly urbanized, imported much food, and were centers of trade and manufacture to a degree quite unlike typical agrarian states.) From the Mediterranean, the innovations adopted and pioneered by the Italians spread to Northwestern Europe. From this time onward, the development and spread of transport and manufacturing technology was rapid and continuous, and the hegemony of European ideas and peoples became global. A Genoese entrepreneur, Christopher Columbus, turned the skills of the era into the discovery of the New World, which is a convenient historical marker for the emergence of the West.

The culminating development, still in progress, was the development of industrial technology, the application of mechanical sources of energy to an ever increasing number of production problems. By about 1800, the agricultural population of Britain had sunk to about 1/3 of the total. By mid-l9th Century, all the countries of Western Europe, plus the U.S. had more than half their populations in non-farm occupations. Even today, the industrial revolution is far from complete in two senses. First, only a minority of the World's people today live in industrialized societies by our definition (although most predominantly agrarian societies have a significant industrial sector). Second, industrial advances still go on, at an accelerated pace if anything. Of course, there is no guarantee that the industrial revolution will ever be complete. Nor, on the other hand, is there any guarantee, as we shall see in Chapters 22 & 23, that its accomplishments are permanent. The rate of environmental deterioration caused by industrial development may (or may not) exceed the rate at which technical innovation can make good the damage in the long run.

II. Technology

A. Commercial Innovations

The key initial development of commercial/industrial technology was a cheap means of seaborne transportation. The improvement of sailing ships to 100+ tons was, in hindsight at least, one of history's most pregnant developments. All-weather, seagoing vessels that could navigate the length and breadth of the Mediterranean and carry on a trade with Northern Europe were available by about 1300, according to McNeill (1974). (See figure 7-1.) Some of you may have visited replicas of such vessels. They quickly evolved into vessels that could sail the open Atlantic. Using these 100 Tonners, Columbus crossed the Atlantic in 1492, and Magellan circumnavigated the globe in 1519-1522. Samuel Elliot

Figure 7-1. “A Flemish version of the machine with which the {European mariners} changed the world: the three-masted ship, square-rigged on the foremast and mainmast, lateen-rigged on the mizzemast, with smaller vessel in sight” (Crosby, 1986: Plate 2).

Morrison (1974) gives a classic, admiring account of the Voyages of Discovery.These ships are tiny and primitive by modern standards, but huge and sophisticated by any earlier comparison. Combined with navigational aids like the compass and ship mounted cannon, reasonably reliable long distance maritime trade could be initiated, and in the 16th century, Europeans used them to build direct global networks of commerce. Columbus, Vasco da Gama, Drake, and their cohorts were the first to demonstrate how far European technology had outstripped the rest of the world. Long-distance trade was largely for high-value per unit weight products like spices, precious metals, dyes, slaves, and sugar. But in the vicinity of Europe, there was extensive trade in much more mundane bulk products such as grain, cloth, dried fish, and timber.

Other technical innovations besides ships appeared quite early in Europe. For example, water power was developed early on in the late Middle Ages for grinding grain. Various other bits of technology were acquired or invented at a steadily increasing rate as the modern era gathered momentum.

B. Industrial Innovations

Industrial innovation began in the late 18th century. The application of inanimate energy to basic production processes on the farm and in the shop dramatically increased the productivity of labor in such a broad variety of occupations that many large societies were able to make the transition from the agrarian to the modern type. By contrast, commercial societies without industry are inherently dependent on low productivity labor in other societies and for food and raw materials. Trade may make a few small societies relatively modern, but only industrial production can permit large proportions of the world's population to leave the farm.

Transport continued to improve with the application of industrial technology. Technically the sailing ship is an industrial machine. The application of more powerful sources of inanimate energy--coal in the early stages of the industrial revolution--to propulsion led to steam vessels, railroads, automobiles, and aircraft. The early commercial societies were limited in scale because bulky commodities like food could be moved economically only relatively short distances (e.g. Sicily to Venice). After the application of industrial technology, transportation costs fell dramatically, so that the wheat market became global. The first agricultural boom of California's Central Valley and in Australia in the 19th Century was based on the export of wheat to Europe from these then-remote regions in advanced iron-hulled sailing vessels.

C. Other Technical Innovations in the Commercial/Industrial Period

Agricultural innovations swelled the stream of labor to cities. For any significant number of societies to develop past the agrarian type, large numbers of people had to be able to leave the farm and enter other occupations. Innovations in European agriculture that began in the Medieval period (see last Chapter) were followed by other technical improvements in agriculture, such as livestock breeding, legume rotations, winter forage crops for livestock, and the import of new crops, especially potatoes and maize from the New World. Industrial technology was rapidly applied to agriculture in the form of new implements (seed drills, threshers) and later mechanical tractors.

Once people left the farm, they were drawn into first craft and later manufacturing occupations of a quite awesome variety. Cloth manufacture, spinning, weaving and dying, absorbed large numbers in England and the Low Countries, for example. Mining, metalworking, building, and glass- and paper-making were among the early ones. These trades had widely varying rates of technical improvements. Mining was well advanced in Germany before 1500 and German techniques allowed the exploitation of vast quantities of precious metals in the Spanish New World during the 16th and 17th centuries. Mining, metalworking, and textiles were among the first industries to experience industrialization. The beginning of the industrial revolution is often dated to the application of steam power to run a rotating engine (1775) or running thread-spinning machinery (1785). The magnitude and variety of such changes is vast, and we must be content with a small sketch here. (A series of tables of key industrial innovations is given in Tuma, 1971).

The development of industrial technology is to this very day quite uneven. Some occupations are still hardly industrialized at all. The building trades are still relatively primitive, involving substantial amounts of hand labor. We teachers still lectureto *relatively* small groups, much as the ancient Greek philosophers did. Students still spend endless hours reading books and doing exercises by hand. Mass produced education seems technically feasible (nationally televised lectures, etc.), but the customer seems to want a live body up here in front of the class. We don’t lecture to any greater number of students than Plato or Aristotle did, while movies and music play to millions. Why are we satisfied with industrial entertainment, but not industrial education?

D. Information Processing, Literacy, and Technological Innovation

The management of industry and commerce requires considerable improvements in information processing to be successful. The development of printed books, the spread of literacy, improved mathematical skills, and the like are one of the hallmarks of commercial/industrial societies. The Italians developed such innovations as double-entry bookkeeping and celestial navigation (for latitude only) before 1500. Mail services, banking and credit institutions, and the like were also very early. Clocks, telephones, computers and so forth were added to this repertoire as technology improved.

III. Demographic Consequences

A. European Population: Growth Followed by the “Demographic Transition”

From 1500 onwards, European populations increased steadily, especially counting the outflow to and increase in the New World. However, until the Industrial Revolution the rates were modest, ca. 0.5% per year. During the 19th century rates went up to 1.5% for substantial periods of time.

Towards the end of the 19th century, rates fell again, an episode demographers call the “demographic transition”. We will cover these phenomena at more length in Chapter

16.

B. Industrial Achievement: Technological Progress Outruns Population Increase

It is interesting that general increases in per capita incomes did not result from the improvements in technology until the Industrial Revolution. From 1500 until 1800 improvements in technology in European societies were absorbed by a rising population and the average individual was hardly if any better off (the “Malthusian” model, see Chapter 15). Only since the Industrial Revolution have living standards for the mass of people improved substantially. Despite rapidly growing populations, technological improvements have more than kept pace in the industrial and industrializing societies. This is an unprecedented development as far as we know, and is one of the best reasons for making some sort of distinction between industrial societies and all other types.The attached graphs give some feeling for these differences. Figure 7-2 shows how prices rose during the 16th century, and how wages actually fell. This was a period of population increase. (The inflation index is obtained from historical records of the prices of key commodities, and builders’ wages are used as a surrogate for general working-men’s’ wages. Of course, modern economic statistics are a product of the 19th and 20th centuries, so economic historians have to be content with more or less good proxies for the more distant past. Taken from Tuma, 1971.) Figure 7-3, prepared by Peter Lindert of the U. C. Davis Economics Department, shows some comparative statistics for the period since the beginning of the Industrial Revolution. Note that on Lindert’s graph, a straight line is exponential growth. Thus, by contrast with an advanced agrarian/commercial society like 16th-18th Century Europe, many 19th and 20th Century industrial societies have managed exponentially growing incomes per capita, even in the face of rapid population growth. Still, it is easy to imagine that this is a temporary aberration, and that per capita consumption will cease rising at such rates in the relatively near future (as it almost certainly must at some point).

C. Extreme Urbanization

Improved transportation, declining requirements for labor on the farm, and the demand for large concentrations of workers promotes the growth of cities in commercial and especially industrial societies. Only among such societies can the majority (today it is the vast majority in the advanced industrial societies) live in urban areas. Many of the consequences of commercial and industrial technology are a by-product of the urbanization of the bulk of the population. Cities are inevitably “sophisticated” places with a quite different impact on social organization that rural homesteads and villages. A complete course in human ecology would devote an entire lecture to the phenomenon of urbanization.

Figure 7-2. Builders' wages and the cost of living: five-year averages. (Source: *Cambridge Economic History of Europe, IV*. 1966:482-483.)

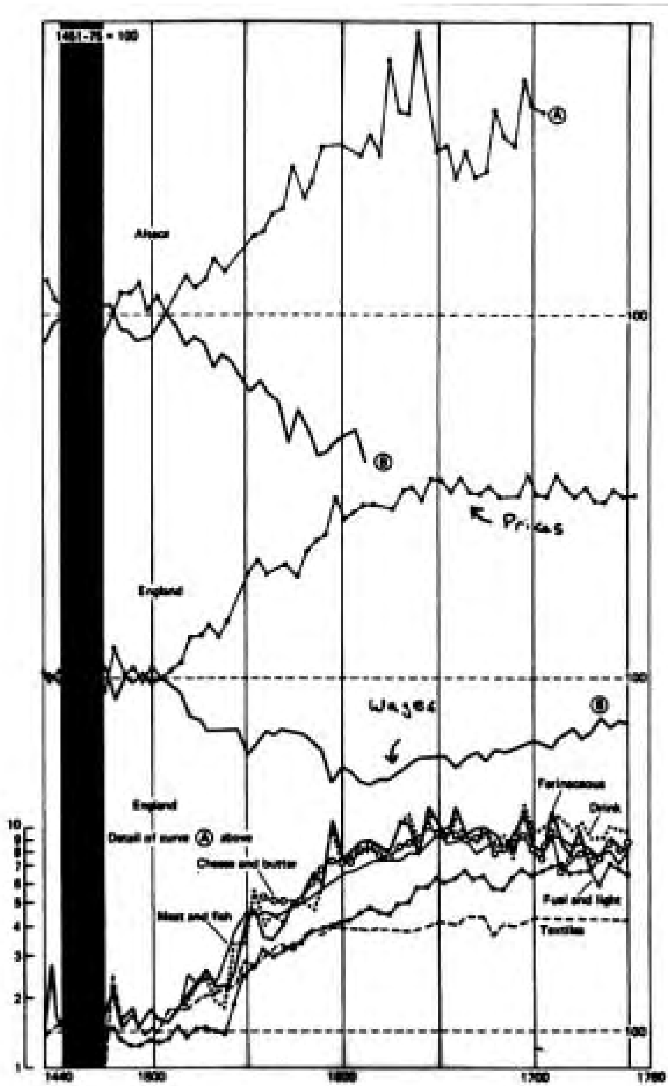
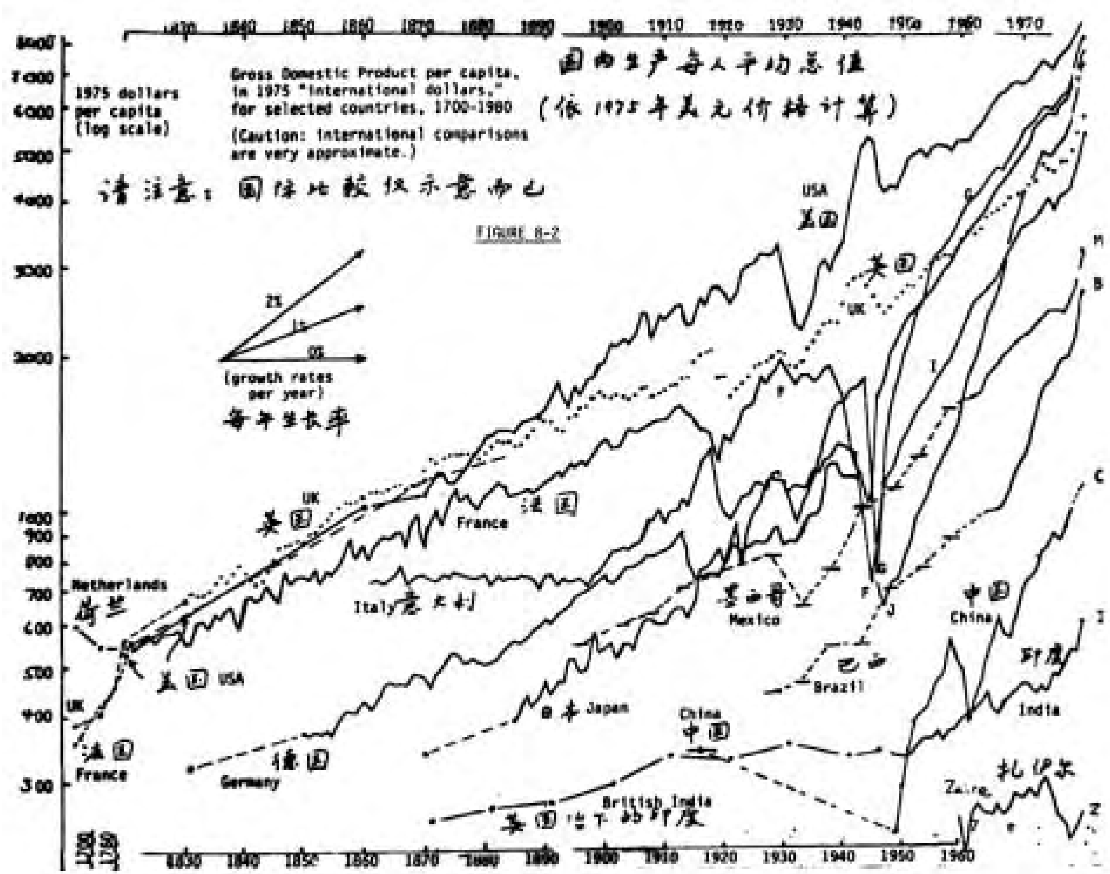


Figure 7-3. Gross Domestic Product per capita for selected countries, in 1975 “international dollars,” 1700-1980. Caution: International comparisons are very approximate. (Source: Peter Lindert, Economics Department, U. C. Davis.)



IV. Social and Political Organization

A. Social & Political Organization Transformed

The degree of occupational specialization increases dramatically in commercial and industrial societies. These are the societies that take maximum advantage of the virtues of the division of labor. Named occupational specializations expand from a few dozen in advanced agrarian societies to thousands in industrial ones. Furthermore, the vast majority of the population has withdrawn from primary production to the extent that trade for food and other essentials is a requirement for life. This confronts industrializing societies with an enormous organizational problem. Thus the trend we have been observing continues: Kinship continues to decline relative to other institutions as a means of social organization, and the importance of bureaucratic forms continues to grow.

B. Social Structure—Dominance by Achieved Elites

The social structure of commercial and industrial societies is quite unique in the numerical predominance of a middle class based on achievement. The subdivision of society into a governing aristocracy and a peasant mass, with a small artisan and professional class, is typical of agrarian states. Elite status is typically ascribed (by birth), and in the case of caste and caste-like statuses like slavery and peonage, many other statuses may also be ascribed. In commercial and industrial societies, the artisan and professional groups rise to numerical and political dominance, and these statuses generally are relatively open to anyone who aspires to them. Status tends to be achieved rather than ascribed. (This is not to deny the existence or importance of ascription and prejudice in these societies.) In the classical case, this lead to the liberal capitalist democracies of Western Europe and the USA, in which there is more or less open competition for political influence among many contending interest groups. Even in the pre-industrial commercial societies like Venice and Holland, the ascribed agrarian nobility was dominated in government by the achieved business and commercial community. Often, such societies were Republics.

This is an “organized chaos” way of running a state with a certain parallel to markets. There is free competition for political leadership that has a certain primitive flavor to it (recall the bigman system that is common in horticultural societies). In modern one-party states things are quite differently organized, but still the same general dominance of people with “middle class” backgrounds is apparent, and careers in the Party are open to talent. The old elites based on landed wealth and ascribed membership in the aristocracy have declined to near ceremonial significance (e.g. Britain) or have vanished entirely (USA, imperial Russia) in favor of an achieved “aristocracy” based on entrepreneurship in politics, bureaucracies, and business.

C. Markets & Bureaucracies—Mechanisms of Redistribution

Societies with strong market-orientation are usually the most dynamic. Having many specialists means that there must be an extension of trade or sharing so that each specialist can acquire all he/she needs to survive and prosper. Two major mechanisms are used in varying proportions to manage the redistribution necessary, markets and bureaucracies. Historically, the most rapidly developing and dynamic commercial/industrial societies have relied disproportionately on markets. This is true of the Italian city states, the Low Countries, England, the USA, and the currently dynamic East Asian countries during the periods of their leadership. Countries that have emphasized state controls of the economy have generally not developed as fast, for example Spain and France in earlier periods, many contemporary Latin American countries, and the communist USSR. In many of the most dynamic commercial/industrial societies, the state does play an important role in promoting business, quite unlike the *laissez faire* model, however. Venice was an old example, and Japan is a modern one. The struggle between more market and more state-oriented notions of how development (and in detail, just what government and markets ought to do) ought to proceed still furnishes high political drama in China under Deng, in the former USSR, and in Britain under Thatcher and Major—not to mention the USA under Bush and Clinton!

Markets have pluses and minuses. Two market-oriented issues are particularly relevant to our discussion: (1) the economist's hypothesis that competition spurs technological innovation; and (2) problems with cooperation and coordination that accompany the development of markets. Markets promote economic efficiency through the effects of competition; any of you who have had Economics 1A know the argument. In a well-functioning market buyers and sellers can convey information about their wants through the price mechanism more efficiently than by any other means. Markets also make laggards in the use of new innovations pay a relatively swift penalty and sometimes very richly reward innovation and other forms of entrepreneurial risk-taking. On the other hand, markets are rather anarchic and prone to all sorts of problems including failures to supply *public goods*[1], unscrupulous manipulation, panics and crashes (e.g., October 1987 stock market crash), an insensitivity to the distribution of income (the fairness question of F. Mondale in the 1984 Presidential election; Bush's pledge of a kinder, gentler America, Clinton's "change" theme), etc. The very dynamism of markets often means that the pace of economic change is much greater than many would desire; just the stress of a decline in income because your business or industry has become outmoded is a significant drawback. The devil-take-the-hindmost flavor of market competition is not to the taste of the hindmost at least! Last year

---

[1] Goods like public order, national defense, and clean water whose use everyone shares.

IBM and Sears were among the giants that fell in stature. (See Dahrendorf, 1968, for a classic discussion of this dilemma.)

Bureaucratic management has pluses and minuses. The optimal market/bureaucracy mix has been endlessly debated. All commercial and industrial societies have found a more or less elaborate state management of economic affairs necessary. Empirically, the pure free market system is a figment of a few economists' imaginations. At the very least a fairly elaborate set of state institutions must ensure "fair" markets, manage a currency, conduct foreign affairs, secure public order, and the like. Almost all have gone much further, conducting income redistribution schemes to relieve the worst excesses of the maldistribution of income, through poor laws and relief for example. Often they have acted to preserve the economic privileges of powerful groups who would lose out in market competition. This is most frequently felt to be fair when the competitors are foreigners, hence tariffs, immigration restrictions, and the like.

Both market and bureaucratic run economies have had to develop organizational innovations to cope with the increased scale of economic activity, and the distribution necessary to support the extreme division of labor. Governments have expanded bureaucracies and rationalized their operations with increasingly detailed laws and regulations. Businesses have long used the joint stock company to organize larger ventures than is possible with the capital of one or a few individuals. As a result of these arrangements private corporations are often as bureaucratic as the government bureau proper. Multinational industrial corporations use bureaucracies on the scale of small states to coordinate the manufacture and sale of complex, capital intensive products in international markets.

D. Political Fragmentation

International conflict is one problem that commercial/industrial societies have not been successful in solving. Thus far, no one state has been able to dominate the others; the analog of the great civilized empires of classical agrarian societies has not arisen. We might expect that cheaper transportation and communication, together with gross disparities in development between societies, would have led to a single worldwide industrial empire. The European colonial empires of the past were perhaps a start in this direction, but the Europeans themselves were never united. Rather, the European states, and more recently the US, Japan, and China, have competed intensely among themselves for wealth and influence.

Many states have tried to construct a united empire in Europe. This began with the medieval popes' failed attempts to set up a politico-religious empire on the Roman plan, the Holy Roman Empire. Then Philip II of Spain tried and failed to conquer England and dominate France in the 16th Century. Then the French tried, most conspicuously under Napoleon. Then the Germans tried it several times, 1871-1945. Britain built a huge extra-european empire in the 18th and 19th Century, but never attempted to unite Europe itself. Since WWII the US has run a sort of empire in collaboration with the Western Europeans (the NATO Alliance) and it has a shaky sort of global dominance since the collapse of the USSR.

In every case so far, the European tendency for all states to collaborate to defeat the strongest has been successful. The balance-of-power politics of the contemporary world is very much on this model (e.g. the complex shifts of Chinese policy in the post WWII period to try to ensure that neither the USSR or the US could entirely dominate to modern world). Played well (1814-1917) this works well enough. Played badly (1789-1812, 1914-18, 1939-45) it leads to severe wars. Nowadays, improvements in military technology are of such a scale that we must play it very well to avoid catastrophe. One hopes that this will provide sufficient motivation to encourage new innovations in political institutions. Neither the League of Nations nor the UN have filled this role very effectively. The 1991 Persian Gulf War was perhaps a step in the right direction, but recent events in the former Yugoslavia remind us of the lack of reliable effective institutions at the international scale.

One of the biggest single blows to the 19th century idea of progress and progressive evolution is the fact that the international institutions that seem necessary have not shown any signs of arising naturally during the 20th century. Indeed the present anarchic international structure of the world strikes one as a “primitive” feature. In a progressive world, such as some social scientists still envision, we could depend on some natural force to correct the situation, but they have not. WWI and WWII sharply dimmed the touching faith in progress that Europeans had inherited from their Victorian ancestors. We are presently stuck at a most dangerous point, a far more sophisticated technology than our political institutions are capable of controlling without the real threat of awesome catastrophe to make us pay attention. This is more reminiscent of the ***undirected*** Darwinian sort of evolution than the smooth progress of Spencer (see Chapter 9).

V. Other Aspects of Culture

A. Rationalism (Science, Business, Ideology)

Perhaps the most striking trend has been the development of rationalism. While the old religious ideologies of agrarian states have survived, their influence has been considerably reduced. In part these modes of thought have been replaced by a rational, scientific, attitude toward life. Indeed, it is likely that the development of science, entrepreneurial business and technological progress are closely related in that they require similar individual independent thinking, a suspicion of traditional practices, and a calculating approach. Certainly, the developments of mathematics have been applied to most fields of modern endeavor. This is particularly conspicuous in the modern period when new technologies are developed in a few decades from ideas generated on the frontiers of science (the chemical, electronics, and military hardware businesses are good examples). Before the industrial revolution, the coupling was much looser but even then, mathematics and physics were applied to such problems as navigation and ballistics quite early. A strong, but controversial case has been made for a close coupling between science and industrial innovation during the early stages of the industrial revolution by Mussen and Robinson (1969).

Nevertheless non-rational ideologies remain, often dressed up as rationalism. Nationalism and various political ideologies are becoming increasingly important, often buttressed by religious beliefs. Science offers no answers about the ends of human life, only explanations of a cause and effect kind and prescriptions about means to reach ends, so an ample field for other kinds of ideological and theological systems remains. Pat Robertson, the Ayatollah Khomeini and ‘fundamentalists” of many different hues illustrate the kind of reaction to the secularism of modern society that is possible, and one wonders if the maintenance of modern society would be possible under such leaders in the long run.

It is interesting that rationalism has such high prestige in the modern world that ethical systems and non-rational belief systems are often dressed up in rationalist garb. Thus, we have Christian Science, Scientific Socialism, Creation Science, and Scientology.

B. Child-Rearing Styles

Modern middle class child-rearing styles resemble those of hunters and gatherers more than they do those of the peoples of agrarian states. The stress is once again on relatively relaxed discipline, and on the encouragement of independence. In some ways the demands of middle class roles for individual self-reliant action seem to be similar to those of hunters and gatherers, despite vast difference in technological complexity.

VII. Gradient Test

The gradient test is not so simple to apply in the case of variations in commercial/ industrial societies. Trade reduces dependence on the local environment. As noted in the last chapter, trade greatly reduces the direct impact of environmental variations on the technical form of societies by internalizing, but not necessarily eliminating, the effects of environment on society. Thus, we see relatively resource-poor nations like Britain and Japan develop industrial societies before their better endowed neighbors, such as Russia and China. As always, the historical factor plays a role. European societies evidently had some factor that gave them a head start on the development of commercial and industrial societies, a question we will address in Chapter 28. Trade allowed early industrial societies like Britain to leap ahead by acquiring the resources it lacks from others.

The most conspicuous gradient is probably more historical than truly ecological. There is a strong pole to equator gradient in degree of industrialization of contemporary societies. Even within single nations like the US or Italy, the North is comparatively rich and the South comparatively poor. In South America, the richest countries are in the temperate Southern Cone, and the poorest are tropical. Most likely, this is a result of industrial technology having first developed in the North Temperate zone. People and technologies spread most rapidly to relatively similar environments, and diffuse more slowly across environmental gradients (Crosby, 1986). For example, the Southern Cone countries of South America are mainly European derived, whereas tropical American populations have more Native American and African immigrant genes. What are probably much more important than the genes are the ideas about technology and social organization that the immigrants brought with them; it is easier to apply technology invented in the temerate zones by people used to living in temepate zones in New Zealand and Argentina that in New Guenea or Colombia. There does not seem to be any reason why, in the long run, the tropical countries will not become as industrial as the temperate ones.

It is important to realize that environmental effects still play a large role in commercial/industrial societies. Transportation routes and the location of resources frequently affect the development of cities. Large cities are very frequently on the seacoast or navigable rivers for example. Competition for raw materials has long affected political calculations in these societies. For example, the early maritime commercial cities like Venice had to take great care not to be cut off from the grain-growing regions on which they were dependent for food. Eventually, the societies facing the bigger puddle (the Atlantic) sprang ahead of the societies limited to the Mediterranean. The fortunate oil-producing states have political and economic power directly related to their lucky endowment of resources. The existence of commerce and industry alters and complicates the impact of environmental variation, without necessarily reducing its fundamental importance. In a later Chapter, we will also consider the potent effects that industrial societies especially can have on environmental processes.

As bulk transportation becomes cheaper, electronic communication exceedingly cheap, and global trade more important, all of the World's societies are increasingly being drawn into a common production system with an extensive regional division of labor. At the present time, this system is evolving extremely rapidly to the accompaniment of explosive population growth, great disparities of wealth and power, and large environmental impacts. In the midst of such great changes, it is exceedingly difficult to discern what the commercial/industrial adaptation might look like near equilibrium!

VI. Conclusions

The development of modern commercial and industrial societies saw the most sustained technical change in the whole human record and caused a transformation of culture core variables. This revolution took about a millenium to accomplish.[2] However, since it is the latest technical revolution, it is by far the best recorded, and thus makes a good one against which to test theoretical models.

But it certainly leaves a lot of puzzles. Why was Europe the locus of such changes, instead of China (the source of many key innovations), or the Islamic societies that transmitted classical knowledge and Chinese innovations to the West? Why didn’t the commercial/industrial revolution start far earlier? Is there any obvious reason why the sophisticated civilization of the classical Mediterranean societies could not have embarked on this path 2,000 years earlier? Why is it spreading at different rates in different societies today? What role did environment, evolutionary processes, and chance play in the Drama? The rest of the course will be devoted to trying to pose these kinds of questions about the evolution of human societies in a more rigorous way and to (at least) formulating useful hypotheses to answer them.

VII. Bibliographic Notes

References:

Crosby, Alfred W. 1986. *Ecological Imperialism: The Biological Expansion of Europe, 900-1900.* Cambridge: Cambridge University Press.

Dahrendorf, R. 1968. *Essays in the Theory of Society*. Stanford: Stanford University Press.

McNeill, W.H. 1974. *Venice, The Hinge of Europe 1081-1797*. Chicago: Univ. of Chicago Press.

Morrison, S. E. 1971, 1974. *The European Discovery of America,* New York: Oxford University Press.

Mussen, A.E. and E. Robinson. 1969. *Science and Technology in the Industrial Revolution.* Manchester: Univ. of Manchester Press.

Tuma, E. 1971. *European Economic History.* New York: Harper and Row.

---

[2] Its roots were in the spurt of technical progress in China 1000-1500 AD, and in the recovery of the West from the Middle Ages 1000 AD.

General notes:

Much modern social science is, of course devoted to industrial societies. In terms of social organization, a good textbook on sociology is a place to start (e.g. Lenski and Lenski). Relatively little conventional social science work is written with the broad evolutionary and ecological questions of this course explicitly in mind.

Part II. PROCESSES OF HUMAN EVOLUTION

Chapter 8. BASIC DEMOGRAPHIC CONCEPTS

> The human species would increase in the numbers 1, 2, 4, 8, 16, 32, 64, 128, 256; and subsistence as 1, 2, 3, 4, 5, 6, 7, 8, 9.
>
> Thomas Malthus, 1798

O. Introduction to Part II of the Course

A. Culture Core and Human Variation Revisited

In the last section we saw that a large fraction of the variation in human behavior is correlated with environmental variation and is plausibly adaptive. Steward's culture core concept, with its ecological component, does lead to a compact taxonomy that organizes the mass of data on humans in a useful way. In addition an evolutionary schema of societies seems to emerge quite nicely.

What Steward's culture core concept lacks is a precise account of the mechanisms by which adaptive variations within technological types arise, and how evolutionary transformations between technological types occur. Ecological anthropologists like Steward developed a very successful *descriptive* scheme, but a less impressive *explanatory* system. The evolutionary concept of adaptation has been invoked, and the evolutionary process alluded to, *but what evolutionary mechanisms might account for these environmental correspondences and historical changes*? Seward imagined a progressive evolutionary impluse carrying societies from lower to higher technology, but the process driving the progressive improvement of technology was not clearly related to ecological mechanisms. The separation of evolution and ecology into two separate realms, strikes a biologist as very odd. For Darwinians, evolutionary processes are merely ecological processes plus lots of time.

What is required is a mechanistic understanding of the processes of evolution. Until recently there has been no synthetic theory describing how cultures adapted and evolved, comparable to Darwinian theory. The theory of human ecology and evolution had none of the pleasing explanatory elegance of the biologist's hypothesis that evolution proceeds mainly due to natural selection, even though the basic nature of the problem of cultural evolution is very similar to the problem of organic evolution, as Darwin (over)stressed.

Darwin's theory, and its successors today, are still incomplete and perhaps wrong, certainly in detail. But Darwinian evolutionary theory does give a comprehensive and plausible account of organic adaptation and evolution. It would be quite surprising if any theory utterly replaced, as opposed to modified, the modern synthetic theory of evolution. A viable candidate to make a radical replacement of Darwinian theory would have to be really impressive, because the accomplishments of Darwinian theory are so spectacular. On the other hand, it is widely acknowledged that the social sciences have no theoretical foundation of the same caliber; the relative inadequacy of Stewardian ideas is plain to all. We are now prepared to remedy this lack, as well as it can be remedied at the present state of our knowledge. Our approach will be to modify the very same Darwinian theory used by biologists to explain the human case.

B. Next Six Chapters Will Apply Darwinism to Culture

In the next six chapters we will be considering the basic processes that affect the evolution of human phenotypes[1]. This chapter we will consider the basic elements of demography, and next chapter of organic evolution (all of the basic neo-Darwinian theory in two chapters; be warned about the level of simplification here!). Chapter 10 will deal with application of neo-Darwinian theory to human behavior. In succeeding Chapters 11 and 12, we will turn to the analogous processes of cultural evolution and the processes that link them to genetic evolution. We will see what progress can be made in postulating a synthetic evolutionary theory that takes account of the coevolution of genes and culture. This theory suggests at least some provisional answers to the four basic problems of human ecology outlined in Chapter 2:

1. Why do humans have so much culture?
2. Why do humans live in such big, complex groups?
3. Why do humans engage in so much symbolic behavior?
4. What is the relationship between scientific and historical explanations for the variation we observe between human societies?

In order to keep things simple, we will focus on elementary general models of evolutionary processes. One of the most drastic simplifications will be to keep considerations of the environment at a minimum level. The ecological part of evolutionary processes will be reduced to very abstract selective regimes, influences on individual decisions, and the like. In Part IV of the course we will add some ecological realism back in. (This tactic of studying simple models first and adding complexity back in afterwards has been very useful in evolutionary biology and the social sciences, as was mentioned in the introduction.)

---

[1] Remember the definition of ‘phenotype’: the visible properties of an organism that are produced by the interaction of the genotype and the environment. Thus, phenotype includes *both* physical factors such as amount of body fat and cultural factors such as adolescent dating behavior.

I. Introduction to Basic Demography (Basic Population Ecology)

Reverend Thomas Malthus was the first person to reason hard about the nature and behavior of populations. In *An Essay on the Principle of Population*, first published in 1798 and amended, altered, and enlarged up to 1830, he produced a landmark in many respects. His ideas founded the study of demography, the science of population growth and decline[2]. Both human demography and the study of plant and animal population ecology are built squarely on Malthus' foundation.

Malthus' ideas and method of investigation were, according to Darwin, the direct inspiration for his idea of evolution by natural selection. In the next chapter we'll discuss in detail how Darwin's ideas rest on a Malthusian foundation. The key idea of Malthus was to trace out clearly the implications of individual reproductive behavior for the longer run behavior of whole collections of individuals, the population. His method was the deductive mathematical argument in very simple form: "Give me a few plausible assumptions about human biology and environment, let me do some simple arithmetic, and I'll show you the most amazing conclusion, the inevitability of competition for limited resources." Such simple arguments are almost always oversimplified, and to that extent wrong, but they often give us a very clear insight into a particular process. They also tend to sharpen and clarify debate. Simple, clear arguments are the most important tools we use to think about causal processes that affect complex, diverse systems. Malthus was a pioneer in applying this style of thought to human ecology.

A population is a set of interbreeding individuals that interact with an environment, reproduce, and then die. According to the famous evolutionary biologist Ernst Mayr (1984), the concept of population (*"population thinking"*) is the greatest contribution of Malthus and Darwin to science. Malthus considered how such populations behave in the relatively short run; he pioneered ecology. Darwin took Malthus' ecological population, focused on variation between individuals, and considered how ecological interactions might produce longer run evolutionary change. Earlier thinkers had conceived of larger units as the key to biology, the species for example. This focus on the species instead of individuals-in-a-population Mayr stigmatizes as *"typological thinking"*, taking the types to be more real than the individuals and populations that make them up. In population thinking, it is individual level processes that give rise to species. In typological thinking, individuals are merely the imperfect vessels of the essence of a species that do nothing really important. Typological thinking was fine for basic taxonomy perhaps, Carl von Linné was a typological thinker. But it turns out that the key to understanding the *causal* processes involved in

---

[2] Note that this is a more or less serviceable definition of ecology!

ecology and evolution is paying close attention to individual behavior then doing the math to go from individuals in the short run to populations in the medium and long run. Description alone doesn't explain *why* things change.

Population thinking is really very commonsensical and easy. Once you "get it", it is lots of fun. In the next seven chapters, we are going to trace out the basic implications of population thinking as applied to humans. Remember the basic idea is this simple:

The Key to Population Thinking:
Pay attention to what individuals do in the short run. Then add up over all the individuals in the population, and imagine the same basic processes go on for many generations. Do the arithmetic and see what ought to happen."

In this chapter we will forget Darwin's problem of variable individuals and examine Malthus' questions about the elementary processes of population growth and regulation. These questions form the foundation for all that follows.

II. Elementary Models

A. "Laws" of population growth

Malthus noted that biology by itself tends toward exponential (explosive) growth. Malthus' first assumption was that, forgetting about the environment for a second, each couple will tend to have a certain number of children. The "passion between the sexes is necessary and will remain nearly in its present state," Malthus (1798 [1970:70]) says. Put healthy young men and women together, and, well it makes an old fashioned clergyman blush, they'll tend to make babies. Malthus had data from several American censuses by 1830, indicating that human populations could double every 25 years or so when "passion" had relatively free play. In a relatively open environmentalist as land-rich America, the first assumption is very roughly correct. Now, the next step is a little arithmetic. (If you have a math anxiety, this is the time to tell it to be quiet. We'll keep things real simple, and it will be easy—if only you'll be calm and a bit patient. Take a deep breath, let it out slowly….)

a. Assume that growth is proportional to the number of individuals already present.

b. In a unit of time, each individual has so many offspring, say ***b***, and a certain probability of dying, say ***d***. "***r***", the net expected contribution to population increase made by each individual, can therefore be calculated as $\boldsymbol{r} = \boldsymbol{b} - \boldsymbol{d}$. For example, your contribution to the growth of a population to which you belong *in any year* is the number of children you produce minus the probability that you will die during that year.

c. This leads to the formulation of a classic equation (where N = the number of individuals in a population, t= time, and r = the average net expected contribution per individual to population increase)[3]:

$$\frac{dN}{dt} = rN \qquad (1)$$

In words: the growth rate of a population per unit of time (also known as the instantaneous rate of increase) is equal to *net* birth rate per individual times the number of individuals.

$$N_t = N_0 e^{rt} \qquad (2)$$

In words: the population after time t is equal to the starting population times the base of the natural logarithm raised to the power of the instantaneous rate of increase times the elapsed time. This is Malthus' geometric progression of population. Figure 8-1 provides a graph and a table to illustrate how this works.

Note how the growth rate seems slow at first, but amazingly explosive after generation 20, even though individuals continue to do nothing but have 4 living offspring per couple. Given any time at all, exponential growth is a very rapid process, unless the excess number of children per couple above replacement is very, very small.

Clearly this model has strict limits. It cannot explain real populations very well; populations can grow exponentially only for limited periods at best. Exponential growth can be a fairly accurate model only for short periods of time, for example the first 500 years after the first people crossed the Bering Strait into the Americas. Most important, it does capture one essential element of population growth, populations are intrinsically capable of exponential behavior *in the absence of environmental limits* (***r*** interpreted as a biological constant, the intrinsic rate of natural increase). In fact, this was Malthus' point. The model also gives us a descriptive parameter which can be used as a variable to describe the growth rate of a population (***r*** can be interpreted as a descriptive variable, reflecting actual births and deaths in a population). The model tells us something if we use some common sense in interpreting its message.

---

[3] Don't let the notation confuse you here; in difference equations of this sort, *d* means "change." Thus you would read this equation as "The change in N per unit of time T is equal to *r* times *N*".

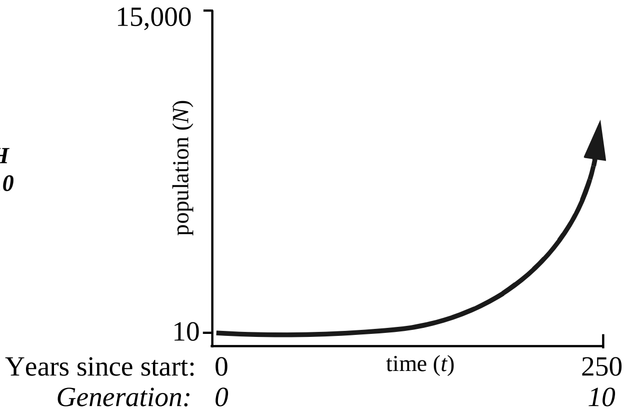
Figure 8-1. Exponential population growth is very fast. Start with a founder population of 5 couples that double every generation—much as humans might have done when they first reached North America 12,000 bp—and watch us grow. No wonder the Reverend Malthus was concerned!

THE NUMBERS:

Generation	Population Size (*N*)	Years Since Starting Population
0	10	0
1	20	25
2	40	50
3	80	75
4	160	100
5	320	125
6	640	150
7	1,280	175
8	2,560	200
9	5,120	225
10	10,240	250
.		
.		
.		
20	10,485,760	500
30	10,737,418,240	750
40	10,995,116,277,760	1,000

***Note**: This is close to the projected world population for the year 2,000.* → (row 20)

PICTURE THE GROWTH RATE FOR THE FIRST 10 GENERATIONS:



The model also shows its weakness in very graphic terms. There must almost always be something limiting population growth. Without competition (or something else), l0 paleo-Americans could have produced more people than there are in the world today in about 750 years. Malthus' assumption about the power of "passion" seems safe enough, so we must look for another element to add to develop even the most basic theory of population—one that doesn't let populations get too large very fast.

Malthus' additional element was food limitation leading to the logistic model of population growth. Land area is fixed. Technological developments could certainly make improvements in production, but they could never be as rapid as the potential for population growth[4]. Therefore, population powered by passion will grow until it is limited by a shortage of food. The shortage can act through "positive checks" such as famine, disease and warfare due to crowding and competition for limited food; or in "preventative checks" such as late marriage and "vice." To Malthus (1830 [1970: 250]), vices included "unnatural passions and improper arts to prevent the consequences of regular connections." In other words, birth control and the x-rated practices for having sexual pleasure fun without risking babies; (Malthus was decidedly *not* pro-choice). Today we use the logistic model as the simplest exemplar of Malthus' idea:

a. Assume that there is some upper limit to how many organisms a particular habitat can support (a *carrying capacity*), and that reproduction is gradually reduced (e.g., by competition for resources) as this limit is approached.

b. Rate of growth = the intrinsic (Malthusian) capacity of individuals to **r**eproduce—(limiting effect on reproduction due to competition) x (size of the population).

c. To derive the logistic model: suppose there is a constant increment of competitive effect, ***C***, for each additional member of the population. Then Malthus' "law" becomes:

$$\frac{dN}{dt} = (r - CN)N \qquad (3)$$

If we then let $r/K = C$ (where ***K*** is the "carrying capacity"), we recover the more familiar version of the logistic:

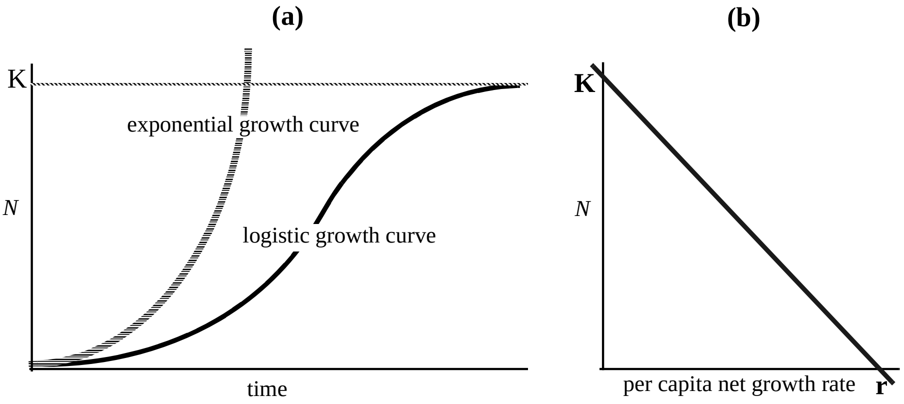
$$\frac{dN}{dt} = r\frac{K-N}{K}N \qquad (4)$$

---

[4] Recall from the last chapter that Malthus lived at the very beginning of the Industrial Revolution; in Chapter 17 we'll review how good this assumption was in the context of his times.

A graphical description of the logistic is given in figure 8-2[5]:

Figure 8-2. Comparison of exponential and logistic growth curves. In (a) the logistic increases rapidly when the population (N) is far from the carrying capacity (K) then begins to slow as it approaches K. In (b) the per capita net growth rate = r when population is low; as the population approaches K, r → 0.



It is fairly easy to see how this model will apply to human groups. For example, take a population of hunters and gatherers. Food foragers probably limit populations because of need for mobility. Infants have to be carried, and young children can not walk very far very fast. If treks are infrequent and short because game is abundant, women might have as many as 8 children (allowing for 50% mortality, this will permit a doubling every generation). In this case, movements cannot be much further than a 2 year old can walk, and a mother can carry one infant, but not an infant and a toddler, say approximately 3 km/day. Moms could have the 8 birthsor a little more counting some children dying very young, assuming births are spread out over l6 years. As competition depletes game, and longer movements are required, births will still have to be spaced so that moms don't have to carry 2 kids, so that the second-to-last child is capable of the longer march. Births may have ultimately to be spaced to 4 years, giving 4 children in a 16-year reproductive span, and with 50% mortality, a stable population. Four year olds can walk perhaps l0 km/day. Note here how population thinking encourages us to make some assumptions about how individuals

---

[5] **We strongly recommend that you spend enough time on all of the graphs and charts in this manual to really understand them; they are much more than just pretty pictures.** If you are unused to analyzing graphs and charts, one of the best ways to glean information from them is to ask yourself questions about what they tell you. For example: "What general relationship do you see between mortality and fecundity?" (High survivorship, as for humans, is associated with low fecundity….) "What does the vertical line for the fecundity of many invertebrates in figure 8-3 indicate?"

deal with their environment, and use these as the raw material for a little arithmetic (see Chapter 9).

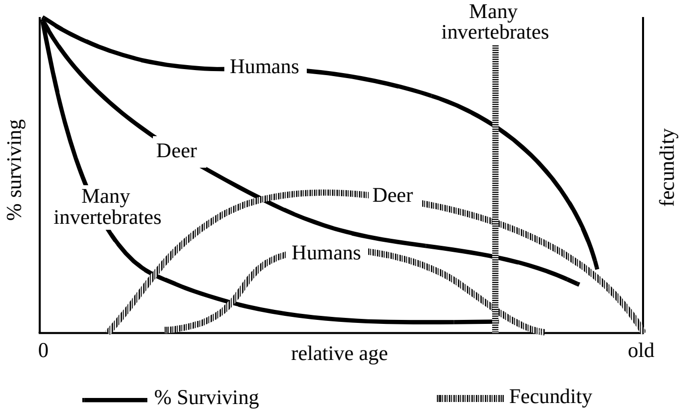
Demographic theory can get pretty hairy, but the basic concepts are well illustrated by the very elementary models and calculations here. Often the very simplest calculations give you 50-75% of the insight into causal processes that could be obtained from the full-blown theory at a small fraction of the work. Even if you are a pretty inept mathematician it is worth trying to master the simplest models[6].

B. Age specific phenomena

Simple models ignore the fact that not all individuals in a population are equally capable of reproduction—populations are age structured. Figure 8-3 shows graphically how demographers think of age structured populations. At each age, an individual has a certain probability of surviving, and a certain probability of having an offspring. These “vital statistics” are often referred to as the fertility-mortality schedule of a population

.:

Figure 8-3. Comparison of fertility and mortality curves for various types of organisms. Note that ‘age’ is calculated relative to the organisms’ respective life spans. Mortality is calculated as the proportion of an age cohort surviving. Fecundity is also in relative units.



---

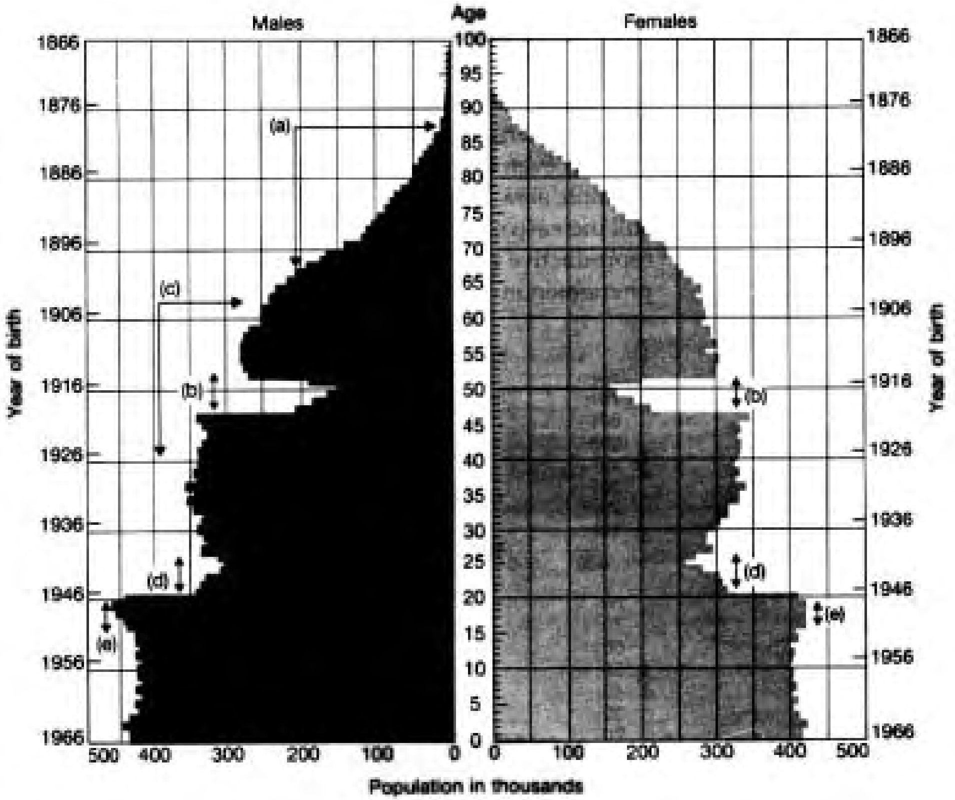
[6] If you are less fluent mathematically, you can still learn to understand the implications of these concepts by using a computer spreadsheet. Enter the equations, set things up to calculate changes over a number of generations, then watch how the graphs change when you modify the value of r, K, etc.

Figures 8-4 and 8-5 contain information about the age structure of different human populations. The data are presented in the form of what is known as a *population pyramid*. Each age-class is represented by a horizontal bar and the length of the bar indicates the size of the age class. Note that the youngest age classes or cohorts are on the bottom and the oldest are on top. Figure 8-4 shows a population pyramid for France on January 1, 1967. Note the literal ‘bites’ that World Wars I & II have taken out of the population. Figure 8-5 compares the sizes of age cohorts in populations that are stable, expanding, or declining. It is possible to compute “r” for age-structured populations, but the algebra’s a bit complicated (see Begon, Townsend, and Harper (1986:153-157) for an accessible discussion.)

The age distribution of a population can have dramatic ecological effects. The dramatic swings in American fertility create small and large cohorts that move through society together. Most of you have “baby boom” parents and are members of the “baby nadir” cohort that followed. The economist R.A. Easterlin argues that these fluctuations have important demographic and economic consequences. Your parents’ cohort had too many young adults for the economy to easily absorb. Their employment experience was bad relative to their parents, so they reduced their fertility relative to their parents. Conversely parents of Baby Boomers were mostly born during the hard years of the depression but there were relatively few of them and they enjoyed boom times in the 1950s and 60s, so they had large families.

Easterlin argues that hard times result when too many young people crowd the job market and that people adjust their fertility according to how their income expectations compare to those of their parents. Others attribute crime waves and revolutionary activities to baby boom cohorts. (When there are too many young folks, and too few old folks to control them, crime and revolution ensue to oversimplify the complex hypothesis of Goldstone, 1991.) According to this argument, the Boomer generation ran wild on the campuses in the 60s because there were always too few adults to really supervise them well, while your generation is pretty tame because there have always been plenty of boomers to keep an eye on so few of you! Figure 8-6 shows Easterlin’s comparison of the earnings received at different ages by young male baby-boomers with those received by the previous generation at similar ages

Figure 8-4. A population pyramid for France on January 1, 1967. (Source: Begon et al. 1986:161.)



(a) Military losses in World War I (b) Deficit of births during World War I
(c) Military losses during World War II (d) Deficit of births during World War II
(e) Rise of births due to demobilization after World War II

Figure 8-5. Comparison of population pyramids for stable, expanding, and declining human populations.

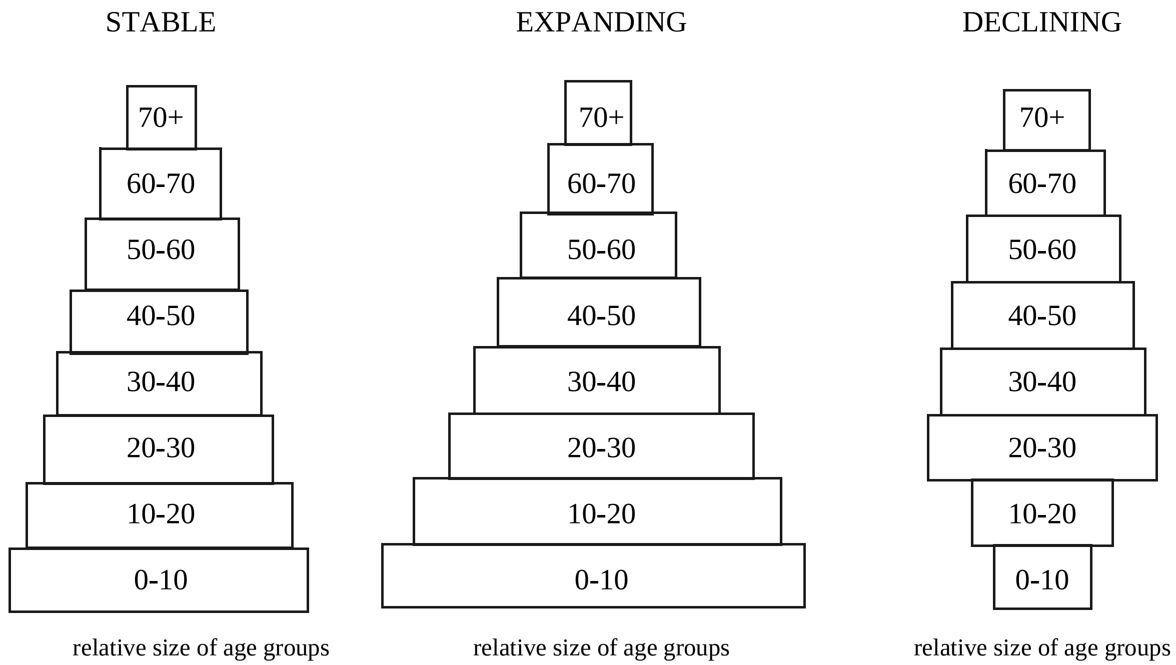
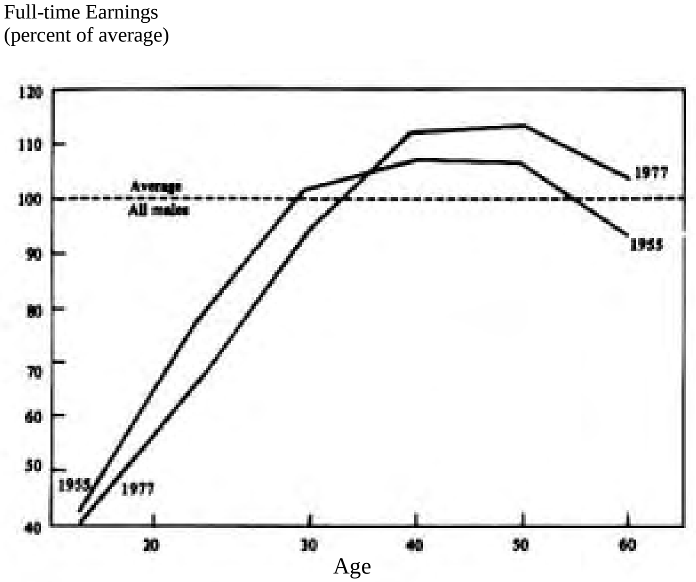


Figure 8-6. Comparison of the earnings received at different ages by young male baby-boomers with those received by the previous generation at similar ages. (Source: Easterlin 1987:22.)



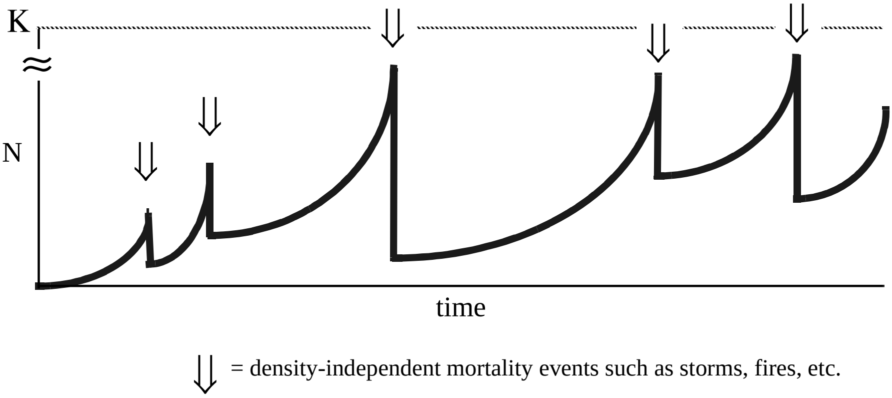
For each date, earnings at the age shown at the bottom of the chart are expressed as a percentage of the average for all ages (the horizontal broken line). At both dates, the left-hand portion of the curve lies below the average, showing that younger workers earn less than older. In 1977, however, the shortfall for younger workers is greater than it was in 1955, showing that the relative position of younger workers is worse at a time when their relative numbers are greater.
Source: Appendix Table 2.2.

III. Mechanisms of Population Regulation

A. Density-independent factors:

Some factors like random weather catastrophes, tend to kill a certain factor of a population regardless of whether the population is abundant or rare. Such factors are *independent* of population density, and independent of competition; i.e., they do not cause some individuals to be more exposed to mortality than others. Biotic catastrophes such as hurricanes, volcanic eruptions, fires, etc. are the usual examples of density-independent factors. If we were to plot the growth of a population over time that was regulated solely by density-independent factors, its crashes would be independent of its size, or its nearness to the carrying capacity (K). Figure 8-7 illustrates this concept.

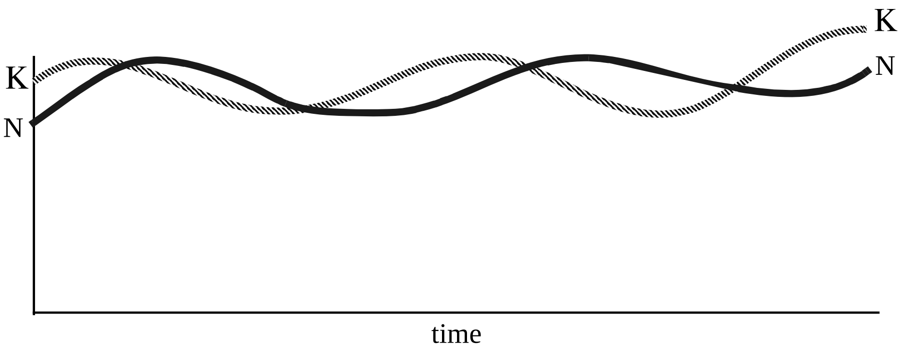
Figure 8-7. The effect of density-*independent* factors on population growth. (K= carrying capacity. N=population size.)



B. Density-dependent factors:

If the mortality rate of a population is proportional to the number of individuals present, population growth is said to be (partially, at least) density-dependent. Under this regime of population regulation, biotic factors such as competition for scarce resources are often important. Figure 8-8 illustrates the manner in which a population which is controlled *solely* by density-dependent factors would change over time. Note that the carrying capacity in this illustration fluctuates over time although it need not be[7].

Figure 8-8. The effect of density-*dependent* factors on population growth. (K= carrying capacity. N=population size.)



C. For Humans, Both Types of Factors are Often Important

Much human mortality is often caused by a mixture of both density-independent and density-dependent factors. Some examples:

1. Catastrophes—poverty, which may be a consequence of high population densities relative to prevailing technology, usually exposes the poor most severely to the consequences of flood, famine, and war. What are some recent examples?

2. Disease is usually a function of population density, but many epidemic diseases are effectively spread over a wide range of densities and have effects that are episodic, catastrophic, and weakly density-dependent.

Pure density-independent population regulation results in a "random walk" to zero or infinity. In other words, the population may increase or decline regardless of its size. What type of environment would be required for pure density-independence to occur[8]?

Fertility as well as mortality can be thought of in terms of density dependent and density independent factors. Think back to Malthus' "passion of the sexes". To what extent is this independent of population size?

There has been a good deal of debate about whether historical human populations responded mostly to density-dependent or density-independent regulation. Polgar (1972) made a case for density dependence via fertility limitation. In his view, population growth occurred mostly in response to technological changes that raised K. Others have argued that episodes of disease and famine cause most historical populations spent most of their time growing exponentially from the last catastrophe they experienced. (See figure 8-7.) There is some evidence that many peasant populations in Eurasia and some parts of the New World did spend long periods of time near the subsistence carrying capacity limited by high density-dependent mortality rates (the position Polgar explicitly argued against). Nevertheless there may have been considerable variation in demographic behavior among human populations, a subject we will consider in more detail in Chapter 16.

IV. Conclusion

The most important lesson of demography is that, historically speaking, even quite

---

[7] Fluctuating carrying capacities are more realistic since stable environments are not found in the natural world. UC Santa Barbara biologist Daniel Botkin (1990) makes the point that our perception of some environments as stable is an artifact of scale—they actually fluctuate a great deal if one adopts an appropriate time scale!

[8] The environment would have to provide more resources than can be consumed by the growing population; i.e., K would have to be much greater than N (K >> N), since competition becomes appreciable far short of K. Such situations are improbable.

slow exponential growth can bring about large populations in a relatively short period of time. The biology of reproduction ensures that all populations have the potential for at least slow exponential growth. The natural “time scale” for population growth is 10 generations or so, depending on demographic details, say 250 years when we are speaking of humans. This is the time scale necessary for populations to recover from major catastrophes. It only takes a small multiple of this time scale for a tiny founding population to reach unimaginable sizes. Because the demographic time scale is so short, demographers since Malthus have put a lot of effort into trying to understand the processes that regulate animal and human populations. Work has concentrated on both density-dependent effects like those generated by competition, and on density-independent processes. We will use the basic ideas presented in this chapter as building blocks for later chapters.

V. Bibliographic Notes

References:

Begon, Michael, John L. Harper, and Colin R. Townsend. 1986. *Ecology: Individuals, Populations, and Communities*. Sunderland, MA: Sinauer Associates.

Blurton-Jones, N. 1986. Bushman birth spacing: A test for optimal interbirth intervals. *Ethol. Sociobiol.* 7: 135-142.

Blurton-Jones, N. 1987. Bushman birth spacing: direct tests of some simple predictions. *Ethol. Sociobiol.* 8: 183-203.

Botkin, Daniel B. 1990. *Discordant Harmonies*. New York: Oxford University Press.

R. A. Easterlin. 1976. The conflict between aspirations and resources. *Pop. Dev. Rev.* 2: 417-25.

Goldstone, J.A. 1991. *Revolution and Rebellion in the Early Modern World*. Berkeley, University of California Press.

Malthus, T. 1970 (1798, 1830). *An Essay on the Principle of Population*. Harmondsworth (England): Penguin.

Mayr, E. 1982. *The Growth of Biological Thought*. Cambridge: Harvard Univ. Press.

Pianka (see Chapter 10).

Petersen, W. *Population*. New York: Macmillan

Polgar, S. 1972. Population history and population policies from an anthropological perspective. *Current Anthropology* 13: 203-211.

General:

Begon, Townsend, & Harper.

Roughgarden (see Chapter 10).

United Nations. 1973. *The Determinants and Consequences of Population Trends: New Summary of Findings on Interaction of Demographic, Economic and Social Factors*. Population Studies 50. New York: U.N. Dept. of Economic and Social Affairs.

Weller, R.H. and L.F. Bouvier. 1981. *Population: Demography and Policy*. New York: St.

Martins.

Wilson, E.O. and W.H. Bossert. 1971. *A Primer of Population Biology*. Stamford, Conn.: Sinauer.

Chapter 9. NATURAL SELECTION AND BIOLOGICAL EVOLUTION

> Which beginning of time [the Creation] according to our Chronologie, fell upon the entrance of the night preceding the twenty third day of Octob. in the year of the Julian Calendar, 710 [i.e. B.C. 4004].
>
> Archbishop James Ussher (1581—1656)
> *The Annals of the World*[1] (1658:1)

> "How stupid not to have thought of that!"
>
> Thomas Huxley (1825-1895), about Darwin's theory of Evolution by Natural Selection.

I. Introduction

A. Classical Discoveries of Biology

From the mid 18th Century to the early part of the 20th, a large fraction of biologists' efforts went into two massive collective discoveries, the discovery of biotic diversity, and the discovery of evolution.

Over the period from 1750 to 1950 the careful descriptive analyses of Swedish biologist Karl von Linné and his followers showed there to be on the order of 10 million or so different types of living organisms. The differences in biotas in different parts of the world came to be appreciated, the amazing diversity of the tropics was documented, and previously unimagined major groups of organisms were discovered, including microorganisms and the biota of odd habitats like the oceanic plankton. The sometimes bizarre and always impressive adaptation of organisms to their habitats and ways of life greatly impressed the early scientific naturalists, who argued that it proved the existence of an All Seeing Designer.

Similarly, paleontologists described a huge variety of fossil plants and animals. The succession of forms, and the presence of many detailed structural similarities between living and extinct forms, as well as structural parallels between living forms, strongly suggested that living and ancient forms of life were connected by branching lines of descent. By the mid-19th century, the evidence that modern forms of life had evolved from ancient ones became well-nigh inescapable, and it became much more difficult to hold the notion that

---

[1] Full title: *The annals of the world. Deduced from the origin of time, and continued to the beginning of the Emperour Vespasians reign, and the totall destruction and abolition of the temple and common-wealth of the Jews*.

each species had been separately created.

B. Darwin’s Contribution

Natural selection is a model of how evolution works. Darwin is sometimes mistakenly credited with discovering evolution. This is misleading. Many people besides Darwin contributed to this enterprise. Darwin’s real contribution was to develop models of how the evolutionary process worked, the most famous of which was his model of evolution by natural selection. Wallace independently hit on the idea. Darwin and Wallace also gave simple verbal models of evolution by chance, artificial selection, sexual selection, and by the inheritance of acquired variation. They could depend on most active scientists (laymen were another story) of his day accepting evolution. His proposals regarding the causes of this evolution, especially his hypothesis that chance and natural selection played major roles in causing evolution, were both more novel and more controversial. It is only since the mid-20th century that we can fairly confidently speak of moving Darwin’s hypothesis about natural selection into the category of a discovery.

Charles Darwin developed his basic theory of evolution by natural selection in 1838, shortly after he returned from the voyage of the Beagle and married Emma Wedgewood (she was an heir to the Wedgewood China family, owners of the pioneering 19th century manufacturing enterprise). In his autobiography he claims the idea came to him one day, after many weeks of false starts grappling with the “species problem”, while “reading Malthus for pleasure.” (Darwin’s autobiography is just a sketch for his family, and is known to be not very accurate. The Malthus remembrance may be apocryphal, but it is good propaganda for general education. Read broadly, a bit eclectically, think very carefully about what you read, and you too may one day make a famous discovery!) He did not publish his ideas until 1858, when A.R. Wallace sent him a paper noting the process of natural selection from the East Indies, where he worked as a professional collector of plants and animals for taxonomists. Shocked into publishing, Darwin’s (and Wallace’s) ideas created the immediate furor that Darwin apparently deeply feared (Gruber, 1974), although much of the scientific community was very sympathetic.

C. Population Thinking: Simple But Counterintuitive

Why had not natural selection been discovered long ago? *As the epigraph from Huxley shows, Darwin’s basic model was almost absurdly simple.* Why was the reaction in all but prepared minds so skeptical? Why, even to this day, do many professional biologists, not to speak of laymen, have trouble with natural selection? The answer seems to be that Darwin’s basic insight violates people’s intuitions about how nature ought to work. The problem is that the population thinking lying at the basis of the natural selection model violates two simple thinking procedures that people use in every-day life. (Psychologists who study these things argue that intuitive thinking procedures that people use generally tend to work well for *some* kinds of problems but fairly poorly for others.)

First, people tend to be typological not population thinkers. People are very good intuitive taxonomists, but they take their categorization too literally. In everyday life, it is often very efficient to ignore all the fuzzy variation in the world and classify things into arbitrarily bounded classes. For example, the vowel sounds that people make when speaking vary continuously. However, human listeners sharply classify sounds into discrete vowels, ignoring all the fuzz and individual variation. We do the same things with color names. We saw in an earlier chapter how good hunters and gatherers were at classification. We think of things as exemplars of classes, for example species of organisms, and discount individual variation as departures from type, or as aberrations. Ethnocentrism, the classification of people by race or culture, coupled with a tendency to ignore individual differences in outgroups, is an example of typological thinking. In population thinking, by contrast, we have to learn that the individual variations are more important to the theory than the categories we put them into**.**

Darwin's insight that individual variation—the small departures from the "type" that previous biologists had dismissed as uninteresting error in developing the essence of the species—was fundamental to evolutionary processes and was his first stroke of genius. As it were, his mechanism derives imperfect species from variable individuals rather than imperfect individuals from a perfect type. The conceptual leap here was profound, and must be rediscovered by each new generation of students. This was the culmination of the development of population thinking started by Malthus.

Second, people are prone to believe that the causes of phenomena should have certain gross resemblances to their effects. Psychologists have discovered that people commonly use something they call the "representativeness heuristic[2]" to make judgments (Tversky and Kahneman, 1974). We have already met one manifestation of this thinking procedure in the "doctrine of signs", the theory that the cures of diseases should in some way resemble their symptoms, or the organ involved. In many everyday cases the intuition that the causes of things should be like their effects is correct; a smashed house must have been struck by a large impressive object or force. Big, spectacular effects should have big, spectacular causes. In the case of evolution, the phenomena we want to explain is the spectacular diversity and adaptedness of organisms. Surely this awesome phenomenon ought to

---

[2] 2. Heuristics are the basic ways we approach learning, discovery, or problem-solving by experimental and especially trial-and-error methods.

have a awesome cause, say a Divine Creator of unimaginable power and wisdom. Such was invoked by Darwin's teachers under the name of the "argument from design"; the Craftsman is necessary to explain the Wonders of Nature. Darwin's population approach turned all this on its head. He looked for the cause of adaptation and diversification in the grubby events of the everyday lives of organisms. Small chance variations among individuals, the competition among these variants as they fed, fled, and mated, and a sufficient amount of time were all Darwin's theory required. Even Huxley, Darwin's "Bulldog" could not bring himself to believe that natural selection was all that was needed to account for evolution! There must be something fancier going on he felt because he could not entirely free himself of the grasp of the representativeness heuristic.

The whole trick to understanding natural selection, and indeed this part of the course, is to understand population thinking. This is fun and easy once you abandon the bad heuristics.

D. Importance of Natural Selection for Human Ecology

Many human anatomical and physiological traits are adaptations. For example, skin color varies as a function of latitude, and this variation is plausibly adaptive. Prominent hypotheses include that dark skin protects from sunburn in high light environments, and that pale skin is required for adequate vitamin D synthesis in more poleward climates. Although we will concentrate on the quantitatively more important cultural adaptations in this course, some human biological variation has to be at least assessed for its adaptive value. We return to this topic in Chapter 21 on disease.

The most important human adaptation is the capacity for culture. As we have seen in Steward's scheme, much cultural variation is correlated with environmental variation, and is certainly adaptive by common sense standards. However, it has proven very difficult to specify exactly how culture comes to be adaptive. In other words, social scientists have not had an easy time developing the analogs of biologists' models of the evolutionary process. In the subsequent chapters in this part of the course we are going to see how Darwinian ideas have been used (1) to try to understand culture as an adaptation (Chapter 10), and (2) as *methodological* inspiration for trying to formulate models of cultural evolution itself (Chapters 11 and 12). Regarding the latter, there is a school (to which we subscribe) that believes that population thinking is the key to understanding cultural evolution, just as it is in the case of organic evolution, no matter how much culture and genes differ in material terms.

II. Darwin’s Basic Model

A. Malthusian Principle + Heritable Variation → Adaptation

Offspring resemble their parents. Biologists say that the one important cause of parent offspring resemblance is *heritable variations,* now known to be mainly caused by genes in typical organisms. If variation can be accurately passed down the generations, then long-term evolution is possible. Usually some portion of the variation is heritable and some portion is due to non-heritable effects.

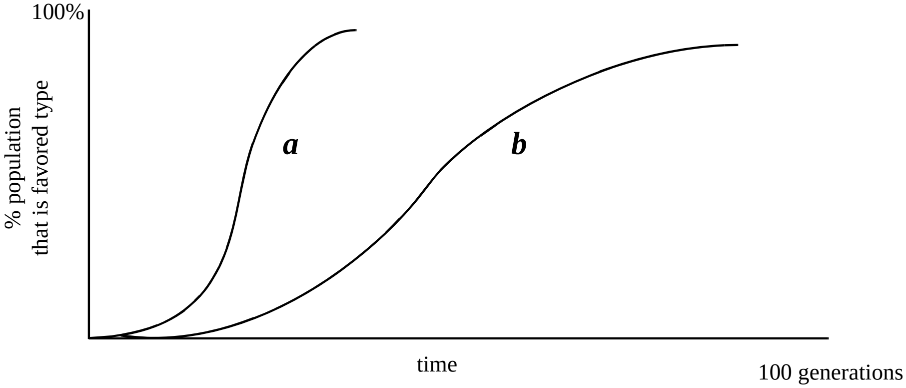
Normally organisms will have to compete for resources to reproduce. Darwin borrowed the idea of exponential increase leading to competition from Malthus. Populations are liable to grow rapidly if they are far from resource limits. If environments are permanently unstable, individuals will scramble for resources to have many children. If populations are allowed growth for long, resources will become limiting and individuals will have to struggle for resources to survive and have any offspring at all.

Darwin devoted most of the pages of the *Origin* to give empirical evidence that heritable variation exists and that competition is important. What must necessarily happen over a number of generations if these two assumptions are true? The heritable variants that cause individuals to be better competitors will increase, and the variants that cause poorer competitors will decrease. Depending on how large the competitive differentials between the variants are, and how much of the variation is heritable, the variants causing poor performance will disappear more or less rapidly. If some process is creating new variation, say at random, at some small rate, there will occasionally arise a newer and better variant, and selection will favor its increase. Unfavorable variants that arise by chance will not increase simply because they are unfavorable.

Reproductive success is the key. Natural selection will result in populations of adapted individuals by favoring those that “work better” in a given environment. Notice that “work better” has a precise technical meaning here; the differential ability to survive, and reproduce, hence to differentially propagate some heritable variants relative to others under prevailing environmental conditions. Those heritable variants that leave the most offspring are defined as conferring higher *fitness* or as being better *adapted*. However, we mustn’t think of fitness itself as the cause of evolution by natural selection. Fitness is merely the result of the differences in the performance of everyday tasks that happen to result from how organisms with heritable phenotypic differences interact with their particular environments. In the end, it is reproductive success of the types over the whole life cycle (e.g., taking into account of the probability of survival) that is the key measure of fitness.

The rate of evolutionary change varies. Figure 9-1 illustrates the way selective change depends upon the magnitude of competitive difference and on the amount of variation present in the population. Notice that the ***rate of change*** due to selection is most rapid when the mixture of types is about 50:50, and is slow at the beginning and end. There is little heritable variation when a population is composed of almost all one type, but the maximum amount when all types are equally abundant.

Figure 9-1. The selective replacement of one heritable type by another over time. Note how differences in the amount of competitive 'edge' conferred by a particular type influence how rapidly it becomes common in a population over generational time. The type indicated by curve (***a***) has a strong influence on competitiveness, that in curve (***b***) has a moderate influence.



Darwin imagined that the accumulation of small adaptive differences by selection generation after generation leads to even the fanciest adaptations. Natural selection is quite unspectacular, down-in-the-dirt process on the generation to generation time scale. Nothing much happens. But the fact that variation is heritable means that small changes can accumulate from generation to generation if selection is persistently in the same direction. Over tens to hundreds to thousands of generations first readily appreciable, then quite spectacular changes, result. It is like population increase in the last Chapter. Changes that seem slow from the perspective of one generation can seem quite rapid when they accumulate over a few generations.

Such a pretty piece of deductive reasoning! It can all be reduced to the idea that even the random generation of variation plus a principle of selective retention of some of those variants will result in adaptation by natural processes. The process matches anything a Divine Designer could do by way of generating adaptations.[3] As we'll see in later Chapters, Darwinian theory can account for some exceedingly strange twists in evolutionary patterns.

Part of Darwin’s argument was that the *imperfections* of adaptations betray a natural rather than a divine process.:

Postulate 1: Potential for exponential increase ensures competition for resources.

Postulate 2: All populations have heritable variability, at least some of which affects performance in important ways.

Conclusion: So long as the environment is relatively consistent, heritable variants that confer a competitive advantage in survival and reproduction (greater fitness) will increase. Populations must become better adapted with time as long as (1) and (2) are true.

While evolution by natural selection is incredibly complex in practice, Darwin’s extremely simple model turns out to give us a tremendous amount of insight into the diverse processes by which evolution proceeds.

B. Darwin’s Achievement

More than anything else, Darwin and Wallace introduced a method of studying evolution. They might have said “study the dynamics of individual variation as things happen to individuals during their lives, and as variation is transmitted to the next generation. A good account-book tracing the increase and decrease of heritable variation through time will reveal the principles of evolution.” The model of natural selection he introduced is an excellent example of population thinking, but the method is far deeper than this one model. Population biology has a huge array of models derived by using population thinking, not to mention the empirical studies that apply its precepts literally.

Note also how he looked for the cause of grand things—the vertebrate eye and the fossil record—in drab everyday events: the causes of evolution are ecological processes. This approach to evolution focused biologists’ attention on problems they could investigate, the biology of inheritance and the ecology of competition among variants in nature. In a way Darwin’s theory created more problems than it solved (the argument from design

---

3. If you would like to pursue this idea further, we suggest Richard Dawkins’ *The Blind Watchmaker* (1987) which bears the subtitle “why the evidence of evolution reveals a universe without design.”

accounted for adaptations themselves well enough), but it set workable biological problems in the context of an interesting general theory that made all the little problems seem important. One might say that Darwin set up evolution as a concrete scientific problem instead of a speculative "philosophical" one. Spencer and other progressive evolutionists' ideas suffer from this latter defect in the scientist's mind. They don't give us any interesting work to do, they just entangle us in a hazy gauze of vague concepts.

III. Modern Synthetic Theory (Mendelism + Darwinism)

A. The Mechanism of Inheritance

Around the turn of the 20th Century, Hugo De Vries, William Bateson, and other experimenters with heredity, rediscovered Mendel's principles of particulate inheritance, and founded the modern science of genetics. This ushered in a period of intense confusion and controversy as biologists tried to understand how the new genetics fit with natural selection and Darwin's general ideas about evolution. Bateson believed that the two were incompatible because genes caused large effects rather that the small ones that Darwin had postulated for the elementary units of inheritance. This all turned out to be a red herring; the early genetical experiments focused on genes with large effects, such as those that caused tall and short pea plants in Mendel's classic experiments, because these were easy to study. As it turned out, most traits of evolutionary interest are underlain by many genetic variants, each of which does have a small effect.

It took more than 30 years, from 1900 until about 1936, before genetics and evolution were united in the Synthetic Theory. In part, the problem was the personal antagonisms between important actors. For example, among the important Darwinians were Karl Pearson and Ronald A. Fisher[4]. Pearson was hostile to genetics. He dismissed the younger Fisher's paper showing how easily genetics could reconciled with natural selection with an insulting letter, and used his influence to ensure that Fisher could not get a university post. Fisher was "exiled" to work at Rothamstead Agricultural Experiment Station in England, and did not get a university professorship until Pearson retired. (While at Rothamstead, Fisher invented a large fraction of modern statistics to analyze the experiments conducted there.) Eventually field biologists like Theodosius Dobzhansky, Ernst Mayr, and Ledyard Stebbins had a hand in a second Darwinian revolution 1930-50. One thing must be said about this episode. Science does not progress because scientists always act like mature adults or

---

[4] You may remember Fisher and Pearson from your statistics classes. Sir Ronald A. Fisher (1890-1962) made major contributions to 20th century statistics, research methodology, and evolutionary theory. Pearson, of course, you remember from the Pearson product-moment correlation coefficient (more commonly referred to as Pearson's ***r***.

nice people! See Provine's (1971) history.

In the Synthesis, genes replace earlier vague and erroneous ideas about the nature of heritable variation. Modern genetics gives us an increasingly detailed picture of the structure of the inheritance system on which selection works. The earliest accomplishment was to show that individuals of many species are diploid (carry two copies of each gene), that genes occur in blocks called chromosomes, and that sexual reproduction resorts the parental contributions each generation in sexual species through independent assortment of chromosomes and crossing over within chromosomes. Later, Watson and Crick in the 1950's showed that genes are DNA, and initiated the field of molecular genetics that now gives us a huge amount of detail about the structure of the genetic inheritance system.

Genetics also furnished the tools to study evolution in detail. Actual changes in gene frequencies could be studied in the field and lab as selection regimes changed.

B. Forces of Evolution

After the Synthesis evolution was mainly studied with models assuming various kinds of structure in the genetic inheritence system. Models of inheritance come in two common types, mendelian (discrete) and quantitative. *Mendelian models* mimic the actual properties of the genetic inheritance system. We imagine that particles with certain effects are being transmitted, as in Mendel's famous tall and short pea plants with wrinkled and smooth seeds. We suppose that there are a countable number of genes underlying the trait we are interested in, each associated with a phenotypic effect. This approach works well for eye color and blood type in humans because there are only a few genes with quite distinctive effects influencing phenotypes in these traits. However, most real traits are underlain by many genes, each with a small effect. Mendel's peas notwithstanding, height is commonly a *quantitative trait*. There are so many genes affecting this trait in most organisms that we cannot recognize any specific one of them in phenotypes except in pathological examples of dwarfism and gigantism. Height varies continuously without jumps or gaps between types. In such cases, we can deal with the mean value of the trait in the population and the measured variation. Some portion of the variation is transmitted from parents to offspring (a statistic called the *heritability* measures the degree to which this is so), and some portion will be composed of environmental variation.

Geneticists discovered new evolutionary mechanisms, and redefined natural selection, that change gene frequencies over time. Thus *natural selection* increases the frequency of genes "appropriate" for a given environment via differential mortality and fertility of variants produced by mutation (ultimately). *Mutation*, resulting from random changes in DNA structure due to environmental mutagens and other copying errors, increases variation. *Drift*, which results in random changes in gene frequency due to sampling errors, increases as populations become small. It leads to reduced variation within populations, and increased variation between populations. Other important forces include *recombination* (the shuffling of genotypes each generation due to recombination in sexually reproducing species), *migration* (the movement of individuals with different genotypes from one environment to another), and *sexual selection* (resulting from competition for mates or choices among potential mates). We can get along without a detailed discussion of these for the time being. Darwin also thought that the inheritance of acquired variation was an important evolutionary force. The genetic system does not allow for this mechanism; Darwin made a number of mistakes about evolutionary processes because his theory of inheritance was wrong.

C.Three Kinds of Selective Situations

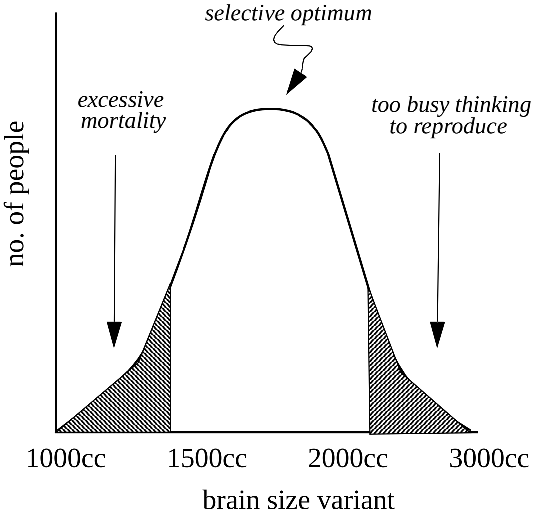
One form of selection, ***stabilizing selection****, actually prevents evolution by random factors.* Stabilizing selection works against both extremes in a population; i.e., it tends to keep a trait from becoming either too great or too small. Stabilizing selection is often thought to be very common. In other words, most populations, most of the time, are thought to be near selective optima. Human brain size provides a hypothetical example. See figure 9-2a. It doesn’t seem to have increased for perhaps the last 100,000 years. We don’t know exactly what forces balance the disadvantages of larger and smaller brains. It does seem to require considerable intelligence to manage the complexity of human technology, social organization, and symbolic culture. This must put some sort of selection against small brains, although the correlation between sheer brain size and intelligence is weak over the normal human range of brain size. People with very large brains (and their mothers) have difficulties at birth. Brains are physiologically costly and fragile organs. Perhaps big-brained people are more susceptible to the divergent claims of cultural as opposed to genetic fitness (see Chapters 12, 15, and 16).

Evolution occurs when **directional selection** *acts against one tail of a distribution pushing the population toward a new optimum.* Directional selection tends to push the distribution of a favored trait in a particular direction. In the example shown in figure 9-2b, *Australopithecines* had bodies that were similar in size to modern humans but had brains about the size of a chimpanzee (500 cc). For some reason, selection favored larger brains, and over the last 2 million years or so large-brained humans arose from the small-brained ancestral type (see Chapter 25).

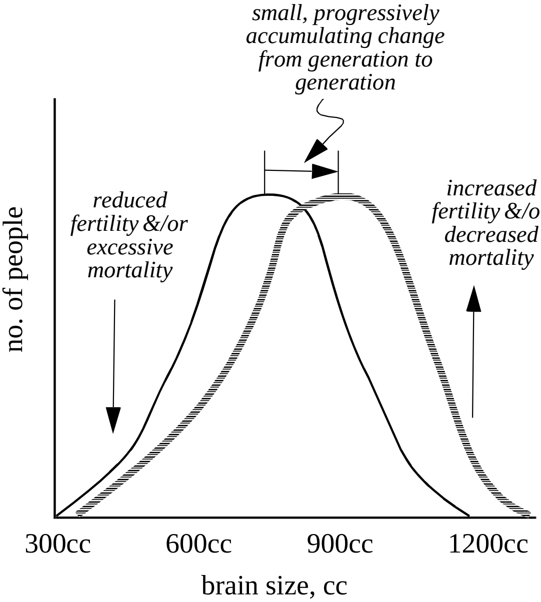
Directional selection can be very rapid on the geological time scale. Geneticists have selected corn for high oil content, for example, and gotten responses under strong selection

Figures 9-2 a & b. A comparison of the effects of stabilizing and progressive (directional) selection on human brain size. Note that stabilizing selection acts against both extremes of the population distribution while progressive (directional) selection acts against only one extreme.

(a) Stabilizing Selection:
The *Homo sapiens* case



(b) Directional Selection:
The *Australopithecine* case



of about 1/3 of a standard deviation per generation for many generations in a row (this is a quite highly heritable trait). If the standard deviation of Australopithecine brain size was 50 cc, this means a size increase of 17 cc per generation. At that rate, it would take about 60 generations to reach modern brain sizes, or about 1,500 years. Since the actual evolution of large brains took much longer, directional selection is probably very weak most of the time in nature.

It is interesting to note that in Darwin's time the age of the earth was thought to be relatively short, although little scientific opinion held it to be as short as Bishop Ussher's calculation of 4,004 years since Genesis quoted in the chapter epigraph. Darwin had to worry whether the earth had been around long enough for his relatively slow process to have "created" the diversity and complexity of life. Darwin figured he needed about 400 million years to fit in all the organic evolution in the fossil record. Lord Kelvin used physical calculations to compute the age of the earth in the 1860s. He supposed that it started out at the temperature of the sun, and estimated how long it would take to cool to present temperatures. He concluded the earth might be from a few million to about a 100 million years old, and his best guess was 25 million years. The actual figures for the length of the fossil record are about 550 millions years, and the Earth formed from solar nebula about 4.5 billion years ago. Kelvin disliked Darwinism, and used his figure to attack his ideas. His calculations were wrong because he knew nothing of radioactive elements, whose decay heats the interior of the earth. Now we know the earth is many times older than even the oldest 19th century estimate, and the embarrassment is, if anything, reversed. Natural selection in the short run is too powerful to account for why evolution in the long run proceeds so slowly. The time since life began (3.5 billion years ago) is long even compared to Darwin's estimate, and Natural Selection can work perhaps even faster than he guessed. We will return to the problems of macroevolutionary limitations on the rate of evolution in Chapter 24.

Evolutionary biologists used to suppose that weak selection was the norm in nature. John Endler (1986) has recently upset this old truism. He finds that field studies show quite a wide range of strengths of selection, but include many examples of strong directional selection. However, these are short term, local studies. Perhaps we can rescue the old generalization by imagining a lot of back-and-forth selection of some strength in different times and places, with the average result being rather weak. In any event, even very weak selection can lead to great changes *on a time scale that is short by the standards of geological time*. Natural selection is thus a potent force of nature, on a par with the geological forces that move the continents. Biological processes like photosynthesis, “built” by natural selection, are extremely important, along with purely geophysical forces like seafloor spreading, in the evolution of the earth’s crust. Thus it seems that stabilizing selection must normally be more important than progressive selection.

Other possible kinds of selective regimes exist, such as frequency dependent selection and sexual selection. we will come to these in later Chapters.

IV. Organizational Levels and Natural Selection

Natural selection is a maximizing or optimizing principle. Because natural selection tends to increase the mean reproductive fitness of a population over evolutionary time, we can say that it works to “maximize” the net reproductive output. Because the implications of this are frequently misinterpreted, one has to be very careful to understand what it is that tends to be maximized. Let us consider evolution at three levels, genes, individuals, and groups of individuals.

Some argue that individual genes can maximize their reproductive success. The best known proponent of this view is Richard Dawkins who, in his book *The Selfish Gene*, pushes the argument for selfishly motivated genes about as far as it can go. However, because genes are packaged into individuals, and transmitted as packages between generations, it is dangerous (even from the gene’s point of view) to be too selfish. For example, a selfish gene like one that causes cancer, that optimizes its own spread at the expense of others, is ultimately selected against, at least if the cancer victim is young enough to have its production of offspring reduced. (Most cancer victims in fact are elderly. We return to the theory of why the old are especially prone to disease in Chapter 21 on disease.) Thus the conventional view is that genes do not normally compete against each other for fitness within an individual organism.

Others assert that selection at the individual level is of paramount importance--indeed this is the current majority opinion. Adaptations are the fitness-maximizing attributes of individuals. G. C. Williams (1966) made a very influential argument to this effect. There is a small caveat under the term “inclusive fitness”, which allows for the fitness help lone individuals can give their genetic relatives (see Chapter 14). The strength of this basic dogma is based on the recognition that because individuals are the basic phenotypic and reproductive units selfish individuals can very conceivably increase their reproductive success in competition with other individuals in the population. A solitary individual can carry on with the fitness enhancing business of surviving and reproduction much more independently than the solitary cell or individual gene.

A third position argues that the fitness of populations, species, or communities can be subject to selection. British biologist V.C. Wynne Edwards (1962) claimed that animals commonly sacrifice their own reproductive success, in situations in which selfishness would put the group in danger. He believed that, to some approximation, individual animals were as dependent upon the group for survival and reproduction as solitary genes are upon whole individual phenotypes. This book gave rise to the "group selection controversy" which over time was resolved with the recognition that group selection is theoretically possible if there is: (1) high variability between groups; (2) low variability within groups; and (3) substantial group extinction rates, or differential group success rates. The problem is that migration between groups will tend to spread selfish individuals into unselfish groups if any such exist. Within a group of unselfish individuals, selfish ones will have a special advantage. They can take advantage of the altruists[5], without bearing the costs of altruism themselves.

The common conclusion is that selection usually favors individual advantage, rather than the interest of genes or of groups. Genes are selected to cooperate to make a reproductively effective individual, but individuals are not nearly so likely to be selected to make a successful group by sacrificing their own advantage for the advantage of the group. Of course, individuals who strive to survive and reproduce as individuals also tend to perpetuate their group. The rub comes when it might be useful for individuals to cooperate to reproduce the group as a functional entity the way genes collaborate to produce a body that then jointly reproduces all the genes in the genome. Nevertheless there is a recognition that group selection is not impossible, and that there may be conditions in which group selection is quite strong relative to individual selection. This is particularly the case with humans, with their high levels of cooperation. Indeed some biologists who are otherwise persuaded that group selection is unimportant see a possible role for it in humans. We will return to this topic in Chapter 14. In the meantime, beware of the picture of animals cooperating in their collective interest. This theme is common in TV nature films and childrens' books. It sets modern evolutionary biologists' teeth on edge!

V. Many Complexities

As was mentioned already, evolution by natural selection can get very complicated when we begin to attend to details and raises some intriguing puzzles. Even so it is amazing how far you can get by patiently and carefully applying simple models.Remember, it is also

---

[5] *Altruism* is defined as behavior by an individual organism that is either not beneficial or is harmful to itself, but that benefits the survival of others.

these peculiarities that often give the best evidence about the operation of natural selection. Lots of processes--such as a Divine Creator--might produce perfect adaptations. But what process besides selection could do some of the following things:

Sex ratio is a phenomenon that provides a wonderful Darwinian puzzle: Why do most species have such an excess of males? In most animals, the ratio of the sexes is 50:50, or close to that number. As anyone who has had experience with livestock raising is aware, the large number of males in a population is far more than are needed. The rule for beef bulls on the range is that one bull per 20 cows is perfectly sufficient. Why doesn't selection normally adjust the sex ratio to something like 1:20? It seems like a much smaller portion of males would be more adaptive; cattlemen and dairymen certainly think so. (A similar point has been made by a number of feminists in recent years!)

R. A. Fisher worked out the basic selective logic. Suppose there are two sexes, and both are necessary for reproduction. This pattern characterizes many, but by no means all, organisms. Each offspring will have one male and one female parent. Now, suppose one sex is rare, say males. Then, *the average male will have many more offspring than the average female*. (As animal breeders say, your bull is half your herd.) If there is any heritable variation for sex determination the rare sex will have more reproductive success than the common one. The two sexes will be equally fit only when the sex ratio is 50:50. Once animals or plants are committed to sexual reproduction they will suffer the burden of excessive males.

The male excess leads to another question: Why have sexual reproduction at all? Consider the problem from the female's point of view. In most species, the female contributes almost everything to the offspring (egg mass, parental care, etc.). Yet she accepts sperm in sexual reproduction and cuts the number of genes she transmits to the next generation in half. Why don't females always reproduce asexually, so as to double their fitness? There actually are many species that can reproduce asexually, so switching is not a big biological problem. Why do females tolerate males in the world at all? This is one of the "hot topics" of the last dozen or so years, and there is not yet a universally accepted answer[6]. The most basic reason seems to be that sexual reproduction reassorts genes, creating variable offspring. Individuals with variation are perhaps more likely to resist disease (see Chapter 21). Females may be able to take advantage of male competition to pick fathers with good genes on behalf of their kids (see Chapter 15). Populations with recombination

---

[6] Lynn Margulis, (perhaps one of the most creative biological scientists of this generation) and her son, Dorian Sagan, have published an interesting and accessible book on this topic entitled *Mystery Dance: on the evolution of human sexuality* (1991).

can respond more rapidly to variable environments, because favorable mutations can be brought together to create especially superior types. This last mechanism requires a bit of group selection to work; sexual populations would out-evolve asexual ones, even if sex was an individual fitness disadvantage for females.

Here is a puzzle for you to try your hand at related to the sex ratio question. The y sex determining chromosome is transmitted only by males in mammals (females in birds). Mitochondria are transmitted only by females. Both of these structures contain a little DNA, but much less than a regular chromosome. What would happen if a mutation favoring alteration of the sex ratio appeared on one of these structures? Can you give a selective reason why these structures contain so little DNA compared to the regular genome? The famous evolutionist W. D. Hamilton (1967) wrote a nice paper outlining the simple selective logic here about 20 years ago. Hint: think in terms of Dawkins' selfish genes. What would you do about the sex ratio to maximize your fitness if you were a selfish gene on a y chromosome?

VI. Conclusion

Darwin's proposed mechanisms of natural selection and the inheritance of acquired variation gave biologists interesting scientific hypotheses to explain the diversity, adaptedness and evolutionary history of the earth's biota. It made these topics for real scientific investigation, as opposed to support for metaphysical notions like a divine creator. Some of Darwin's ideas turn out to be wrong; the inheritance of acquired variation mechanism turns out to be unimportant in the genetic system of inheritance, but that is the work scientific hypotheses do. In stimulating critical empirical inquiry, some ideas fall by the wayside. As far as genetically transmitted adaptations are concerned, only natural selection *causes* adaptation. Other processes, for example mutation, cause evolution in the sense of a change in a population through time, but only natural selection "guides" or "directs" this change in ways that create complex adaptations. Since the ecological study of contemporary organisms fundamentally involves their adaptations, ecology derives from evolution. Perhaps an even better way of stating it is that *ecological processes actually* **cause** *evolution.:.*

Ecological processes actually *cause* evolution.
Selection is just everyday ecological processes,
repeated for many generations.

Natural selection is a proper materialistic explanation for evolutionary change and adaptation that can be investigated in the field and lab. In this regard it is quite different from progressive evolutionary schemes, such as Steward's, which have no causal referents to investigate. There is just the evolutionary trajectory, which is what is to be explained; the only evidence for the progressive force is the pattern which is to be explained. The "theory" doesn't specify any independent observations that would help us decide whether there is a progressive force or not. This is circular reasoning: a pattern cannot explain itself! Typical progressive evolution theories are thus bankrupt as causal explanations on purely logical grounds.

In coming chapters, it will be important for us to take a step back from the model of selection itself to the methodological principle that lies behind it, population thinking. By paying close attention to individual variation within populations and the propagation of this variation through time, evolutionary biologists have come to understand a lot about organic evolution. In the human case, much individual variation is cultural, and cultural variation obeys "laws" of inheritance quite unlike Mendel's, but the trick of focusing attention on the plain everyday events of individual lives pays the same scientific dividends. This is the method we will adopt in the next few chapters.

VII. Bibliographic notes

References:

Dawkins, R. 1982. *The Extended Phenotype: The Gene as the Unit of Selection*. Oxford: W.H. Freeman.

Dawkins, R. 1987. *The Blind Watchmaker.* New York: W. W. Norton.

Hamilton, W.D. 1967. Extraordinary sex ratios. *Science* 156: 477-88.

Endler, J.A. 1986. *Natural Selection in the Wild.* Princeton: Princeton University PRess.

Gruber, H.E. 1974. *Darwin on Man: A Psychological Study of Scientific Creativity*. New York: Dutton.

Provine, W.B. 1971. *The Origins of Theoretical Population Genetics*. Chicago: UNiversity of Chicago Press.

Tversy, A., and D. Kahneman. 1974. Judgement under uncertainty: Heuristics and biases. *Science* 185: 1124-1131.

Ussher, James. 1658. *The annals of the world. Deduced from the origin of time, and continued to the beginning of the emperour Vespasians reign, and the totall destruction and abolition of the temple and common-wealth of the Jews*. London, Printed by E. Tyler, for J. Crook and G. Bedell.

Williams, G.C. 1966. *Adaptation and Natural Selection*. Princeton: Princeton Univ. Press.

Wilson, D.S. 1983. The group selection controversy: History and current status. *Ann. Rev. Ecol. Syst*. 14: 159-188.

Wynne-Edwards, V.C. 1962. *Animal Dispersion in Relation to Social Behavior*. Edinburgh: Oliver & Boyd.

Useful general references:

Dobzhansky, T., F.J. Ayala, G.L. Stebbins, and J.W. Valentine. 1977. *Evolution*. San Francisco: Freeman. (A good, upper-division level text.)

Harrison, G.A., J.S. Weiner, J.M. Tanner, and N.A. Barnicot. 1977. *Human Biology: An Introduction to Human Evolution, Variation, Growth, and Ecology.* Oxford: Oxford Univ. Press. (Upper Division level text on these topics, with an emphasis on the selective importance of contemporary variations.)

Margulis, Lynn, Dorion Sagan. 1991. *Mystery Dance: on the evolution of human sexuality*. New York: Summit Books.

Pianka, E.R. 1978. *Evolutionary Ecology*. New York: Harper and Row. (a good upper division text emphasizing the ecological underpinnings of ecological phenomena.)

Roughgarden, J. 1979. *Theory of Population Genetics and Evolutionary Ecology: An Introduction*. New York: Macmillan. (An advanced undergrad/graduate-level text with emphasis on quantitative theory.)

Chapter 10. THE SOCIOBIOLOGY HYPOTHESIS

> Culture represents "the cumulative effect of inclusive-fitness-maximizing behavior (i.e, reproductive maximization via all socially available descendant and non-descendant relatives) of the entire collective of all humans who have lived.
>
> Richard Alexander (1979:68)

I. Introduction

A. Recap of Arguments

In this chapter and the two that follow, we will address the question of how Darwin's clever idea of natural selection might be relevant to humans. Think back a bit. We came to an understanding after the five empirical chapters (Chapters 3 to 7) that although the Stewardian notion of a culture core was a useful conceptual peg on which to hang our ideas about how social organization and culture might be related to ecology, the Stewardian method was unable to address adequately the issue of change; that is, the big "WHY" questions were not only still unanswered, but we actually had no tools with which to start tackling them. Then in Chapter 8, you were introduced to the idea of population thinking, which set the groundwork for the important material presented in Chapter 9, the concept of natural selection.

So now we know a little about the fruits of the discovery of natural diversity in human populations, and we have a theoretical tool—natural selection together with population-thinking—with which to start unraveling the question "*Can human evolution and diversity be seen as a product of natural selection and ecological heterogeneity?*"

B. Relevance of Natural Selection Theory to Humans

A number of physiological and morphological[1] *human characteristics are plausibly explained as the result of natural selection*. We talked briefly about skin color: that dark skin seems to be adapted to environments of high light, insofar as it protects from sunburn; pale skin seems to be adapted to low light environments, insofar as it facilitates the critical synthesis of vitamin D. There are plenty of other examples. For example, people tend to be squat and stout in cold climates and tall and lean in hot ones. The compact physiognomy conserves heat, and the slender one helps one to lose heat.

Selection on morphological variation has also been proposed for variations that we know from the fossil record have occurred over time. Thus, large brain size seems to have

---

[1] having to do with the *form* and *structure* of an organism or any of its parts

come under particularly strong selection pressure in the period between 2 million and 1 million BP. Similarly for bidpedalism: evolutionary biologists and paleoanthropologists play endless games trying to guess what the important selection pressures were that may have accounted for some of these dramatic changes in the hominid lineage (we'll go into these more in a later chapter).

Whether natural selection has anything to do with human behavioral variation has been the subject of much controversy from Darwin down to the present day. Using natural selection theory to account for either current variability within humans, or for evolutionary changes that occurred amongst our ancestors, is central to the pursuits of biological anthropologists, paleoanthropologists and primatologists. It is important to remember this because, from this chapter onwards our focus is mainly behavior, and not the less controversial matters of anatomy and physiology. Before delving into a subject where everything seems debatable, it is important to reflect on the main message of the last lecture: biologists have no well verified mechanisms other than natural selection to account for complex, costly organs (Dawkins, 1987, cite in previous chapter). The human brain is a is a very complex, very costly organ. The human brain is the basis for human behavior. Natural selection works directly on phenotype, and only indirectly on deeper sources of variation. Behavior is the phenotypic product of the brain so natural selection could get at the brain only through acting on behavior. Does this mean that natural selection works on human behavior, or at least must have done so over the long haul as the brain evolved? Yes. Scientists are schooled to entertain doubts, but the alternatives to natural selection as an explanation for the evolution of human behavior are much more dubious. Natural selection wins the "least dubious" contest hands down. On the other hand, natural selection is a "big tent." There are many fascinating puzzles to solve in understanding exactly how natural selection has shaped human behavior.

II. Study of the Evolution of Behavior

A. The Beginnings

In biology the study of the evolution of behavior began its "golden age" only in the 1960s. Of course biologists prior to this date, such as the ethologists, Lorenz, Tinbergen, Hinde etc. had recognized this, but the theoretical developments of the 1960s stimulated a growth industry in a new subdiscipline called "sociobiology", from which sprang the modern versions of animal behavior and behavioral ecology. The term was introduced as the title to Edward O. Wilson's (1975) famous book *Sociobiology: A New Synthesis,* which celebrated the even then large body of evolutionary studies of (mostly) non-human animal behavior. Giraffes, for example, were no longer simply interesting to the biologist on account of the evolution of their long necks and long legs, but because of their behavior, for example, keeping offspring in communal daytime creches. How might natural selection have shaped the *behavior* pattern of a giraffe mother so that she takes her offspring to the creche, with one of the mothers staying behind to look after youngsters while the other adults go off and eat all day and then return to collect their young in the evening? Darwin had anticipated that these kinds of questions should come into the purview of the evolutionary biologist, but it was not until the late 1960s that systematic examination of these issues was begun.

B. An Example of Studying Behavior With Darwin's Theory

Before we examine how sociobiological hypotheses are applied to human behavior you should have some idea of how questions about the evolution of behavior have been investigated in non-humans. You need to know how to start thinking in a selection-minded way.

Consider starlings and how they hunt for insects in the soil in order to feed their offspring. Starlings must feed their ravenous nestlings with small larvae ("leatherjackets") that are found in the soil in the meadows surrounding their nesting areas. At the height of the breeding season a parent has to make about 400 round trips from the meadow to the nest in a single day. The question is how many leather jackets should the parent bring back each time? This might seem like an inconsequential question, but size of load brought back has a critical effect on the parent's overall delivery rate to the nest, which determines whether or not the chicks survive to become healthy fledglings. Juvenile starvation is a serious risk in starlings, so parental feeding skill and efficiency is under strong selection pressure.

Basically, a poor parental strategy would be to bring a single larva back each time; (like going to the grocery store and bringing back one item per trip). A better strategy might be for the parent to bring the largest number of larvae back that it can carry. But, because of the way starlings probe in the soil for leatherjackets with their beak, they become very inefficient searchers once their bills are full of larvae. This diminishing returns curve presents a starling parent with this problem: if it gives up larvae collection early, it spends a lot of time flying back to the nest with only a very small meal. If it struggles on until its beak is jammed full, its larvae collection becomes so inefficient that it would be better to fly back to the nest and feed the nestlings. If you do the math, it turns out that the optimal load depends on how far away the nest is from the leatherjacket meadow: if the meadow is distant the load should be heavier than if it is nearby.

The solution makes intuitive sense. Think how differently you pack and box your possessions depending on whether you are moving to a new room down the hall, or to a new college.

Incidently, Alex Kacelnik (1984, the author of the starling study) did experimental work varying the distance between nest boxes and feeding sites that showed that starlings did just what they should do if they had evolved to forage optimally under the guidance of natural selection. There are all kinds of complications that can be brought into this model, but the important message from this example is that we can make quantitative predictions about what we think the optimal behavior would be (given our knowledge of certain constraints) and then go and test our ideas in the field.

III. Sociobiology—Some Applications to Human Behavior

We now move onto two examples of some very similar kinds of thinking with respect to human behavior. We will consider these empirical cases first, and then finish up with a discussion of what assumptions underlie the studies that we have considered.

A. Birth Intervals, as Studied in the Kalahari !Kung

Deciding how long to leave between the production of each offspring is a major decision that must be made by every potential parent. If natural selection favors individuals who produce as many copies of their genes as they can, the simple prediction would be that parents should produce young in huge litters, and at very short intervals. Some organisms do this, but such a strategy normally entails great costs, both to the parent and to the offspring. The parent gets physically burnt out, and is likely to have a short life-span, and the offspring get little care or nurturance from their parent, and are much less likely to survive.

Human populations are quite variable with respect to the length of time they leave between each child as we discussed in the chapters on human diversity. A group that has drawn particular interest are the !Kung of the Kalahari, who have very long mean interbirth intervals of 4 years. Richard Lee, one of the early ethnographers of the !Kung (whom we discussed in Chapter 4), attributed this long interval to the necessity for mothers to carry their young children on day-long foraging trips. Collecting mongongo nuts, and digging up tubers, and then carrying everything back home to the camp in the desert sun certainly suggests that a mother who had to carry *two* children and all their food would have a very difficult life. Lee thought that having children any closer than 4 years[2] would pose intolerable stress on the mother. This was the first really ecological explanation for the slow population growth of the !Kung.

---

[2] 4-year-old toddlers can follow their mothers through the desert without needing to be carried.

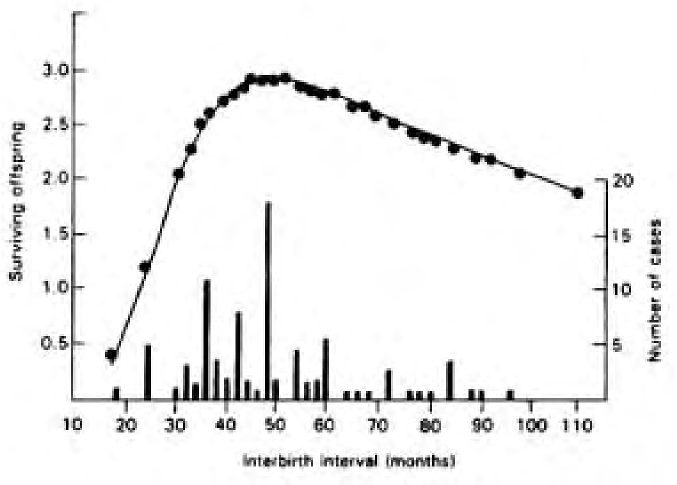
Lee's observations laid the groundwork for a very neat Darwinian model showing that the IBI of 4 years is the optimal birth interval. The thinking behind this is very similar to the starling example we considered earlier. A woman would "like" to have as many children as possible[3], but there is a cost: the cost of carrying and feeding these children.

Nicholas Blurton Jones (1986) examined the relationship between infant mortality and IBIs of different lengths. First he had to investigate the cost of short interbirth intervals to the child. Not surprisingly, he found that children born after very short intervals were much more likely to die, probably for the reasons Lee outlined.

Indeed it was only children who were born at more than 40 months after the birth of a preceeding child who had a greater than 50% chance of survival.

Does birth spacing maximize reproductive fitness among the !Kung? From this diminishing curve, and assuming a reproductive life-span of about 20 years (which is true for !Kung women), Blurton Jones could do a mathematical calculation to see how closely births should be spaced in order to produce the maximum number of *surviving* offspring. In figure 10-1, the curved line shows the results of this calculation. If a !Kung mother spaces all births at 25 months she can only hope to produce a little more than 1 survivor on average, because the chances of mortality for closely spaced children are so high. If she spaces children at 90 months, she can only produce 2 survivors, because she "wastes" so

Figure 10-1. !Kung infant mortality as predicted by mother's backload and interbirth interval (IBI). (Source Blurton Jones 1986:99)



---

[3] What do we mean by this?

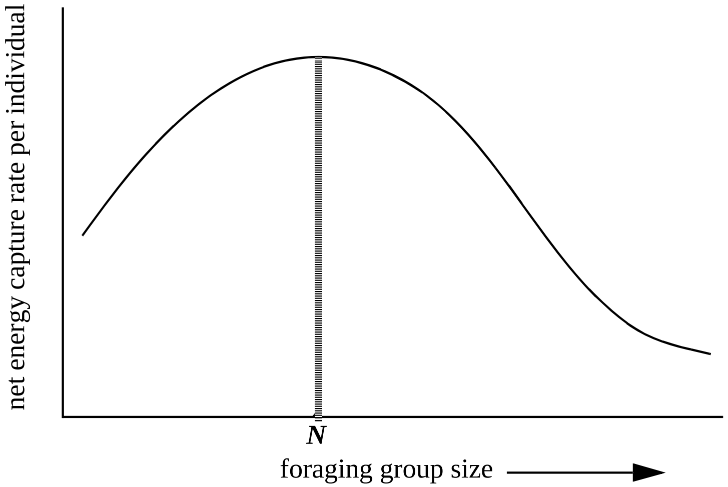
much time reproductively speaking. In terms of maximization of fitness, it turns out that it is best to space children at an average of between 45-50 months, a behavioral strategy that produces 3 surviving offspring. The bars in the figure show the distribution of empirically observed interbirth intervals; notice how these approximate the prediction from optimality theory, although there is an awful lot of scatter in the empirical distribution, In general, however, we can say that !Kung women are behaving more or less optimally with respect to the spacing of their births. By incorporating the weight of food needed to feed children, Blurton Jones developed a somewhat better prediction of the scatter of the real data.

B. Group Size

A simple sociobiological hypothesis would predict that people should select group sizes for foraging that maximize their own individual energy returns. Smith tested his hypothesis in a study of optimal group size among the Canadian Iniut. The Inuit hunt for different species of mammal, bird and fish in groups of very different sizes.

Essentially, while hunting efficiency might increase with number of hunters, the prey must be shared among a greater number of people. It is a very simple mathematical problem to calculate what group size is optimal for the individual in any particular hunt type, if you know the relative hunting success of different sized groups, and the amount of edible flesh on the carcass (Figure 10-2). Note, that in line with the Darwinian model, we are talking about *individual* energy capture; remember the emphasis on individuals kin Chapter 9..

Figure 10-2. Optimal foraging group size ($\hat{N}$) for any type of resource is described by the curve below. (Source: Smith 1981:42.)



Smith (1985) tested this idea, using data he collected on Inuit men engaged in 10 different kinds of hunts. These hunts include taking seals at breathing holes, winter caribou hunting, canoe seal hunts, spring goose hunts, ocean netting, lake jigging, etc. We show three examples. (See Figure 10.3)

Figure 10-3. Hunting group size in three different kinds of Inuit hunts. Note that in all cases, foragers often hunt in groups larger than that which gives the best returns, even when most hunts are undertaken by optimally sized units. Beluga hunts are apparently regularly undertaken by larger-than-optimal groups, but the sample size is small (From Smith, 1991).

(This image not scanned in, pasted up, 1994). Is your copy good enough to use for the paste-up, or do you need an original? Pete R

Ocean netting is the main form of fishing in the summer. Gill nets are set in coves and at river mouths for arctic char. Travel to and from nets is in canoes powered by outboard motors. Very high efficiencies are obtained by individual fishermen, but these decline rapidly as more men join in. (This is presumably because one man can do the job just as well as two or more, but has to share the catch). The data show that single hunting is almost always the most efficient group size, and also the most common. Smith therefore shows that with respect to this one area of Inuit foraging, people were behaving optimally.

If we look at ptarmigan hunting, the picture is very similar. In the late winter and early spring men go off on snowmobiles with.22 rifles to look for ptarmigan. Again both efficiency and group size frequencies peak at groups of one.

For beluga whale hunting, the picture is not so clear. For these hunts men go off on special purpose long distance canoe trips to known concentrations of beluga at estuaries in the early summer. Efficiency drops off markedly above groups of size 5 or 6, but larger groups were observed in 4 out of 6 cases.

Of the 10 different kinds of hunts Smith looked at, the model (most common) group size was also the optimal group size in 4 types, as with the ptarmigan and ocean netting. In two types, the results were equivocal, and in 4 others there were clearly other factors influencing how many people go out hunting together. In a later article (Smith 1985) some of these other factors are investigated.

IV. Discussion of Applications of Darwinian Models to Humans

A. Does Culture Make a Difference?

There are problems with a simplistic application of ideas developed in the study of animal behavior to humans. When we moved away from starlings and started thinking about the !Kung and the Inuit, you will may have been getting progressively more uneasy. The most prominent problem is one which was introduced in the first two chapters of this course—the fact that humans are probably unique with respect to the amount of information that is transmitted by non-genetic means, that is through cultural transmission, such as learning and imitation of the behavior of others. Cultural information can be transmitted laterally, can be borrowed and passed on between relative strangers, can be deposited in manuals, resurrected from history books, and can be invented and forgotten. This form of transmission is very different from the strict mendelian inheritance of genetically based traits. This is explored further in Chapters 11 and 12. Many social scientists argue that cultural transmission means that the effect of natural selection is completely obviated in the human case, and that quite other processes guide our cultural evolution.

Sociobiologists counter this objection by claiming that culture itself be explained from pure and simple natural selection thinking. Thus Irons (1979:39) argues that "Most forms of [human] behavior will either be biologically adaptive or will be expressions of evolved tendencies that were adaptive in the past." How could an elaborate capacity for culture have arisen in the first place unless this was true, so that directional selection could favor our big, complex, culture-managing brain?

This quote, and the one from Alexander in the epigraph, rests on two foundations, a deductive argument from Darwinian theory, and the empirical claim that most human behavior does indeed fit the theory. We have already considered some of the empirical evidence for this claim (birth intervals and hunting group size), and will turn to one more classic example, before investigating the assumptions of the sociobiological hypothesis.

B. The Yomut: A Classic Example of the Sociobiological Hypothesis

If culture is a product of natural selection, people who are viewed in their culture as particularly successful individuals should also be the people who have the greatest reproductive fitness. If successful people are the most likely to be imitated, then cultural successwill be a means of perpetuating cultural behaviors that make us successful in fitness terms as well. William Irons proposed this idea, and tested the proposition that cultural success might contribute to genetic success among the Yomut Turkomen pastoralists of Iran. He found strong correlations between wealth and culturally defined prestige, and genetic fitness[4]. Irons interpreted this to mean that culturally defined goals and objectives are actually those that favor genetic fitness.

Similar findings come from studies of hunter gatherers (the Ache of Paraguay), horticulturalists (the Yanomamo of Venezuela), agropastoralists (Kipsigis of Kenya), and many historical populations. Such studies can be seen as at least a step in the direction of showing that cultural differences reflect, at least in part, the behavioral strategies of people in different populations all over the world to maximize their genetic fitness. This is what Richard Alexander was getting at in the quote at the front of this chapter. Look at it again! Alexander is suggesting that everything in human culture is, one way or another, directly or not so directly, a consequence of individuals striving for reproductive success. A bold hypothesis!

C. Deductive Argument From Natural Origins

The capacity-for-culture must have arisen under the influence of natural selection, and thus culture must ordinarily result in adaptive behavior in the usual sense that evolu-

---

[4] Measured as number of surviving offspring.

tionary biologists use the term. Practically no one familiar with modern evolutionary biology can doubt that humans are descended from non-cultural ancestors. Nor do most scholars have much doubt that natural selection is the most important directional force in organic evolution. The capacities that humans use to acquire, store, and use culture (large brains, hands, speech) are based on ordinary anatomical traits underlain by genes. If culture regularly resulted in maladaptive behavior, selection would have reduced or altered the capacity of culture to ensure that more adaptive cultural traits would be favored. The capacity for culture must be an adaptation, hence cultural variation must be adaptive in the usual Darwinian sense of increasing survival and reproductive success.

The standard sociobiological argument therefore depends on the “argument from natural origins” outlined above, and it can be caricatured as follows:

THE STANDARD SOCIOBIOLOGICAL ARGUMENT:

Forget about this business of culture being so terribly special. To a tolerable approximation, we can treat culture and any other mode of phenotypic flexibility, such as ordinary learning or conscious strategizing, as a mere means to an end—optimizing the number of copies of their genes that individuals pass to the next generation. The important thing is which behaviors maximize fitness in a given environment, not the details of whether (or in what proportions, or by what devious and complex interactions) such behaviors are produced by learning, tradition, or genetic influences. What counts is the bottom line—reproductive success, fitness. The evolutionist can depend on this maxim to generate interesting testable hypotheses, and eventually the broad answers to behavioral questions in any species will follow. The dull dogwork of describing all the proximal details of how this is accomplished can safely be left to pedantic psychologists; evolutionary reasoning will get us the ultimate answers straightaway.

D. Plausible Mechanisms

Our decision-making rules come from sensations, motivations, desires, etc. that insofar as they promoted survival and reproduction have been shaped by natural selection over our evolutionary past. The assumption underlying Irons’ and Alexander’s hypothesis is that individuals must chose amongst a variety of strategies, some of which are already in the cultural repertoire, some of which they must learn for themselves. These decision-making forces require preexisting rules for making decisions. The rules that guide these decisions must come from somewhere. It is plausible that selection on genes arranges the rules of human choice so that we tend to invent and imitate those cultural variants that do indeed have a tendency to enhance our fitness. For example, senses of pleasure and pain are by and large arranged to encourage behavior that promotes survival and reproduction. This is demonstrated by the fact that people who lack a sense of pain in some parts of their bodies because of various diseases are prone to serious injury of those parts. If your hand has no sense receptors, you are less likely to drop the hot pan. This, incidently, is a serious side effect of leprosy. (Of course, not all senses of pain and pleasure are completely trustworthy, as the prevalence of addiction to pleasurable, but harmful, substances testifies.) Our enjoyment of sweet things may be another important force guiding our decisions. A food that is sweet tasting probably lacks dangerous tanins, and certainly provides part of the necessary daily intake of carbohydrate. In the environment of our hominid ancestors, a genetically based enjoyment of sweet things was very likely to have been selected, as against a genetically based enjoyment of eating two-week old rotting carcases. (Again, the very cheap sugary foods in our modern grocery stores, can lead to pathological overeating of sugar). Now we get an inkling of how selection must have worked backwards from behavior to structures in the brain.

One of the essential things to keep in mind when thinking about sociobiological hypotheses is that the environment in which humans evolved genetically was quite different from the environment in which most contemporary humans live. For all but the last blink of human time, hominids were hunters and gatherers. The genetic adaptations we see today may therefore be expected to be consistent with a hunting and gathering environment. this lies at the root of one of the sociobiological hypotheses put forward for the modern demographic transition described in Chapter16.

Note that the sociobiologists' argument is not simple genetic determinism. People like Irons agree with the standard criticism of genetic determinism. There is little interesting genetic difference between, say, Turkomen and Anglo-Americans. Our standards of prestige differ from theirs for cultural reasons (a pilgrimage to Mecca carries no weight with us for example), not because Turkomen carry a Moslem gene and we do not! But, under the guidance of decision-making rules that are ultimately rooted in genes, cultural evolution is bent in fitness enhancing directions. (Some varieties of the sociobiological hypothesis, for example Lumsden's and Wilson's, imagine a larger role for genetic variation, see Boyd and Richerson, Ch. 5 for an analysis of various sociobiological positions.)

V. Conclusion

In our opinion the sociobiological hypothesis is a good argument. You will note that the mechanism (individuals choosing to do things as a result of basic genetic propensities that guide them in their decision-making towards the behavioral strategy that is most fitness enhancing) is what, in the next lecutre, will be called *guided variation* and *direct bias*[5]. Thus the sociobiological hypothesis is a first and important step in our attempt to develop cultural evolutionary models for human diversity. Be warned though, the next two chapters are going to dispute too literal a use of it. Treat it as something to build on and amend, not as something to reject out of hand, as some of its harsher critics have tried to do, perhaps because it threatens the "splendid isolation" of "Man" from the "beasts"!

In the next two chapters, we are going to do a bit of population thinking, and build a model to see how the processes we have been considering lead to evolutionary change. We are also going to consider under what circumstances it pays not to experiment with new forms of behavior: that is, under what circumstances it pays to follow culturally transmitted information blindly, irrespective of consequences on fitness.

VI. Bibliographic Notes

References:

Alexander, R.D. 1979. In Chagnon & Irons

Blurton Jones, N. (1986) Bushman birth spacing: A test for optimal interbirth intervals. *Ethology and Sociobiology* 7:91-105.

Irons, W. 1979a. In Chagnon & Irons.

Irons, W. 1979b. Cultural and biological success. In *Evolutionary Biology and Human Social Behavior*. N. Chagnon and W. Irons, (eds.). North Scituate, Mass.: Duxbury.

Kacelnik, A. 1984. Central place foraging in Starlings. *Journal of Animal Ecology* 53:283-99.

Smith, E.A. 1981. The Application of optimal foraging theory to the analysis of hunter-gatherer group size. In *Hunter-Gatherer Foraging Strategies*, B. Winterhalder and E.A. Smith (eds). Chicago: Univ of Chicago Press. Pp 35-65.

Smith, E.A. 1985 Inuit foraging groups. *Ethology and Sociobiology* 6:27-47.

Smith, E.A. 1991. *Inujjuamiut Foraging Strategies: Evolutionary Ecology of an Arctic Hunting Economy*. New York: Aldine de Gruyter.

Wilson, E.O. 1975. *Sociobiology: A New Synthesis*. Cambridge: Harvard Univ. Press.

---

[5] Daly and Wilson (1988) provide a good example of how one can go about testing for the existence of this mechanism.

Chapter 11. MECHANISMS OF CULTURAL EVOLUTION

> “Mohammedans are Mohammedans because they are born and reared among that sect, not because they have thought it out and can furnish sound reasons for being Mohammedans; we know why Catholics are Catholics; why Presbyterians are Presbyterians; why Baptists are Baptists; why Mormons are Mormons; why thieves are thieves; why monarchists are monarchists; why Republicans are Republicans and Democrats, Democrats. We know that it is a matter of association and sympathy, not reasoning and examination; that hardly a man in the world has an opinion on morals, politics, or religion that he got otherwise than through his associations and sympathies.”
>
> Mark Twain, “Cornpone Opinions”
> in *On the Damned Human Race,* p. 24

> “Custom is the principal magistrate of man’s life. Men do as they have always done before; as if they were dead images and engines moved only by the wheels of custom.”
> Sir Francis Bacon, ca. 1580

I. Introduction

A. History

Culture (often under related terms like tradition, values, custom, skills, ideas, socialization, etc.) is one of the central ideas in the social sciences. Recall the discussion of Steward’s ideas on the culture core as adaptation, exemplified in Chapters 3-7, and the discovery that free imitation is unique to humans.

The social sciences lack a generally accepted basic theoretical framework for understanding the processes of cultural evolution. There is no generally accepted set of mechanisms underpinning ideas about human cultural evolution or cultural adaptation that has anything like the appeal of Darwinian theory. In this chapter and the three following ones we will investigate the application of Darwin’s methods to the study of culture itself. The basic hypotheses of these chapters is that the processes of cultural evolution (1) originated under the influence of natural selection and can be understood as adaptations, and (2) that cultural evolution itself is best studied using Darwinian *methods*.

Darwin himself tried to initiate the application of his ideas to humans in the Descent of Man. However, Darwin’s ideas had practically no direct influence on the social sciences. Rather, evolution was treated descriptively as a series of stages, and there was little concern with mechanistic theories like natural selection. Darwin was re-introduced to the social sciences distinguished psychologist and methodologist Donald Campbell (1965), for whom evolutionary theory was a sort of hobby. Campbell criticized the prevailing social scientific theories of evolution that derived from Spencer and Morgan, including the mid-20th Century theories of Leslie White, Julian Steward, and Marshall Sahlins. Most of the work applying Darwinian theory to human behavior and cultural evolution dates after E.O. Wilson's 1975 book *Sociobiology,* which had a controversial final chapter on humans.

Campbell made a very insightful observation about stage theories, namely that they are not really theories at all. They all *describe* changes in societies over time in terms of a series of stages or grades like "savagery," "barbarism," and "civilization," essentially from simple hunting and gathering to industrial societies. Now, there is no quarrel with the fact that a trend to greater technical and social complexity characterizes human evolution, albeit not in a completely straightforward way as we saw with pastoral "regression." Dividing this rough trajectory into stages, naming them, arguing critically about the patterns that actually occurred, and so forth, is all useful work. But, Campbell said, after Herbert Spencer's 19th Century principle of universal progress was abandoned as incorrect, because no one could find any physical manifestation of his universal law of progress, nothing had really taken its place. (Spencer thought that the whole universe had a tendency to get more complex and organized with time. For those of you who know a little physics, this is the 2nd law of thermodynamics backwards. That is, Spencer was demolished utterly.) There was no explanatory principle at all in modern evolutionary theory of this tradition, there was just a descriptive account of stages. For example, Campbell criticized Leslie White's theory that evolution was driven by a drive for greater energy use. It is true, as we have seen, that greater energy use per capita is one of the trends in human evolution. But to say that a particular evolutionary pattern is caused by a drive for that pattern runs the grave risk of being circular. There is only one set of data, a trajectory of increased energy use through time. The one set of data cannot simultaneously describe the effect and the cause, if these two are different, as they must be to have a valid explanatory theory. In other words, we must have separate evidence for the existence of a cause, apart from their putative effects. The neo-Spencerian sort of evolutionary theory is still defended (Corning, 1983), but it seems to me that Campbell's critique was devastating.

The path that Campbell advocated, the use of Darwinian methods to build a theory of culture, is one we will adopt. He noticed that Darwinian theory escapes circularity quite nicely because it explains evolutionary trends in terms of ecological mechanisms. In addition to evidence from fossil records or comparative anatomy, we can get direct evidence on the mechanistic details of the processes of organic evolution through research in the field, in the lab, and through computer simulations. The whole game is to try to make the micro-and macro-evidence fit together to form a single coherent explanation.

Campbell noted the formal similarity between genes and culture. In the terms of the last chapter, both of these are systems for transmitting heritable variation. You and I resemble our parents partly because we inherited their genes, but also because we learned from or were taught by them. Parents typically reproduce some of their culture in their children, as well as some of their genes. Of course, we inherit our genes *only* from our parents, whereas a substantial amount of our culture is acquired from people other than our biological parents. Why not borrow the basic *methods* of theory building from biology, amend the models as required, and create a parallel theory of cultural evolution?

Several investigators have taken up Campbell's suggestion in various ways during the last 15 years or so, including sociobiologists, (Charles Lumsden and E. O. Wilson, 1981), economists, (R. Nelson and S. Winter, 1982), and population biologists, (M. Feldman and L. L. Cavalli-Sforza; 1981; H. R. Pulliam;,1980; Boyd and Richerson, 1985). There is presently an air of excitement in the field, complicated by some controversy and confusion (Durham, 1991 gives a recent update). It is a little like the decade after the rediscovery of Mendel's laws in genetics. There is a core of practitioners using the same basic approach, but with considerable disagreement over the general outline of what the method will discover. Not enough work has yet been done to explore all of the theoretical possibilities and to settle the empirical issues of when and where which effects are most important. This is the body of work that we'll be reviewing in the next several chapters. Be warned that we'll largely be talking about science-in-progress, not finished discoveries.

B. Work for Theory To Do

How are genes and culture related? This theory was derived by applying Darwinian methods to the problem of explaining human culture. What we want this theory to do is give us models of human adaptation. You saw the general outlines of how this might work in the last chapter. We may also need theories that account for some of the systematically *maladaptive* systems of cultural variation[1]. Even if we do not suspect much human variation is maladaptive, the practice of thinking up even far-fetched alternative models and hypotheses plays an important role in scientific skepticism and critical thinking. The key problem to solve here is how genes and culture are related. Why did selection on genes favor the development of a large culture capacity in the hominid line? How do genetic and cultural

---

[1] Recall the previous discussion on the doctrine of signs or, for a more immediate example of maladaptive cultural behavior, consider the "War on Drugs".

influences on phenotype[2] interact to produce the behavior we see in people today?

THE KEY PROBLEM:
How are genes and culture related?

How did humans acquire sociality and symbolic behavior? Also recall the related question of the other two major points of human uniqueness besides culture itself: eusociality, and symbolic behavior. We want some sort of explanation of why these differences arose under natural selection in the first place and how they work in current microevolutionary and ecological circumstances. Why did hominids develop these adaptations, if adaptations they are, beginning around 2 million years ago? What are the adaptive benefits and costs of culture, sociality, and symbols that might explain why some creatures develop them in some environments, yet, considering animals as a whole, they are relatively rare?

C. How to Apply Darwinian Methods to Culture

According to Campbell's argument, Darwin's same basic idea of population thinking obviously applies to culture despite the differences between genes and culture. In both cases, we have a set of variable individuals, and the variation can be transmitted to other individuals. Cultural variation, at least that having to do with the culture core, is important to how people make a living, compete and cooperate with each other, and so forth. There is no reason we can't open our Darwinian account books on cultural variation, and begin to keep track of where variants come from, what happens to individuals who possess one as opposed to another variant as they deal with the environment in their everyday lives, and what happens to variants during the imitation/socialization/cultural transmission process. This exercise ought to turn out to be quite informative. Even if it is for some reason less applicable to culture than to genes, it is hard to see how it can fail to be partially applicable. To whatever extent important information is passed forward through time, the Darwinian tactic of studying the nitty-gritty of how this passage works cannot be wholly wrong! There has been a lot of controversy over applying population thinking to culture, but to those of us schooled in evolutionary biology, it is hard to see how anyone can fail to see the need for the basic account-keeping demanded.

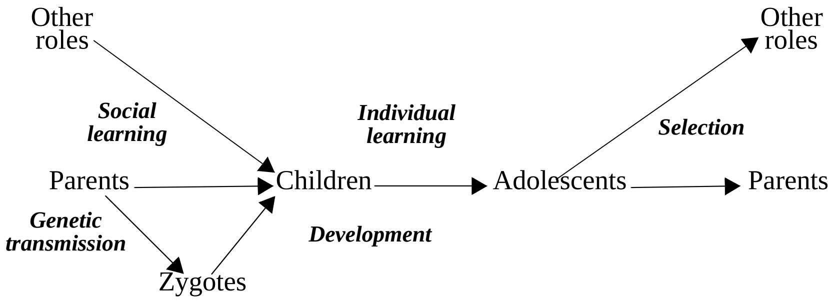
---

[2] Remember that phenotype is defined as "The sum total of observable structural and functional properties of an organism; the product of the interaction between the genotype and the environment (Lincoln, Boxshall, & Clark 1982)." Note that this definition includes behavioral properties such as mating displays, foraging strategies, and aggressiveness as well as structural properties like body size, strength, and speed.

Note how utterly commonsensical the method is. Conceptually, all we want are methods for keeping track of cultural variations and what happens to them over time. *We want to identify and describe the cultural analogs of the "forces" of genetic evolution*. Each generation, selection, mutation, and other evolutionary processes cause the numbers of some genetic variants to increase, and others to decrease. If we can measure the increases and decreases, we can make a budget for the gains and losses of each variant; if we understand the ecological processes that explain why the gains and losses differ by variant, we understand an example of evolution. Nothing could be plainer, simpler, or more straightforward than the Darwinian approach to evolutionary problems. A little thought and observation should reveal a similar set of cultural evolutionary "forces."

We begin by simplifying the human life cycle thinking of all the important things that could happen to individuals carrying genetic and cultural variants at each step of their lives. An example of such a life cycle is shown below. Then we try to classify the processes of evolution using a simple taxonomy, so that we have the basis for building models of some generality. As you will see there are really two taxonomies, one for the structural features of culture and the other one for the system of forces. When this all seems too abstract, think up a personal example of each element of the taxonomy as we go along. If you get confused, go back to the basic population method. Ask yourself, what will happen to individuals that adopt different variants? What will happen when we shift our focus from one individual in the here and now to many individuals in a population over time?

Figure 11-1. The human life cycle, simplified. The first step in building an evolutionary ecological model is often to specify a life cycle for the organism under consideration. The idea is to think in an orderly way about what happens to us and our culture as we live out our lives. Where does culture come from, and where does it go?



What are the essential events of life from the point of view of cultural evolution? Genetic transmission creates zygotes that develop into children who are enculturated by a set of individuals who typically occupy certain social roles. For example, for many cultural traits the biological parents typically play the most important roles in enculturation. In other cases, individuals occupying social roles such as grandmother, teacher, or priest may be important in enculturation. children acquire some behaviors and modify others as they mature into adolescents. The result is a population of adolescents and young adults who interact with the physical and social environment. Some of these young adults acquire the resources necessary for cultural and/or genetic transmission.

The next step of population thinking is to think of what happens when these same processes apply to many individuals generation after generation. Individuals don't live in isolation. At the minimum, they acquire culture from a sample of the adult population, and most have some influence on the next generation as parents or role models. Ideas we have, say about how to make a living, make differences in our lives, differences between wealth and poverty, prestige and shame, friendship and retribution, life and death. If some ideas have systematic differences in these regards, it will not be surprising if some increase and some decrease over the generations. If the environment changes, old bad ideas can become new successes. Basic common sense, no? Now let us put some flesh on the bones.

II. Culture as a System of Inheritance

A. Culture is Broadly Analogous to Genes

Culture as a mechanism for inheritance of acquired phenotypic variation. Culture is often described as a Lamarckian system of inheritance, by which people mean it is like genes—but with the inheritance of acquired variation feature added. A formal definition of culture is a useful place to start:

> **Culture is socially learned information capable of affecting individual phenotypes. People acquire culture from other individuals, via teaching or imitation.**

In the very simplest case, whether something is transmitted culturally or genetically makes almost no difference. For example, in some families the Christmas holiday package opening is done on Christmas Eve, and in others on Christmas morning. Rarer variants include celebrating according to the Russian Orthodox calendar, not observing Christmas by non-christians, and non-celebration of Christmas by certain Christian sects, such as Jehova's Witnesses. Traditions about Christmas tend to be transmitted by families to their kids, much as genes for eye color might be, except that they are transmitted by teaching or imitation, not as part of you DNA. Some people have adopted the term *meme* to signal this elementary similarity.

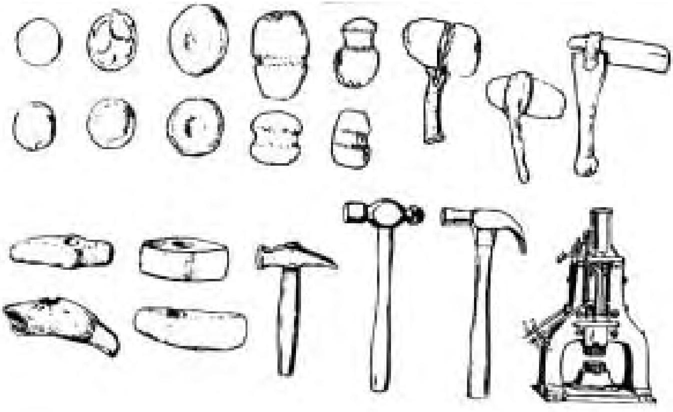
There are many dissimilarities between genes and memes, the most basic of which is that culture is a system for the ***inheritance of acquired variation.*** In the case of genes, phenotypic modifications cannot be transmitted; for example, no matter how many generations one cuts off the tails of sheep, it still has to be done again each generation to obtain tailless sheep. However, consider the family in which Mom or Pop has a job that requires work on Christmas day. They will probably adopt the Christmas Eve celebration date, even if it was not a family tradition. Unless the parents make a point of trying to maintain the Christmas Day time as an ideal not practiced, the kids are likely to adopt the Christmas Eve variant when they grow up out of habit. More generally, culture can change because people change their minds. We don't necessarily have to wait around for mutation and selection to do the work of evolution. Dad and Mom may convert to a sect that frowns on Christmas, and establish a family tradition of non-celebration.

The claim advanced by Campbell and defended here is that the differences between genes and culture are very important, but that Darwinian methods are equally applicable to both because of the key similarity of transmission of information by variable individuals through time. Figure 12-2 illustrates this idea by showing how one piece of basic cultural knowledge, how to make something with which to hammer on something else, has evolved over time. We happen to live in a time when some items of technology have changed very rapidly compared to the preindustrial era. But even now, it is almost always the case that each modification is a small step away from a pre-existing model. Modern systems of innovation may make somewhat larger steps because of formal design aids like engineering calculations based on physical principles. We certainly pack in more steps per unit time, and expose a given innovation to more potential improvers by mass distribution and mass communications. It is quite surprising the degree to which the "descent with modification" model of Darwin applies when we put even these cases under the microscope. (See Basalla (1988) for an interesting treatment of this issue).

B. Crucial Conceptual Distinctions

It is important to keep genes, culture and environment distinct in the discussions that follow. Darwin's great mistake was not to see that genes and culture are completely separate transmission systems rather than one. He thought that organic inheritance had strong effects of inheritance of acquired variation in the case of behavior, and weaker effects in the case of anatomical characters. But basically there was only one kind of inheritance system, and it was, ironically more like culture than like genes. We moderns tend to make different mistake. You've all heard of the "nature-nurture" debate. This debate is confused

Figure 11-2. The evolution of the hammer from pounding stone to 19th Century steam hammer. (Source: Basella 1988:20.)



because it lumps culture—transmitted effects that are very gene-like—with direct effects of environment on behavior through individual learning and the like. It is very important not to confuse environment and culture. There are interactions of great importance among all three of these categories, but we mustn't let the three concepts get fuzzy!

Differentiating between Genes, Culture, & Environment:

→ GENES are a complex DNA-based system of inheritance transmitting information from parents to offspring.

→ CULTURE is acquired via social learning or imitation from other individuals.

→ ENVIRONMENT consists of things and processes external to the organism or population under study.

Genes are a complex DNA-based inheritance system which is often associated with the concept of 'nature.' *Environment* consists of things and processes that are external to the organism or population being studied. *Culture* is acquired via social learning or imitation in a particular environmental setting. These two different concepts—culture and environment—are often lumped together as 'nurture.' However it is important for our purposes to differentiate between culture and environment.

Given the distinction between genes, culture and environment, it is important to remember that they are not isolated, but interacting parts of the human behavioral system. For example, individuals often learn for themselves. What they learn is liable to depend on the environment that they are in and the culture they've been exposed to. Genes affect our perceptual senses, and specify a reward system (some things hurt, some are pleasurable). If someone learns for themselves, say inventing a new Christmas celebration (the Christmas beach barbecue in Australia), this novel innovation may be imitated by others and spread culturally. Individual and social learning are distinct processes, but they are coupled through the inheritance of acquired variation feature of culture. To take another important example, human genes have long lived in a world in which social behavior is strongly influenced by culture. Presumably human genes are coadapted to culture due to a long history of selection to fit into a culturally determined world. Thus, much of human language capacity is underpinned by genes, and language is certainly in part an adaptation to managing a complex social life.

C. Culture Has "Population Level Properties"

Because culture transmits ideas it requires analysis at the population level. This is the more formal way of stating the argument for the applicability of "population thinking." Most animals are capable of learning, but not social learning; the learned variants die with the individual that learns them. By contrast, socially learned variants can be retained in the population by transmission. Thus the two components of "nurture" differ substantially in their properties. Not only is a population thinking approach to culture likely to be interesting, it is also likely to prove essential. Individuals "sample" their culture from the population and in turn become part of the population sampled by the next generation. We cannot understand *individuals* without understanding the properties of the population they sample. Nor can we understand *populations* without understanding how individuals contribute (or fail to contribute) to the next generation's pool of ideas. Informally, we can say that individuals are substantially the prisoners, even the brainwashed prisoners, of the culture they are exposed to. Culture gives us the very concepts we think with and nearly blinds us to other realities. On the other hand, the culture we are prisoners of was completely built by human hands one step at a time. Each individual makes a small but active contribution to the transmission and evolutionary modification of culture.

What culture an individual gets depends on the population in which it lives. Two individuals that have very similar *genotypes,* and live in the same environment, may behave quite differently if they have been socialized by different cultures. For example, the psychologist Sandra Scarr (1981) has studied trans-racial adoptions in the U.S. Black children raised by white families have IQ scores much like their white adoptive siblings, and much higher ones than Blacks typically have. The difference probably results from the greater stress on cognitive skills in white adoptive households, different socialization practices, and other cultural effects. Also, wherever sufficient records are available in the industrialized world, IQ has been increasing at the rate of about 1/3 of a standard deviation per generation. You students are on average about 5 IQ points smarter than people of your professors' generation (some of you may have suspected this already). This rate of change could only be produced by extremely strong natural selection on genes, and it seems a more reasonable inference that culture is involved. Perhaps the quality of schools has improved, or the tendency for child-rearing styles to become more relaxed is the cause. Or perhaps all that television is good for you after all!

We do not really understand what this change means (or what IQ means for that matter) but the implication that culture plays a major role in determining human phenotypes is clear. Culture evolves more rapidly than genes[3], but surely can have genetic consequences in the long run. ***We cannot understand human behavior unless we can explain the way in which cultural traits vary between populations and change over time.*** In the long run, we have to treat the problem of how genetic and cultural evolution interact (coevolve).

As with genetic adaptations, if we want to understand cultural adaptations we have to understand how the frequencies of different "culture-types" evolve in a population over time.

D. What is the Relative Importance of Culture?

How important is culture relative to genes, individual learning, and other environmental effects in explaining behavioral variation in humans? We will take it for granted that genetic variation explains very little of the behavioral variation in humans, particularly the variation between human groups. (Data like Scarr's alluded to above suggest that the genetic variation between races for IQ is negligible, but that there is some genetic variation within races for this trait.) However, it is possible to believe that there is not much heritable cultural variation. The sociobiologist R. A. Alexander has argued that cultural transmission is relatively unimportant. He hypothesized that people choose or invent whatever culture they need and are never dependent on merely imitating others.

The importance of culture is assumed by anthropologists to be huge, but do they have any empirical proof? One of the best studies on this topic was done by the psychological anthropologist Robert Edgerton (1971). He surveyed a long list of attitudes in four East Af-

---

[3] How is it that culture can evolve more rapidly than genes?

rican tribes. Each tribe included *both* a horticultural and a pastoral group. He asked a sample of people from each group to tell little stories about pictures he gave them, for example a father confronting a misbehaving son. Then he coded their responses in categories like “attitude towards authority.” To his surprise, the ecological difference between groups within a tribe explained much less of the variation for most variables than did the tribe to which people belonged, though there were usually small departures toward a common set of attitudes for pastoralists and horticulturalists. In his study, all the pastoralists were very open about conflict with their neighbors, compared to horticulturalists who are very diplomatic and whose hostility is repressed. This is presumably because pastoralists who are angry with someone in their camp can easily pick up and move, while the horticulturalists are forced to stay put because they own valuable land in the village and cannot easily get new lands elsewhere (these are highland cultivators of rich soils, not shifting cultivators). What surprised Edgerton is how few attitudes reflected the ecological pastoral/farmer difference, and how many, like attitudes to military prowess were determined by tribal history.

How does this square with Alexander’s assertion that cultural transmission is relatively unimportant? The groups within the tribes Edgerton surveyed appeared to have been separated for several generations. We may therefore infer that, in the short run, cultural tradition was ***more*** important than individual or group choices, decisions, and learning. But over the longer run, changes were accumulating. This is consistent with an evolutionary model of cultural transmission. It is *not* what we would expect if people could quickly and easily choose new behaviors for new environments as Alexander’s hypothesis states. Cultural evolution is most like genetic evolution when individual decisions or inventions are hard and costly to make. For example, very few of us could invent calculus just because we needed it, although most of us can acquire it culturally (though this admittedly requires considerable effort and motivation for most of us!).

There are not as many critically controlled studies like Edgerton’s as one would like. All too many social scientists of culture have been content with the argument that cultural explanations are good and genetic arguments bad, and they have neglected such investigations. Recent studies by behavior geneticists (Eaves, Eysenck, and Martin, 1988) have suggested that there is more genetic variation for personality variation than anyone would have suspected a few years ago. So far, these data have not gotten the cultural anthropologists as excited as they should be.

III. Structural Properties of Culture

A. Structural Properties of an Inheritance System are Crucial

Structural properties of an inheritance system are crucial for understanding how it evolves. By “structure” we mean the pattern of transmission from one individual to another. Figure 11-1 sketched the structural properties of both cultural and genetic human systems of inheritance in the form of a life cycle diagram. The genetic system of inheritance is structurally variable, and this variation affects how genes evolve. Haploid organisms will respond differently than diploid, sexual organisms differently than asexual, large populations will respond differently than small, some kinds of population structure may lead to group selection, etc. How are the structural properties of culture different from genes? Are the differences likely to be interesting and important?

B. Major Structural Differences Between Genes and Culture

There are four major structural differences between genes and culture. Understanding these structural differences is the key to understanding how the list of forces that act on culture has to be modified and expanded beyond those we considered for genes. As we said, structural properties of an inheritance system are crucial to understanding how it evolves.

> 1. *The cultural “mating system”:* In the case of culture, teaching and imitation are not restricted to just one or two parents. People frequently imitate many others besides their biological parents, though parents are typically very important, especially in primary socialization. We will call transmission from biological parents *vertical* transmission and from non-parental adults *oblique* transmission[4]. These terms are borrowed from epidemiology, where they describe patterns of disease transmission. In fact, as we shall see, the transmission of infections is a pretty good partial analog of cultural transmission and gene-culture coevolution. Many important evolutionary effects stem from the non-parental transmission that culture makes possible.
>
> 2. *Cultural “generation length” is variable:* The length of cultural generations can be longer than biological generations rather than shorter. People not only imitate their parental generation, they also imitate peers, slightly older children, grandparents, and long-dead sages and prophets[5]. *Horizontal transmission*—transmission of cultural information within a generation—is perhaps the most important and interesting type of transmission. Intra-generational imitation of this sort is not possible under genetic transmission. On the one hand, imitating your peers may be the best way to keep up with the times. On the other, horizontally transmitted culture is quite analogous to microbial pathogens. Heroin addiction, for example, spreads from friend to friend during the period of the addiction before the addict becomes seriously dysfunctional. This cultural “pathogen” spreads in a way that is analogous to the way a disease (e.g., mononucleosis) that has a short generation time spreads from host to host. Presumably, not all horizontal transmission is pathological. (Although it is often

---

[4] These descriptions fit the direction of the transmission arrows in Figure 12-1.

[5] Give some examples of each type of transmission.

difficult to convince parents of teen-age children of this!) Horizontal transmission is important because it allows faster evolution, but exposes people to the risk of evolved cultural “parasites” that we will discuss later.

3. Cultural transmission is sequential. Cultural transmission does not even begin until genetic transmission is complete. Then you acquire your culture in dribs and drabs over a span of many years. Some of us figure we’re still learning at 40+. As we shall see, this difference is important because it allows for decision-making rules one acquires early in life to affect later cultural transmission.

4. Culture is acquired by directly copying phenotype. Genes are segregated into the germ line early in development, and are unaffected by what happens to phenotypes[6]. As we’ve already seen, culture has the property of allowing us to inherit acquired variation**.** This property is important because it allows individual and social learning to interact. Being able to inherit acquired variation is one of the prime advantages of having a cultural system of transmission to supplement genes.

IV. Forces of Cultural Evolution

We would like initially to try to make a complete taxonomy of the possible micro-evolutionary processes, without regard to which ones are most powerful, or how they link up with genes. What are all the processes we can think of that might cause a particular cultural variant to increase or decrease in a given environment as people acquire variants, use them and become available for imitation? What should be the main gain and loss categories in our cultural evolution account-book? What are the main ways that a new variant can arise in a cultural group? Among pre-existing variants, what sorts of processes could conceivably affect which variants increase or decrease over time relative to others? We’re just going to apply a little population thinking to classify the immense complexity of cultural processes into a few basic kinds.

An understanding of what these forces of cultural evolution are, and how they function, will allow us to examine a wide variety of perplexing and interesting problems with human behavior. Some examples are: high fashion, conflict between ethnic groups, overpopulation, anthropogenic[7] environmental degradation, male aggressiveness, child rearing styles and strategies, adolescent dating behavior, crime, etc.

---

[6] There are two types of cells: (a) germ plasm cells from which gametes (sperm and ova) are formed, and (b) somatic cells which form the rest of the body.

[7] caused by humans.

Here is a hierarchical list you can refer back to for an overview.: After you read the following sections, come back to this list and explain what each force is and how they differ from one another. You must master this information; it essentially forms the language in which the rest of the course will be conducted.

THE FORCES OF CULTURAL EVOLUTION:

- **A. Accidental Variation**
- **B. Cultural Drift**
- **C. Decisionmaking Forces:**
  - **1. Guided Variation:**
  - **2. Bias Forces:**
    - **a. Direct bias**
    - **b. Frequency dependent bias**
    - **c. Indirect bias**
- **D. Natural Selection**

A. Accidental Variation— “Cultural Mutation”

It is unlikely that cultural variation is error free. There must be some variation created by accidents during transmission or in remembering. These errors will result in a certain amount of random variation being injected into the population each generation. Language is a good example. When linguists carefully examine our speech, they find that each person has a unique micro dialect (ideolect), presumably because of minor errors in imitation. Richerson says for***ward*** instead of the standard ***for***ward in the context of using the word as a verb as in “forward my mail, please.” Another example (unfortunately) of accidental variation can be seen each quarter at exam time: we attempt to communicate new cultural information to you; you try to acquire that information; yet when we test how well this cooperative task has been accomplished, *some* level of error is almost always seen. We may mis-state or misexplain the information, or you may get the wrong idea or forget. Accidental variation creates new ideas, but unsystematically. If it were the only evolutionary process, cultural would gradually be corrupted by the accumulation of mostly useless mistakes.

B. Cultural Drift

Recall that sampling errors in small populations can substantially affect frequencies of genes[8]. Similarly, an idea can be lost by accident, since the only person who knew it might die before anyone imitated him/her. The ecologist Jared Diamond (1978) has pointed to a possible example of the effects of cultural drift. It seems from the archaeological evidence that on the Australian island of Tasmania native peoples originally arrived with a moderately sophisticated tool kit at a time when lower sea level connected Australia to Tasmania. After the Tasmanians were isolated 10,000 BP, many items, including seemingly useful ones like boats, gradually disappeared. On a small island with relatively few inhabitants, it is easy to imagine that chance would occasionally lead all boatbuilders to die before they were imitated during some generation, or for similar accidents to lead to the loss of rarer skills. We call it "drift" because, while sampling error can make the frequency of a trait increase or decrease over time. Drift alone has a tendency to reduce variation within populations, but increase variation between populations. You can see why, no?

Cultural drift can be important in populations with a high head count because the human division of labor is so extreme, and because of "many to one" transmission. Even large populations tend to have specialists of various kinds; these are in effect small sub-populations. As Cavalli-Sforza and Feldman point out, there are often only a few opinion leaders in a society, and those leaders may have a very large cultural influence. In both cases, the sub-population relevant to a particular set of cultural traits can be very small and subject to chance events.

C. Decision-Making Forces

People are not entirely passive imitators. We learn for ourselves, and select whom and what we imitate from others. We modify the culture we receive by conscious or unconscious decisions we make. Then potential imitators who observe us observe the modified rather than the original traits. Until recently we have had no hope of deliberately engineering our own genes, but we can, to some extent, engineer our culture. The closest analog of cultural decision-making forces is mate choice. To some extent, you can engineer the genes of your kids by choosing a mate with certain genes, but this is a one-shot decision, and little complex tailoring is possible, compared to the cultural case.

You have a lot of kinds of decisions you can make about adopting or not adopting a

---

[8] Take the example of a population with, say, 20 couples where only two individuals carry the gene for red hair. If mating is truly random, the red hair trait will be conserved at about the same level over time. However, any accident that involved those two would remove the red hair variant from the population. Small sample size can be as important for populations as it is for researchers.

particular cultural variant. Hence there are several decision-making forces. They all depend upon the sequential transmission property. Before an individual can make decisions, there has to be an individual. In the case of genes, the fact that we get them all at once, and that the germ line of cells that will become the gonads are segregated early, means that it is mechanically difficult to see how an embryo's "decisions" could affect its genes. But it is easy to see how it works in the cultural case. Even infants have surprisingly active little minds. They pay attention to some things and not others, and like some things and not others. It is easier to learn to like ice cream than pickles and peppers.

Decision-making forces are derivative forces; to have a really satisfactory theory, we must explain where the rules that people use to make decisions come from. If decisions are to be other than random, they must depend on rules. So individuals first have to acquire rules before they can exercise a decision-making force. These rules may be genetic (senses of pleasure and pain, for example), or they might be cultural (religious or ethical rules that, for example, make certain potential items of diet seem disgusting). This makes the evolution of these forces a bit complex to think about, because we must attend both to what the rules do to other traits as well as where they come from (e.g. are they rooted in genes or culturally transmitted).

The decision-making forces are important because they are not present in the genetic system. The ability to use decision-making forces is (a) what causes culture to be a useful system from the point of view of genes, and (b) provides a wonderful set of complexities and twists of the evolutionary process to entertain us in subsequent chapters. Here is an overview:

> *1. Guided variation*: This is the most basic decision-making force, formed by adding individual learning to the social learning of culture. Trial and error learning or deliberate invention will generate variation nonrandomly (contrast with random variation), and acquired variations can be transmitted. This is a directional force, if environments change, cumulative individual learning could cause the evolution of new adaptations. (Or it could be a stabilizing force as people who imitate the errors of others correct them by learning.)
>
> *2. Bias forces:* You do not have to invent new variants for yourself in order for decision-making rules to have an effect. You can also be a smart imitator, choosing to imitate some preexisting traits or individuals you observe over others. Just as tastes, pleasures and pains can guide learning and strategizing, they can guide cultural acquisition. In general, it is probably much easier to bias imitation than it is to discover useful new variants for yourself. Thus, bias forces are perhaps usually more powerful than guided variation. There is also a technical difference of some importance here. In the case of guided variation, individuals are creating their own variation, and the rate of evolution can be rapid even if we start with no initial variation. The bias effects, like natural selection, work best when there is plenty of variation to observe. As an example

of bias, all other things being equal, it is much easier to transmit being sexually active than being a celibate nun or priest, because of the bias imposed by sexual pleasure. Perhaps you have heard of the Shakers, who attempted, starting in the 1830s to create a society of celibates. They are famous for the furniture, but not for being a large group! The contrast with the pronatalist Mormons, who started in the same frontier revival outburst, is striking. On the other hand, if celibates have great prestige and influence because of their role in an important religion, people may choose to imitate them despite the pleasure principle. To reiterate, *biased decisionmaking is a force that DIRECTS the evolution of human culture.* In this sense, it is a little like natural selection. New cultural adaptations can arise by decision-making effects, as we saw in the last chapter.

There are three rather distinctive types of biases:

a. *direct bias:* Here a person decides whether to adopt a cultural trait on the basis of the trait itself (e.g., try out celibacy and active sex, choose whichever you find more pleasurable).

b. *frequency dependent bias*: Here a person prefers to adopt whichever variant is most common (e.g., conform to the majority choosing either celibacy or sex depending on what most of your friends do.)

c. *indirect bias*: Here a person uses one trait to select someone to use as a role model, then copies other traits from the same individual indiscriminately (e.g., if the most impressive person you know is a celibate, you might choose to imitate many aspects of her behavior and pick up celibacy as a troublesome by-product.)

A hypothetical example may clarify these abstract definitions. Say you are a farmer newly arrived in the American West ca. 1875. You must produce enough food each year to support your family of six. If you fail, it is likely that at least some of your children will die from malnutrition or disease during the long hard winter. The problem with which you are faced is this: how to increase the amount of food your family produces?

Guided variation: In this case, you might roam around your land, trying to figure how to improve food production by personally testing the natural plants and wildlife. You find a wild grain that seems edible and hardy, gather some, give it a taste test, then plant it to see if it can be cultivated. If you succeed, your innovation adds to the number of cultural variants (in this case, the number of different ways in which one can raise food crops). However, if you fail, the effort spent on figuring all this out and trying a new crop may be the margin that leaves your children starving come February. Developing new cultivars is in fact rarely done, presumably because it is an awful lot of effort, though folk breeders very commonly develop local varieties of old crops.

direct bias: You could borrow some cultivated plants from neighbors, observing which seem likely to be suitable for your farm, and which not. You might plant a few test plots, try to give them equivalent water, manure, etc., and compare the yields. Since your family's lives are on the line, you would probably do this several different years in a row—if you had all the extra time and resources to experiment. In spite of your thoughtful analysis, there is still substantial potential for error, not to mention the cost of all the trials.

> *frequency dependent bias:* You can plant the same crops as the majority of your neighbors. By and large, this is usually a safe and effective strategy for decisionmaking. Although you may not gain the extra margin of productivity that a new type of crop tailored to your own farm could give, local experience with the majority strategy indicates that your family is unlikely to starve either. If the local common strategy was terribly bad, the local folks would likely have already starved out.
>
> *indirect bias*: Here you use some indicator of success to choose one of your neighbors as a model. For instance, you might choose the person who owns the biggest farm and nicest house in your region as your model[9]. You then plant whatever that person plants, use the cultivation techniques they use, store your produce in the same kind of root cellar, etc. Presumably, he has the biggest farm and nicest house because he has the best way to farm for the area figured out. Of course, this strategy has its problems. Perhaps the most apparently successful farmer was lucky in his choice of land, inherited money, or has defrauded his banker. Frequency dependent and indirect bias are cheap and easy, but are perhaps not usually as accurate as doing the work to figure out the best crop directly for yourself.
>
> *no decisions, depend on tradition*: You could do exactly what you did back East where you came from and hope it worked well enough in the West.

Anglo settlers in the West did all of these things, but the successful ones tended to rely upon indirect and frequency dependent bias, at least at first. Hispanic settlers could often depend upon tradition, for they came from Spanish and Mexican farm traditions already reasonably well adapted to the arid and Mediterranean regions of the West. Western farming and ranching, of course, has quite recognizable Ibero-American features.

D. Natural Selection of Cultural Variation

It is many people's intuition that natural selection does not apply or cannot be important in the case of cultural variation. This isn't necessarily so. All Darwin's mechanism of natural selection requires is heritable variation for something important to people's lives. Take our case of farming in the America. In the 19th Century, several different ethnic groups pioneered in the Midwest in the mid-19th Century. According to rural sociologist Sonya Salamon (1985), even today, different cultural traditions regarding farming are maintained by these groups. For example, Anglo-Americans treat farming as a business. If they can't earn a good living, they quit farming and take up other occupations. German-Americans, on the other hand, brought a certain European peasant attitude to Illinois. They consider farming to be a much better way to make a living than any other job. They will accept small incomes to remain farmers, and take much more active pains to set their kids

---

[9] In contemporary times, you might choose the person who has the most expensive new car, or most fashionable clothing, or fanciest house, or best looking spouse, etc.

up in farming. Not surprisingly, German farming communities are declining much less rapidly than Anglo, and the rural scene is gradually becoming dominated by Germans. People don't decide to be Anglo or German in farming attitude (at least this is small effect according to Salamon). It is just that culture has effects, and as a consequence some ideas increase at the expense of others. If Salamon's data is correct and the basic situation doesn't change, the Amican Midwestern farm belt will one day be entirely dominated by people with German peasant attitudes toward land ownership.

E. Individual versus Population Effects (Again)

Can you think of any more basic forces that might act on culture? Some others have been suggested, but we think they are relatively minor in importance or just variants of the above.

When you think about the evolutionary forces acting on culture, it is easy to see the differences between potential individual-level consequences but it is also important to pay attention to population-level effects. At the population level, consider the ways in which these ***"forces"*** *bias the evolution of culture over time*. In the example just discussed, think about the manner in which the population-level distribution of different variants for raising food crops among all the farmers in the region might be moved over time depending upon which decision-making rules are employed and how often. The idea is that the effects of individual decisions are cumulative if there is imitation. Even if only a few individuals each generation use only a little direct bias and guided variation, these activities will improve the pool of knowledge that is accessible to the population as a whole. Indirect bias, if it works right, can spread good ideas from one smart or hard-working individual to a number of others. By sequential improvement over many generations, very sophisticated adaptations can be built up gradually. Cultivated plants like wheat are the result of this long, cumulative improvement by many individuals over a long period of time. This is possible with genes or culture, but not with individual learning, where the knowledge gained by each learners disappears from the population when the individual dies. In the long run, the population level effects of transmitted information can be enormous, even if what happens at the individual level seems very unimpressive, say modest half-hearted attempts to collect seed wheat from superior plants. Contrariwise, without population level effects, impressive individual feats of learning lead nowhere in the long run.

V. Evolutionary Origins of Culture

A. Guided Variation and Direct Bias as Sociobiological Forces

As we mentioned in the last chapter, the basic rule-guided forces of cultural evolu-

tion are forces that link cultural evolution to genetic evolution. Imagine that selection works on the basic neurophysiology of human perceptions, senses of pleasure and pain, and so forth. These may be mostly coded by genes. Senses of pleasure and pain and so forth in turn certainly act to reinforce some behaviors and extinguish others. If you invent a behavior that is pleasurable, or observe someone else doing something that seems pleasurable when you try it, you are very likely to adopt it. The opposite is true if it is painful. Although we can all think of exceptions, most pleasurable things tend to enhance your fitness, and most unpleasant ones reduce it. For example, socializing with the opposite sex under pleasant circumstances is fun and will tend to improve your fitness, if one thing leads to another (more fun!). Thus, even the most puritanical cultures have a very difficult time suppressing the customs associated with the "mating game." This idea is the entre into investigating the way in which culture confers or does not confer advantages on a culture-bearing organism. Once we can link cultural and genetic evolution, we can study the *coevolution* of the two systems.

B. The Origins Problem

The main question is why bother with culture at all? Most animals don't. Only humans make massive use of culture. If the function of culture is just to increase genetic fitness, why not just adapt directly using genes, and forget the clumsy intermediary of culture? One could avoid long harangues from Mom and Pop, endless lectures and homework, and get straight to life's real work, eating, staying warm, making love, and raising children. Most big animals can reach sexual maturity in 18 months or so. All else equal, such creatures should easily outcompete an animal that takes 18 years! It is useful to look at culture as a problem in this way lest we just make the anthropocentric assumption that humans are just better. That really doesn't answer the question.

If culture evolved under the guidance of natural selection, it must not just do what genes could do for themselves, it must also have some positive advantages. To simplify the problem to a manageable level, let's imagine we start with a conventional mammal, that can learn for itself, but has only a very modest capacity for social learning. *Under what conditions will selection on the brain favor an animal that makes more use of social learning?* We'll proceed in two stages, first trying to figure out how social and individual learning should be balanced, then turning to the issue of the role of genes.

What are the advantages and disadvantages of individual learning? In general, the advantage of individual learning is flexibility, but the cost is that the evaluation process is costly and error prone. For example, if all red, round objects are good to eat, and nothing else is, it makes sense to save time and effort sampling oval red objects and round green ones and just depend on a “round red, eat” instinct. But if fruits come in various colors and shapes in different environments, then a good deal of sampling may be required to find out what is edible. But, if individuals are too influenced by experience, mistakes will be made. Instincts can be perfected by cumulative evolution, something not open to pure individual learning. The chance tasting of a few distasteful red fruits may cause their rejection even if the majority of such fruits are nutritious. One can take larger samples, and have fancier discrimination apparatus (more and fancier senses or elaborate statistical techniques), but all this is costly in terms of time and effort that could be devoted to growth and reproduction. Thus, it makes sense to inherit a basic idea of what is good to eat, and use learning to fine tune things. Our genes, perhaps, tell us: “Red, soft, sweet fruits are generally good to eat, eat them unless strong experiences (e.g. frequent sickness) indicate otherwise. Other colorful fruits also tend to be advertizing palatability to all comers (they want you to disperse their seeds), and are worth a try. Still other fruits are likely to be trying to avoid being eaten because they are not ripe, are interested in specialized dispersers, etc. Green, brown, and black fruits tend to be defended by tanins and poisons and are to be avoided or sampled with care. You figure out the details.”

What if we add the possibility of socially learning as a substitute for individual learning? Personal experience, and the behavior of Mom and Pop, are both potential sources of information about the right way to behave. You can mix and match. Suppose you look to Mom and Pop for an initial guess about what fruits are good to eat and then do some sampling on your own. How much weight should you give to the initial guess from Mom and Pop, and how much to your own experience? They say tomatoes are poison, but they taste all right to you. If selection can act on the genes that control how culture and individual learning are mixed, how would we expect the relative dependence on individual learning and social learning to evolve? Given that some individual learning is possible, when is it an advantage to evolve the capacity to transmit some of this learning to the next generation by imitation? The answer is relatively commonsensical. When individual learning is relatively error-prone (or when it is very costly to reduce these errors) it is useful to rely mostly on tradition. The answer also depends on the rate of change in the environment. When environmental change is slow, not much individual learning is required to keep populations near the optimal behavior, and a strong dependence on tradition is favored. In rapidly changing environments, one should think for oneself. The graph in figure 11-3 below illustrates this general pattern.

The second very important question is: *when should the individual inherit its initial guess about the state of the environment culturally and when genetically?* Should you use

Mom and Pop's genes, or their culture? The advantage of culture in the model we are considering is that the *learned behavior* of the parents can be transmitted to their offspring as the offspring's *initial guess* about what to do in a particular situation[10]. This is the inheritance-of-acquired variation difference between culture and genes. Will this not always be an advantage relative to genetic transmission? Or, when nearly pure tradition is favored, would it not be better to use the genetic system to transmit "initial guesses" about the environment, and forget about culture? (Remember, many animals have extremely complex behavioral repertoires which are transmitted almost exclusively via genes.) As transmission systems, genes and culture serve the same function, genes probably have the advantage of lower random error rates, and do not depend on a long, costly period of socialization. In contrast, culture can take advantage of the inheritance of acquired variation (and has other special properties, as we shall see). How might selection on genes trade off among these advantages and disadvantages to "design" an optimal mix of genetic transmission, cultural

---

10. For example, many contemporary middle class parents in this country teach their children that it is wrong to settle disputes by yelling & screaming or physical force. A young person who is out on his/her own for the first time may initially use this behavioral pattern when deciding how to settle a disagreement. After leaving home and moving into a tough neighborhood, however, they may decide that it is better to talk tough and hit first when confronted. The grandkids will then get "tough" as an initial guess.

transmission, and individual learning?.

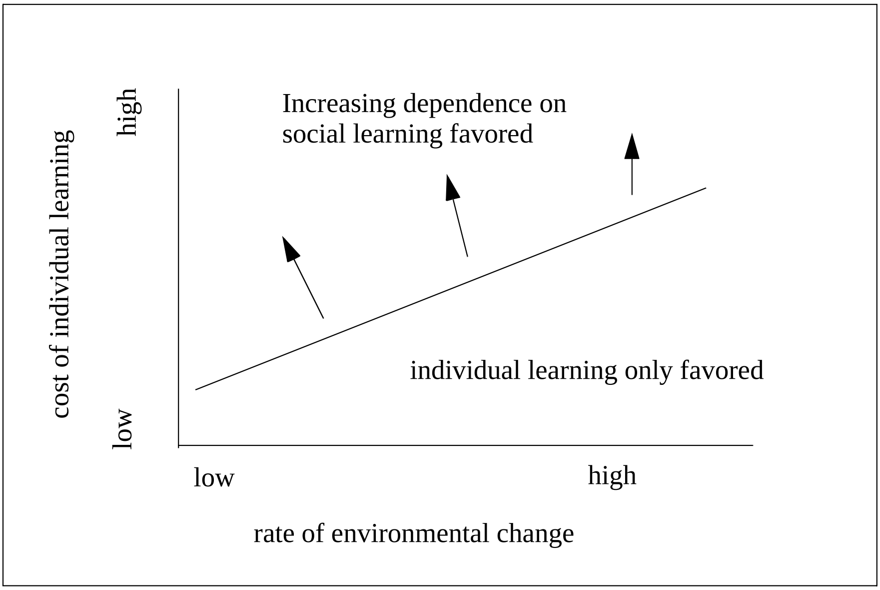


Figure 11-3. Shows a diagrammatic trade-off line describing when individual learning or social learning is favored. When the cost of individual learning is low and/or the rate of environmental change high, individuals should learn for themselves. Social learning (cultural transmission) is favored by slow environmental change and/or high costs of individual learning.

The basic logic of this trade-off has been worked out with mathematical models: Under what kind of environments would three alternative systems of inheritance and learning be favored by natural selection: (1) pure individual learning with fixed genetic initial guesses that do not evolve, (2) individual learning with cultural transmission of the initial guess, and (3) individual learning with genetic transmission of the initial guess. In case 2, both guided variation and natural selection could influence the evolution of the initial guess. In the third case, selection on genes could only influence the initial guess. In all of these models it was possible to study the *evolution* of the relative reliance on the inherited initial guess and individual learning. Boyd and Richerson (1985: Ch.4) imagined that the environment varied through time, but at different rates. When the environment changes slowly, the environment experimented by offspring are only slightly different from those experienced by their parents; when it changes rapidly, the environment of parents is very unlike that of their offspring.

The answer again is pretty commonsensical: *When environments change very rapid-*

ly from generation to generation, but without any overall trend, any form of information derived from the experience of parents via learning or selection is useless. In this situation, the fixed learning rule is best. Any evolutionary response of the initial guess is detrimental when parents' and offspring's environments are utterly different. It is best to have a fixed genetic starting point, and depend upon your own experience.

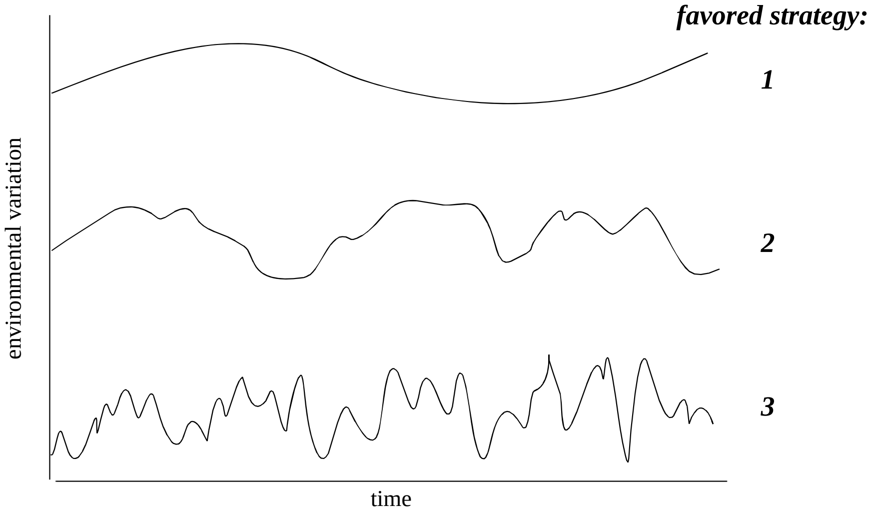
When environments change very slowly, selection on genes causes the genetically transmitted guess to track the environmental change almost perfectly, and any individual learning is disadvantageous because of the extra costs and errors caused by learning. Either a faithful adherence to cultural tradition or the genetic transmission of a high-confidence initial guess is favored. Since, individual learning aside, cultural transmission is itself somewhat more costly and error-prone than genetic transmission, in reality this presumably means that slowly changing environments favor "instincts" that evolve slowly.

When environments change at moderate rates, the inheritance of acquired variation is a virtue. Cultural transmission can track environmental change faster than genetic transmission because both guided variation and selection are acting together. There is a balance between the higher error rates due to transmitting the mistakes of individual learning, which handicaps culture in a slowly changing environment, the uselessness of depending on Mom and pop in very fast-changing ones, and the saving of individual learning effort and faster tracking of change that are the benefits of culture. Figure 11-4 illustrates these relationships.

These results suggest that cultural transmission with relatively strong traditions and weak individual learning ought to be favored in many environments of the moderately variable type. Perhaps Bacon's disparagement of tradition as quoted in the epigraph was a bit too hasty! In many kinds of environment, it may well pay not to think for yourself, but simply depend upon tradition. Of course Bacon lived at a time when rates of change were accelerating due to our own discoveries. The world was moving from more like type 2 in the direction of type 3 environments, and the need to depend more on individual experience and less on tradition turned out to be the right answer.

Although the mathematical model from which these conclusions are drawn is very basic, we think that this analysis illustrates in a general way the evolutionary advantages and disadvantages of culture. Social learning, because it is a means of the inheritance of acquired variation (and thus makes a place for forces like guided variation) can more easily track temporarily varying environments. In environments that vary moderately, this is a strong enough advantage to overcome the costs of depending on culture, of which we have only discussed the risk of making learning errors so far. Thus, a theoretical analysis of an

Figure 11-4. In what kinds of environments would three alternative systems of inheritance and learning be favored by natural selection?



Best Strategies in Three types of Environment:
1. Individual learning with genetic initial guesses that track slow change.
2. Individual learning with cultural transmission of the initial guess.
3. Individual learning with fixed instinct for the initial guess.

evolutionary process can give us some idea of how this rather odd adaptation (cultural transmission) might have arisen in the hominid past. It also suggests that humans are basically weeds, adapted to exploit rapidly changing environments with a potent, flexible mix of individual and social learning. We'll revisit this question in Chapters 24 and 25.

VI. Conclusion

By following the idea of "population thinking" one can construct a taxonomy of the kinds of structural variation in transmission and the kinds of evolutionary forces that might affect culture. Because of the general resemblance of the two systems of inheritance, the evolutionary mechanisms influencing culture and genes are roughly analogous. However, the analogy is far from exact, and several of the structural possibilities in culture do not exist in the genetic system. Furthermore, there is no parallel in genes for cultural decision-making forces.

Relative to the more common system of using only genes plus individual learning employed by almost all other organisms, there are evolutionary advantages to a system of cultural inheritance, but only in certain kinds of environments. Most of this advantage seems to arise from using imitation to cut the costs of individual learning while preserving much of the flexibility conferred by learning. It is this flexibility that enables us to meet the challenges of a variable environment. If this is the whole story, it is still something of a mystery why humans are unique in using so much culture. Were we just lucky to achieve this elegant adaptive breakthrough, or is there something wrong with culture we haven't discovered yet? We turn to this question in the next chapter.

VII. Bibliographic Notes

References:

Alexander, R. D. 1979. *Darwinism and Human Affairs*. Seattle: Univ. of Washington Press.

Campbell, D. T. 1965. Variation and selective retention in sociocultural evolution. In: H.R. Barringer, et al (eds.). *Social Change in Developing Areas*. Cambridge Mass.: Schenkman.

Basalla, George. *The Evolution of Technology*. Cambridge: Cambridge University Press.

Cavalli-Sforza, L. L. and M. W. Feldman. 1981. *Cultural Transmission and Evolution*. Princeton: Princeton Univ. Press.

Diamond, J. 1978. The Tasmanians: The longest isolation, the simplest technology. *Nature* 273: 185-6.

Durham, W. H. 1991. *Coevolution: Genes, Culture, and Human Diversity*. Stanford: Stanford Univ. PRess.

Edgerton, R. B. 1971. *The Individual in Cultural Adaptation*. Berkeley: Univ. of Calif. Press.

Eaves, L.J., H.J. Eysenck, and N.G. Martin. 1989. *Genes, Culture, and Personality. An Empirical Approach*. London: Academic Press.

Lincoln, R. J., G. A. Boxshall, P. F. Clark. 1982. *A Dictionary of Ecology, Evolution and Systematics*. Cambridge: Cambridge University Press.

Lumsden, C. and E. O. Wilson. 1981. *Genes, Mind, and Culture*. Cambridge: Harvard Univ. Press.

Nelson, R. R. and S. G. Winter. 1982. *An Evolutionary Theory of Economic Change*. Cambridge: Harvard Univ. Press.

Pulliam, H.R. and C. Dunford. 1980. *Programmed to Learn: An Essay on the Evolution of Culture*. New York: Columbia Univ. Press.

Salamon, S. 1985. Ethnic Communities and the Structure of Agriculture. *Rural Sociology* 50: 323-40.

Scarr, S. 1981. *Race, Social Class, and Individual Differences in I.Q*. Hillsdale, N.J.: Erlbaum.

Chapter 12. NATURAL SELECTION ON CULTURAL VARIATION

> (a) Experienced weather forecasters, when performing their customary tasks, are excellently calibrated. (b) Everybody else stinks.
>
> Paul Slovic, behavioral decision theorist, 1977

I. Introduction

A. Review of the Sociobiological Hypothesis

The sociobiological hypothesis is an extremely important point of reference. It proposes a solution to the genes-culture problem, namely that cultural transmission is a means to cut the cost of individual learning in spatially and temporarily varying environments. The decision-making forces (reviewed in the inset which follows) can, and presumably to some extent do, act as a “leash” constraining cultural variation to serve the ends of genetic fitness. If this hadn’t been so, how could complex capacities for culture have arisen in the hominid lineage? Natural selection is the only known process that can “create” such an adaptation. Notice also that the sociobiological hypothesis gives us a clear picture of how ecological and evolutionary processes are integrated again via the decision-making forces. Even weak decision-making leads to adaptive traits in the long run.

THE FORCES OF CULTURAL EVOLUTION:

- **A. Accidental Variation**
- **B. Cultural Drift**
- **C. Decisionmaking Forces:**
  - **1. Guided Variation:**
  - **2. Bias Forces:**
    - **a. Direct bias**
    - **b. Frequency dependent bias**
    - **c. Indirect bias**
- **D. Natural Selection**

B. Potential Problems

So far, the sociobiology hypothesis does not say anything about the large scale co-operation and the elaborate use of symbols. When one considers these two basic aspects of human behavior, they often fail to look fitness maximizing adaptations at the individual level. Although, as we'll see in the next two chapters, sociobiologists have some arguments about this, it remains a major weakness in their hypotheses.

Complications can arise due to the costs of making decisions. In illustrating the sociobiology hypothesis in the last chapter, we only considered the effects of the most costly decision-making forces, guided variation and direct bias. If individual decision-making is costly, there will be much transmission of culture, causing culture to act as an inheritance system. Recall from the last chapter that when the individual learning part of guided variation is very strong, imitation has virtually no effect. A dependence on tradition is favored when individual learning is costly ***or*** error prone. (Note that these are very similar variables, since we could presumably always decrease the error of learning by raising the costs devoted to sampling and thinking.)

As the tendency to depend on tradition rises due to weak decisions forces, the cultural system will begin to preserve ***heritable cultural variation.*** For cultural variation to be considered heritable, it must depend upon accidents of who you imitated, not on your own decisions. Contrariwise, when the decision-making effects are strong, little behavioral variation depends on who your cultural "parents" were and more depends on how you see the environment. Consider direct bias. If you consulted a large range of models, and carefully evaluated all their alternative behaviors before choosing the best one for you, your behavior would not depend very much on who your models were. As the range of models you consult before making up your mind increases, and as the thoroughness with which you evaluate each one increases, the likelihood that your behavior will reflect the environment you are in rather than the models you happened to consult also increases. In the most extreme imaginable case, you might very carefully determine what sort of environment you are living in, then go to a big library and do very careful research to determine exactly the optimal behavior in that environment. This could be an awful lot of work. On the other hand if you observe only a few models and do not exercise strong bias, your behavior will most likely depend on happenstance; i.e., it will depend on who was available for you to choose as a model. While this isn't terribly analytical, the effort involved is modest. In the latter case, much heritable variation can be preserved. This heritable variation due to light use of costly decision-making strategies does not directly impugne the sociobiology hypothesis, but it does mean that other forces besides guided variation and direct bias play a role in cultural evolution.

Unless you acquire culture only from your biological parents and transmit only to your children, there is a potential conflict between your genetic and cultural fitness. If there is heritable cultural variation, natural selection will act on it, in theory with quite startling results as we'll see a bit later.

> ***Unless you acquire culture only from your biological parents and transmit it only to your children, there is a potential for conflict between your genetic and cultural fitness.***

Thus we cannot rest content with the sociobiological hypothesis, as attractive as it is. Guided variation and direct bias forces will unambiguously yield the simple sociobiological hypothesis when they are strong. But there is plenty of evidence that we humans do not employ strong decision-making techniques before we adopt cultural traits. We are sloppy shoppers in the marketplace of ideas, probably because the cost of making sophisticated decisions about our whole immense cultural repertoire would be overwhelming. We can be good Baconians, but only at considerable cost and over a narrow range of behaviors, as Slovic's epigraph suggests. Slovic's statement is a summary of a large experimental literature on "behavioral decision theory" that appears to justify the weak decision-making hypothesis.

II. Natural Selection on Cultural Variation

A. Natural Selection Versus the Decision-Making Forces

There is no reason why cultural variation should be exempt from natural selection. Selection can be an important force whenever there is heritable variation so long as this variation has important effects on behavior. Any time we use our cultural traits we are liable to affect our life-chances. You have a certain level of commitment to school that you acquired in part from your parents and others and which others may imitate. How earnest you are in school affects your grades which in turn affect your post-university career. In your post-university career, you may have your own children to socialize, and/or you may achieve some role, say by becoming some kind of celebrity, that leads your values to be widely imitated by unrelated children or adults. Aside from the decisions people make about what to imitate, merely what happens to them as a function of their culture also has consequences.

On the argument summarized in the introduction, we must carefully consider the direct effects of natural selection on cultural variation because suspect that information is costly, and therefore significant heritable cultural variation maintained.

B. Natural Selection Versus the Sociobiology Hypothesis

If cultural variation is maintained by horizontal or oblique transmission, it will tend to evolve differently in response to selection than genes, in the extreme like a pathogenic microbe. How important is the transmission of culture from non-parents? Selection effects cause no problem for the sociobiology hypothesis if cultural transmission is symmetric (there is no non-parental transmission, and the two biological parents have equal weights). W. Durham (1979) has suggested that this is true for many basic values and beliefs. The idea here is that for cultural traits whose pattern of transmission is just like genes (i.e., from one's biological parents), culture is sort of like an extra gene as far as selection is concerned. If selection on genes normally favors traits that increase individual survival and reproduction, a cultural trait that is transmitted alongside of genes will respond in just the same way.

The complication for the sociobiology hypothesis comes if there actually is a significant amount of non-parental transmission. Selection on non-parentally transmitted cultural variation *can cause cultural adaptations to differ from genetic adaptations*. This selection can be very strong if the competition for certain social roles is intense (e.g. to be a big-man). We will see that even if the weight of the non-parental role is small, "teacher" type variants can increase even if they reduce genetic fitness.

"Teachers" can be purveyors of ideas that will reduce our genetic fitness! The easiest way to get an intuition for this problem is to adopt Richard Dawkins' model of "selfish" genes and "memes" (his term for units of culture) for a moment. You mustn't get carried away with the anthropomorphism inherent in this terminology—imagining that genes have conscious motives—but Dawkins argues that the gain in making selection more intuitive is worth the risk of being misled by the metaphor. If you've thought through the sex ratio genes on the y chromosome problem from Chapter 9 you already have the idea.

> *Here is how selection on non-parental culture can cause conflicts with genes: Suppose* an idea (meme) arises that causes a person to seek political office, become a teacher, or have ambitions for a similar role that (a) does not result directly in biological reproduction, but which (b) has enhanced opportunities for cultural transmission. Suppose also that achieving this role in a competitive world requires sacrifices, such as gifts to clients, or long, costly years in school. These sacrifices cut the ambitious person's fitness; the same resources we'll assume could be devoted to reproductive activity. If this idea can only spread via parents, it will reduce its carrier's fitness and tend to disappear by natural selection. On the other hand, suppose that being a big-man or teacher

> exposes you to many more young people than the average citizen, at least some of whom are prepared to imitate you. If this non-parental transmission route is important enough, it is intuitive that the “selfish” meme can spread even though it is harmful to the carriers’ ordinary reproductive success. Eventually virtually everyone might carry the harmful (to genetic fitness) meme.

Why will selection on genes that affect the degree of attachment to parents not fix this problem by doing away with non-parental transmission? From the point of view of the sociobiology hypothesis, this possibility seems dangerous and absurd. Consider the counter argument: There are problems with a sole reliance on Mom and Dad. One or both might die in the long period of socialization. And even if they are present, the bias forces all work better the more variants the imitator sees. If Pop is a lousy hunter or farmer, it would be nice to pick up better skills from someone else. There are considerable sacrifices implied in a sole reliance on parents especially in a slow, sequential transmission system. Thus, despite the best “efforts” of natural selection to “design” a resistant mind, a selfish meme of the type we are considering here is going to have some room to maneuver.

Once genes have created a cultural system of inheritance, they have made a sort of pact with the devil. Memes will try to slip and slide around the leashes set up by genetic decision rules to favor their own reproductive success at the expense of the genome’s. The coevolutionary trajectory may get quite complex as selfish genes and memes get locked in a partly cooperative, partly competitive evolutionary game. It is conceivable that genes could even reverse the leash. Think about what might happen if memes use mate selection to affect genes!

C. A Mathematical Simple Model

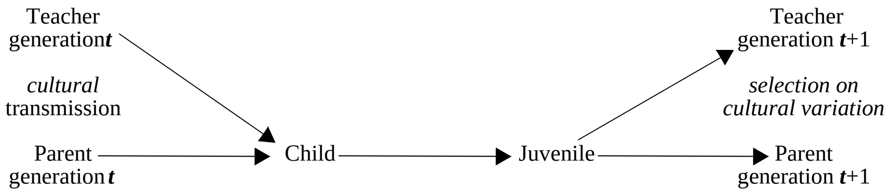
Why complicate things with all that math? As you work through the formal model that is developed in this section, many of you—as many do when exposed to this method of inquiry—will groan, roll your eyes, mutter a few expletives, and wonder “Why on earth do professors have to make things so damn difficult?” The situation we will examine here is perhaps simple enough so that you could reach the same conclusions given by the model without doing the arithmetic. However, there are strong arguments for using mathematical models to test and develop theory. Two of the most important reasons are that mathematical models: (1) hone our notoriously unreliable intuition, and (2) impose an unambiguous structure on arguments that can be readily tested. This last is particularly important because it is easy to make plausible sounding verbal arguments that, underneath, are illogical. (Examples swarm around us during an election year.) Doing the arithmetic becomes absolutely necessary to reach reliable conclusions when things get complicated. Even in the simple example that follows, the math should give you an extra bit of confidence in the argument and help you to see what selection on cultural variation really means.

The selective conflict inherent between inheritance systems with different structures can be demonstrated with a very simple model. We'll keep track of only two cultural variants, ***c*** and ***d***, and only two role models, one parent and one teacher.

We keep it very simple in order to gain insight into the operation of a process, not to make exact predictions. Engineers, economists, physical scientists, and population biologists are all fond of this technique for schooling their intuitions about complex processes. We are big fans of it ourselves. Combining the model analysis with the empirical evidence cited a bit later, we're attempting to convince you that selection is a force in cultural evolution that must be taken seriously. As is common in the more mathematical disciplines, these models are a key part of building hypotheses, in this case an alternative to the sociobiology hypothesis.

Suppose we have the following life cycle:

Figure 12-1. Life cycle with comparison of parent and teacher transmission dynamics.



Now set up submodels of component processes:

Suppose we have rules for the transmission of culture to naive individuals (children) such as are described in Table 12-1.

Explanation: In table 12-1 ***A*** can be interpreted as the weight of influence a parent wields and (1-***A***) is the weight of teachers' influence in the socialization process. As an example of how to interpret this matrix, lets put the first two rows into words:

row 1: If *Parent* has trait ***c*** and *Teacher* has trait ***c***, the probability that child acquires trait ***c*** = 1. (Remember that probabilities range only from 0 to 1.)

row 2: If *Parent* has trait ***c*** and *Teacher* has trait ***d***, the probability that child acquires trait ***c*** = ***A*** and the probability that child acquires trait ***d*** = 1-***A***.

Table 12-1. The probability that naive individuals acquire cultural trait ***c*** or ***d*** as a function of two available models, one parent and one teacher. *A* measures the relative importance of the parent in transmission and 1- *A* the weight of the teacher. Source: Richerson and Boyd 1984:431.

Trait of		**Probability that child acquires trait**	
Parent	Teacher	***c***	***d***
c	***c***	1	0
c	***d***	*A*	1-*A*
d	***c***	1-*A*	*A*
d	***d***	0	1

Now you interpret the last two rows and write in the answer below:

row 3: ____

____.

row 4: ____

____.

We need a model of transmission in population. The transmission rule above for individuals with given pairs of parent types can be combined with data on the frequencies of the two types ***c*** and ***d*** (percentage of parents and teachers with each type) in the population to scale the individual level transmission events up to what we expect to happen in the whole population using the following formula:

“Matings” with:

both parent &parent ***c*** &parent ***d*** &

teacher ***c*** teacher ***d*** teacher ***c***

$$P'_o = P_pP_t[1] \quad + \quad P_p(1-P_t)[A] \quad + \quad (1-P_p)P_t[1-A]$$

which simplifies to:

$$P'_0 = AP_p + (1-A)P_t \qquad (1)$$

Explanation: Where $\boldsymbol{P'_o}$ measures the frequency of c types in children of the next generation, $\boldsymbol{P_p}$ the frequency of c among parents of this generation, and $\boldsymbol{P_t}$ the frequency of

c among teachers of this generation. (Frequencies are just the fraction of each type in the population; multiply by 100 and you have a percentage. In typical evolutionary models, the absolute number of individuals who are of a particular type is unimportant, and it is convenient to keep track of only frequencies[1]. This equation just says that the frequency of ***c*** in the population after transmission is its frequency among parents in the previous generation weighted by their importance in transmission plus the frequency among teachers weighted by their importance in transmission; transmission is a sort of weighted averaging process. (Notice that one does not have to worry about the frequencies of ***d*** explicitly; since frequencies must always add up to 1 (i.e., 100%) and there are only two types, we can always find the frequencies of *d* because they are just 1 minus the frequency of *c*. You can begin to see why we want to keep things simple to demonstrate the bare logic of non-parental selection. Just adding another heritable type would double the number of equations without adding much to our understanding of how selection works in this case[2].

The effect of selection can be modeled like this. Let us suppose that we can measure the effect of ***c*** and ***d*** on becoming a parent or a teacher. Let us suppose that c types like to study hard and hence are likely to get good grades and jobs as teachers. Let us suppose that d types are more interested in the opposite sex. This might well lead to a markedly lower chance of ***c*** types becoming parent ($\boldsymbol{W_c}$) relative to *d* types (W_d), while *c* types have a fairly high chance of becoming teachers (V_c) relative to *d* types ($\boldsymbol{V_d}$). This leads to a pair of equations that describe the natural selection step in the life cycle, as juveniles of different types are sorted differentially into adult roles:

$$P_p = \frac{P_0 W_c}{(1-P_0)W_d + P_0 W_c} \quad , \quad P_t = \frac{P_0 V_c}{1 - P_0 V_d + P_0 V_c} \qquad (2)$$

Explanation: The terms in the bottom of the fractions just add up the total fitness of both types in getting into each role, and dividing by this number keeps everything in units of frequencies (percentages/100).

Now, a mathematical trick is invoked to keep the equation nice and simple. If one assumes that selection is weak it is OK to assume that:

$$\frac{W_c}{W_d} = 1 + w, \quad \text{and} \quad \frac{V_c}{V_d} = 1 + v \qquad (3)$$

---

[1] See Boyd and Richerson’s book, pp. 181-2 to see in detail how this works.

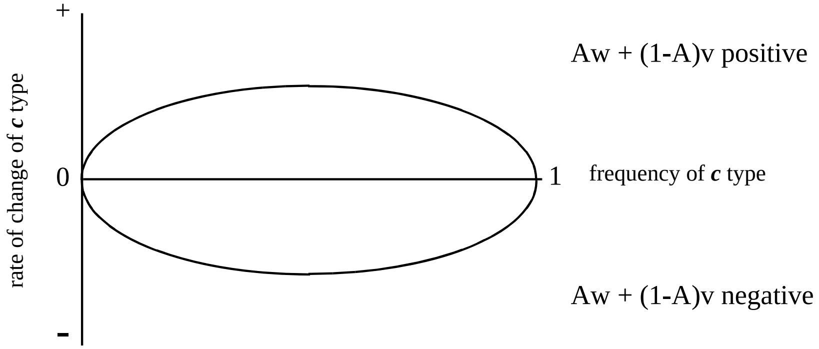
[2] The 6th chapter of Boyd and Richerson’s book employs a fair amount of gory mathematics to show that the essential point here generalizes to multiple traits and multiple parents. Consult it if you are feeling frisky.

Here *w* can be read as a small disadvantage for *c* in becoming parents, so that it has a negative sign, and ***v*** a small advantage for ***c*** types in becoming teachers[3]. The same qualitative interpretation of the following equation for the whole life cycle is correct even if we do assume selection is strong, but the answer will not be exactly correct. The simplified approximation is:

$$P'_0 = P_0 + P_0(1 - P_0)[A_w + (1 - A)v] \qquad (4)$$

The part of equation 4 after the leftmost plus represents the effect of selection in the model. Notice that if there are no forces (selection in this case), *v* and *w* both = 0, and we just get faithful copying, no evolution. Also notice that $P_o(1 - P_o)$ is 0 if the frequency of ***c*** is equal to 1 or 0, and if this term is 0, selection also has no effect. This must be since in either case there would be no heritable variation for culture to work on, and the $P(1\text{-}P)$ term measures the amount of variation in the population. All ***c*** or all ***d*** types leaves nothing for selection to work on. Assuming neither of these things is true, selection will cause either the teacher-favoring type or the parent-favoring type to increase, eventually until all individuals are ***c*** or ***d***. Which depends on whether the term in brackets is + or -, (recall that we are assuming ***w*** is negative and ***v*** positive to make the model correspond to the teacher-parent conflict case) as follows:

Figure 12-2. Graph of the Aw + (1-A)v effect.



Notice that even if teachers are not too important in cultural transmission (i.e., (1 - *A*) is smaller than *A*), the trait favored by selection on the role that transmits non-parentally can increase if *v* is enough larger than *w*. *Thus, traits that tend to reduce genetic fitness can*

---

[3] See Boyd and Richerson (1985:184-5) for details if you are interested.

spread even when parents are more important than teachers, if *c*-type traits are a big advantage in getting to be a teacher (if teachers are more highly selected than parents).

Strong selection of cultural variation may be common. This would still be pretty academic, except that cultural transmission is by its very nature prone to create situations where there is strong competition to influence others. Just because culture can be acquired by observing others' phenotypes, there is essentially no limit to the number of imitators a person in theory can have. If there happens to be some social role, such as teacher or big-man, that gives a person visibility and influence, such a person is likely to be differentially imitated. Any cultural variant that helps a person attain such a role will spread by imitation (cultural transmission). Those that do care about influencing others are probably more likely to desire such roles and get them, compared to those who are indifferent. Soon desiring such roles will become common, and competition for positions of cultural influence will become strong. Why shouldn't the desire to perpetuate your ideas (to have cultural offspring) be as strong as your desire to have actual offspring? The little model we have analyzed gives us some insight into what circumstances should favor one urge relative to the other. Figure 12-3 illustrates one of the less desirable consequences of our tendency to copy this type of cultural information.

The informal selfish meme argument gave the same basic insight as this little model. As we said at the beginning of this section, mathematical models provide a method for injecting more rigor into theoretical arguments; they hone notoriously unreliable intuition, and provide a formal structure that is much easier to test than verbal arguments alone. Doing the arithmetic becomes absolutely necessary to reach reliable conclusions when things get complicated. Even in our simple example, the math should give you an extra bit of confidence in the argument, and help you to see what selection on cultural variation really means. For those of you who are already familiar with such techniques, this model will give you a glimpse of how many of the less formal arguments in this course can be made more rigorous. If you are non-mathematical, we hope to have given you some insight into the way the numerate think about problems.

III. The Costly Information Hypothesis

A. The Simplest Alternative to the Sociobiological Hypotheses

The case that we have been building here is that the interaction of cultural and genetic evolutionary processes is liable to be somewhat more complex than the sociobiological hypothesis envisions. The cultural system cannot be too strongly leashed lest its advantages of flexibility and speed of adaptation be sacrificed and/or enormous decision-making costs imposed. But if it is not strongly leashed, it will become evolutionarily active in its own right—selfish memes will start to filter into the population's culture as variants arise that take advantage of the loose leash. Let us summarize the idea as a set of deductive propositions.

B. Basic Deductive Argument

We'll call the basic bit-of-cultural-realism alternative to sociobiology hypothesis the costly information hypothesis. Based on the parent-teacher model and supporting empirical facts it seems plausible that:

1. A fair amount of cultural variation is transmitted non-parentally via oblique and horizontal transmission.

2. Selection will act on this variation to favor traits that are effective in non-parental transmission even at the expense of vertical transmission.

3. Therefore, the adaptation that results from cultural transmission will be more or less significantly "distorted" away from traits that enhance genetic fitness.

C. Meeting the Sociobiologists' Argument From Natural Origins

Defenders of the sociobiology hypothesis are very skeptical. They argue that since culture arose as an adaptation under the influence of natural selection, that selection would never permit culture to "slip the leash" in the way envisioned in the costly information hypothesis. The argument so far depends on the empirical assertion that heritable cultural variation is transmitted non-parentally. We'll see in a bit that the empirical claim is plausible, but we can carry the deductive argument a step deeper as well.

Why is it probable that selection on genetic capacities for culture will favor weak decision-making and non-parental transmission, thus setting up the selfish meme effect?

1. There is an advantage to non-parental transmission. The various bias forces all tend to work better as there is more variation for a naive individual to observe. Imitating individuals besides your parents is often an advantage.

2. Information is very costly to acquire for many traits (e.g. the best way to farm). This means that using the direct decision-making forces (guided variation and direct bias) is often likely to be very costly, especially if people try to make very accurate decisions.

3. Selection on genes may favor inexpensive rules of thumb:

a. weak bias and guided variation—try out or observe a few alternatives and mostly guess which one is best.
b. depend upon vertical transmission—your parents can't have done disastrously in terms of their own genetic fitness—after all, they had you.
c. use really crude rules like conformist transmission (positive frequency dependent transmission) or indirect bias. See the next two chapters.

> 4. As a result, selection on genes will tolerate a fair amount of genetically maladaptive cultural traits resulting from selection acting on non-parentally transmitted culture. Averaged over many traits, many individuals, and a long time, a given genetic capacity for culture must provide an increase in reproductive fitness, but not necessarily for any particular trait in any particular society. The systematic maladaptations introduced by selection on culture will be tolerated because the cost of reducing them still further by using better decision rules will be greater still.

Decision rules of high enough quality to eliminate the selective conflict between genes and culture are too costly to be worthwhile.

From the gene's point of view, the evolutionary problem is essentially as stated in the following inset box. Can you see from this argument how the existence of a second system of inheritance with somewhat different properties from genes is almost inevitably a double-edged sword? Without some properties different from genes, culture is of no use. But once it becomes different enough for its special features to be useful, it is different enough to cause complications.

THE EVOLUTIONARY PROBLEM FACED BY GENES:

Ordinary individual learning is expensive and prone to random errors. Cultural transmission is cheaper, but prone to systematic errors as selection acts on heritable cultural variation. To whatever extent the higher costs and large random errors that result from individual decisions are important, selection on genes for mental capacities and decision rules affecting culture will not favor completely eliminating cultural traits that diverge from those that enhance genetic fitness. Tolerating some cultural goofiness is likely just to be part of the price of depending on the information-cost-shortcutting properties of culture.

IV. Empirical Evidence

Is there any empirical evidence (1) that decision-making forces can be weak, and (2) that selection on cultural variation can cause genetically maladaptive traits to increase? See Boyd and Richerson (1985: Ch 3 & 6) for more citations.

A. Macro Evidence of Traits that Demonstrate Conflict Between Genes & Culture

In many agrarian societies, substantial numbers of people enter celibate priesthoods. These are elite "teacher-type" roles, with limited opportunities for reproductive success. How could institutions such as celibate priesthoods be sustained unless some mechanism like that illustrated by the parent-teacher model is in operation?

You all face a conflict between going to college, getting a good job, spending money on prestige items, and having as many children as you can. Aren't most middle class people reducing the number of children they have in order to respond to the dictates of memes that demand professional performance, and high consumption of material goods? The poor have more children than we do, perhaps because they are less influenced by the "success" memes? It seems pretty obvious that modern middle class people sacrifice reproductive success to compete for prestigious careers, much along the lines of our little models in this chapter. (See the section on the demographic transition in today's reading. We'll return to this evidence in Chapter 17.)

Lots of demographic practices don't make sense from the sociobiological perspective. You may have recently read that Chinese attempts to limit families to one child have run into the problem that the Chinese feel that at least one child must be a male. This has a disastrous tendency to distort the sex ratio, as people dispose of female infants in various ways. It is fairly common for sex ratio to be biased by female infanticide in societies with a strong masculine emphasis. However, natural selection favors an emphasis on the rare sex. The Chinese sex ratio problem should be self-correcting under the sociobiological hypothesis. In extreme cases, like among the warlike Yanomamo Indians of Southern Venezuela, a quite significant fraction of wives are captured from other societies.Wife capture is motivated by the high female infanticide rate in the Yanomamo. Genetically, the Yanomamo are perhaps being swamped by such forced migrants. Sustained one-way migration will eventually dilute away the genes of the receiving population, but culturally the system is quite viable because males are socialized to be aggressive enough to maintain the female-infanticide/wife-capture system. If you thought about the problem of sex ratio distortion presented in Chapter 10, you can see the similarity here.

B. Micro Evidence—Indicates that the Mechanism Could Function

There is a fair amount of evidence that cultural variation exists and that some of it is transmitted horizontally and obliquely. Parent-offspring resemblances for traits like religious preference and political party preference are quite high. People do convert from one religion to another, but many more adopt the same affiliations as parents. For example, in a study of Catholics and non-Catholics in Wisconsin, Janssen and Hauser (1981), about

11.8% of the sample were converts, but both groups lost nearly as many people as the gained. There was a slight net conversion of Catholics from non-Catholic, but it was considerably smaller than the growth of the Catholic group due to natural increase. At the same time, it is clear that kids learn from peers, and organizations like schools and work have demonstrable effects on attitudes and values. Catholic fertility in the US has fallen to near national norms in recent years, despite Catholic pronatalism. Presumably, non-Catholic education, achievement, and consumption norms have influenced Catholics, despite Church teaching. Relative to our parent-teacher model, it is as if *A* is considerably larger than 1-*A*, but 1-*A* is still appreciable.

The behavioral decision theory literature is consistent with the idea that decision-making forces are weak. There is pretty strong empirical evidence that people are relatively poor decision makers, particularly on statistical problems:

a. People often ignore statistical aspects of the problem in favor of other cues.

b. People often form strong beliefs on the basis of a very small sample, and resist any further information, e.g. when buying a car, you may consult your friends rather than *Consumer Reports* to form a reliability estimate.

c. People tend to think that causes should resemble consequences; we have already met these in the “doctrine of signs” and “the argument from design.”

An example given by the pioneering behavioral decision theorists Kahneman and Tversky (Science, 174:1124, 1974) from their research works like this: People are given a stereotyped description of a person. Some subjects might be given the description of a shy, meticulous person, others of an outgoing verbal type. Then they are asked to judge how likely this person is to be a lawyer or a librarian, given that the description is of a person drawn from a group composed of 30 lawyers and 70 librarians. Different subjects are asked the same questions using the same description while the proportion of lawyers and librarians in the sample is varied, say 70/30 instead of 30/70. Almost everyone judges the descriptions on the basis of the stereotypes of lawyers and librarians. They pay almost no attention to the kind of population from which the sample was drawn. Yet a little reflection will convince you that some lawyers are shy and meticulous, and some librarians outgoing and verbal. People should alter their guesses substantially as the relative number of librarians and lawyers in the sample changes from say 30% to 70% lawyers. They don’t. For a more extensive discussion see R. Nisbett and L. Ross (1978) *Human Inference*. Since so many real life decisions involve statistical matters, the decision making forces are often likely to be weak. Nisbett and Ross argue that people often make poor judgments by using poor decision rules because the poor rules they use are often not too misleading, and the statistically appropriate rules require costly sampling and analysis.

Selection on culture should not always conflict with what selection on genes would favor. To meet the natural origins problem, we need culture to be fitness enhancing on average, and selection directly on culture may often assist decisionmaking forces in this direction. There is fairly strong selection against various bad habits in modern society. Abuse of strong drugs, for example, leads to increased mortality (e.g., fatal traffic accidents) and depressed fecundity (heroin addicts, alcoholics, and others who are liable to be institutionalized form families and have children at a lower than normal rate). Selection is probably an important factor counterbalancing the biases in favor of using pleasurable but harmful substances. On the other hand, belonging to a conservative pro-natalist religious faith such as the Mormons may lower your risk of substance abuse and increase your fertility. Religious belief tends to have a strong element of vertical transmission (from biological parents to offspring). Thus selection seems to favor some religions over others; conservative Protestant denominations are currently increasing relative to liberal denominations and secular people due in substantial part to population growth, as was the case in Janssen and Hauser's sample.

VI. Conclusion

We've argued here that it is plausible to imagine that selection on cultural variation is likely to be a reasonably important evolutionary force, at least not one we can neglect at this stage of knowledge. Some important cultural traits are *copied* pretty faithfully—as the model from last chapter suggested they should be when individual decision-making is costly or inaccurate. There is heritable cultural variation upon which natural selection can work. We have also briefly reviewed the evidence from psychology that people use cheap, relatively error-prone decision-making rules, as if they knew that using better ones would be costly in terms of time and effort. Again, if this is so, the decision-making forces cannot quickly get human behavior to the state determined by the rules of decision-making (to the fitness genetic optimum if the sociobiologists are right about what causes the rules to evolve). This indicates that selection on cultural variation has some scope in which to work.

We also saw that when non-parental models (like college professors or priests) are active in teaching the young, the traits that are selected for can differ from those that enhance fitness. The urge to, say, compete for a high status job that may make you active in a teacher-like role can cause you to neglect your genetic fitness. ***You are endangering your genetic fitness right now by wasting an hour of time during your valuable prime reproductive years reading these notes!***

The conclusion of the last chapter was that culture should be useful across a broad *spectrum of variable environments*. The model of guided variation described there suggested that a cultural system of inheritance would generally be an advantage in variable environments. This left us with the puzzle of why culture is not more common among other organisms. Now we have a possible answer. It is not easy to capture the advantages of a cultural system without allowing it to become "evolutionarily active." Once culture starts responding to selection, conflicts between genetic and cultural fitness may arise and impose additional costs from the point of view of selection acting on genes. Speaking metaphorically, culture may be a difficult system for genes to manage. Thus, tolerating some cultural goofiness may be the price of the adaptive properties of culture.

We have applied the term ***costly information hypothesis*** *to the proposal that the conflictive evolutionary activity of culture is appreciably important*. In the following 2 chapters we will explore some further consequences of the costly culture hypothesis.

V. Bibliographic Notes

References:

Durham, W. H. 1978. Toward a coevolutionary view of human biology and culture. In A. Caplan, ed., *The Sociobiology Debate*. New York: Harper & Row, 428-448.

Janssen, S.G. and R.M. Hauser. 1981. Religion, socialization, and fertility. *Demography* 18: 511-528.

Knauft, B.M. 1987. Divergence between cultural success and reproductive fitness in preindustrial cities. *Cultural Anthropology* 2:94-114.

Nisbett, R. E. and L. Ross. 1980. *Human Inference: Strategies and Shortcomings of Social Judgement.* Englewood cliffs, NJ: Prentice-Hall.

Piraro, Dan. 1992. Bizarro. *Los Angeles Times*, View Section, 4/2/92.

Slovic, P. B., B. Fischhoff, and S. Lichtenstein. 1977. Behavioral decision theory. *Annual Review of Psychology* 28:1-39.

Tversky, A. and D. Kahneman. 1974. Judgement under uncertainty: Heuristics and biases. *Science* 185: 1124-1131.

Chapter 13. EVOLUTION OF SOCIAL ORGANIZATION

> "Honor, duty, country"
>
> West Point Motto

> "To us at the time, a suicide air force was a very natural thing, nothing more than a means of self-defense toward the end of the war. True, the war ended and saved me 28 years ago, but if I had to be a Kamikaze pilot again, I would."
>
> Sei Watanabe
> Lt. Gen. Japanese Defense Forces, ret.

I. The Problem of Cooperation

A. Three Unusual Features of Human Societies

Human societies exhibit ***cooperation****,* ***coordination****, and* ***division of labor****, three features that place them at striking variance with most animals*. *Cooperation* involves individuals doing something for the common benefit of everyone in a social group, as when soldiers defend a whole nation against its enemies. *Coordination* involves everyone doing things one way instead of another so that social activity can proceed efficiently (Susden, 1986). For example, we all agree to drive on the same side of the road and to pronounce words in the same way to avoid the chaos that would result if everyone 'did their own thing' (as we children of the 60s once imagined possible). The *division of labor* results when different individuals undertake specialized tasks, and then exchange the products of their labor. The sexual division of labor is the most ancient example in human societies. Historically, men's and women's activities have differed fairly radically, but within the household each sex's products are contributed to a common pot that family members draw upon.

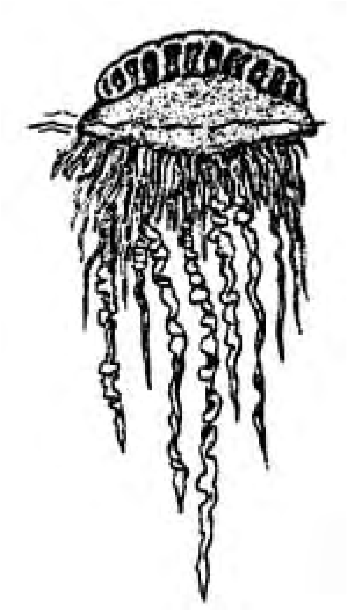
Highly social animals are rare, and basic Darwinian analysis shows why (Alexander, 1974). An animal's *conspecifics,* members of its own species, are its closest competitors for food, mates, shelter, and so forth. Groups are likely to be easier for predators to spot, and group living ought to favor the spread of diseases. The theoretically most interesting problem is competition. Why should any animal help its competitors? It will cost me some resources, ultimately fitness, to help you, and selection should favor me increasing my fitness, not yours. If one individual helps another, isn't the smart thing to take advantage of the help, but never reciprocate? Animals are thus usually solitary, staying as far away from their fellows as is practically possible. In most mammals, the contact between the sexes is limited to mating, and "society" consists of the minimum coordination between adults necessary for fertilization, mothers' contribution of resources to juveniles to the point of independence, and no division of labor at all. Bears are a good example. Except for mothers taking care of cubs, and brief mating episodes, they are belligerently antisocial.

Even in the case where animals do live in groups, the degree of cooperation, coordination and division of labor within groups is usually very modest. For example, in herds of grazing animals or in schools of fish, there is virtually no cooperation, or division of labor. There is just a system of coordinating movements. The evolutionary explanation here is that in very open environments with no place to hide, big groups of animals are a passive form of predator protection. Predators have to discover the herd in a vast, otherwise empty landscape. Once the herd is discovered, only a few can be eaten before the rest run away. Then the search for the herd must begin again. Life would be much easier for the lion and the tuna if wildebeest and sardines were evenly distributed. Individual victims would almost always be in sight, and there would be little chance of starving between finding them. The clumping of herds forces a feast-or-famine regime on the predator. The benefit to members of such herds is simply that when a predator does find a group, the bigger it is, the less chance you personally will be the lunch. Biologists call this sort of coordinated group a "selfish herd" because there is no cooperation, for example individuals actively guarding the herd or attacking predators. In essence, in a selfish herd animals are hiding behind each other; nothing more sophisticated is involved. In a dense forest, where hiding is easy, selfish herds are not found. Sometimes animals collect around a scarce resource, and are forced to be minimally social. Bears sometimes collect at prime fishing spots for example. In such circumstances, each animal defends the largest territory it can, though the rich resource often means this as small as a vicious paw-swipe or peck can reach.

When cooperation does exist, the groups are typically very small. Many birds form mated pairs that cooperate to raise a nest of young, but bird flocks, when they exist, are selfish herds. A division of labor is even rarer, aside from those differences directly enforced by the biology of sex. Even in the case of sex, the commonest form of "division" of labor is that males contribute less or nothing to the rearing of offspring compared to females. The discovery by ethologists that cooperation and complex societies are rare in the animal world was an important advance over the anthropomorphic ideas of early naturalists. Small societies are fairly easy to imagine through the mechanisms of *kin selection* and *reciprocal altruism,* as we'll see below.

There are three conspicuous groups of animals that are eusocial and have complex societies (Wilson, 1975). One set of social species occurs in the "lower" invertebrates. The Portuguese Man-O-War is an example (see figure 15-1) . It is actually a communal organ-

Figure 13-1. The Portuguese Man-O-War is an example of a collective organism where specialized individuals cooperate, coordinate, and specialize.



ism whose gas-filled float, digestive apparatus, and tentacles are all specialized individuals that cooperate, coordinate, and specialize to make this spectacular “jellyfish.” The second set of species occurs in the “higher” invertebrates, the social insects. Bees, wasps, ants, and termites also have societies with all three attributes well developed. Finally there are humans. Since Wilson wrote, one other eusocial mammal has been discovered, the African naked mole rat. *All cases of eusociality except humans turn out to be cases of kin selection*(see Section III below) *writ large, leaving us a unique problem for Darwinian explanation*.

The problem of complex societies did not escape Darwin. He realized that his mechanism of natural selection favored selfishness, and exceptions like bees and humans worried him. The sharpest theoretical problem is cooperation.

II. The Evolutionary Dilemma of Cooperation

A. Theoretical Advantages of Cooperation

The theoretical problem is especially acute because cooperation often seems to have huge benefits that natural selection usually can achieve. Ants, termites, bees, and wasps are very abundant. In the human case, we’ve argued that pastoralists live in groups to defend their herds from human and animal predators (and to make effective raiding parties to seize animals from other groups). Two-against-one is very tough to beat; cooperation in defense and offense has very decided advantages if it can be organized. Similarly, cooperative hunting, such as humans practice, means that much larger game can be taken. Moreover, food sharing provides an insurance function that seems to be a general advantage for predators. In complex societies we've seen how a division of labor and exchange can increase human welfare. Humans seem to be very successful due to cooperation. Similarly, despite having evolved eusociality only once, ants are a hugely successful group. Other animals, such as our close relatives baboons and chimps, whose ecological niche is rather similar to that of hunters and gatherers, have not evolved cooperative hunting and division of labor. Recall that both chimps and baboons hunt, but without much cooperation and sharing; the dominant animal tends to monopolize the carcass regardless of who killed it.

B. Evolutionary Advantages and Disadvantages of Selfishness

Why is it so hard for cooperation to evolve, if it is so successful when it does evolve? This is a classical problem. Economists have analyzed the problem under the heading of the "public goods problem". Game theorists have dealt with the same problem in their research into the perverse logic of the "prisoners' dilemma game". Similarly, evolutionary biologists have addressed the tendency of selection to favor those traits that are advantageous to individuals rather than the group. In all of these manifestations, the problem is that the altruistic self-sacrifice of individuals for the common good is hard to explain.

The precise evolutionary reason for being selfish is straightforward: Suppose I sacrifice my selfish personal interests, fitness, or payoffs in a game so that everyone will be a little better off. If everyone does this, we'll all be better off, perhaps much better off if there are big rewards to cooperation and collective action. But what if there are individuals who cheat, taking advantage of others' altruism[1], but act selfishly themselves? When altruists are common, cheaters will have a big advantage, and when cheaters are common they suffer no penalty relative to other cheaters. Theorists have found it easy to imagine situations in which neither rational calculation nor natural selection will lead to much cooperation, and correspondingly it is much harder to produce situations where cooperation ought to arise. Perhaps this result is quite reasonable; cooperation is relatively rare in nature. But we also have to account for the conspicuous exceptions like humans that do live in large cooperative societies.

To pose the problem in a more formal way, let us adopt the economists' approach.

---

[1] *Altruism* is defined as behavior by an individual organism that is either not beneficial or is harmful to itself, but that benefits the survival of others.

Public goods are those goods or services which are not depleted by an additional user, and for which it is difficult or impossible to exclude users. A typical example is national defense. Adding more people to a country does not make its borders any more expensive to defend, and every citizen is protected by whatever level of defense is provided. The defense of one is the defense of all, more or less. Economists argue that people will not ordinarily provide public goods in optimal amounts because rational individuals will find the private costs of providing their share of the public good exceeds the incremental benefit to themselves—even though the total benefit to society greatly exceeds this private cost. For example, economists find it hard to imagine why people vote. It costs each of us only a little time and effort to vote but it costs us *something*. The chance that our one vote will influence the outcome of even a local election is very small. Democratic government is good for us all, but why shouldn't I let you pay that cost, and save myself the time and trouble, given the tiny difference my one vote makes? According to this logic, we should all think this through, and not vote. Democracy will collapse, even though we were all better off when we had it.

Public goods are those goods or services which are not depleted by an additional user, and for which it is difficult or impossible to exclude users.

C. A Game Theory Example

One of the most common ways to illustrate the dilemmas of cooperation is to use simple game theory models. The philosophy is now familiar to you. We want to boil the essence of a problem down to a simple understandable model that schools our intuition about a whole class of problems. Game theory imagines that there are individuals interacting in the framework of a game with rules and strategies that can be played. The essential thing about games is that my payoff in general depends upon both my strategy and your strategy. Given a set of rules, and a specified set of strategies, the theorist asks "what is the right strategy to play?" "Right strategy" is often defined as the strategy that is individually "rational" (maximizes the payoff to individuals) or the one that is an "Evolutionarily Stable Strategy (ESS)." An ESS is one that selection can favor. If the ESS is common, no rare mutant strategy can increase. In other words, if a new strategy arises due to mutation from an existing strategy or migrates into a population, selective pressures cannot cause it to grow and replace an ESS. *One of the most famous results of game theory is that cooperative be-*

havior is not, in general, either rational or an ESS.

Let's use pastoralists collectively guarding their herds as an example to see what is the problem with public-goods-producing or altruist strategies Imagine two herders, Genghis and Attila. We assume that each individual's animals are mixed in a common herd, so that any effort spent guarding benefits both men equally. Suppose that the average loss reduction (benefit) gained by an individual herder who guards is B and the cost he pays for guarding is C. The calculation that each herder should make is as follows:

Attila's Payoff Matrix With One Other Pastoralist:

Attila's behavior	**Genghis's behavior**	
	don't guard	*guard*
don't guard	0	B/2
guard	**b/2-C**	**B-C**

If Attila doesn't guard and Genghis doesn't guard either, neither of them gains any benefit (B) nor pays a cost for guarding (C). Put your finger on the cell in which each player's 'don't guard' behavior intersects with the other's. You should have selected the cell with the lightest shading. What is the value given in that cell? If Attila guards and Genghis doesn't guard, what is Attila's payoff? Put your finger on the cell in which these two behaviors intersect. You should have selected the cell with the next-to-the-darkest shading; Attila's payoff is half the benefit (B/2)[2] minus the cost of guarding (C).

For simplicity sake, we'll assume Genghis's payoff matrix is identical. There is no problem here if B/2 > C; both will be selfishly motivated to guard. But suppose B/2 < C, but B > C. Now, both Ghengis and Attila will be better off if both guard, but if both are "rational", neither will guard. Notice that no matter what Ghengis does, Attila is better off if he does not guard (when B/2 < C but B > C). If Ghengis doesn't guard, Attila will be better off if he doesn't and if Ghengis is so foolish as to guard, Attila is better off if he takes advantage of him. Under this system of payoffs, it is irrational to guard; neither herder will guard, the public good of herd protection is not furnished, and both will get 0 payoff. If we imagine that payoff means Darwinian fitness, Don't Guard is an ESS. When common, it cannot be invaded by Guard, but when Guard is common, rare Don't Guard individuals will have the parasite's field day taking advantage of all the guarding while avoiding the cost.

---

[2] because he share's the benefit equally with Genghis

If this common analysis is correct, people will be better off if everyone cooperates, but everyone will be motivated to cheat, to save the private cost of producing the public good, hoping someone else will do it. But everyone has the same motivation to cheat. Therefore, cooperation is neither rational nor an ESS. Cooperation doesn't evolve.

The problem gets much worse as groups get larger. Consider Attila's payoff matrix if he is in a group of N pastoralists, M of whom guard and the rest don't:

Attila's Payoff Matrix With 'N' Other Pastoralists:

Attila's behavior	
	His payoff if M others guard
don't guard	**B(M/N)**
guard	**[B(M+1)/N] - C**

Now, in a big camp, Attila is even less motivated to guard. If N is at all large, his help guarding the herd provides only a small incremental benefit (+B/N) to himself, but his cost remains the same, C. A great deal of theoretical attention has been paid to this problem, and it is not an easy one to solve. Selection will not favor guarding in this circumstance. Suppose that B and C are measured in units of fitness. Unless B is very large, or N quite small, or C quite small, the fitness of altruistic guarders will be less than selfish non-guarders.

It might be supposed that the possibility of punishment will cause people to do their fair share, but punishment is itself a public good. Attila is a tough brute, and it is likely to cost Genghis something to punish him. But in a large group, everyone will benefit if Attila is punished if he does not guard. Genghis is liable to figure it is not worth his private cost to punish Attila, though everyone would be better off if he did. This is the same problem as guarding the herd in a new guise. The dilemma of punishment is familiar to you as the problem of reporting small property crimes. We'd all be better off if we reported every crime because it would help the cops catch the bad guys. But if it is more trouble to me personally to report a small crime, why should I bother? (Actually, games with punishment are just now being studied, so the consequences of punishment are not yet clear.)

The problem is that people, unlike bears, don't behave according to theory! Any modern infantry's junior officers are an extreme, but very common, example. To provide national defense they engage in acts that are very frequently fatal. The deliberate, premeditated suicide of the kamikaze a bit more than West Point expects, but West Point expects much more from a 2nd Lieutenant than you could expect of a bear. The common voter is, in his and her own small way, just as *baka* (Japanese for crazy) as a Kamikaze pilot according to the game theory analysis.

There must be something wrong with this simple calculation in the special case of humans and the other cooperative animals. Just *what* is wrong, however, is the center of long-standing debate. (Incidentally, psychologists often ask people to play cooperation games in the laboratory. Most people cooperate when the theory says they should cheat. An exception is economics students; they have been taught about selfish rationality and that it is OK, if not a virtue. Having learned the theory, they obey it!)

This brings us to the problem that will occupy the remainder of this chapter: Given that we can explain the fairly common cases of small-scale cooperation, we want to ask if any of the standard animal mechanisms of cooperation are sufficient to account for the extremely high levels of cooperation found in humans compared to other mammal societies. How do we do what otherwise only jellyfish and bugs can do?

KEY QUESTION:
Are any of the standard animal mechanisms of cooperation sufficient to account for the extremely high levels of cooperation found in humans compared to other mammal societies?

III. Kin Selection Theory

A. Darwin's Worry

Darwin worried specifically that the self-sacrificial altruism of the worker honeybees was not in accord with his theory of evolution by natural selection. Then he saw the answer: in bees, wasps and ants, *workers are daughters of the queen*. Altruistic worker variants are cooperating, helping the queen produce other daughters and brothers, the reproductives. The altruistic worker's heritable variation for altruism is not passed on directly, but through its siblings who will replicate the cooperative impulse due to family resemblance. In other words, altruistic behaviors arose from shared heritable variation.

B. Inclusive Fitness or Kin Selection Theory

W.D. Hamilton (l964) extended and formalized Darwin's insight into one important mechanism, *inclusive fitness*, that can favor the evolution of altruism and cooperation. John Maynard Smith (1964) termed it *kin selection*.

Hamilton deduced the benefit-cost rule for altruistic behavior: B/C > l/r, where r is the probability of getting the same gene as someone else by common descent. ('r' is also the fraction of genes a potential altruist has in common with a potential recipient of her largess—the fraction that they are ***I***dentical by ***C***ommon ***D***escent, ICD). That is, it is only the genes that are shared by virtue of a known genealogical relationship that are entered into the calculation.

Let's examine the example of genes ICD between full siblings:

	Mother	*Father*	Each sibling gets 1/2 of each parent's genes. Because of independent assortment of chromosomes, this sample is independent; so, on average, each sibling will *share* 1/4 of each parent's genes.
	2n	**2n**	
Offspring A	**1/2**	**1/2**	
Offspring B	**1/2**	**1/2**	
r =	1/4	+ 1/4 = 1/2	

Half sibs are related by l/4, first cousins by l/8 and so on, and B/C calculation must be adjusted accordingly. This is true in any sexual reproduction system where each offspring's sample of its parent's genotype is independent[3].

Put anthropomorphically, *if I am an altruist, I can gamble there is at least a l/2 chance that a given brother or sister is also an altruist because we are that likely to share the same altruist gene ICD. If I can help one of them raise 2 offspring at a cost of less than one to me, I will (on average) increase the number of copies of my altruist gene in the population.* Inclusive fitness is like dollars—selection encourages individuals to get as much as possible.

Another evolutionary puzzle for you to think about: Chimpanzees are said to share some 90+ percent of their genes with humans. Human races are much more similar still. Why can't we substitute 0.9+ for r in Hamilton's rule, and predict near-perfect cooperation even between closely related species, much less between individuals within a species? Why does Hamilton's rule stress *identity by common descent,* rather than total number of genes in common? Hint: What happens to the frequency of an altruist gene in a population where there are also non-altruists if there is an act of indiscriminate altruism to completely unre-

---

[3] Mendel formulated the "law of independent assortment" which is applied here when we calculate genetic relatedness. Mendel thought that "genes segregate independently at meiosis so that any one combination of alleles is as likely to appear in the offspring as any other combination. It is now known… that genes are linked together on chromosomes and so tend to be inherited in groups. The law of independent assortment therefore only applies to genes on different chromosomes (Tootill, 1981:132)."

lated individuals? A kin altruist needs to be quite discriminating to protect its altruism from going to waste. If you see altruism as allocated on the basis of direct kinship links, and why total% of genes in common is irrelevant, you understand kin selection pretty well.

An individual's inclusive fitness is its own offspring **+ r * x** *offspring of relatives* (but only counting the relative's children that are due to the altruism of the donor individual). Hamilton's rule suggests that selection will act to increase inclusive fitness rather than simple individual survival and reproduction. In cases where relatives live close together, selection can thus favor a measure of nepotistic "altruism" if individuals can help their relatives reproduce in conformance to the B/C > 1/r rule.

In cases where relatives live close together, selection can favor a measure of nepotistic altruism if individuals can help improve their relatives' reproductive fitness, & the net reproductive benefit to altruists is greater than the costs they bear.

C. Empirical Evidence

Most animal societies in which cooperation is important are kin-based. Kin altruism is frequently observed in nature. In many primates, such as baboons and macaques, the basic social unit of the troop is a set of related females, say four or five sisters and their offspring. Males disperse from their natal troops and enter foreign troops in which they have no relatives. There is a good deal of cooperation among females of a matriline in encounters with females from other matrilinies, for example. Cooperation among males is limited to unstable coalitions and hostile relations are the norm. In some species, for example chimpanzees, the situation is reversed and a group of related males forms the core of the group. Jane Goodall has observed dramatic examples of cooperation among related males, especially in aggressive encounters with neighboring groups (one of her groups exterminated another as males went on collective, murderous raiding parties). The rule, that when there is conspicuous cooperation it is usually among relatives, thus commonly corresponds to observation.

Another famous example of the workings of kin selection is the case of the haplodiploid hymenoptera (bees, ants, and wasps). In these and some other arthropods, males result when females lay unfertilized haploid eggs (so that a male only has one set of chromosomes, while females have the usual double diploid complement). This leads sisters to be related by 3/4 rather than usual half:

	Mother	*Father*	Since males are haploid, they transmit only one set of chromosomes, and the daughter’s sets of father’s genotype are not independent samples. The halves of daughter genotypes received from fathers are the same.
	2n	**n**	
Offspring A	**1/2**	**1/2**	
Offspring B	**1/2**	**1/2**	
r =	1/4	+ 1/2 = 3/4	

Hymenoptera (bees, ants, wasps), with haplodiploid inheritance structures, have several independent origins of eusociality. The colonies are associations of related daughters of the Queen, with this unusually close relatedness. Some sociobiologists argue that haplodiploidy is a preadaptation to sociality, and that is why there are so many examples of highly social species in this Order of insects. Since the worker sisters are even more closely related than normal sisters, altruism can more easily evolve. The threshold B/C ratio is lower. Termites are a bit of an embarrassment for this argument, as they are highly social but diploid.

Note that *this is another example where the structure of the inheritance system affects what selection can favor*. The social hymenoptera, the possible role of selection on non-parental cultural variation, and sex ratio distortion all illustrate the same point.

IV. Reciprocal Altruism

A. Theory of Cooperation With Repeated Plays of the Game

Another mechanism for producing (usually) small-scale altruism, is establishing trust between pairs of individuals who reciprocally help each other (Trivers, 1971). A political scientist Richard Axelrod has collaborated with W.D. Hamilton (1981) to study this mechanism in the context of repeated plays of prisoner dilemma. Suppose we imagine a game with the basic structure of our guarding game above. But let us suppose a somewhat more complex situation and a more complex strategy. Suppose that Attila and Ghengis don’t just interact once, but rather live in the same camp for a fairly extended period. Also suppose they can use *contingent strategies.* For example, the first night in camp, Attila might figure “on the off chance that Ghengis is another good guy like me, I’ll guard tonight. If he also guards, I’ll keep guarding, but if he doesn’t I’ll stop guarding until he starts.” Axelrod and Hamilton call this the “tit-for-tat” strategy. If Ghengis is a good guy, the herd will be guarded and both will get benefits for as long as they remain together. If Ghengis turns out to be a bad guy, Attila suffers the cost of altruism, but only for one night. If both are bad guys, neither will pay the cost of guarding nor reap its benefits.

An evolutionary analysis of this game shows that the tit-for-tat strategy is an ESS if the game persists for enough nights. If the B/C ratio is high, any given game need not have too many iterations for tit-for-tat to be an ESS, but if the B/C ratio is closer to 1, the number of iterations must be large. A rare mutant non-guarder will be at a disadvantage because it will get only one parasitical payoff per set of turns, while the guarders will get multiple payoffs for cooperating as long as the game persists. It is a little hard for guarding to get started when it is rare[4], but there are ways around this. For example, a little kin selection will get tit-for-tat started.

To many people, the idea that tit-for-tat, as well as strategies with the same basic property, will work is quite intuitive. If you have some way of coercing and punishing other people you can induce them to cooperate, and the theory seems to support this idea. There are of course many strategies of this type and many as yet unexplored complexities in the reciprocal altruism problem. This is right now a booming field of research.

B. Trivers' (1971) Examples

Robert Trivers at U. C. Santa Cruz introduced the idea of reciprocal altruism in his classic paper with some nice examples. *There are fish and shrimp on tropical reefs that clean the insides of the mouths of larger fish*. Some mimics of these "cleaner-fish" take a bite out of the host instead. Of course, the cleaned fish can always cheat by eating the cleaner just as it finishes cleaning. Trust must be established on both sides. Cleaners have conspicuous coloration and stylized displays. They also have rather permanent stations where they display their willingness to clean. Apparently this allows enough trust to develop so that cleaners can evolve even when the possibility of mimic cleaners complicates things.

Trivers' other conspicuous example was humans. We live a long time and commonly form long-lasting friendships, trade relationships, and so forth. We are smart, so we can be very discriminating, stopping reciprocation with those that disappoint us[5].

---

[4] All bad guys is also an ESS, see if you can determine why.

[5] Although non-altruists' deceptive tactics may also get more sophisticated as we get smarter. This can lead to an "arms race" where cheaters evolve new ways to cheat and their victims evolve new ways to detect and protect against cheaters. This insight is the basis for my own work examining how the nature and distribution of crime evolves in human populations.

V. Sociobiological Explanations for the Scale of Human Social Organization

A. Kin Selection + Reciprocal Altruism?

Alexander (1979, 1987) argues that simple kin selection plus lots of reciprocal altruism will explain human levels of cooperation. He introduces the term "*indirect reciprocity*" for the tendency of people in a diffuse network of cooperation to behave cooperatively to strangers on the premise that "what goes around comes around." However, it is hard to explain costly altruism like military heroism with such a concept. The theory of reciprocal altruism runs into difficulties when groups get "large" (i.e. ≥l0 individuals). This is the problem of the N sized group of herdsmen given above. So far, the theoretical work on this topic indicates that tit-for-tat works well in small groups (e.g. 2-3) but breaks down very rapidly as group size increases.

W.D. Hamilton (1975) and P. van den Berghe (1981) think that modern scale of human society is an evolutionary mistake. There is some group selection in 'primitive' human societies because of warfare and group endogamy(marriage within a group) which tend to reduce intra-group variation and raise group extinction rates. They suggest that the impulse to cooperate evolved due to kin or group selection in the relatively tiny, simple societies of our hunting and gathering past, and that this impulse misfires in the present because the rapid cultural evolution of social complexity has not given selection an opportunity to correct our tendency to treat large groups of strangers as if they were relatives or band-mates. General Watanabe is acting as if every Japanese is a close relative, as they might have been in the hunting and gathering societies in which the heroism impulse arose. Recall that all human groups were small and close-knit until relatively recently.

A major problem with the Hamilton/van den Berghe approach is that the common practice of victorious warrior groups is to incorporate vanquished women and children into their groups. This would produce a high flow of cowardly (or at least poor warrior) genes into the most successful warrior groups. This flow of women to victorious groups seems common, and means that group selection on human societies, even at the level of small, warring groups with lots of group extinction may be difficult.

B.Something Special About Culture?

This is an example of a research topic in human ecology where there is plenty of room for new ideas. *Nobel Laureate Herbert Simon (1990) recently suggested that two factors, human docility and bounded rationality, can account for the evolutionary success of genuinely altruistic behavior (i.e., behavior that cannot be explained by reciprocal altruism or inclusive fitness).* Simon defines 'docility' as receptivity to social influence. Since being receptive to social influence often contributes to a person's genetic fitness in human species, Simon argues that the physical traits that tend to make one more docile will tend to be favored by selection. "As a consequence, society can impose a 'tax' on the gross benefits gained by individuals from docility by inducing docile individuals to engage in altruistic behaviors. Limits on rationality in the face of environmental complexity prevent the individual from avoiding this 'tax' (Simon, 1990:1665)." It is not clear to us from why docility in the sense of a susceptibility to altruism automatically has to arise from a tendency to imitate.

VI. Cultural Group Selection

A. Introduction

Human eusocial cooperation is unique and so is our dependence on culture. Is this coincidence or causation? The reciprocity mechanism just doesn't work well for large groups. The closest animal analog of human societies in degree of cooperation, coordination, and division of labor are those of the social insects, but our "queens" do not suppress the reproduction of our "workers;" so the kin selection with large mechanism isn't the exact answer. It is certainly probable that kin selection and reciprocity are important to explain parts of the small-scale parts of human cooperation, but they don't seem sufficient to explain the cooperation of dozens of weakly related Hunters and Gatherer, much less the millions of members of a modern society.

Simon's idea has the virtue of treating one unique feature of humans, culture, as the cause of another, large-scale cooperation among non-relatives. This is a natural approach to the apparent fact that humans are a unique special case as regards cooperation. In this section, we pursue a hypothesis of group selection on cultural variation, which is akin to Simon's idea, but with a more explicit mechanism. The hypothesis is that the use of frequency dependent bias (1) might have been favored by selection and (2) result in group selection on culture as a by-product. The argument is much like the hypothesis that haplodiploidy results in eusociality among the hymenoptera. Haplodiploidy is apparently (1) fairly widely evolved as a sex determining mechanism, which (2) makes haplodiploid species susceptible to exaggerated kin selection as a by-product.

B. Evolution of Frequency-Dependent Bias

REMEMBER The Forces Of Cultural Evolution?

- A. Accidental Variation
- B. Cultural Drift
- C. Decision making Forces:
  - 1. Guided Variation:
  - 2. Bias Forces:
    - a. Direct bias
    - ➡ b. Frequency dependent bias
    - c. Indirect bias
- D. Natural Selection

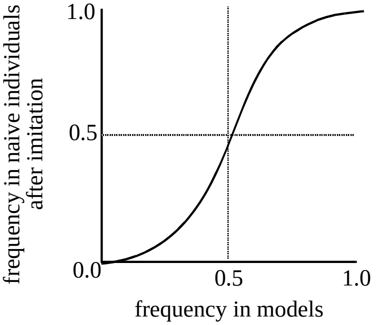
Frequency dependent biases are decision rules for adopting cultural traits that use the commonness or rarity of traits as a basis for deciding whether to imitate or not. If you are a non-conformist, you try to be as unlike most people as possible. If you are a conformist, you try to be as similar as possible. Here we are interested in conformist transmission.

A conformist bias might easily evolve by natural selection. When information is costly, and environments vary in space, the use of conformist rules of imitation tend to be favored by natural selection. “When in Rome, do as the Romans do” as the saying goes. Every adaptive process--direct bias, guided variation, natural selection--will conspire to make adaptive ways of behaving common. Imitating the common type is generally good sense. At the same time in an environment where the adaptive thing to do varies a lot from place to place, and where people move about, many people will be trying to do the Naples thing in Rome. Conformist decision rules discriminate against relatively rare Neapolitans in Rome. It is interesting that this trick requires at least three “parents;” the genetic system with only two is forbidden this trick. In the jargon of statistics, the reason is that a sample of two has only one “degree of freedom” and hence no information about the state of the population. A sample of three or more begins to have enough information to say something reliably about the state of Rome, and hence to implement a conformist strategy. As the number of cultural models you survey goes up, the more powerful conformity can be. (As in Chpater 11, we admit this idea is completely heretical. Professors are supposed to tell students to think for themselves! Conformity is supposed to be bad! If so, why do people conform???) Figure 13-1 illustrates how the conformity effect works.

B. Some Micro-evidence That Conformity Exists

The evidence that conformity is important as regards cultural transmission is weaker than you might think. There are many studies showing superficial conformity of behavior to what others expect. Few of the studies that have been done have tested specifically for the non-linear conformity effect as we have defined it, but some experiments show it (Ja-

Figure 13-1. Conformist-based rules for the transmission of culture are potentially a strong force for making common traits more common—and rarer traits more rare. It also increases and preserves variation *between* populations as it reduces variation *within* populations.



cobs and Campbell, 1961). We presume that the many studies demonstrating superficial conformity are indicative that deep conformity is common, but this certainly needs further study.

C. The Population Level Effects of Conformity

Conformity greatly affects the structure of variation in a population. Non-conformity preserves variation *within* a population, while conformity greatly reduces it. However, conformity has a powerful tendency to preserve variation *between* populations. To see this, imagine what happens to people who migrate from one population to another. As long as migrants are fairly rare, their differences will be discriminated against in cultural transmission in the populations they enter if there is conformist transmission. Young people will tend to ignore them just because they are unusual. Compared to the case of genetic transmission, this effect diminishes the effect of migration. It is much easier to maintain a cultural difference between Naples and Rome than a genetic difference, for the same amount of migration, if cultural transmission is conformist.

D. Evolutionary Biologists Hate Group Selection

Recall from Chapter 10 that the idea of group selection is in bad odor among evolutionary biologists. There we said that it would be theoretically possible for selection to favor animals that sacrifice their own reproductive success where selfishness would put the group in danger only if there is:

(1) high variability between groups;

(2) low variability within groups; and

(3) substantial group extinction rates, or differential group success rates.

The problem is that migration between groups will tend to spread selfish individuals into unselfish groups. Once in a group of unselfish individuals, selfish ones will have a special advantage. They can take advantage of the altruists, without bearing the costs of altruism themselves. This processes is what makes it hard to imagine how the high levels of cooperation we observe in humans arose. It is very hard to see how the genetic transmission system can maintain enough heritable variation between groups to let group selection work. The general conclusion reached was that genes are selected to cooperate to make a reproductively effective individual, but individuals are not nearly so likely to be selected to make a successful group. Because an earlier generation of biologists, before George Williams wrote his famous book in 1966, often carelessly appealed to benefit to the group arguments, modern evolutionists have an almost dogmatic distrust of group selection arguments.

E. Group Selection on Cultural Variation Easier

The group variation-maintaining by-product of conformity makes group selection on cultural variation much easier to imagine than group selection on genetic variation. By preserving the variation between groups and suppressing the variation within groups, it tends to overcome the potent impediments to selection at the level of groups. According to the model described in the reading for this chapter, the rate of group extinction need not be very high to produce considerable change in the long run, and group “extinction” only needs to be *cultural*, it need not actually involve the physical death of members of a group. It is enough that defeated individuals are dispersed to other groups where they are a minority.

Thus, if we can once get a group with strongly altruistic predilections going, it will persist in the face of a substantial ***immigration*** *of selfish individuals, and will be able to replicate itself (colonize empty habitat) faster than a group composed of mostly selfish individuals*. This assumes that cooperation is an advantage, so that groups of mostly altruists will be rather better off compared to groups of mostly non-altruists. As we’ve seen, the relatively few eusocial animals that have evolved have been unusually successful. Us, the ants, the termites, and the eusocial jellyfish!

E. Some Empirical Evidence Supports Cultural Group Selection Hypothesis

In the reading, Boyd and Richerson argue that ethnic groups are potentially a result of a cultural group selection processes. There is no animal analog of the ethnic group in which a large number (hundreds to millions) of rather distantly related individuals show sentiments of solidarity and a propensity to cooperate. Such group sentiments as motivated Poles, Pathans, Armenians, Lithuanians, Estonians, etc. to defy the USSR in recent years—not to mention the ~350 year long attempt by the Irish to free their country from the British—are examples of individual risk-taking for the benefit of a very large, open group. It is hard to see how this can arise by natural selection on genes.

Otterbein's (1966) study of the evolution of warfare turned up an interesting pattern of cooperation for violent conflict that is consistent with the cultural group selection model. He found that warfare existed only on a small scale in human societies with characteristics such as local group endogamy (within-group marriage), a tendency of males to reside with relatives, and no cross-cutting institutions such as men's warrior societies. When local groups were more exogamous (marry outside the local village), when males tended to live with unrelated males, or when there were strong cross-cutting institutions to bring unrelated males together, then warfare tends to be on a larger scale. In our terms, when the scale of the institution in which males are socialized regarding use of violence is small (i.e., the extended family) then the unit that is selected and that cooperates is small. Warfare is then limited to the level of feuds between families. Sicilians are reputed to use relatively narrow family loyalties, and can generate extremely effective small-scale conspiracies as a result of intense loyalty at the level of the extended family (the Mafia). On the other hand, Sicilians have weak loyalty at the whole-island level and have historically been prey to the imperialism of stronger states. It is the scale over which conformity is effective that is important. When the group that experiences a common socialization is large, large-scale sentiments of solidarity exist, and local peace is maintained; however, this makes large-scale violence possible.

Close Local Group Endogamy → Small-Scale Warfare
Local Group Exogamy → Small-Scale Peace, Large-scale Warfare

In modern societies, there are many cultural institutions that generate loyalty. Economists have worried that big economic firms like Chrysler Corp. should not exist. Shouldn't each individual employee of a firm act selfishly? Yet economists tend to assume that such firms exhibit organized profit maximizing behavior, rather than individualized anarchy. Suppose new employees are taught work norms by old employees in most firms. If there is a conformity effect, new employees will tend to conform to the existing "corporate culture" (recently a buzz word in business management circles). If the corporate culture is one of cooperation in pursuit of collective corporate goals, the firm is liable to prosper. On the other hand, firms full of selfish careerists, pilferers, and embezzlers are likely to go bankrupt. The bankrupt firms' employees will be dispersed to many surviving firms, and they will have to undergo a period of resocialization. Thus, the tendency to loyalty to the company, honest hard work, and similar attitudes can spread, even if individuals have direct biases toward selfishness. Effective corporate socialization processes will be group selected to "fool" people into cooperating. Of course, everyone is better off if everyone cooperates; a prosperous firm can afford higher wages than a failing one. As Peters and Waterman (1982) argue in their best-selling book *In Search of Excellence: Lessons from America's Best-Run Companies,* we are all better off if most of us are fools in this sense.

Simple societies, such as might have characterized humans for the last 30,000 years or so, look as if they meet the main requirements for being group selected. Joseph Soltis et al. (1995) recently looked at the potential for group selection among highland New Guinea groups. These groups all engage in warfare and land competition between villages. The pattern of intense competition survived into the late 1940s, when contact with the outside world was first established. In most places, European contact disrupted patterns of intergroup competition before competent ethnographers arrive. Thus the Highland New Guinea situation is unusually interesting. Intergroup competition was intense and often violent. Soltis could make estimates of group extinction rates per generation (25 years) for 5 groups, and the values run from a few percent to about 30% depending upon group and method of estimation. "Extinctions" were counted whenever a group broke up and went to live with other groups. Complete genocide is rare; most often defeated groups disperse piecemeal to neighboring groups. This form of "extinction" is very hostile to genetic group selection, because defeated groups will inject any failed genes they might have into the groups that accept them as refugees. However, the conformity effect could protect host groups from the bad culture of the refugees they take in. He also documented considerable variation between groups in cultural traditions, and a pattern of new group formation by budding that preserves between group variation.

Soltis concluded that the cultural group selection hypothesis meets the test of the New Guinea data. The rate of change due to this process would be fairly slow; it would take something like 1,000 years for this process to make an innovative mode of social organization common in all groups in a larger population. This rate of cultural evolution may seem slow, but remember that in Eurasia, the evolution of the modern types of states is a product of 10,000 years of political evolution. Western Europeans were approximately at the level of political sophistication of New Guinea Highlanders for perhaps 3,000 years after the evolution of the first simple states in the Middle East. The evolution of political evolution does have a 1,000 year time scale, which is roughly correct.

VII. Conclusion

The extremely high level of cooperation exhibited by humans is an evolutionary anomaly. The only other animals where thousands of individuals can be organized into cooperative units are the social insects and the colonial lower invertebrates such as jellyfish. And in both of these cases, kin selection seems to provide an acceptable explanation; these are close families, albeit huge ones.

In our closest relatives, the higher primates, groups are often as large as hunter-gatherer bands, but the level of cooperation within such groups is very low. For example, males do not cooperate in defense, except in those groups where males do not disperse (e.g. chimpanzees). The levels of cooperation observed seem easily explicable in terms of kin-selected cooperation with close relatives plus a small amount of reciprocal altruism.

Humans by contrast, at least when it comes to post-agricultural societies, are organized on a very large scale and with lots of cooperation, coordination, and division of labor. It is clear that humans do not literally use the kin selection mechanism to achieve these levels of cooperation. We do not have the sterility-of-the-workers mechanism that ensures that all members of society are closely related.

Sociobiologists have advanced a series of hypotheses to account for human societies based on the classic kin and group selection, and reciprocal altruism mechanisms. We think these explanations all have fairly serious problems. An alternative explanation is that the use of simple decision-making rules, like conformist transmission (frequency dependent bias), to reduce the cost of acquiring adaptive cultural traits might lead to group selection on cultural variation as a by-product. Once altruism arose culturally, altruists could punish cheaters and set up selection against genes that encourage cheating. In this scenario, a peculiarity of the human inheritance system, the existence of culture, is invoked to explain a peculiarity of our behavior, a high degree of cooperativeness.

We might suppose that group-selected human culture has gradually (if imperfectly) domesticated our selfish genes over the last 100,000 years or more. The human docility that Simon refers to really does seem to exist. People have attempted to raise chimps like children, and all these animals become unmanageably aggressive as they approach sexual maturity. The wild progenitors of other domesticated animals, like cats and dogs, are practically unmanageable as pets. Somehow Simon must be right, we domesticated ourselves. If not by cultural group selection how?

The testing of all of these hypotheses is incomplete. Perhaps not even all the hypotheses needed have been formulated. Pieces of the puzzle are certainly missing, no matter what your favorite hypothesis might be.

VIII. Bibliographic Notes

References

Alexander, R.D. 1974. The evolution of social behavior. *Ann. Rev. Ecol. Syst.* 5: 325-83.

Alexander, R.D. 1979. *Darwinism and Human Affairs*. Seattle: Univ. Of Washington Press.

Alexander, R.D. 1987. *The Biology of Moral Systems*. New York: Aldine De Gruyter.

Axelrod, R. and W.D. Hamilton. 1981. The evolution of cooperation. *Science* 211: 1390-96.

Hamilton, W.D. 1964. The genetical evolution of social behavior I & II. *J. Theoret. Biol.* 7: 1-52.

Hamilton, W.D. 1975. Innate social aptitudes of man: An approach from evolutionary ecology. In: *Biosocial Anthropology,* R. Fox (ed.), pp 133-55. London: Malaby.

Jacobs, R.C. and D.T. Campbell. 1963. The perpetuation of an arbitrary tradition through several generations of a laboratory microculture. *J. Abn. Soc. Psychol.* 62: 649-58.

Maynard Smith, J. 1964. Group selection and kin selection. *Nature* 201: 1145-1147.

Otterbein, K.F. 1968. Internal war: a cross-cultural study. *Amer. Anthrop.* 70: 277-89.

Peters, Thomas J. and Robert H. Waterman. 1982. *In Search of Excellence: Lessons from America's Best-Run Companies.* New York: Warner Books.

Simon, Herbert A. 1990. “A Mechanism for Social Selection and Successful Altruism.” *Science* 250:1665-1668.

Soltis, J., R. Boyd and P.J. Richerson. 1995. Can group-functional behaviors evolve by group selection? An empirical test. *Current Anthropology* 36: 473-494.

Sugden, Robert. 1986. *The Economics of Rights, Co-operation and Welfare*. Oxford: Basil Blackwell.

Tootill, Elizabeth, ed. 1981. *The Facts on File Dictionary of Biology*. New York: Facts on File.

Trivers, R.L. 1971. The evolution of reciprocal altruism. *Quart. Rev. Biol.* 46: 35-57.

Van den Berghe, P.L. 1981. *The Ethnic Phenomenon*. New York: Elsevier.

Chapter 14: STYLE AND ETHNICITY: THE EVOLUTION OF SYMBOLIC TRAITS

> "... what are the advantages which we propose by that great purpose of human life that we call bettering our condition? To be observed, to be attended to, to be taken notice of with complacency and approbation, are all the advantages we can propose to derive from it."
>
> Adam Smith, 1790

> [The hobby of ocean] "sailing is like standing day after day in a cold shower tearing up five-dollar bills."
>
> Anonymous blue water sailor

> In a Luann comic strip Luann is doing her nails. Brad asks "What's that, another new nail polish?" Luann answers "Yup, after it dries, it still looks wet." Brad asks "Why do you want it to look wet when it's dry?" Luann replies testily "I don't know Brad. I'm just a slave to fashions, I don't *create* them!"

I. Introduction: Style a Puzzling Problem

Why should we devote any time, attention, or other resources to the seemingly frivolous traits exemplified by fashion? As Adam Smith and Luann tell us, human life is deeply influenced by our quest for attention from others and our use of "style" to attract that attention. We adorn our bodies with gaudy clothes, cosmetics, jewelry, tattoos, and scars. We make and collect art, and decorate even mundane utilitarian objects with logos and bright paint. We speak thousands of languages when any one of them would seem to do perfectly well. Even when designers like Bauhaus architects forswear style for pure function, no-style itself becomes a stylistic statement. Brad may disparage Luann's nail polish, but wearing old Levis can't escape being a kind of fashion either. Style and our preoccupation with it are an important puzzle from an evolutionary perspective. Sure, boys seem to be attracted by prettily made up girls, but shouldn't evolution have favored males who are attracted by no-nonsense earthmotherly types? What are we to make of the aesthetic analogy between human style and the colorfully variable traits of some animals (e.g. pheasant feathers and tropical fish tails)?

In this chapter we will introduce and apply the evolutionary theory that applies to symbolic cultural variation. The theory is borrowed from the biologists' theory of sexual selection, so the argument here is that the resemblance between the colorful dress of real cardinals and the red feathers of the bird of the same name is more than superficial. Using the theory, we'll try to answer some of the controversial questions that social scientists have posed about human preoccupation with style and symbolic behavior.

II. Basic Background

A. Style Ubiquitously Important in Modern Humans

It is easy to give anthropological examples of stylistic "excesses." On the Pacific Island of Ponapae, a man's prestige is partially determined by his contribution of very large yams to feasts held by district chiefs. Contributions of ordinary foods like breadfruit, coconut, or standard yams count for little. Rather families compete to grow very large "prize" yams using special varieties and laborious cultivation techniques. These can be really huge, up to 9 feet in length, 3 feet in diameter, and requiring a dozen men to carry. Families expend great effort in producing such yams, according to their ethnographer Bascom (1948). Yet the yield of food per unit effort is much lower than for ordinary yams. Despite the apparently wasteful effort involved, the competition is taken very seriously by Ponapaens. Success in growing prize yams is taken as an index of a man's ability, industry and generosity, and bringing one to a feast is taken as a token of his love and respect for the chief. Chiefs raise the rank of men who contribute large yams consistently.

American life is as full of arbitrary stylistic behavior taken seriously as Ponapaens or any other. Our own behavior seems to us so natural and sensible that we forget its giant yam-like attributes, although those of Ponapaens and other exotic people do seem bizarre and useless. This is simple ethnocentrism. Think of the generational styles in matters such as music, clothing, and recreational drugs. It is interesting that major conflicts between parents and teenagers can erupt over such seemingly trivial matters of style. Most of you have probably experimented with pleasing your parents by imitating their style or displeasing them by flaunting one they don't subscribe to. Think of the way that advertisers try to manipulate our commitments to style to sell their products. Vendors of functionally equivalent or near equivalent products like cars and beer are especially clever in this regard. The author Tom Wolfe is perhaps America's most acute and entertaining commentator on style. He is good on our giant yams.

B. Style's Recent Origin

Human preoccupation with style is an evolutionarily recent phenomenon. It is associated with the so-called Upper Paleolithic Transition (UPT), which occurred in Europe about 35,000 years Before Present (BP) (Stringer and Gamble, 1993; Klein, 1989: Ch. 7; Marshak, 1976). The European UPT is well excavated and understood descriptively, and is marked by the simultaneous appearance of (a) Anatomically Modern Humans (replacing

Neanderthals), (b) artistic artifacts like statuettes and beads, (c) stylistic (apparently non-functional) variation in otherwise utilitarian artifacts like projectile points, (d) local variation in styles on a quite small scale, and (e) debatably, fully functional speech (Lieberman, 1984). (The more fragmentary evidence so far recovered elsewhere suggests more complex patterns.) Thus, for most of human history, we got along without style. It is notable that the Upper Paleolithic Transition is associated in Europe with a big jump in population densities.

C. Controversy Over Possible Functions

Function:
Evolutionary biologists define function in terms of what natural selection favors. Adaptations *function* to promote the survival and reproduction of individuals in conventional evolutionary arguments. Social scientists have traditionally defined function similarly with regard to cultural traits, although they have usually been group functionalists. Non-functional behavior will be produced by processes such as random error or drift if they are strong enough overwhelm natural selection and similar function-generating processes.

Debates over the function of style or the lack thereof have a long history. The post UPT population increase suggests that style may have functions despite its seeming costly frivolity. Biologists and social scientists have conducted rather parallel discussions. Darwin started the ball rolling. He proposed that many colorful stylistic traits, both organic and cultural, are the result of mate choice sexual selection, usually female choice of males. He suggested a non-functional or even anti-functional mechanism by which female choice and similar processes could arbitrarily amplify peacock tails and human decoration to wasteful extremes in defiance of ordinary natural selection.

Be careful of definitions here. We can define “function” any way we want; some evolutionary biologists include sexual selection in their definition, some don’t. Thus, we can speak of peacock tails functioning to attract females, although we speak of them as dysfunctional from the point of view of survival. The important point, beyond mere matters of definitional taste, is that sexual and (ordinary) natural selection can conflict. Sexual selection became Darwin’s theoretical alternative to natural selection to explain traits that were apparently dramatically afunctional from the point of view of ordinary natural selection.

Culturally, people are able to chose whom to imitate, a process that is quite analogous to choosing whom to mate with, and if Darwin's anti-functional mechanism will work for culture, something like it might work for culture. We argue in this chapter that the anti-functionalist ideas of certain social scientists make sense in terms of a sexual-selection like mechanism, indirect bias.

Others have objected vehemently to such notions, and have proposed various ordinary functional hypotheses to account for style. For example, style can identify which species or cultural group you belong to for purposes of mating or other kinds of social interaction, something which may be highly functional. We will discuss a variety of these hypotheses below.

There are also some very interesting hypotheses that blend the functional and afunctional hypotheses. The best known of these goes under the term the "handicap principle." Perhaps carrying a conspicuous, costly, burden around is a *signal* to potential mates or imitators that your genes or culture are unusually good. Those gaudy tail feathers, costly clothes, or expensive, rarely four-wheeling, four-wheel-drive vehicles are saying loudly that you can not only survive and prosper, but survive and prosper in spite of wastefully spending resources on feathers, clothes, or cars.

There are two types of style (Wiessner, 1989): (1) People use stylistic variation *assertively* to express their individuality, as in the case of personal adornment or competitive displays of prestige items and (2) People use style *emblematically* to signal membership in a group, such as an ethnic group. Of course, the same system of style, such as car ownership, can have variation at the individual and group level. At one level businessmen and college professors use cars emblematically to signal what subculture they belong to (big American sedans versus "sensible" but classy foreign cars). At another level, the details of manufacturer, model, color, and so forth reflect individual taste. Quite different functions (or non-functions) might apply at the two levels.

The evolutionary questions turn on the issue of honest versus dishonest signals, and on the total effort devoted to competitive advertizing versus "real" quality. The theory imagines that animals (and people) advertize. The ultimate sales pitch is for your genes or your culture. Are the population level consequences of advertizing the accumulation of dishonest signals "designed" to mislead imitators and mates? Does advertizing lead to a wasteful arms race, even when signals are basically honest? Or do strictly utilitarian uses of advertizing dominate?

D. Definition of Style as Symbolic Characters

Technically, stylistic traits are usually described as symbolic. A symbol is a type of a sign. A sign is something that stands for something else. According to semioticians, the theorists on the issue, signs come in three flavors: (1) *Icons*: signs that resemble the thing they stand for, for example a map or an anatomical drawing in your biology textbook. (2) *Indices*: signs that are factually related to what they indicate. For example the size of a person's house or the fullness of farmer's storage bin are indices of wealth and farming talent, because without them it is tough to display the index. (3) *Symbols*: signs that indicate what they indicate by conventional agreement. The purest example of symbols are found in language; it doesn't matter what words or grammatical structures are used to represent particular meanings, only that we all agree on which to use for what. Any sign may have some scope for stylistic alternatives that are functionally equivalent, but the scope for stylistic variation is greatest for symbols. An exceedingly rich symbolic repertoire is a human specialty. Primates like monkeys are known to have a few symbolic calls, on the order of one dozen. Humans have active vocabularies of a few thousand words.

III. Evolutionary Forces Acting on Stylistic/Symbolic Traits

A. Ordinary Adaptive Forces

Purely stylistic variation cannot be subject to ordinary natural selection in the usual way. Symbols by definition are equivalent until we decide to invest them with particular meanings. Take linguistic variation. English is not an adaptation to the British Isles, nor is Chinese an adaptation the Yellow River Plain. If history had made the inhabitants of England Chinese speakers (more plausibly, they might have remained Celtic speakers, or become French speakers), life would go on just fine.

Adaptive forces like natural selection and direct bias can act on symbol ***systems*** *in three specific ways. First,* in the case of communication systems like language, the ability to communicate can be selected for its functions, even if the symbolic variation is adaptively neutral. It may be adaptive to communicate food sources, danger, and social information to your fellow humans, whatever language you use. *Second,* selective forces may act to counteract the excesses of the run away process, or to minimize the costs of signaling. Remember Darwin's idea here: The peculiar dynamics of sexual selection may conflict with the effects of natural selection, and in any given case one or the other may be the stronger. Natural selection will fight our tendency to wasteful competitive signalling. *Third,* frequency dependent selection can also act on symbolic variation itself, much like the operation of frequency dependent bias discussed in the next section.

B. Social Choice-Based Forces

Frequency dependent bias and similar effects, such as social ostracizing of people who display "odd" tastes, may be important in the evolution of style for the same reasons that frequency dependent natural selection affects symbol systems. At least when functioning as a straightforward communication system, conformity is important in that we must all use the same symbols for the same meaning. If communication by symbols is to be successful, we must "agree" to use the same symbols for the same meanings. Bias (or selection) will favor the common type and discriminate against rare variants. For example, a rare individual who cries "hell" instead of "help" when in trouble will be less likely to receive aid and is perhaps significantly more likely to die. Knowing this we tend to use the same sounds everyone else does for the same meanings. Note that none of these three processes tend to cause functional convergence and fit to the environment of stylistic variants. We say "cat," Spanish speakers say "gato," and both are equally effective for communication. In the case of assertive style, non-conformist forces may be important; for creative artists, it is important to be new, fresh, and unique.

Indirect bias is an important force on symbolic traits and has very interesting properties. Because symbolic characters are used in communication, they are a natural locus for evolutionary forces based on choice of whom to imitate or mate with. People often seem to act like they want to pass on their genes and culture to others. The epigraph from the arch-rationalist utilitarian Adam Smith reflects his acknowledgment that people's fundamental desires are to be imitated and mated. We can easily imagine that people choose mates and cultural teachers with an idea to acquiring good genes and good culture to pass on to genetic and cultural offspring. Ideally, we would be able to survey potential mates and "role models" (let's use "role model" as a shorthand for any type of cultural model we might have the chance to choose rather than be stuck with) and estimate as precisely as possible what their genetic and/or cultural quality is. However, this is not easy to do. On the other hand, in order to attract mates and imitators, individuals are perhaps willing to advertise.

The simple step of trying to choose mates and role models based on limited information that includes advertising leads quickly to complex but fascinating evolutionary dynamics. As a mate or model chooser, honest communication will greatly help our choice. Those who seek mates or "proteges" may be quite willing to give signs of their cultural or genetic quality. These signs may or may not be honest. That is, mate or protege seekers with less than ideal genes or culture may well benefit from false advertising.

It matters what other people think. Once a system of communicating mate or model quality becomes widespread, it matters not only what you or I as potential mate or role model choosers desire for our own advantage, but also what others are likely to choose. For example, a female choosing a mate may think that a colorful tail (or the habit of smoking) is a stupid display, poorly correlated with genetic fitness (or cultural achievement). However, if she is convinced that most females in the population do think that colorful tails or smoking are associated with success, she may choose a colorful male or a smoker *in order that her sons, inheriting colorful tails or smoking from their fathers, have a better chance of being attractive to their potential mates.* This was Darwin's basic intuition about mate choice. Once an “aesthetic capacity” developed in (usually) females, successful appeals to female taste could counterbalance quite considerable ordinary fitness costs. (Cronin, 1992, gives a good analysis and history of the sexual selection issue, going back to Darwin and Wallace.)

Indirect bias has a lot of similarities to mate choice sexual selection and, general conclusions that apply to one are also likely to apply to the other. Recall, cultural transmission is indirectly biased when people use some traits displayed by potential role models, such as indicators of prestige, such as dialect, to bias the imitation of other traits, such as subsistence technique. In other words, some attributes of a model are used by naive imitators as a basis for choosing to imitate a more general class of traits for the same model. It is useful to distinguish three classes of characters when thinking about this mechanism of cultural evolution: (1) *Indicator traits* are displayed by models and used as a basis for weighting their importance by imitators. For example, suppose that imitators are inclined to admire and then to imitate successful individuals, and that success is estimated using particular indicator traits--number of cows, number of children, or style of dress. (2) *Indirectly biased traits* are acquired as a by-product of choices based on indicator traits. Once a particular model is given a large weight in enculturation, naive individuals might tend to acquire animal husbandry lore, beliefs about appropriate family size, or a set of study habits from this role model. (3) *Preference traits* are the criteria by which naive individuals evaluate indicator traits of potential models. In some cases, a simple more- is-better rule (e.g., the wealthier, or the better student, the better) might be used. Other times, intermediate values of an indicator trait may result in the strongest weight. For example, contemporary middle-class Americans seem to most admire people with intermediate-sized families, not the childless or those with very large families. Later on, we'll look at a case in which people prefer as models someone who is simply like themselves on a stylistic trait--birds of a feather flock together.

Language evolution shows indirect bias in action. Sociolinguists have shown that patterns of the spread of linguistic variants are under the influence of an indirect bias mechanism (Labov, 1980). One of Labov's most famous examples is the development of a distinctive phonology (way of pronunciation) on Martha's Vineyard, an island off the coast of Massachusetts. People on the island are mostly involved in the tourist business, but they consider catering to the whims of tourists to be rather low status. Most Islanders admire the independence of the few fishermen left working on Martha's Vineyard. They see them as exemplifying the individualism and independence of Old Yankees. Preferring independence, and treating fishermen's salty talk (including frequent disparaging remarks about tourists) as an indicator of an independent frame of mind, Islanders put fishermen at the top of the local prestige hierarchy. Have done so, they tend to imitate the pronunciation of fishermen, who have thus become the leaders of dialect evolution on Martha's Vineyard. Interestingly, those young individuals whose ambitions will lead them to leave the island are responding to the wider New England prestige system, and conform to mainland rather than Island phonological patterns. The pronunciation traits changing on Martha's Vineyard seem to be indirectly biased (rather than being important indicators) because data suggest that people are not very self-aware concerning these particular small-sale dialect differences.

There is considerable evidence that people use indirect bias in a number of situations similar to the linguistic example to choose whom to imitate:

(1) *Evidence from social learning theory*. Laboratory studies of human imitation have shown that naive individuals often use indicator attributes of role models to bias their attention to models and their acquisition of other behaviors (Rosenthal and Zimmerman, 1978:251-254). For example, Yussen and Levy (1975) exposed preschool children and third graders to warm and neutral adult models. Warm models increased student's attention, reduced their susceptibility to distraction, and enhanced their recall of modeled behaviors.

(2) *Evidence from the diffusion of innovations*. Rogers with Shoemaker (1971:ch 6) review how patterns of information flow during the adoption of innovations are affected by sociological attributes of adopters and models. They discovered that a class of individuals whom they label “opinion leaders” play a disproportionate role in the spread of innovations within a local community. These individuals are usually higher in status than average in the local community, and seem to be picked as role models based on local prestige indicators. If opinion leaders adopt an innovation, it spreads to the rest of the community; if not, few adopt the innovation (more on this topic in Chapter 20).

It is easy to imagine that indirect bias is a functional mechanism for acquiring cultural traits (Flinn and Alexander, 1982). By imitating successful role models, naive individuals can increase the chance that they will acquire the beliefs and values that lead to success. In the case of diffusion of innovations, for example, Rogers suggests that copying opinion leaders is a sensible way for potential adopters to decide whether to adopt an innovation. Potential adopters of new techniques have a wide range of abilities and resources to devote to judging the utility of new techniques, and it makes sense for adopters with moderate resources to use opinion leaders with more resources as models of what to adopt. On the other hand, a choice of models of very different status is unlikely to be an effective strategy because the circumstances of life of such a model are likely to be too different to provide a good guide for optimal techniques. Thus, rural people use the best farmers in the village rather than rich city based amateur farmers as opinion leaders for farming techniques. Foreign "experts" are also often viewed skeptically by 3rd World aid recipients. In our experience such experts do sometimes show an unfortunate carelessness about local constraints and conditions.

C. The Runaway Process

Indirect bias can also result in maladaptive runaway evolution. As we noted earlier, one of the most interesting questions is what leads to the apparently maladaptive elaboration of stylistic displays. In this section, we briefly describe the structure of a very simple model that we think captures the bare bones of the problem. A detailed description of the model is given in the reading.

We begin by assuming that each individual can be characterized by the values of two cultural traits. The first trait is an *indicator trait* that affects the individual's attractiveness as a model, and the second is a *preference trait* which determines which variant of the indicator trait that the individual finds most attractive. To keep the model simple we do not include any indirectly biased traits other than the preference trait itself. We assume that different variants of the indicator trait are characterized by different genetic fitness. The model also lacks any explicit details about the genetic system. We merely assume that selection on the (cultural) indicator trait favors a variant that is optimal in terms of genetic fitness. The two traits themselves are modeled as quantitative characters. That is, it is assumed that they can be measured as real numbers rather than taking on discrete values. Such a characterization is quite apt for traits like wealth that do vary continuously, but might not be a very good representation of a trait like class that may have only a few discrete variants in some social systems.

We assume that the life cycle of cultural transmission begins with an episode of simple unbiased transmission from parents to children in which children acquire both traits. This is followed by an episode of indirectly biased transmission in which adolescents may modify one or both traits after choosing a number non-parental adults as role models. The extent to which a particular role model influences a particular adolescent is affected by the preference trait that the adolescent acquired from his or her parents and the adult role model's indicator trait. That is, adolescents use the preferences learned from their parents to select a set of non-parental models based on these models' easily observable characteristics, their indicator traits. For example, children raised in religious households will be more prone to learn from people who are evidently pious than from those that are not. The adolescents then modify their original indicator and preference traits on the basis of the models chosen. This is not an either/or choice, rather the adolescent imitators weight the influence of the models in accord with their preferences and the models' indicator trait values.

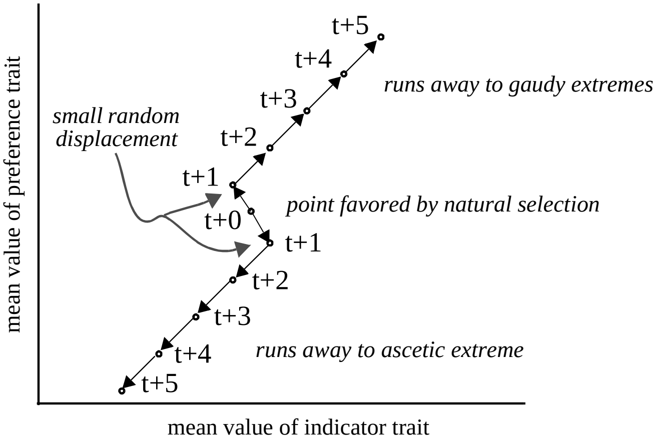
Finally, there is the episode of natural selection favoring the value of the indicator trait that maximizes genetic fitness. Then the next generation begins with an episode of parental transmission to the next generation, completing the life cycle.

Based on these assumptions, one can construct a mathematical model for the distribution of indicator and preference traits in the population (details, again, in the reading). The model suggests that cultural evolution under the influence of indirect bias has two distinct modes:

(1) *Stable fitness maximization, honest advertising*. If the strength of indirect bias acting on the preference trait is weak compared to the combined adaptive forces of selection and direct bias on the indicator trait, then the preference trait will eventually reach a stable equilibrium at the value that maximizes genetic fitness. In other words, both direct and indirect bias will evolve so that naive individuals tend to imitate models with the optimum value of the indicator trait. This occurs when selection is strong enough to ensure that the indicator trait remains a good index of fitness, and individuals are usually able to imitate the indicator trait they prefer.

(2) *A runaway case, costly exaggerated advertising*. If the strength of indirect bias acting on the preference character is strong compared to the combined adaptive forces of selection and direct bias acting on the indicator character, then according to the model, the values of both the indicator trait and the preference trait will run away, becoming indefinitely larger or smaller depending on the initial condition. Clearly, this cannot be literally true; nothing can really grow or shrink without bound. Some process not accounted for in the model will eventually restrain the evolution of the population. The correct qualitative lesson to be drawn is that when the evolution of preference trait is affected by indirect bias, the resulting process may be inherently unstable. Where it exists, such instability is likely to result in preference and indicator traits that are some distance from their genetic fitness optimizing values. Figure 14-1 illustrates the behavior of the model graphically. Thus, when the situation of the runaway obtains, a slave-of-fashion effect can indeed arise. An

Figure 14-1. Cultural evolution can "runaway" due to indirect bias forces. If the strength of bias for the *preference* trait is stronger than the combined strength of selection and bias for the *indicator* trait, the value of the indicator trait in future generations (t+1, etc.) can runaway to increasingly maladaptive values. Here the two extremes might be everyone wears only skimpy, sexy clothing (Madonna's underwear regardless of the weather) and the other everyone wears completely concealing unisex clothing (regardless of weather).



arbitrary signal of what sort of person is best to imitate will arise, and each of us will be motivated to go along merely because everyone else thinks it is the right indicator. Like peacock feathers, the result is beauty without function.

To see how the runaway process works in a simplified case, let's use another example of language evolution from Labov (1972). In New York City, middle class speakers have historically not pronounced the *r* in many words like *fourth* and *floor*. However, middle class speakers are very sensitive to the status gradations of language, and prefer to speak what they regard as the higher class dialect. It is a fact that higher class speakers in New York tend to use more *r* than middle and lower class New Yorkers. *r* use is a variable that people are more aware of than the dialect variants on Martha's Vineyard we discussed above. By having a preference for upper class dialect, and using *r* use as one of the indicators to select language models, middle class New Yorkers are tending to use more and more *r*. This should all have come to a halt when middle class and upper class speech contained the same amount of *r*. It hasn't because of a curious mechanism Labov calls "hypercorrection."

Although Middle class speakers have enough awareness of r to use it as an indicator, they do not actually have very good control over how much r to use. It is interesting how imperfectly we are aware of our speech, even in the case of a fairly conspicuous and publicly stigmatized bit of behavior like dropping *r*. The most "advanced" middle class speakers tend to use even *more r* than upper class people, the phenomenon of hypercorrection. Presumably, most middle class people don't actually have upper class language models, merely slightly higher status middle class people. No matter how much *r* middle class people use, they "hear" the higher status people, whose dialect they prefer, using more. Everyone up and down the status hierarchy uses more *r* in the next generation, and so more *r* is genuinely spoken. The class-based correlation between preference for *r* and amount used remains. The next generation repeats the whole indirect bias/hypercorrection process, and *r* use increases again.

In these kinds of situations, even the upper class tends to follow along, pushed by the middle class, so the system doesn't simply overshoot a little bit and then stop or come back down to upper class norms. (Middle class perceptions acting as preferences are more important here than what the upper class actually does; there are too few of them to matter much.) There is every indication that this system will run off to complete use of *r*. Perhaps New Yorkers will start to roll their *r* like Spanish speakers! Interestingly, in England, the middle class perceives *r*-less speech to be higher status, and English speech is running in the opposite direction to that in New York.

The linguistic example is simpler than most presumed cases of the run away process because there are no strong adaptive forces acting to restrain the purely symbolic dialect indicator, and because the psychology of hypercorrection "artificially" maintains both a correlation between preference and indicator and creates a mean preference that remains higher than indicator until the dialect change goes to completion.

Even in language, where the range of selectively neutral variation is so enormous, the run away process presses the envelope. Some languages favor rather difficult tongue maneuvers to speak some words. For example the Amerindian language family Salishan is characterized by very complex strings of consonants in words. It is conceivable that Salishian languages are complexified to the point of real difficulty by exaggeration for stylistic effect. English has two painfully exaggerated features. One is its huge vocabulary. It is said that the retention of many French derived synonyms for Old English words was originally a result of lawyers retaining more synonyms to generate ever more complex legalese. The second is spelling. English is one of the few languages without regularized spelling rules. We seem to resist regular spelling because mastering spelling is considered a mark of intelligence. Objectively, a spelling bee would seem to be a form of child abuse, yet the national winners of such irrational contests are juvenile celebrities!

Pure run away models are controversial. The controversy among theorists (see Pomiankowski, 1988) is over whether when more realism is added, cases like the Ponapaens prestige system based on giant yams can respond the way r when the added realism of selection against the wasteful growing of costly items for display is introduced, and when there is no hypercorrection effect to produce a displacement and maintain a correlation. When an element of natural selection or direct bias is added, the correlation between the preference and the indicator tends to collapse in some models.

The handicap hypothesis proposes that the exaggeration effect is rules by real adaptive advantages. Zahavi (1977) has argued that males can signal their overall fitness by managing a serious handicap successfully. The gaudy tail feathers of a male peacock are essentially saying to females "look, my genes must be good, or I wouldn't be able to obtain food and avoid predators carrying around all these lovely (OK, useless too) feathers. If you mate with me rather than drab old Joe over there, your offspring will benefit from my excellent genes." The complex social life of humans is likely to involve signaling all sorts of things, and it is easy to imagine that Zahavi's hypothesis extends to cultural traits.

If the ongoing theoretical debate settles in favor of the run away process, then we would interpret Ponapaen giant yams (and American giant cars) as a situation that started out as an adaptive case of indirect bias that got away. Those who grew larger-than-average yams (or drove slightly better cars) were perhaps once better farmers (businessmen). However, once the size of yams had been elevated to the status of an important indicator trait, the run away process might take over. Soon people began to grow special giant yams just to attract the attention of people who were trying to use yam size as a way to learn to be better farmers. Then the role model choosers stopped caring if large yams were really an index of farming skill or not, because once "everyone knows" that yam size is an index of people's general skill and wisdom, and that prize yams earn the respect of authorities, the actual correlation of the skill of growing yams with any non-socially defined skill or quality is beside the point. The slave- of-fashion mechanism is off and running!

If the handicap hypothesis wins, we will have to give an honest signal interpretation to the same cases of exaggeration. At the beginning of the evolutionary process, it may be easy to fake a handicap, say by having some colorful feathers but hiding them except when displaying to females. In such a case, there is no serious handicap due to the anti- camouflage of bright feathers. The handicap has to be exaggerated enough so that it is an unfakable honest signal. A male pheasant or peacock must really expose himself to being seen by predators and get away in spite of it. Any Ponapaen could fake being a good farmer by devoting some extra attention to a little patch of regular yams. Like any reasonably successful businessman can buy a nice model Toyota, Chevy or Ford. But when it is a flat out competition to consistently grow really huge ones, you call forth maximum the horticultural effort and wizardry you possess, and the size of your yam is likely to reflect real your skill. However, such extreme devotion of time and talents to this one task may mean that the actual food production of the best farmer is only a little better than that of low-skill individuals who stick to real business. Like businesses along a suburban strip, everyone would be better off if they could agree to display only a small, cheap, but honest advertisement. But cheap, honest, signs are easily subverted by aggressive, unscrupulous advertisers, and a sort of arms race follows. The competition-driven exaggeration to prevent fakers from taking advantage only stops when each bird, farmer or business dissipates vast resources displaying a sign whose size and expense are pretty well correlated with the size, skill and health of the business/bird/farmer, because everybody who could afford a more elaborate signal would be driven to do so.

The difference between the pure run away and the handicap hypothesis is that in the case of the handicap, the exaggerated display is maintained because elaborate displayers still have the best genes/culture from the ordinary fitness point of view. Unlike the pure run away hypothesis, it is not *just* a matter of everybody else’s attention to style that motivates you to pay attention to Lexus drivers in preference to drivers of ordinary Toyotas. Style will be correlated with better ordinary adaptive traits; Lexus drivers will really tend to be better business people. We imitate them because we think they have better business skills, as well as because we know no one will ever imitate us unless we can display an unfakable signal of being good at business. A Lexus is hard to fake as a signal because it is costly. Only good business people can afford them.

It is not clear that the handicap hypothesis is much less pathological than the pure run away hypothesis. In the extreme case, practically all of an individual's advantages due to having superior genes or culture may be cannibalized to support the costly signal. If I try to reserve any of my cultural superiority to actually try to live longer or teach better, a rival with slightly less advantage, but slightly more willingness to display a more severe handicap, will attract more imitators. Every ounce of a superior Ponapean farmer’s extra skill may be poured into his giant, useless yams.

On the other hand, the famous evolutionary biologist W. D. Hamilton and his student Marlene Zuk (Hamilton and Zuk, 1982) have proposed that unfakable signals are usually not much more expensive than is required by observers to make an accurate assessment. They think that the brightness and sheen of feathers and the red, blood suffused comb of a rooster are a bird's medical report to potential mates. If a chicken carries a large load of blood parasites, like malaria, it will be anemic and its comb more dull than a health bird that is resistant to malaria. If it is infested with lice, its feathers will chewed up and dull. On this hypothesis, honest signaling is possible with a minimum of costly, competitive, exaggeration required to generate unfakability. A Hamilton-Zuk signal is unfakable because it gives pretty direct visibility to the underlying biology. Attempts to evaluate the two hypotheses by biologists have been controversial so far. As far as cultural signals are concerned, the work has hardly started. A Lexus seems pretty expensive relative its transportation function to us, but perhaps you can think of a way to support Hamilton/Zuk for such cultural traits.

The exaggeration effect in the run away and handicap situations is most extreme in the case where individuals contribute no real resources to their offspring (or imitators). Thus, male characters are most exaggerated in polygynous species like the chicken-like birds, where males play no role in rearing the young and spend all their effort trying to attract as many matings as possible. In many songbirds, where males and females both sit on nests and feed young, males and females differ little in coloration, etc. Likewise, in cultural prestige systems, the most extreme display behavior seems to occur in roles that are active in horizontal and oblique transmission. Media stars, who have a lot of money and the ability to reach the masses, often spend massively on display. Rich businesspeople who plan on leaving the family fortune to the kids seldom bother with really extreme showiness. If Dad is really willing to contribute directly to his family, it is important to Mom and the kids that he doesn't spend it all on fast cars and fancy whiskey.

In human cultures, roles effective in horizontal and oblique cultural transmission with little contribution of resources to imitators are very common. Casual friendships are a common example. There is ample scope for both men and women to behave like the polygynous males of classical female choice sexual selection. Our devotion to symbol systems that have apparently been exaggerated is not so hard to understand!

You are busy acquiring an expensive signal of your cultural worth to display to potential employers, your college diploma. There are two schools of opinion about what diplomas are all about, and they convey two extremes of the quality signaling idea well. The most common, championed by most professors, university administrators, etc., is that your diploma is an accurate index of what you know and how well you know it. Your diploma, transcripts, etc. are relative cheap and unfakable signs of your real skills. Many of these real skills you acquired in classes like this, and such skills justify the high cost of a University degree. Employers, mates, and friends value the diploma itself for its signalling your possession of the skills, but the sheepskin itself is a nearly costless way advertizing your talents. This is like Hamilton's and Zuk's hypothesis.

A cogent minority hypothesis is championed by cynical (or realist) economists. They argue your diploma is little more than a signal that you have the mental stamina and tolerance of boredom to do the typical white collar job well. You haven't changed since high school really (the specific skills we teach you are irrelevant), but you will have, if you graduate, hard- to-fake proof of those valuable stamina and boredom tolerance qualities you have already had as a high school graduate. Your high school classmates that didn’t go on to college may also have these talents, but they can’t prove it to an employer, as you will be able to when you graduate. On this hypothesis, the escalation of educational requirements for jobs in the 20th Century doesn't mainly have to do with greater skills but is rather due to ever more costly competitive displays of handicaps. As wealth has gone up, every family can afford to keep kids in high school, and a high school diploma becomes an easily faked signal. Extra time and other resources now have to be wasted to acquire the harder-to-fake college diploma if you aspire to a middling or higher place in the job market. You would be better off, and prospective employers would be indifferent, if there was a cheaper, unfakable signal, than college, but there isn't. An expensive signal is required, and we have an ideology about education that legitimizes a college education as the handicap of choice. Employers in another society might find evidence that you routinely turned up for several hours of silent meditation every day for several years just as useful!

IV. Application of Evolutionary Theory to Social Science Debates

The issue of whether symbolic traits are functional in some way or another, or whether they represent a major challenge to functional interpretations has been one of the major debates in the social sciences. Anthropologist Marshall Sahlins (1976) decried the endless, sterile “cyclical and repetitive” debate caused by feuds between functionalist and anti-functionalists. One of our major claims for ecological and evolutionary theory is that it gives us a better tool than social scientists have had in the past to understand the issues involved in such debates, and to get science moving forward again.

In this section we compare four classic social science hypotheses about stylistic/symbolic variation. The *first* looks for hidden, but quite ordinary, adaptive messages behind apparently maladaptive signals. The *second* invokes highly functional explanations for this variation, analogous to Hamilton/Zuk in the biological case. The *third*, a favorite of many cultural anthropologists, depends upon hypotheses like run away, or at least the high-cost version of the handicap hypothesis. The *fourth* has little parallel in biology; imagining that the group-level variation generated by symbolic evolution produces group selection for cooperation, much like conformity.

A. Cryptic Functionalism

Marvin Harris (1974), from an ultra-functionalist school of anthropologists, looks for ordinary functional explanations of symbolic traits. For example, he explains religious dietary prohibitions against pork in the Middle East as resulting from pigs competing too much with humans for food in a rather dry environment. He explains the Hindu prohibition against cow slaughter as stemming from a need to protect cows from over slaughter in a system where their traction, milk and dung are valuable commodities.

Harris is a bit loose as to how all these hidden functional traits (adaptations) come about. He is also rather unsystematic and suspiciously imaginative in the way he discovers these hidden functions. For example, he invokes group and individual level adaptations seemingly as suits his fancy.

It is quite plausible that many indicator traits are highly correlated with genetic fitness or other conventional standards of functionality. We can help him out. Recall the fitness maximizing case of the indirect bias process. Often indicator characters may themselves be adaptive, as well as being signs correlated with an adaptive complex of indirectly biased traits. The most adaptive sign to use as an indicator trait is one that is causally related to fitness, so we should not be surprised that indicator characters are often directly adaptive.

Harris' hypothesis is well to keep in mind because ethnocentrism may lead us to mistake anything exotic that others do as an arbitrary maladaptive symbol. It is plausible that real adaptations often serve as indicator characters and get woven into belief systems. Style may often substance or be awfully closely correlated with substance.

B. Communication Function Hypothesis

Symbolic traits have basic communication functions. A. Cohen (1974), and many others, argue that symbols are functional in the sense that they are useful in communication. Communication may be at the level of individuals exchanging various kinds of information, as in the basic use of language, or it may be more group oriented communication, as in using clothing style to signal what ethnic group or class you belong to. On this hypothesis, stylistic variation does not do anything at all mysterious. It just symbolizes some underlying meaning people want to communicate, just as a word does. Symbolic behaviors may be rather elaborate and costly, but not really any more than is required to serve their rather complex communication function. The symbol experts (priests, spin doctors, and the like) do acquire a certain amount of power that they abuse, but that is no different in kind from the tendency of other specialists in complex societies to act in their own interest. *Given that communication is useful in lots of ordinary adaptive contexts, this hypothesis is undoubtedly often part of the answer.*

Communication functions do not conflict with free variation. According to this hypothesis, the symbolic system is free to vary and change, because, as we argued when introducing the evolutionary theory of symbols, the communication function is served equally well by any sign we care to attach to a particular meaning. As long as language or other symbol systems change slowly enough that we mainly understand what others are trying to say, they are free to change any which way without disturbing function. The evolution of ordinary adaptations (what we talk about) is in the medium run almost completely divorced from the evolution of language and other symbolic communication systems (how we talk about what we talk about).

Insofar as symbol systems like language respond to assertive uses of style by individuals, a great deal of stylistic variation will be created by the almost unrestrained freedom of the run away as we saw in the examples like New York r. Groups will almost automatically tend to accumulate stylistic differences because of the very weak functional constraints on what symbol we use to communicate what meaning. This variation may be simply functionally irrelevant, neither of much use nor much harm. We could all speak the same language, but it doesn't really cost much if people in distant communities speak differently. This hypothesis has a close resemblance to Hamilton and Zuk’s explanation of “exaggerated” traits in birds. There may be adaptive functions for group marking styles. This “tower of babel” effect of the indirect bias force acting on symbolic indicators may have indirect functional implications by creating stylistic markers of groups. There may even be an advantage to speaking differently from your neighbors. It is widely believed by functionalist anthropologists (Cohen is a good example again in this context) that stylistic markers of group membership are an essential part group level functioning of political systems. Complex societies involves lost of coordination between specialists, and it may be quite important for you to signal your group membership to others so that they can appropriately adjust their own behavior. When this is true, markers of group membership can arise by cultural evolution without the need to necessarily to invoke group advantage.

Boyd and Richerson (1987) studied how ethnic markers, or similar markers of ecologically distinctive groups, might arise using a theoretical model. This is a very simple example of how functional signals of group membership can arise due to individual level advantages.

Here is how it works:

Suppose there is an ecologically heterogeneous area in which [say] raising more cows and fewer crops is an advantage in one region, and more farming-fewer cows is an advantage in another. There is a certain amount of cultural contact across the boundary, so that people living in one area are exposed through trade, intermarriage, and the like to people living in the other. Such contacts will tend to result in a flow ideas from one region to another. Selection or adaptive biases will tend cause populations to adapt to the local environment, but, if information is costly and selection and/or biases imperfect, the flow of ideas across the boundary will prevent populations from perfecting local adaptations. Unless something intervenes, the degree to which human populations can develop highly specific adaptations to local conditions will be reduced by the flow of maladaptive ideas from neighboring communities.

This is a quite general problem of evolution in heterogeneous environments. In the case of genetic evolution, we often find species replacing one another at ecological boundaries, and the reproductive isolation between related species is thought to be important in allowing expansion into a new habitat. A small population at the species' margin facing a new environment can't adapt to it because gene flow from the large populations adapted to the species' old environment dilutes the gene pool of the small population trying to adapt to the peripheral environment. If a new species arises, reproductively isolated from the old species, it can proceed to adapt to the new environment free from the disrupting effects of migrants bringing genes from the old environment.

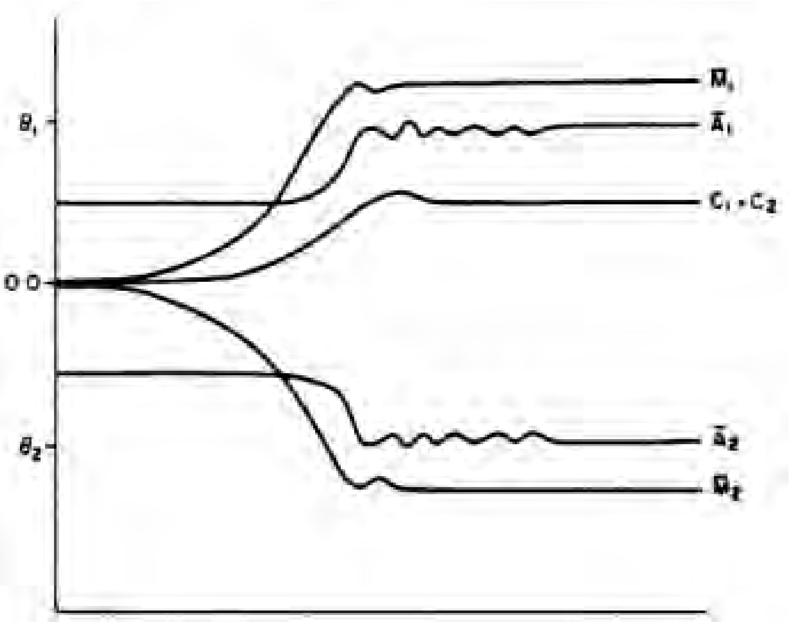
Humans can play a cultural variant of the speciation trick which is actually more efficient. Suppose each of our two model populations is characterized by a variable quantitative marker trait (M_1 and M_2) the two model environments respectively, an adaptive character (A_1 and A_2), and a correlation or covariance (C_1 , C_2) between the adaptive and marker character. For example, we might imagine again a drier environment in which the best adapted subsistence technique might be to raise more cattle and fewer crops next to a wetter one where more crops and fewer cattle is favored. The marker character could be anything conspicuous and stylistic, such as style of hat or amount of pronunciation of *r*. Correlation or covariance will arise if there is a patterned association of style and adaptive behavior, for example if cattle raisers tend to wear bigger, floppier hats than farmers.

Now, suppose that people acquire their hat style or dialect when they are young from their parents, and later adopt their subsistence strategy as young adults. As young adults, they are exposed to oblique influences, including people raised in the other environment, and who possibly carrying locally mistaken ideas about the appropriate mix of cows and crops. As young adults they use two decision making strategies to select their subsistence strategy. They prefer people similar to themselves on the marker character, a kind of indirect bias. They also put some weight on the economic success of the people they propose to imitate (this could be an adaptive direct bias, an indirect bias effect on an accurate index of fitness, or even just natural selection for economic success).

The theoretical question is whether a correlation between the linguistic symbolic trait and the adaptive trait can arise. If so, then using the ethnocentric preference for imitating people with a like dialect will help protect individuals

> from the change of imitating the wrong sort of subsistence trait to culture flow from a second population. A typical result of the model is plotted in figure 14-2. θ_1 and θ_2 symbolize the optimum value of the subsistence strategy, and the X axis is time in generations. Note that the populations start out identical for the marker trait. Until a fair amount of difference in the marker traits arises and until the correlation between adaptive and marker traits becomes substantial, the adaptations to each environment are distinctly suboptimal. (The marker trait divergence doesn't get any help from a run away effect in this particular model.) However, eventually, the symbolic difference becomes quite marked, and a good signal of having the right adaptive strategy, and both populations can perfect their adaptations. Once both populations reach the optimum adaptive mix of cows and crops, the evolution of marker characters and the covariation stops..

Figure14-2. “Representative trajectory of the mean value of the adaptive character, the marker character, and the covariance between the two characters in the two habitats (Boyd & Richerson 1987:74).”



This model suggests that the “pseudo-speciation” effect of partial cultural isolation of human groups by stylistic differences and ethnocentric imitation preferences can indeed be useful. This mechanism is potentially much more flexible than a true speciation barrier, because the choice based on success can over-ride the mechanism if an innovation that is an advantage in both environments occurs. Note that it is driven by the advantage each individual gets from imitating someone like themselves in a situation where like individuals also have a tendency to have the right subsistence behavior.

UC Davis archaeologist Robert Bettinger (1991) argues that the ethnic boundaries function of style is the best current explanation of the Upper Paleolithic Transition. Recall the discussion on page 14-3 about the correlation between stylistic variation, local adaptation, and increased population density at the Upper Paleolithic Transition. The dramatic expansion of the human species' geographical range, variety of subsistence forms, and numbers that occurred at the UPT is quite plausibly due to the development of modern hominids' enthusiasm for style!

It is interesting that complex, state level societies are built up out of socially differentiated and stylistically marked subgroups. The social raw material of complex societies includes ethnic units, but also castes, classes, interest groups, political parties, occupational and professional associations, government, business and voluntary organizations, religions, etc. These all tend to have stylistic markers. Perhaps the resemblance between complex social communities composed of cultural pseudospecies and complex biotic communities composed of many species is not entirely superficial (we return to this question in Chapters 27 and 28).

We suppose that most thoughtful observers agree that the adaptive advantages of communication in one form or another are part of the answer to the style puzzle. Especially if it is useful to symbolically communicate about social structure like ethnic group membership, it is easy to understand how a fairly elaborate ability to freely develop new styles to fit new social needs is adaptive, even though the symbolic variation itself is not directly adaptive to local conditions in the sense we're used to from thinking about ordinary selection.

C. Antifunctionalist Hypothesis

Marshall Sahlins (1976) and like-minded social scientists claim that the use of symbols in language, ritual, etc. is important and cannot be explained by any form of adaptive theory, cultural or genetic. His argument is that symbols are arbitrary and cannot be very strongly influenced by selection, direct bias, etc. Humans are free to invent whatever symbolic culture they want. Cultural models of the world are symbolic and imposed on nature, not derived from it. In other words, humans first use symbolic processes to define the world, then live in the world they have invented. This is a major challenge to any form of functionalist theory; adaptation to environment is rather meaningless if we've largely invented the “environment” in the first place! It is a view with a very wide following among “post-modernist” social scientists.

Sahlins calls the process he imagines drives antifunctional behavior "cultural reason." He is quite foggy about what cultural reason is exactly, but many of his examples are fairly compelling. Why are Americans fond of beef, but not of horsemeat and dogmeat? Many people whose cuisine we otherwise admire, that of the French and the Chinese for example, find one or the other quite toothsome! If it is adaptive for the French to eat horse, shouldn't it be the same for us?

The run away process can create maladaptive variation in defiance of adaptation in the ordinary sense. We have a candidate mechanism for Sahlins. Elaborate symbolic systems, including complex ideologies and world views could be built up by the run away process. There is a kind of aesthetic rather than functional principle involved. The run away process is very sensitive to initial conditions. Different societies are very likely to run in different directions, hence American beefsteak, French sauteed horse, and Filipino grilled puppy. Looked at this way, there is a perfectly respectable evolutionary mechanism for anti-functionalists in the social sciences to appeal to.

This hypothesis has been neglected in the social sciences both by ardent adaptationists, and by critics of Darwinian theory. Both camps find it convenient to oversimplify Darwinism to score debating points. The idea that a process like indirect bias can generate functional behavior most of the time, but also sometimes lead to the run away extremes, does not correspond to the typological, dichotomized thinking prevalent among social scientists.

The costly handicap idea makes it even more difficult to make a rigid distinction between functional and afunctional explanations. You should be able to construct this argument for yourself based on the discussion of Zahavi's ideas in the last section.

D. Group-Level Functions for Symbolic Systems

R. Rappaport (1979), and many other social scientists have long espoused the hypothesis that religion and prestige systems are group-functional (the results of group selection in our terms). Religions and political ideologies often include strong norms favoring altruism (e.g. the "golden rule"). Rappaport is especially interested in explaining the subset of symbolic characters that are taken by people to be sacred and holy. These religious aspects of symbolism often invoke the deepest possible commitments from believers. He argues that hiding group functions behind the mysterious veil of the sacred and holy serves to protect them from the selfish calculation of individuals. We would make selfish choices in games like we studied in the last chapter, but religious beliefs "trick" us with promises of rewards in heaven for good behavior and threats of the everlasting fires of hell if we are bad. The tricks are often benign, since commitment to sacred principles allows us to cooperate to keep the peace, avoid destructive overexploitation of the environment, and the like. Thus, Rappaport's symbolic group functionalism stresses social organizational functions, moral norms and the like, while Harris' cryptic functional arguments usually stress direct technological and subsistence functions. As with Sahlins and Harris, the examples are more convincing than the explanation of them.

Why might norms for group altruism, like the golden rule, be routinely bound up in highly symbolic religious ideologies and ritual practices? Why not just be nice to everybody without the mumbo-jumbo? One possibility is this: Recall that the run away and handicap exaggeration processes are highly sensitive to initial conditions. In general each society will run away in a different direction. This is a powerful means of generating random variation at the level of groups. The variation can be quite costly in terms of individual fitness. Selection might act on this variation, but the adaptive wisdom of group altruism might remain cloaked in myths and rituals that were part of the runaway process. This has the added advantage from the point of view of group selection that individuals are mystified; it may be more difficult for selfish genetic rules that underlie guided variation and direct bias to undo such symbolically embedded group functions because the group-functional rules are themselves so confounded and entangled with non-rational symbolic elements. Groups with the most complex, goofy mumbo jumbo may actually have an adaptive advantage!

T*he following scenario illustrates how this process functions embedded in irrational symbol systems might arise*. Among a collection of pioneering Pastoral societies out on the steppe, some men's prestige systems might have developed around themes of conspicuous displays of wealth, others around elaborate religious ritual, and still others around many other things. Only a few might initially have been elaborated in the direction of a deeply felt commitment to aggressive masculine bravado. From the point of view of the run away or handicap display hypothesis, all of these may be essentially equivalent. Depending upon accidents of history, some male prestige systems got started in one direction, others in other directions. However, they would have had very different effects on group success. Given steppe pastoral life-styles where long-distance attacks are feasible, and plundering others' animals is a viable economic strategy, societies with the aggressive bravado system may be richly rewarded at the expense of wealth accumulators and the mystically virtuous.

In other circumstances, the reckless bravado system can be suicidal, say where a strong state maintains effective law and order. In environments where strong states are possible, prestige based on wealth accumulation is likely to build richer societies that can afford the armies and organization to suppress tribes with an excess of bravado but limited sophistication. The arbitrariness of evolution due to signalling may in such cases act like group level mutation that produces variation for group selection to work upon. Like the conformity effect we met in the last chapter, whole groups will be committed to one or another variant to symbolize prestige, and a few “deviant” migrants will be discriminated against.

This mechanism would seem to underpin Rappaport's hypothesis. It seems plausible enough. It is indeed striking that social arrangements and customs are usually “sanctified”--embedded in a ritual system like a religion. This hypothesis will account for that. It might also account for the replacement of non-esthetic, but apparently otherwise quite brainy Neanderthals by modern humans. Our groups might have simply been larger and more cooperative, and able to use collective action (e.g. warfare) to out compete them. It also accounts for the crudity and imperfections of group level adaptations. Only those variants that the run away or handicap process happens to exaggerate are available for group selection, and there is no obvious way for group selection to fine tune where these out-of-control processes go. A few pearls of organizational wisdom, the odd norms of altruism sanctified by religion, and so forth, are bound up in a lot of mumbo-jumbo of dubious utility.

VI. Conclusion

A certain amount of evidence seems to support the existence of cultural evolutionary processes that lead to traits that are not adaptive in the genetic sense. The run away process can generate behavior that is not adaptive in any usual sense of the word. The handicap principle can result in competitive displays of cultural or genetic quality that waste resources. Spectacular examples, like the Jonestown tragedy in 1978 and the similar Waco tragedy in 1993, remind us that human groups are prone to collective insanity. Whatever theory we ultimately adopt has got to account for such things.

The costly information hypothesis suggests that culture even so is an adaptive system, because the costs in genetic fitness of giving up indirect bias would be even more costly than tolerating giant yams and giant cars (on average at least). The capacity to use indirect bias, style and symbols is probably adaptive, even if many of the specific results are of dubious value. We have seen that there are several functional hypotheses involving stylistic traits and indirect bias to compete with the run away idea to explain particular apparently exaggerated traits. The handicap proposal is hard to classify, with its mixture of function and costly exaggeration.

We really do not understand very well why people do all of the wonderful and bizarre things that they do. The real point is not to make too many claims for any one hypothesis.

People are harder to understand than ordinary organisms because they are more complicated from an evolutionary point of view due to having a second system of inheritance, culture, to keep track of. The most efficient scientific progress will come, we think, if we can line up all the logically consistent hypotheses in a row, so we can start shooting at them. That is why I took us out of our way to consider some pretty extreme examples of apparently maladaptive behaviors. Even if they are turn out to be wrong, we ought to give them their best shot to explain the data. This is part of the Darwinian strategy; Darwin wrote almost as long a book about his mechanism of maladaptation, sexual selection, as he wrote about natural selection!

Note that, like natural selection, one evolutionary process, indirect bias, can lead to a multitude of outcomes depending upon the details of the particular case. To the extent that our evolutionary models are apt, they are a powerful tool for investigating the behavioral diversity that we see. The models point to critical things that need to be measured if we are to decide between particular hypotheses in particular situations. For example, is the psychology of indirect bias really ever such as to allow preferences to evolve faster than indicators, and hence set up the run away case?

VI. Bibliographic Notes

References:

Bandura, A., D. Ross and S.A. Ross. 1963. A comparative study of the status envy, social power, and the secondary reinforcement theories of identificatory learning. *J. Abn. Soc. Psyc.* 67: 527-34.

Bascom, W.R. 1948. Ponapae Prestige Economy. *Southwestern J. of Anthropology* 4: 211-221.

Bettinger, R. 1991. *Hunter-Gatherers: Archaeology and Evolutionary Theory*. New York: Plenum.

Boyd, R. and P.J. Richerson. 1987. The evolution of ethnic markers. *Cultural Anthropology* 2: 65-79.

Cohen, A. 1974. *Two-dimensional Man.: An Essay on the Anthropology of Power and Symbolism in Complex Society.* Berkeley: Univ. Of Calif. Press.

Cronin, H. 1992. *The Ant and the Peacock: Altruism and Sexual Selection from Darwin to Today.* Cambridge: Cambridge University Press.

Flinn, M.V. and R.D. Alexander. 1982. Culture theory: the developing synthesis from biology. *Human Ecology* 10: 383-400.

Hamilton, W.D. and M. Zuk. 1982. Heritable true fitness and bright birds: a role for parasites? *Science* 218: 384-387.

Harris, M. 1974. *Cows, Pigs, Wars, and Witches: The Riddles of Culture.* New York: Random House.

Klein, R.G. 1989. *The Human Career: Human Biological and Cultural Origins.* Chicago:

Univ. Chicago Press.

Labov, W. 1972. *Sociolinguistic Patterns.* Philadelphia: Univ. of Pennsylvania Press.

Labov, W. 1980. *Locating Language in Time and Space.* New York: Academic Press.

Lieberman, P. 1984. *The Biology and Evolution of Language.* Cambridge: Harvard University Press.

Marshak, A. 1976. Implications of the Paleolithic symbolic evidence for the origin of language. *Am. Sci.* 64: 136-145.

Pomiankowski, A.N. 1990. The evolution of female mate preferences for male genetic quality. *Oxford Surveys in Evolutionary Biology* 5: 136-184.

Rappaport, R.A. 1979. *Ecology, Meaning, and Religion.* Richmond Calif.: North Atlantic Books.

Rogers, E.M. with F.F. Shoemaker. 1971. *The Communication of Innovations: A Cross-Cultural Approach.* New York: Free Press (Macmillan).

Rosenthal, T. and B. Zimmerman. 1978. *Social Learning and Cognition.* New York: Academic Press.

Sahlins, M. 1976. *Culture and Practical Reason.* Chicago: Univ. of Chicago Press.

Stringer, C. and G. Gamble. 1993. *In Search of the Neanderthals*. New York: Thames and Hudson.

Wiessner, P. 1989. Style and changing relations between the individual and society. In: I. Hodder, ed., *The Meaning of Things*. London: Unwin Hyman.

Yussen, S.R. and V.M. Levy. 1975. Effects of warm and neutral models on the attention of observational learners. *Jour. Exp. Child Psycol.* 20: 66-72.

Zahavi, A. 1977. The cost of honesty (further remarks on the handicap principle). *J. Theoret. Biol.* 67: 603-605.#

Part III.

INTRODUCTION TO SYSTEMIC INTERACTIONS

Demographic Concepts

Society/Society Interactions

Technology/Environment Interactions

Chapter 15. POPULATION REGULATION IN HUMAN SOCIETIES

> "Population regulates itself by the funds which are to employ it and, therefore, always increases or diminishes with the increase or diminution of capital."
>
> David Ricardo, 1821

O. Introduction to Systemic Interactions, Part III of the course

In the last part of the course, we neglected the details of environmental interactions in order to consider evolutionary processes in the abstract. Now we need to turn back and put some ecological flesh on the evolutionary bones, so to speak.

This part of the course will consider a series of examples of processes that web human populations to environmental processes: population regulation, interaction with other human populations (through crime, trade, warfare, and diffusion of innovations and diseases), and interactions with non-human populations (disease organisms) and ecosystems (environmental deterioration). These interactions will provide us with concrete instances of how evolutionary processes influence ecological interactions, and how ecological interactions, long continued, become evolutionary forces.

I. Introduction

A. What Mechanisms Regulate Human Populations?

Demographers devote much attention to trying to answer this question. It is an extremely complex problem for three reasons. *First,* a host of environmental processes affect demography including weather and climate, soils, prevalence of diseases, routes of transport, presence of non-subsistence resources (e.g. precious metals) by influencing birth, death and migration rates. *Second,* the human response to these factors is affected by subsistence technology (as we saw in some detail in the second part of the class) and a host of more subtle factors that determine the response of human births and deaths to subsistence scarcity[1]. Historically, as early as the 18th Century, North-western Europeans seem to have demanded higher standards of living than Southern and Eastern Europeans and Asians. Northwestern Europeans curtailed births at lower population densities by delayed marriage, giving longer life expectancies (35-40 years), while Asians married earlier, had higher fertility, and larger populations that pressed harder on resources, lowering life expectancy to

---

[1] There is a nice example in the reading by A. J. Coale (1986).

25-30 years. Why did basically similar agrarian societies exhibit such different behavior? (See Coale's Fig. 1.2). *Third*, humans are very long-lived animals, and we have only been keeping decent records for a century or two (4-10 generations) in the developed world, and are just beginning to develop vital statistics in some countries. The data we have available to dissect demographic processes are less extensive and accurate than we might desire.

These are intimidating problems to solve in particular cases, much less in general. This is a good example of how complicated things can get when we try to understand how real systems actually work. Demographers are famous for not having their long-term predictions work out (they are right up there with economists and psychics in this regard). However, there are good data from selected countries for the past couple of centuries; and more data from the more distant past are being made available by historical demographers. Demographers have provided us with a wonderful glimpse into the intricacies of human ecology. They have also been in the forefront of using the simple models approach to dissecting processes.

B. Central Importance of Demography

The issue of population regulation has implications far beyond the narrow regulation question; in some sense it incorporates the whole evolution and ecology of a population. It is no accident that some of the classic "big thinkers" of the past contributed to demography and thought about "other" problems in demographic terms. We have already met Darwin, and will shortly meet another example, the economist David Ricardo.

Consider for example a question of contemporary controversy: is population really limited by a combination of technology and environment, as suggested in the earlier chapter on demography, or do low populations act as a spur to technical innovation? Who would quit hunting and fishing for a living until population densities rose to the point of making the development of agriculture necessary? A number of scholars we'll meet in the last part of the coarse (and this chapter) have reversed the Malthusian idea, arguing that population pressure regulates the rate of technical advance, rather than the rate of technical advance regulating the growth of population. Whatever the truth here, the way competition is generated by the interaction of technology and environment is certainly key to understanding human ecology and evolution.

II. Ricardo's Model of the Stagnation of Economies

A. Relationships Between Population Growth and Economic Growth

The problem Ricardo set out to explain was how population growth would interact with economic expansion. It is an example of how Malthus' ideas could be extended to other problems through a nice bit of “population thinking.” This style of theory development is experiencing a resurgence among economists. Peter Lindert at U. C. Davis and Ronald Lee at U. C. Berkeley are examples of the trend.

Ricardo imagined three sectors in a substantially agrarian economy such as the Britain of his time: laborers, capitalists, and landowners. When he wrote in the early 19th Century, this was a tolerable simplification in such economies, especially where a landed aristocracy is distinctly different from the capitalist manufacturing and trading class. Under Ricardo’s scheme things worked like this:

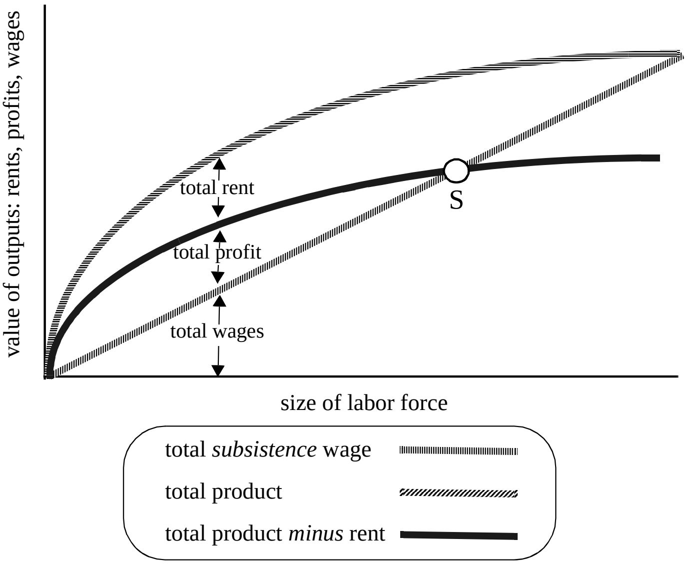
a. Producers (capitalists) compete for land for warehouses, shops, farms, docks, canals, mines, and so forth.
b. After the landlord’s share (rent) is taken out, the rest of society’s product is divided between labor and capital.
c. Capitalists reinvest profits in new productive capacity and research and development. As long as capitalists have enough profits to reinvest, the economy grows.
d. Workers use wages above some subsistence minimum to, among other things, expand their families. The subsistence minimum is defined as much by cultural as by biological needs, Ricardo was aware of this (and it is supported by the Northwestern European/Spanish difference shown in Coale’s graph below).
e. An increasing population meets declining efficiency per unit labor as land fills up. The most productive land is used first, and as population expands, increasingly marginal land must be used for economic activity. Efficiency per hour of labor and dollar of investment falls.
f. Since capitalists must pay at least a subsistence minimum wage to laborers, declining efficiency of labor reduces their profits. As land gets scarce, rents go up as well. Without profits, capitalists can no longer invest in new productive capacity.
g. The final result is a large population, with both workers and capitalists getting minimum returns, but with very rich landlords.

Figure 15-1 illustrates the basic elements of Ricardo’s argument:

At point S, the labor force (population) has risen to a point where rents and wages consume the total product, capital accumulation ceases, and the economy stops growing. Note that rents are maximized in a stagnant economy on this model. (How will this picture change if one does away with rents and uses government investment instead of profits to generate investment, as in a socialist system?)

This scenario seems to fit the agrarian states of the past quite well. They seem to have

Figure 15-1. David Ricardo's (1821) description of the interaction between population growth and economic expansion emphasized relations between laborers, capitalists, and landowners. Note that rents and wages consume the total product at point S.



usually been characterized by a poor laboring and artisan class, to lack wealthy capitalists, and to have been dominated by landed aristocrats. Fertility decisions in the short run lead, via a complex chain of events, to an undesirable outcome, economic stagnation and merely subsistence wages.

Is Ricardo's scheme relevant to post-industrial societies? Since the industrial revolution, some societies have been able to keep technological progress rapid enough (and to slow population growth rates) that profits and wages stay high. What is left out of Ricardo's argument is the possibility that investment by capitalists (or government) in research and development might increase the total product available from the fixed land base. Nowadays economists think that research and development (R&D) has rapidly displaced the total product curve upward since the industrial revolution, making Ricardo's brilliant theory obsolete.

But it is not so clear (1) if the industrial countries can keep this up forever or (2) if Less Developed Countries (LDCs) or Third World nations can achieve Western levels of material well-being at current population growth rates. It might be that competition for land on a populous, environmentally degraded planet might one day overwhelm the potential of scientific and technical advance to sustain high real wages. Note that we still argue the demographic issue in the terms Malthus and Ricardo sketched 150 years ago.

It is interesting that neither of these two scholars saw the potential of the industrial revolution very clearly as it was happening around them! Study figure 15-2 to see how the relationship between real wages, prices, and population for the period 1540-1913 in England. This series from Lindert (1985) spans the important period of the pre-industrial commercial expansion and industrial revolution. Note how up until 1820-30 there seems to be a pretty good inverse relationship between periods of wage decline and rising population. The longer series from Lee (1987), showing the big drop in population and bulge in wages due to the Black Death in the 14th Century, is an even plainer illustration. As far as the information available to Malthus and Ricardo was concerned, population growth did look as if it depressed wages. Both men understandably failed to predict the dramatic effects of the industrial revolution in the late 19th and 20th centuries. Demographic/economic prediction, then as now, is a hopeless business! Note that the rate of technical improvement in the Late Medieval and Early Modern Period in Europe (A.D. 1000-1800) was quite rapid by most standards, it’s just that the rate of population growth was more rapid yet. In other words, it is only after the unprecedented technical advances of the industrial revolution that rates of technical improvement have outrun population growth for any sustained period.

III. Basic Data

A. Demographic Transitions

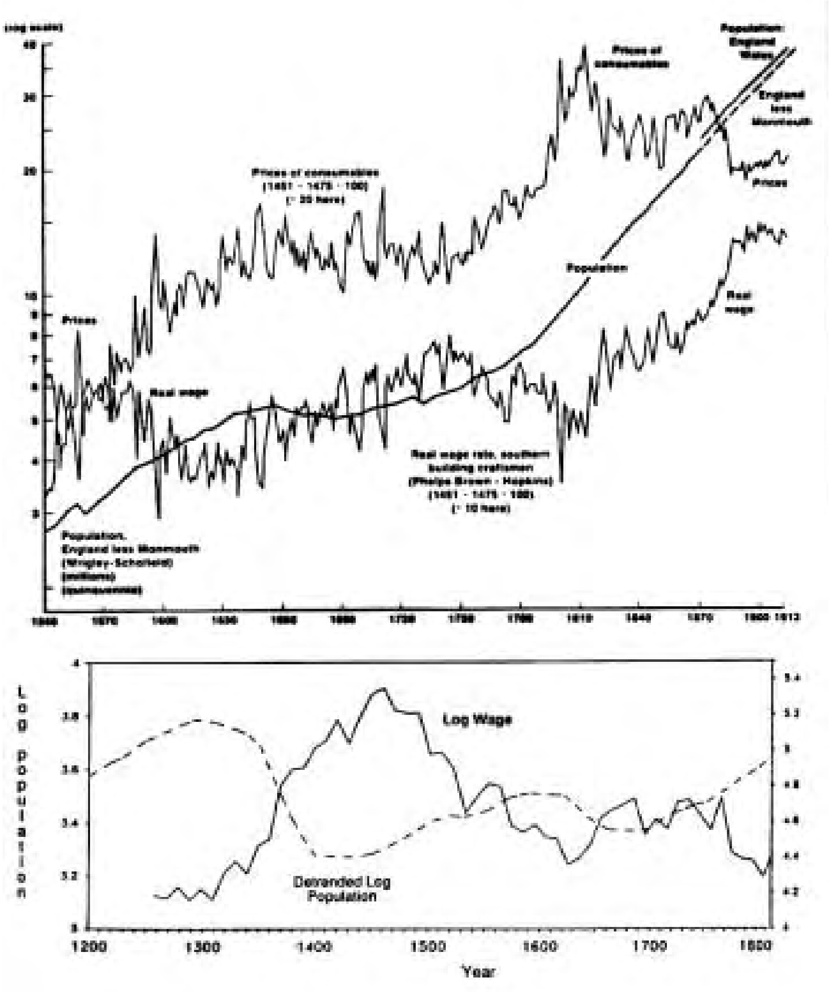
According to rough paleodemographic evidence, human populations have probably experienced many demographic transitions. Figure 15-3 illustrates this idea. This graph was first drawn by Edward Deevey (1960). Deevey’s concept was that technical revolutions have generated a series of population “explosions” in human history. First the development of hunting and gathering led to the original expansion of human populations out of Africa. Then, the agricultural revolution 10,000 years ago led to a second jump in human populations. The current industrial revolution has led to the third.

B. Major Fluctuations at any one locale

Human populations are likely to have fluctuated more or less strongly at any one place as disease epidemics, wars, cycles of environmental destruction, and so forth operated. You have already seen the data indicating the effects of the Black Death in Europe. Much of Europe was also depopulated during the disease episodes and political breakdown accompanying the fall of Rome. Archaeological data and crude census information from classical civilizations give us a dim idea of the magnitude of these fluctuations.

The best data for such fluctuations come from China. Chinese rulers conducted peri-

Figure 15-2. Two data series showing relationships between wages and population in Western Europe. The top figure describing real wages, prices, and population in England and Wales, 1541-1913 is taken from Lindert (1985). The bottom figure describing real wages and detrended population size in Europe from 1200-1810 is taken from Lee (1987). {Note the use of log scales on vertical axes; this means that a one unit increase along the vertical axis represents a ten-fold increase in magnitude.}



odic censuses of widely varying quality. Scholars think the data in Table 15-1 are probably trustworthy (UN, 1973: 18.) Note the substantial swings. Political fragmentation, barbarian invasion and disease sets populations back; a sustained trouble-free period with good leadership allows recovery. Not until the modern period did China’s population develop a steady upward trend.

Figure 15-3. There is evidence that humans have had many demographic transitions as this graph illustrates (adapted from Deevey, 1960). Note the logarithmic scales along both axes.

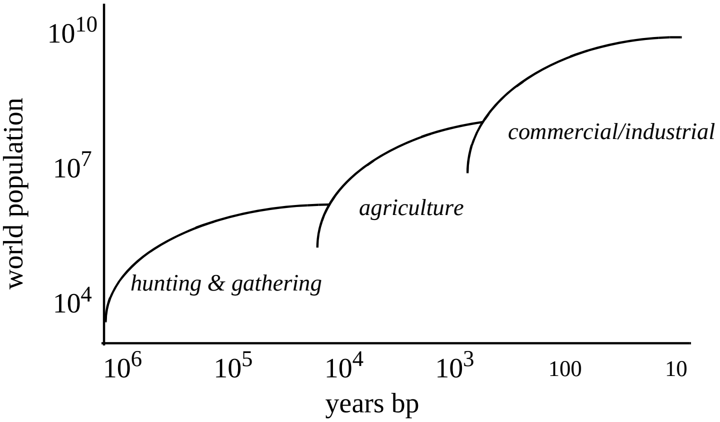


Table 15-1. Historical Data From China

Dynasty	Year (A.D.)	Estimated Population (millions)
Western Han	2	71
Eastern Han	88	62
Sui	606	54
T’ang	705-755	37-52
Sung	1014-1103	60-123
Ming	1393	61
Ch’ing	1751	207

C. Recent Trends in Human Populations

The rate of population growth since 1650 is greater than exponential! As the Table 15-2 shows, **r**, the exponential rate of increase, has itself been increasing! The modern population explosion is illustrated in Figure 15-4. It turns out Malthus had been conservative about population growth rates.

Figure 15-4. World population growth from 1650 to 1950.

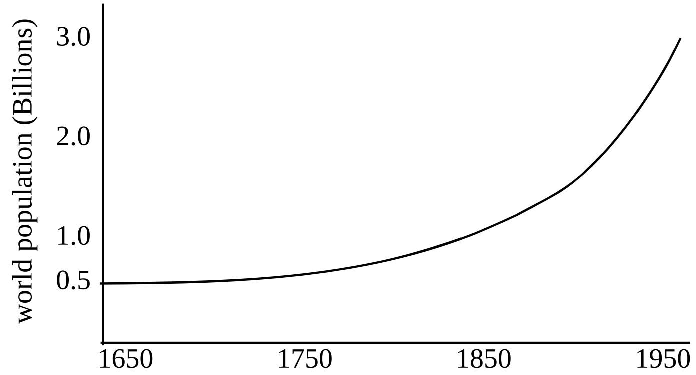


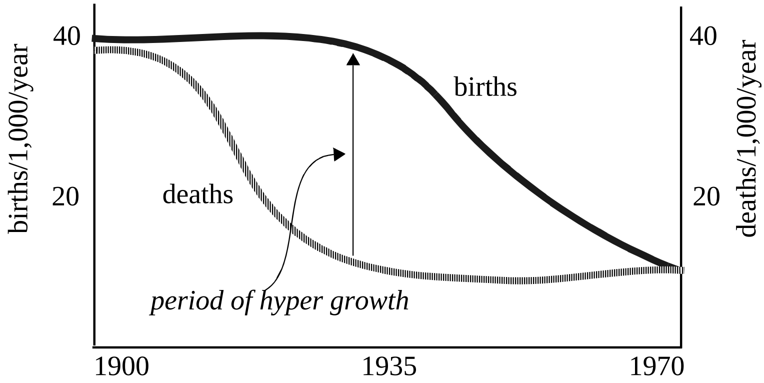
Table 15-2. Changes in population growth rate over time.

Year	Doubling Time
1650	200
1850	150
1950	86
1965	40
1980	slowing

In 1960 Foerster et al. introduced a model in which the rate of increase of population increased as a function of population. This model has the pathological property that population will go to infinity. They fit the parameters of this model to human population data and estimated that human population would approach infinity in 2026. This model is a bit tongue-in-cheek, but it does point out the truly explosive nature of contemporary population increase statistics. This cannot go on for long, and indeed in some populations it has not. Read on!

Since about l850 many populations have undergone demographic transitions. The first modern transitions of this type were in Western Europe, beginning in parts of France around 1800. Figure 15-5 illustrates typical patterns of change in annual birth and death rates., notably that death rates dropped first, followed by a lowering of the birth rate[2]. Later, Britain and the rest of N.W. Europe followed suit, with the U.S., Eastern Europe, Japan,

Figure 15-5. Changes in annual birth and death rates per 1,000 population per year from 1900 to 1970. Hypothetical.



coming along later. Now there are hints of transitions in Third World countries, although only in China and among elites are changes dramatic. There is still little evidence of demographic transition in Africa.

IV. Explanations of Human Population Fluctuations

A.The Malthus-Boserup debate

Very generally, there appears to be a close connection between demographic and technological revolution, at least when we consider things on a large scale. What is at issue is whether technical advance drives demographic change, or vice versa. Here we consider both positions.

Technical revolutions may permit demographic ones. This was Malthus' idea. Population growth will generally be faster than technical improvements, and it will be technical improvements that permit population growth rather than the other way around.

Demographic factors may drive technical revolutions. Esther Boserup reversed the causality in Malthus' model. Boserup suggested that it is population growth that drives intensification and innovation. If people are getting hungry or short of whatever resources they might need, they devise new ways of increasing the efficiency of their current production system. We might think of this as "necessity is the mother of invention". Boserup supports her argument with data from Africa showing that as fallow periods get shorter,

---

2. Notice that only France largely escaped the bulge in population caused by birth rates falling later than death rates (Coale's figure 1.4).

farmers are prepared to put more labor into food production rather than cutting down on their food intake (Boserup 1965). In a later publication she suggests that these innovations probably arise from the kind of labor specialization that characterizes intensive cultivation; a leisured aristocracy, supported by agricultural laborers and crafts specialists, have the capital and time to invent new ways of doing things (Boserup 1970). Note that Boserup's arguments can be viewed in terms of the cultural evolution models outlined in Chapters 11 and 12: low returns for labor increase the payoffs to innovation, experimentation, and invention.

Cause and effect are difficult to disentangle. As in the chicken and egg problem, is technical advance or demographic change the leading variable? From an evolutionary perspective, the important thing to remember is that both population pressure and technological revolutions have effects on one another.

B. Environmental Factors are Clearly Important on an Intermediate Scale

We will discuss the role of biophysical factors such as disease on population regulation in Chapter 21. In Chapter 19 we will discuss the role played by warfare.

V. Explanations for the Modern Demographic Transition

A. Why Do People in Rich Industrial Nations Reduce Fertility?

There is a huge literature on the causes of fertility decline in the modern world. Economists, sociologists, demographers, historians, biologists and anthropologists have all developed sometimes conflicting, sometimes complementary explanations for the transition. Here we focus on the more evolutionary accounts, noting their links to those accounts developed in other disciplines.

B. Sociobiological Hypotheses

Sociobiologists are somewhat confused by the inverse relationship between wealth and number of offspring in industrialized countries. Remember back to Chapter 10 where we discussed the sociobiological prediction that the wealthy and powerful would have more offspring than the poor and powerless. Sociobiologists have come up with several hypotheses for the transition, two of which we will briefly consider here.

First, in limiting family size people may still be maximizing their overall fitness through increasing the ***quality*** *of their children at the expense of the* ***quantity.*** In a highly competitive environment with high social mobility, in which education and inheritance are critically important to a child's success in later life, it may "pay" (in terms of a parent's fitness maximization) to produce only those children to whom (s)he can give a good start in life. Models such as those of Harpending and Rogers (1990) have shown it may be worth "placing" one child in the highest social strata rather than more children in the lowest social strata, at least if children in the lowest social strata have only a very small chance of reproducing. Although this hypothesis doesn't explain why so many women nowadays elect to have no children at all, it is appealing in several respects, insofar as it seems to make sense of modern-day parents' values, objectives and concerns - laying away funds for college, etc.

It also dovetails rather nicely with economic hypotheses that emphasize the economic benefits parents derive from children, both as child labor and old age assistance. In traditional populations, and among some sectors of the rural and the poor, these benefits can be substantial (see Chapters 3 to 6). Conversely, modern urban people get no direct labor benefits from children, although they do have opportunities to maximize family income by investing in expensive educations for a few children. (See John C. Caldwell (1982) for an in-depth discussion of this topic.)

Some economists have gone as far as to equate children with ordinary and substitutable consumption items (Becker 1981). If this is true, we'd expect that as people get richer they will consume more of them. Why does this not happen? Becker's answer basically is that prosperous people can afford a whole host of luxury goods, such as boats and ski weekends at Tahoe, that compete with children for time and attention. Much as caviar eaters must generally cut their consumption of beans, so the prosperous must also cut their "consumption" of children. The problem with Becker's hypothesis is that the transition to lower fertility is not perfectly correlated with economic conditions. Sometimes the transition occurs early in economic modernization, sometimes late. Historical demographers and students of modern Third World demography are generally critical of Becker's hypothesis, pointing out that rich people often have more children than the poor.

Other sociobiologists prefer to see the inverse relationship between wealth and number of offspring in industrialized countries as a kind of evolutionary mistake. They like to think of the human psyche and decision-making apparatus as adapted to evolutionary and ecological forces that operated in the past but are now radically altered. As a consequence they suspect that our actions are no longer well suited to the modern environment, representing a school now known as "evolutionary psychology". Burley (1979) argued that cryptic estrous[3] is set up as a trade-off between sexual pleasure and the pain of childbearing, such that in seeking intercourse women could not avoid possible pregnancies. Modern contraceptives allow women to have one without the other[4]. This hypothesis relies on some odd assumptions (see footnotes) and it doesn't explain the facts very well. In many places the demographic transition started well before effective contraceptive methods became available.

C. Cultural Fitness Hypothesis

The cultural fitness hypothesis emphasizes the evolution of cultural constraints. (This hypothesis is sketched out in the reading for Chapter 12.) The idea here is that modern economies open a niche for the technically sophisticated and ambitious (e.g., teachers, bureaucrats, managers, scientists, and engineers). Achieved social roles therefore become important relative to ascribed ones. These roles are effective for non-parental transmission. That is, the prestige attached to these roles, their inevitable importance in a technological society, and the wide contacts such people tend to have with others inevitably make them effective in non-parental cultural transmission. Moreover, empirical studies indicate that children raised in small families have higher rates of achievement in these modern roles. It seems parents must spend a lot of time and effort encouraging and helping children in order for them to do well in school. Raising children who can compete for prestige roles in such societies is expensive in terms of both time and money. Thus norms for small families spread because of natural selection on asymmetrically transmitted cultural variation[5]. In other words, the kinds of people most commonly admired and emulated (role models) in modern societies are those who have fewest children. When people imitate these role models' life styles, they also copy their small family sizes.

Demographer John C. Caldwell argues that small-family norms are presently spreading to the Third World ahead of significant economic development because the mass media are dominated by industrial norms. This domination is either direct (e.g. Hollywood movies) or indirect (via training Third World elites in Irvine, Moscow, London, Paris, etc.). This observation provides indirect support for the cultural fitness hypothesis.

Knauft (1987) has suggested another way in which elite small family norms might spread through a population, by examining migration patterns in ancient urban societies. Elites in these societies often had low fertility. Ancient cities were also demographic "black holes." In crowded, unsanitary cities with uncertain, expensive food supplies, death rates were typically above birth rates. He gives data for 17th Century London and Ancient Rome.

---

[3] Estrous (or oestrus) is the period of maximum sexual receptivity, or "heat", in female mammals. It usually occurs coincident with the release of eggs from the ovaries. Human females' estrus is cryptic or hidden. Burley thinks that with cryptic estrous women can't have sex without getting pregnant, because they are unaware of ovulation.

[4] Burley's somewhat bizarre argument here assumes that deep down women "don't want" children because of the pain and dangers of childbirth. Hence once contraception becomes reliable they can get sex without babies!

[5] Return and study closely the parent-teacher model from Chapter12.

Demographically, city populations in agrarian societies were continually dying away, relative to the countryside. They did not disappear because of immigration from rural areas. Why did people move to unhealthly cities? City people included the elites that dominated the cultural life of agrarian nations. With high death rates, there were always opportunities to rise in competition for elite roles in the city. The pomp and splendor of life in the cities attracted people to them despite the biological hazard. In essence, cities could exist only because parasitic city cultural variants could spread to healthier rural populations and induce them to move to the exciting, high prestige, but unhealthly and “morally degenerate”, cities. “Once they’ve seen the bright lights, you’ll never keep them down on the farm.”

Coale cites a similar rural example in Hungary, except there the low fertility habits of the “one child system” carried no such success in non-parental transmission and the population just wasted away. Knauft also speculates that many primitive societies that abuse women or engage in heavy female infanticide can persist by bringing female and child captives into a demographically inviable society. Here again, a culturally aggressive, militarily successful society could persist by parasitizing neighboring societies for the personnel to make it all work. These are some of the most plausible examples yet advanced for conflicts between cultural and genetic fitness being important in human affairs.

VI. Conclusions

Over the long haul Malthus was essentially correct. In the very long run, it is clear that technical advance has permitted a series of demographic transitions that have lead to major increases in world population size. Further, on the lines of the Malthusian argument of Chapter 8, it seems clear that population increase is usually fast enough to convert most of the gains into people, instead of more welfare per person; (this conclusion is much less certain: there may be examples in the past we don’t know about that parallel the modern fertility reduction transition). However, the rise in the world’s population may yet eat up the temporary welfare gains of the industrial revolution, as in Ricardo’s model, particularly when we think of the irreversible environmental damage caused by large populations.

Shorter term population fluctuations are more complex with respect to the direction of causality between population growth and technological advance. On a smaller scale, all sorts of environmental and social effects clearly influence population growth rates. In the past, disease and political breakdowns seem to have led to major declines in the populations of agrarian societies from time to time. In our own societies, rapid economic growth, combined with escalating tastes for consumer goods, has sharply cut population growth rates and permitted individual welfare to increase to unprecedented levels in richer nations. It will be some time before the empirical study of past and present human populations allows a satisfactory understanding of demographic phenomena.

VII. Bibliographic Notes.

References

Becker, G.S. 1981. *A Treatise on the Family*. Cambridge: Harvard Univ. Press.

Boserup, E. 1965. *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure*. Chicago: Aldine.

Boserup, E. 1970. *Women's Role in Economic Development*. London: Allen and Unwin.

Burley, N. 1979. The evolution of concealed ovulation. *Am. Nat.* 114: 835-858.

Caldwell, J.C. 1976. Toward a restatement of demographic transition theory. *Pop. Dev. Rev*. 2: 321-66.

Caldwell, J.C. 1982. *Theory of Fertility Decline*. London: Academic Press.

Deevey, E.S., Jr. 1960. The human population. *Scientific American* 203(3): 194-204.

Foerster, H.V., P.M. Mora, and L.W. Amiot. 1960. Doomsday, Friday, 13 November, A.D. 2026. *Science* 132: 1291-1295.

Harpending, H. C. and A. R. Rogers 1990. Fitness in Stratified Societies. *Ethology and Sociobiology* 11:497-509.

Knauft, B.M. 1987. Divergence between cultural success and reproductive fitness in preindustrial cities. *Cultural Anthropology* 2: 94-114.

Lee, R.D. 1987. Population dynamics of humans and other animals. *Demography* 24: 443-465.

Lindert, P.H. 1985. English population, wages, and prices: 1541-1913. *J. Interdiscip. History* 15: 609-34.

Chapter 16. CRIME AND CRIMINALITY

> It is criminal to steal a purse,
> It is daring to steal a fortune.
> It is a mark of greatness to steal a crown.
> The blame diminishes as the guilt increases.
>
> Johann Schiller (1759-1805)

> We sow an act and reap a habit:
> We sow a habit and reap a character:
> We sow a character and reap a destiny.
>
> William Black (1893)

> …the root causes of crime [are] poverty, unemployment, underemployment, racism, poor health care, bad housing, weak schools, mental illness, alcoholism, single-parent families, teenage pregnancy, and a society of selfishness and greed.
>
> Patrick V. Murphy (1985)
> former NYPD Commissioner

I. Introduction

A. The Intractable Problem of Crime

We have made the claim that, aside from being an interesting intellectual exercise, there are important practical reasons for trying to understand human behavior in an integrated fashion. *In this chapter we will test the utility of the human ecological approach on one of the most intractable internal social problems in culturally diverse societies—crime.* In subsequent chapters, we also will test our approach on more group-level problems such as the conservation of public resources and war.

Crime is a particularly interesting problem because it is in many respects the obverse (i.e., the 'flip side') of altruism. This is especially true if we define crime broadly as behavior in which individuals obtain resources from others via force, fraud, or stealth. Think about this. We've discussed the apparent importance of altruism for large-scale social interactions between unrelated people. In order for people to reap the full benefits of group cooperation and division of labor, they sometimes must subordinate their personal interests to those of others—occasionally in dramatic fashion. Altruistic acts cost an individual more than he or she gains. Criminal acts do just the opposite. People who commit these acts intentionally harm others for their own gain.

Of course, sometimes altruism on the small scale is necessary to execute predatory *strategies against the larger societies.* Criminal conspiracies may enjoin considerable self-sacrifice on the part of gang members who are caught. The Sicilian Mafia was apparently successful in part because of its tradition of *omerta,* silence in the face of police questioning and inducenments to rat on the gang. Other criminal conspiracies often try to mimic the Sicilians in this regard, but they were long the most successful.

The following discussion will define key terms in a broad enough sense so that the larger issues associated with crime can emerge. *We then will discuss the ways in which crime harms individuals and groups and why we think that it is necessary from a practical standpoint to take a long-term integrated approach to understanding and controlling crime.* In other words, we'll try to see what special insights the human ecological approach to understanding criminal behavior can bring to this thorny problem that affects us all every day. At the end of this chapter, we'll argue that our approach suggests practical policy alternatives that traditional academic disciplines have tended to overlook. (Surprise!)

So that you can make your own decisions about the reasonableness of our positions, we'll first summarize well established empirical findings about the nature and distribution of crime then try to make sense of them using standard ecological tools and some of the insights developed thus far in this course.

B. Definition of Terms

Legally, ***crimes*** *usually are defined as acts or omissions forbidden by law that can be punished by imprisonment and/or fine*. Murder, robbery, burglary, rape, drunken driving, child neglect, and failure to pay your taxes all are common examples. However, as several eminent criminologists recently have noted (e.g. Sampson and Laub 1993; Gottfredson and Hirschi 1990), the key to understanding crime is to focus on fundamental attributes of all criminal behaviors rather than on specific criminal acts. Instead of trying to separately understand crimes such as homicide, robbery, rape, burglary, embezzlement, and heroin use, we need to identify what it is they all have in common. Much past research on crime has been confounded by its focus on these politico-legal rather than behavioral definitions.

The behavioral definition of crime focuses on, ***criminality****, a certain personality profile that causes the most alarming sorts of crimes.* All criminal behaviors involve the use of force, fraud, or stealth to obtain material or symbolic resources. As Gottfredson and Hirschi (1990) noted, criminality is a style of strategic behavior characterized by self-centeredness, indifference to the suffering and needs of others, and low self-control. More impulsive individuals are more likely to find criminality an attractive style of behavior because it can provide immediate gratification through relatively easy or simple strategies. These strategies frequently are risky and thrilling, usually requiring little skill or planning. They often result in pain or discomfort for victims and offer few or meager long-term benefits because they interfere with careers, family, and friendships. Gottfredson and Hirschi assert that this means the "within-person causes of truancy are the same as the within-person causes of drug use, aggravated assault, and auto accidents (1990, p. 256)." Criminality in this sense brears a problematic relationship with legal crimes. Some drug dealers, tax cheats, prostitutes and other legal criminals may simply be business-people whose business activity happens to be illegal. Psychologically, they might not differ from ordinary citizens. Almost all ordinary citizens commit at least small legal crimes during thier lives. Nevertheless, Gottfredson's and Hirschi's hypothesis is that the vast majority of legal crime is committed by individuals a general strategy of criminal activity.

This conception of crime explains the wide variety of criminal activity and the fact that individuals tend not to specialize in one type of crime. It also is consistent with the well-established tendency of people to be consistent over long periods of time in the frequency and severity of crimes they commit. Even executives who commit white collar crimes probably are more impulsive, self-centered, and indifferent to the suffering of others than those who do not take advantage of similar opportunities.

Focusing on criminality rather than political-legal definitions also allows us to finesse the perplexing problem of why some acts (e.g., marijuana consumption) are defined as crimes while similar arguably more damaging acts (e.g., alcohol consumption) are not. These issues, central to conflict theories and critical theories of crime, are important. However, because they focus on systematically deeper power relations between competing interest groups, they seldom provide feasible policy alternatives and tend to reinforce perceptions of crime as an insolvable problem. What we want to do here is see if the human ecological approach can lead us to some practical strategies for controlling crime.

Human ***resources*** *can have material, symbolic, or hedonistic value.* In crimes such as thefts, individuals take material resources such as property from another person without his or her knowing cooperation. Those who commit crimes such as narcotics trafficking and gambling attempt to obtain money that can be exchanged for material resources. In crimes such as assaults not associated with theft, sexual assaults, and illicit drug use, people obtain hedonistic resources that increase pleasurable feelings or decrease unpleasant feelings. Political crimes such as terrorism or election fraud attempt to obtain symbolic resources such as power or prestige.

C. How Bad is the Problem of Crime?

The US is truly in the midst of a crime wave. Serious crime rates in the United States rose 40 percent from 1970 to 1990. Rates for reported violent crimes rose 85 percent, rates for more common property crimes 35 percent. As we attempted to control crime through traditional approaches, expenditures for federal, state, and local criminal justice system activities increased from $12.3 billion in 1971 to $74.3 billion in 1990. Our imprisonment rates soared from 96 to 292 per 100,000, becoming higher than any other industrialized nation.

Crime has high and diverse costs. The direct physical, material, mental, and emotional injury suffered by victims of crime is deplorable. Perhaps even more tragic, however, is the indirect damage to society. Attempts to control crime through the criminal justice system increasingly intrude in our private lives. Personal freedoms are threatened as we repeatedly choose between public order and individual rights. Moreover, crime amplifies mistrust, feeds prejudice, and generally degrades social cohesion (Vila, 1994). People become more fearful, often imprisoning themselves in their own homes. Guns are kept within reach, a knock on the door evokes terror, a stranger in need of assistance is ignored.

II. A Systems Perspective on Crime

Criminal behavior is the product of a systematic process that involves complex interactions between individual, societal, and ecological factors over the course of our lives. In other words, from conception onward the intellectual, emotional, and physical attributes we develop are strongly influenced by our personal behaviors and physical processes, interactions with the physical environment, and interactions with other people, groups and institutions. These systematic processes affect the transmission from generation to generation of traits associated with increased involvement in crime. As will be discussed, this often ignored fact has important policy implications. Table 17.1 provides a rough idea of some of the kinds of interactions that are possible.

Before discussing the systematic processes that cause crime, we first must outline key ecological-, societal-, and individual-level components of that system. In other words, we must look at the parts separately before we can understand how they work together.

A. Ecological Factors

Ecological factors involve interactions between people and their activities in a physical environment. This category includes things associated with the physical environment such as geography and topography, crowding, pollution, and recreational opportunities. These ecological factors can affect how people develop physically and emotionally over their lives as well as the level of hostility, fear, or well-being they feel from moment to moment as they experience, for example, a crowded subway, dark lonely parking lot, or serene park.

Ecological factors also determine what opportunities for crime exist because they include interactions between people and the ways physical environments channel those interactions. The routine activities of people in a physical setting can have important effects on when and where opportunities for crime occur. A crime is not possible unless a motivated and able offender converges with a victim, property, or illicit substance or behavior in the absence of capable guardianship (people or physical barriers to prevent the crime).

Table 1: Examples of important direct effects that can produce interactions among ecological, microlevel, and macrolevel factors associated with crime.

AFFECTS OF	**ON** *Ecological Factors*	*Microlevel Factors*	*Macrolevel Factors*
Ecological Factors	**X**	-Environment reinforces (& perhaps counteracts) temperamental propensities. -Pollution hazards degrade learning, cause hyperactivity, etc. -Exposure to danger increases aggressiveness and/or fear. -Deviant models provide opportunities to learn deviant behaviors. -Criminal opportunities increase temptation. -Overcrowding may increase hostility.	-Physical resources provide economic opportunities. -Geographic barriers reinforce class/ethnic boundaries and self-interestedness. -Ecological interactions drive population-level evolution of culture.
Microlevel Factors	-Routine activities of individuals affect opportunities for crime. -Individuals can modify local environment. -Individual historical and genetic variation assures some variation between the abilities, motivation, and strategies of interacting individuals.	**X**	-Individual variation provides grist for evolutionary processes. -Individual actions change average payoffs for criminal and noncriminal behaviors. -Individuals form interest groups to change government.

Table 1: Examples of important direct effects that can produce interactions among ecological, microlevel, and macrolevel factors associated with crime.

AFFECTS OF	**ON**		
	Ecological Factors	*Microlevel Factors*	*Macrolevel Factors*
Macrolevel Factors	-Government modifications of built environment channel population movement and change location of criminal opportunities. -Sociocultural heterogeneity creates more opportunities for crime. -Weak regulation or guardianship creates opportunities for crime.	-Cultural beliefs influence parenting styles and parental behavior. -Economic inequality creates pressures for crime via poverty and greed. -Poverty increases child developmental risks by creating strains on parents, & degrading education and health care. -Unequal access to information and education creates power inequities.	**X**

B. Societal or Macrolevel Factors

Societal or macrolevel factors deal with systematic interactions between social groups. Societal factors describe the ways society is structured. They include such things as the relative distribution of the population among groups and the flows of information, resources, and people between groups. Societal factors encompass the variety and heterogeneity of racial/ethnic/cultural/productive groups, their behaviors and beliefs, and economic relations.

C. Motivation and Opportunity

Individuals actually commit the crimes. Although ecological and societal factors must be included in any full explanation of crime, individual factors always intervene between them and a criminal act. For this reason individual factors need to be the center of any description of the causes of crime.

Individual or ***microlevel*** *factors describe how a person becomes motivated to commit a crime*. Before describing those factors, however, it is important to define another key component of the system—*motivation*. Is it just the driving force behind our actions? In this discussion, motivation is more than the "I want." portion of the equation. It includes "I could." "What will it cost me compared to what I think I'll get?" and "Is this right and proper?" Motivation is the outcome of a process in which a goal is formulated, costs and benefits are assessed, and internal constraints on behavior are applied. The relative importance of the components of this process may vary from individual to individual, time to time, and situation to situation. In other words, sometimes a person's motivation is influenced more by rational decisionmaking, other times by emotions such as anger, greed, or lust. Similarly, some people tend to be more motivated by cost/benefit calculations more of the time than others. Moreover, the value people place on different objects or activities can vary as can their ability to resist temptation.

Motivation alone cannot cause a crime to occur; ***opportunity*** *also is required.* And—although few researchers today address this issue—opportunity itself may influence motivation (Katz 1988). Lay people call this "temptation" and probably would consider any discussion of motivation that excluded temptation silly. Thus a person's propensity to commit a criminal act at a particular point in time is a function of both motivation and opportunity. Some may be motivated to seek out and exploit criminal opportunities that offer extremely small rewards; others will commit crimes only when presented with relatively enormous opportunities; and a very few will not commit crimes regardless of rewards.

As Cohen and Machalek (1988) noted in their innovative work on the evolution of crime and criminal strategies, disadvantage may motivate people to commit crimes, but so can advantage. As the past decade's string of institutional scandals has graphically illustrated, the elevated skills and status that provide access to lucrative criminal opportunities with little risk of being caught and punished also can motivate people to commit crimes. We might imagine that most politicians and business-people who take and offer bribes and the like are less impulsive and thrill-seeking than street criminal, but still have higher motivation to commit crimes than their honest colleagues. However, in politics and business, the opportunities are enourmously tempting. Contrariwise, scientific scandals are relatively rare. However, it is not likely motivation but opportunity that is lacking. The main reward in science is prestige, and it is gained by publishing papers. Plagarism and data faking occur, but if the idea is an important one, the victim of plagarism will complain, and other will attempt to replicate the faked experiment. The criminal act of publishing a faked paper is highly public; your name is attatched and the chances of getting caught are high.

Criminologists hypothesize that a number of individual factors determine a person's motivation to commit an act. Motivation at a particular point in time is the result of interactions over a person's life course between biological, socio-cultural, and developmental factors—as well as contemporaneous opportunity. Psychological factors are the result of interactions between biological and socio-cultural factors. Criminologists do not imagine that some simple consitutional factor ('criminal nature") is a very satisfactory explanation for mativational factors.

> *Biological factors* include such things as physical size, strength, or swiftness, and the excitability/reactivity of nervous and organ systems in the body (see

Fishbein 1990; Wilson and Herrnstein 1985). It is easy to imagine that big, athletic, young males are likely to be statistically over-represented among strong-arm robbers compared to small, skinny, awkward fellows. Although these factors set the physical boundaries of our behavior and influence our affective state, they do not *determine* which of the myriad possible behaviors we perform.

Socio-cultural factors influence the strategies of behavior and personal beliefs, values, needs, and desires a person acquires over his or her life. These have been the focus of many well known theories of crime that emphasized such things as social learning, rational choice, self-control, and social strain. They include the knowledge, skills, attitudes, and other cultural information we learn through interactions with other people and groups—as well as from cultural artifacts such as books and movies.

Socio-culturally acquired traits affect which behavioral strategies (ways of doing things to achieve desired ends) one knows how to apply and they influence how we perceive the costs and benefits of a course of action. For example, the value we place on the good will and opinion of others is a socio-cultural factor, as are many of the beliefs that affect the value we assign to material or symbolic goods. Socio-cultural factors influence the strength of self-control that helps us resist temptation. They also can produce "strain" that magnifies temptation when there are disjunctions between what we have learned to desire and the opportunities we perceive.

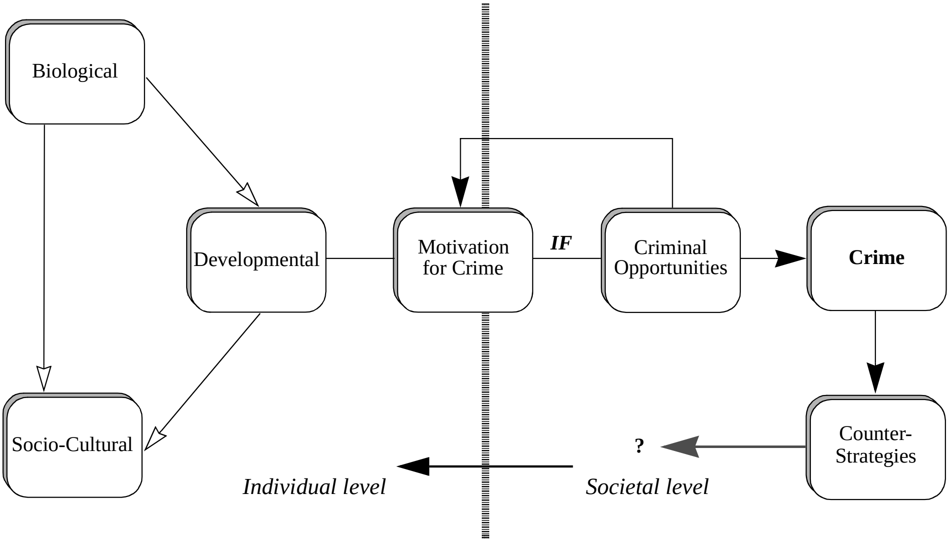
Development is the process of physical, intellectual, and emotional growth that begins with conception and ends with death. Development can be adversely influenced by such factors as environmental pollutants, disease, physical injury, and lack of nurturing. Interactions throughout the life course between biological, sociocultural, and developmental factors determine who we are and how we respond to opportunities at any point in time.

Child development—the source of many core personality traits—is particularly vulnerable to poor family management practices arising from such things as poverty, lack of education, or living in a high crime neighborhood. Family stressors such as unemployment, marital conflict, and divorce also can disrupt family life. According to Patterson and his colleagues at the Oregon Social Learning Center, growing up in a disrupted family is strongly associated with child antisocial behavior—of which crime is one type (e.g. Patterson, DeBaryshe, and Ramsey 1989).

D. Summary of Systematic Relationships

Figure 17.1 illustrates the interactions between the three types of individual factors, motivation, and opportunity. Over time, interactions between biological, socio-cultural and developmental factors affect how motivated a person is to use force, fraud, or stealth to obtain resources when an opportunity is presented. If motivation is sufficiently high in the presence of an attractive opportunity, a crime may occur so long as the person has the ability required to commit it. As we will discuss later, crimes provoke responses from victims and potential victims.

Figure 17.1. Important systematic interactions between individual and societal factors that cause crime.



III. The Nature and Distribution of Crime

A. Correlates and Causes of Crime

A large body of research indicates that crime is highly correlated with *youthfulness and male gender,* and that *early involvement* in crime is predictive of subsequent involvement. Similarly, *poverty, inequality, disrupted families, inadequate socialization, and the presence of criminal opportunities* all seem to be important correlates of crime (e.g., Sampson and Laub 1993; Reiss and Roth 1993; Tonry, Ohlin, and Farrington 1991; Land, McCall, and Cohen 1990; Gottfredson and Hirschi 1990; Blau and Schwartz 1984). These general findings about the primary correlates of crime seem likely to endure—although there remains substantial debate among criminologists in various academic disciplines about the relative causal importance of, and relationships between, different variables. This debate tends to obscure larger issues regarding the appropriate causal scope and scale for understanding and controlling crime; i.e., which variables interacting in what ways should be considered, and at what levels of analysis. The problem not easy to solve with better correlational studies because so many variables are intercorrelated. For example, poverty, recial discrimination, and family disruption all disproportionately affect African Americans, who also disproportionately engage in criminal behavior. However, from the correlational data alone it is impossible to say which variable is the most important or direct cause of crime, or anything about how the variables might be causally inter-related.

As a result, no satisfactory unified theoretical framework yet has been developed. This has diminished the policy relevance of recommendations from even some of the most comprehensive interdisciplinary research on crime. This is a prime example of the kind of interdisciplinary problem associated with the sociology of science that human ecology tries to address.

B. Research vs. Policy?

Although research and policy formulation should be complementary activities, they often have different imperatives. Whereas scientists are engaged in an endless pursuit of information and understanding, policymakers eventually must take action. In this chapter we are not trying to settle debates about which causal variables explain more variance in crime rates or criminal behavior. Rather we want to show how the human ecological approach might be used to systematically and completely organize information and empirically supported insights from the many disciplines that study crime. If this approach makes it possible to develop a truly general theory of criminal behavior, it finally might be possible to establish a unified framework to guide both research and, eventually, policy.

We do think that the policy relevance of research is important. For decades theoretical fragmentation in criminology has contributed to generally ineffective, fragmented, and short-sighted public policies. Without a holistic understanding of the causes of crime, elected officials will continue to shift the focus of control efforts back and forth from individual level to macrolevel causes as the political pendulum swings from right to left. This erratic approach feeds the desperate belief that the problem of crime is intractable—a belief that results in calls for increasingly draconian crime control measures that threaten constitutional guarantees, even commonsense (e.g., “Shoot casual marijuana users [Gates 1992:286-287].”).

C. Partial Theories of Crime

A number of ‘general’ and/or very broad theories of crime have been proposed during recent years. Yet no single perspective has been able to integrate causal factors across important ecological (environmental and situational), microlevel (intrinsic to the individual), and macrolevel (social structural and economic) domains to explain the full scope of criminal behavior. For example, Wilson and Herrnstein (1985) provide an exhaustive review of microlevel biopsychological factors associated with the development of criminal propensities by individuals, but largely ignore macrolevel factors such as social structure, cultural beliefs, and the role of ecological interactions. Gottfredson and Hirschi (1990) attend more to ecological and macrolevel factors associated with development of self-control, but deny that biological factors have any importance. Braithwaite (1989) links micro-and macrolevel factors and processes with the ecological organization of communities, but fails to consider how these relations evolve over time or how the propensities of individuals develop over the life course. Pearson and Weiner (1985) recommend a dynamic processes-oriented approach to understanding how interactions between ecological, micro- and macrolevel factors affect social learning and rational behavior in individuals. But they neglect the reciprocal influence of these individuals on the evolution of macrolevel factors as well as environmental and biological factors. Others (e.g., Agnew 1992; Elliott, Ageton, and Canter 1979) lay a foundation for understanding how the propensities of individuals develop over the life course in response to micro- and macrolevel factors, but ignore biological and ecological factors that influence criminal behavior.

There is a more synthetic trend in recent research. Sampson, working with others, recently has described most of the salient relationships. For example, Sampson and Laub (1993) described how macrolevel factors influence individuals over the life course via systematic links to family relations and the institutions of school and work. And Sampson and Groves (1989) identified how these factors are affected by the ecological organization of communities. However, these scholars avoid discussing the role of biological factors and do not account for the evolution of macrolevel factors over time. Similarly, Farrington (1986) explains crime as the product of a chain of processes that involve biological, microlevel, and ecological factors that influence what is desired, which strategies are selected to obtain desiderata, and situational and opportunity factors that affect decisionmaking. But he does not deal with the evolution of macrolevel and ecological factors.

Developmental psychologists have focused more broadly on the etiology of antisocial behavior. For example, Moffitt (in press) and Patterson et al. (1989) take into account generational and life span issues as well as demographic, micro-, and macrolevel factors. However, they ignore the roles played by criminal opportunities and factors associated with the evolution of criminal behaviors and social responses to crime. All these factors must be understood together before we can explain, predict, or control crime fully.

A human ecological approach is fundamentally different from these earlier theories (Vila 1994). Each of the perspectives mentioned thus far attempted to show how analysis of variables within a favored domain, or associated with a particular construct or set of constructs, could be used to explain all or most aspects of criminal behavior. Each of these perspectives understandably tended to be largely congruent with their authors' academic disciplines—disciplines whose boundaries exist in our minds and institutions, but not in reality. Human ecology similarly has its roots in the 'interdiscipline' of evolutionary ecology. But it uses a problem-oriented, rather than discipline-oriented, approach to understanding criminal behavior. For example, it does not ask “How can one reconcile ‘strain’, ‘control’, ‘labelling’, ‘social learning’ and... theories?” Instead it asks “What relationships tend to be fundamentally important for understanding changes over time in the resource acquisition and retention behaviors of any social organism?” This defines naturally the boundaries of the problem and leads us to view systematic interactions between various domains in a more realistic fashion as dynamic rather than static.

IV. Key Causes of Crime

It is necessary to apply a *generational time scale* in order to holistically understand the causes of individual criminal behavior. We begin the same way an ecologist would approach the study of any organism: by examining the life cycle.

A. The Role of Early Life Experiences

As we noted previously, early life experiences appear likely to have an especially strong influence on the development of criminality because individuals acquire their traits sequentially. The traits we possess at any juncture are the result of the cumulative cognitive, affective, physical, and social effects of a sequence of events that began at conception. As a result of these events, individuals acquire a strategic style over the course of their lives. Some individuals develop a strategic style that emphasizes the use of force, fraud, or stealth to obtain resources and is characterized by self-centeredness, indifference to the suffering and needs of others, and low self-control—criminality.

Some of the more important developmental factors include parenting and family management practices, educational success, pre-, peri-, and postnatal stress (e.g., Wilson and Herrnstein 1985), nutrition, and complex interactions between genes and environment (Fishbein 1990. Two especially important factors are whether an environment helps or hinders a child’s attempt to cope with his/her temperamental propensities and the ability of parents to cope with or redirect the behaviors of a difficult child. As Werner and Smith (1992) note, children are placed at increasing risk of becoming involved in crime by such things as economic hardships, living in high crime neighborhoods, serious caregiving deficits, and family disruption. But these risks appear to be buffered by factors like an easy temperament, scholastic competence, educated mothers, and the presence of grandparents or older siblings who serve as alternate caregivers. The relative importance of risk and protective factors varies according to life stage, gender, and social environment.

Demographic stressors such as poverty, lack of education, high crime neighborhood and family stressors such as unemployment, marital conflict, and divorce all tend to influence development by disrupting family management practices (Sampson and Laub

1993:83). Growing up in a disrupted family is associated strongly with child antisocial behavior, of which crime is one type. The generational time scale is particularly important here because poor family management, antisocial behaviors, and susceptibility to stressors often are transmitted intergenerationally from grandparents to parents to children (Patterson, DeBaryshe, and Ramsey 1989). As will be discussed, this may have important policy implications.

B. An Example

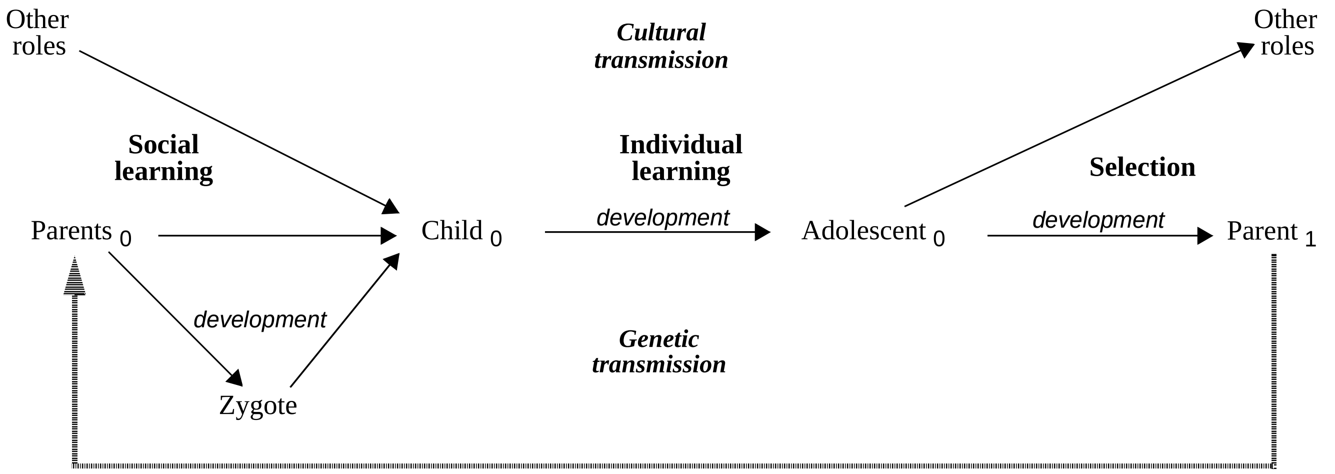
As figure 17.2 illustrates, *parents may transmit genes that—in conjunction with pre-, peri-, and postnatal experiences—cause offspring to develop nervous and organ systems that make them much more difficult and cranky*. This affects the probability they will bond properly with a parent, especially if that parent is under extreme stress from economic, social, or personal factors. For example, children of poor parents beset by economic difficulties and of wealthy parents whose extreme focus on social and career concerns leads them to nurture their children irregularly may be vulnerable to this dynamic[1]. The parent/child bond affects how strongly a child values parental approval—weakly bonded children tend to be much more impulsive and difficult to control. This can initiate a vicious cycle in which a child receives less affection and nurturance because of misbehavior and therefore seeks less and less to please. Over time, the child develops a strategic style in a setting where rewards often are unpredictable as parents struggle with alternating resentment and desire to nurture. Because rewards are perceived as undependable, the child learns to immediately grasp opportunities for short-term gratification rather than learning to defer them for future rewards. In this setting a child also is less likely to acquire conventional moral beliefs. And the risk of physical and emotional child abuse—which further tend to fuel this vicious spiral toward criminality (Widom 1992)—also may be greater.

More impulsive children tend to do less well in school. Poor school performance strongly influences future life chances and thus how much stake they develop in conventional society. It also increases the likelihood children will associate with, and learn criminal behavioral strategies from, deviant associates. Both of these factors increase the likelihood of engaging in serious and frequent delinquency (Hirschi 1969). Engaging in delinquency further can diminish conventional opportunities and weaken beliefs about the moral validity of specific laws, thus reinforcing criminality. This trajectory will tend to continue into adulthood until/unless it is altered. Sampson and Laub cite fundamental shifts in family relations and work as the most important sources of potential change (1993:248).

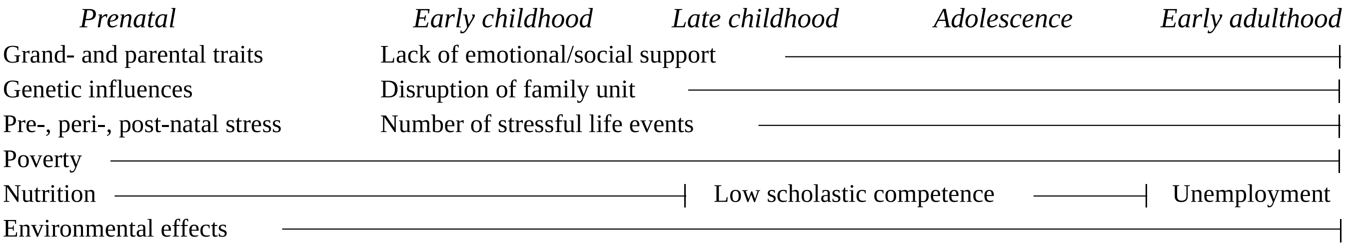
---

[1] See Moffitt (in press: 15-21) for a more detailed description of “problem child/problem parent interactions and the emergence of antisocial behaviors” in adverse rearing contexts.

Figure 17.2. The human life cycle. People acquire traits that influence their behavior sequentially over the life course. Which traits are acquired depends upon interactions between genes, social and individual learning, and environmental factors during development. Examples of factors associated with development of criminality at each stage are listed below the diagram.



Examples of important factors affecting the development of criminality at different life stages:



Unless the trajectory is deflected, this cycle of crime causation will tend to continue when people with high criminality become parents or role models. For example, men raised in a disrupted household are likely to become implusive deliquent adults. Their own children are thus more likely to live in disrupted households that lead to more impulsive, delinquent children. At the *population level*, this process thus can have an important effect on how the frequency, distribution, and character of crime evolves. The long, slow multigeneration increase in crime experienced in the US may well be a product of factors such as poverty that have small effects in any one generation, but accumulate over the generations due to cultural transmission.

V. The Evolutionary Ecology of Crime

Before we can identify effective crime control strategies, we first must understand what makes crime evolve. In the discussion thus far, it was possible to holistically understand *individual* criminality by considering together opportunities for crime and interactions between the biological, socio-cultural, and developmental factors that influence motivation. If we now use Darwin's trick of expanding our focus to look at *population* level changes as the result of individual interactions and behaviors we can understand how the amount and type of crime in society evolves over time. This is the same approach to understanding complex systems that ecologists apply to biological communities, except that it accounts for uniquely human attributes such as the extensive use of culture and symbolic behaviors[2]. Understanding what makes crime evolve as well as what causes criminal behavior makes it possible to identify effective crime control strategies.

A. Individual Variation

The individual interactions that drive societal-level changes in crime occur between people with different characteristics. Over the course of their lives, people acquire characteristics such as knowledge, skills, attitudes, beliefs, and styles of strategic behavior. Which characteristics they acquire is strongly influenced by repeated interactions between socio-cultural, biological, and developmental factors (figure 17.1). These characteristics affect the value they place on material and symbolic resources at a particular point in time. They also affect their ability to obtain those resources. In other words, the characteristics we pos-

---

[2] As we've discussed previously in this course, cultural traits are those based on learned information and behaviors. Humans are unique in their extensive use of cultural adaptations. Most organisms' adaptations are directly driven and constrained by genetic information that only can be transmitted from parents to children over generational time. In contrast, humans readily transmit cultural information within and between generations, between related and unrelated individuals, and across vast distances. Since human cultural traits may be intentionally modified to adapt to environmental opportunities and challenges, we may guide the evolution of culture.

sess at any time strongly influence which things we want and our ability to get them. We may possess the desire and ability to use conventional strategies such as legal employment to get money, goods, or respect. We also might be inclined to use criminal strategies entailing force, fraud, or stealth to get the same things. Alternatively, we could want to use conventional strategies but lack the ability to do so. A person's motivation to commit a crime is determined by these factors plus the effects of temptation exerted by an opportunity for crime. If motivation is sufficiently high and an opportunity exists, a crime can occur.

B. Coevolution of Criminal Strategies and Counterstrategies

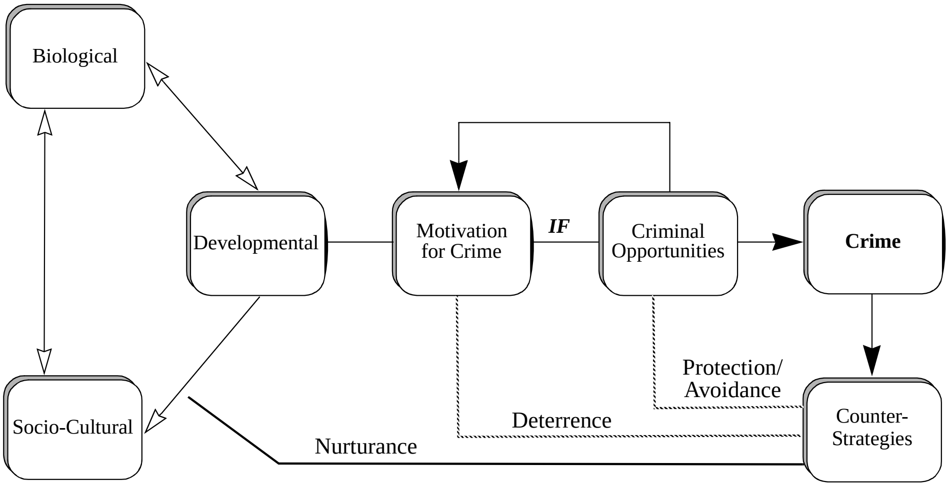
Crimes tend to provoke **counterstrategies***—defensive responses—from victims and potential victims*. They install alarm systems, avoid going out at night, or stay away from rough areas. As information about crime spreads, others adopt similar counterstrategies. Eventually, community groups and government may respond with things such as neighborhood watch programs, increased police surveillance of problem spots, or new legislation.

Over time, criminal strategies and counterstrategies can **coevolve** *in response to one another for several reasons*. As is discussed below, defensive counterstrategies encourage people seeking criminal opportunities to adapt by developing new strategies for crime or shifting to a different type of crime (Cohen and Machalek 1988). More generally, higher crime rates often lead to more rigorous protective measures that initially may cause crime rates to decline. Similarly, lower crime rates may lead to a relaxation of barriers to crime as individuals and communities channel limited resources to more pressing problems. Declining crime rates thus eventually may make crime an easier, less risky, and more attractive, way to get resources. This suggests that crime probably will always exist at some level in society. As fewer people are attracted to crime, potential rewards will tend to increase until they are bound to attract someone. These dynamics—and the tendency of defensive counterstrategies to initiate a vicious cycle by provoking counter-counterstrategies from offenders—suggest that crime probably always will exist at some level in society. Understanding the different ways that counterstrategies address the causes of crime is the key to making criminological research relevant to public policy.

C. Counterstrategic Options

In the past, most crime control proposals ignored the simple fact that criminality is strongly influenced by early life experiences due to the cumulative, sequential nature of development. As the dashed arrows in figure 17.3 illustrate, usually we have employed counterstrategies that attempted to reduce opportunities for crime or deter it. *Protection or avoidance strategies* attempt to reduce criminal opportunities by changing people's routine activities or by incapacitating convicted offenders through incarceration or electronic monitoring devices (Reiss and Roth 1993:325). They also may increase guardianship through such things as target hardening, neighborhood watch programs, and increasing the numbers or effectiveness of police. *Deterrence strategies* attempt to diminish motivation for crime by increasing the perceived certainty, severity, or celerity of penalties. 'Non-punitive' deterrence approaches also advocate raising the costs of crime but they emphasize increasing an individual's stake in conventional activities rather than punishing misbehavior (see Wilson and Herrnstein 1985). *Nurturant strategies* (solid arrow in figure 17.3) seldom have been included on crime control agendas. They attempt to forestall development of criminality by improving early life experiences and channeling child and adolescent development.

Figure 17.3. Short-term crime control strategies (dashed arrows) attempt to diminish opportunities for crime or reduce its rewards relative to conventional behavior. Long-term strategies (bold arrow) address the roots of criminal behavior early in the life course.



The long-term effectiveness of protection and avoidance strategies is limited. The evolutionary dynamics illustrated in figure 3 mean that protection strategies tend to stimulate "arms races" reminiscent of predator-prey coevolution. For example, criminals adapt to better locks by learning to overcome them, to anti-theft car alarms by hijacking autos in traffic rather than while parked, to changes in people's routine activities by moving to areas with more potential targets. Whatever the long-term limitations of protection strategies, however, they obviously always will be necessary because of the opportunistic nature of much crime. Due to the potentially rapid nature of cultural evolution, these strategies should be able to evolve quickly in response to changes in criminal strategies.

The effects of opportunity-reducing strategies like incapacitation through incarceration are unclear and may be confounded by the fact that younger offenders—who are least likely to be incarcerated—often commit the most crimes (see Reiss and Roth 1993:292-294). Moreover, incarceration is expensive and perhaps often counterproductive. Sampson and Laub (1993:9) assert that incarceration indirectly *causes* crime by disrupting families and ruining employment prospects. Newer alternatives like incapacitation via electronic monitoring of convicted offenders in their homes are cheaper than incarceration and may be less counterproductive.

Conventional deterrence strategies also are problematic. There is little evidence that—in a free society—they can be effective beyond some minimal threshold for controlling most[3] crimes (Reiss and Roth 1993:292; Wilson and Herrnstein 1985:397-399). One novel deterrence approach recently suggested by the National Research Council's Panel on the Understanding and Control of Violent Behavior might be more effective. It would attempt to improve the ability of people who use alcohol and other psychoactive drugs to calculate costs and benefits via treatment and pharmacological interventions (Reiss and Roth 1993:332-334).

Non-punitive deterrence strategies that attempt to increase the stake adolescents and adults have in conventional life show promise for 'correcting' life trajectories. Sampson and Laub's (1993) rigorous reanalysis of data from the Glueck Archive indicate that the best way to encourage most adult offenders to desist from crime is to increase their "social capital" by improving employment opportunities and family ties. There also is evidence that military service among young men may help compensate for the criminogenic effects of earlier risk factors because it provides an opportunity to repair educational and vocational deficits (Werner and Smith 1992).[4] However, the paradigm proposed here indicates that non-punitive deterrence strategies still may provide less potential crime control 'leverage' than nurturant strategies. Since criminality has its roots in the early life course, changing the strategic styles of adults generally is more difficult than influencing the development of

---

[3] Traffic offenses and crimes like drunken driving may be exceptions.

[4] Since improving employment opportunities appears to diminish the risk of offending, it is ironic that, compared with most other industrialized nations, the United States has largely ignored the occupational training needs of non-college-graduates who comprise over 80 percent of U. S. adults over age 25. The National Center on Education and the Economy notes that the U. S. may have the worst school-to-work transition system of any advanced industrial country. In an apparent step in the right direction, the Clinton Administration recently approved non-military national service programs that might help smooth the school-to-work transition for young adults.

children. To paraphrase Alexander Pope, it is easier to bend a twig than a mature oak.

Improving child nurturance may be the most effective defense against crime. This paradigm suggests that it should be possible to reduce the concentration of criminality in a population by improving early life experiences[5] and channeling child and adolescent development[6]. However, nurturant strategies such as educational, health care, and child care programs that address the roots of criminality early in the life course seldom have been employed for crime control. And the results of educational and public health programs that attempted to improve early life course factors often have been equivocal or disappointing. In fact, substantial increases in crime have accompanied what some would argue are enormous improvements during the past one hundred years in such things as health care access, public education about family management, and provision of counseling for abuse victims. How might this apparent inconsistency be explained?

Although there obviously have been substantial improvements in these areas at the national level, their distribution undeniably has been uneven. And increases in reported crime rates have been most dramatic during the last forty years. Much of the increase in crime during this period appears to have been associated with such factors as demographic and business cycle fluctuations (e.g., Easterlin 1987; Hirschi and Gottfredson 1983), and changes in people's routine activities (Cohen and Felson 1979). Increased urbanization, social disorganization, and concentration of those who are most deprived as well as population growth also appear to be very important (W. J. Wilson 1987).

Past attempts to measure the impact of nurturant strategies on crime rates may have been confounded by time-lag effects. For example, previous empirical efforts to identify re-

---

[5] For example, nurturant strategies might attempt to 1) assure that *all* women and children have access to good quality pre-natal, post-natal, and childhood health care; 2) educate as many people as possible about the basics of parenting and family management; 3) help people prevent unwanted pregnancies; 4) make help available for children who have been sexually, physically, and emotionally abused—and for their families; and 5) make available extended maternity leaves and quality child care for working parents.

[6] Crime control strategies that channel tendencies such as impulsivity associated with increased risk of criminal behavior are necessary since biological, developmental, and environmental variation assure that some people always will be more impulsive. Here the emphasis would be on improving the match between individuals and their environment. Channeling impulsivity might involve broad-based changes that improve the quality of education for all students. For example, schools could place less emphasis on forcing children to sit all day, instead allowing them to participate in more active learning or to read in a preferred position. Similarly, self-regulation training that improves self-control and diminishes impulsivity would benefit all children. More impulsive students also might be encouraged to prepare for conventional occupations that reward people who prefer *doing* to sitting and talking and/or provide shorter-term gratification. This might help them acquire a larger stake in conventional behavior and diminish risks associated with school failure, making them less likely to develop or express criminality (Sampson and Laub 1993; Werner and Smith 1992; Lemert 1972).

lationships between crime and social structural/economic variables (e.g., income inequality, poverty, and unemployment) using aggregate data primarily focused on contemporaneous rather than lagged effects. The proposed importance of life-course thinking and intergenerational effects indicate that results of educational, health care, and child care programs implemented today should begin to be seen in about 15 years—when today's newborns enter the 15-29 year-old age group most at risk for criminal behavior. Even then, according to the paradigm, change probably would be gradual with the population-level concentration of criminality continuing to decline as each generation of more fully nurtured people became parents themselves. This means that change associated with nurturant strategies might require three or four generations. Attempts to measure past effects of nurturant strategies also might be confounded by immigration because, for example, national programs affecting early life course factors would not have had an effect on those whose childhoods were spent outside the country. *Legal* immigration as a percentage of total U. S. population growth has increased regularly from -0.1 percent during the depression to 29.2% from 1980-1987.

It is unclear whether the apparent failure of past nurturant programs reflects their lack of utility, faulty program implementation, or a failure to persistently pursue them over generational time frames. It also is possible that the effects of these programs have yet to be measured. There could be substantial payoffs if it is possible to successfully implement programs such as these over the long-term. There is strong evidence that the most persistent five or six percent of offenders are responsible for roughly 50 percent of reported crimes. Moffitt (in press) suggests that antisocial behavior in this group is most likely to be the result of early life course factors.

VI. Thoughts for the Future

We have argued that it is possible—and probably necessary—to use a human ecological approach to understand crime holistically if we are to conduct sound research and develop sound public policies for crime control. And we've tried to explain how this approach can be used to describe how ecological, microlevel and macrolevel factors associated with criminal behavior interact and evolve over time and how they influence individual development over the life course and across generations. If the proposed relationships and effects are supported by research, a single theoretical framework could account for the ways individuals acquire behavioral strategies such as crime and how they are differentially motivated to employ those strategies by variation in individual resource holding potential, resource valuation, strategic style and opportunity.

Applying the same well established techniques and concepts that have unified our understanding of complex organic systems in the biological sciences—while giving special consideration to the unique properties of culture—provides a unique holistic perspective on human behavior. It allows us to view crime as a cultural trait whose frequency and type evolve over time as a result of dynamic interactions between individual and group behavior in a physical environment. An appreciation of the nondeterministic nature of these processes encourages us to consider ways to guide the evolution of culture in desirable directions.

Our analysis of the problem indicates that crime control strategies should take evolutionary and ecological dynamics into account. These dynamics suggest that protection/avoidance and conventional deterrence strategies for crime control always will be necessary but will tend to have limited effectiveness in a free society. Non-punitive deterrence strategies that attempt to improve the "social capital" of adults show promise—although they offer limited crime control leverage because the fundamental behavioral styles individuals develop early in life are difficult to change. Strategies that address the childhood roots of crime over several generations appear most promising from a theoretical standpoint but past efforts in this direction generally have been disappointing. This paradigm emphasizes the importance of determining the reasons for their apparent failure and suggests several possible new avenues of research.

However unattainable they now may seem, nurturant crime control strategies are practically and philosophically appealing because they are proactive and emphasize developing restraint systems within individuals rather than increasing governmental control. They also have broader implications. If crime control strategies focused on controlling the development and expression of criminality instead of controlling specific criminal acts, it might be possible to address simultaneously the common source of *an entire set* of dysfunctional behaviors: crime, drug abuse, accidents, and perhaps even suicide. And we might do so in a manner that builds human capital and improves social cohesiveness. It is ironic that some think it naive to consider employing nurturant strategies that, according to this paradigm, will take generations to control crime. We routinely plan cities, highways, and military weapons systems 20 years or more into the future. Twenty years ago Richard Nixon became the first of five successive presidents to declare "war" on crime (Bill Clinton became the sixth in December 1993). Our analysis indicates that it is time to *evolve* the culture of our society and become less impulsive, less dependent on coercion, and more sensitive to the needs and suffering of others.

VI. Bibliographic Notes.

References

Agnew, Robert (1992) Foundation for a General Strain Theory of Crime and Delinquency. Criminology 30:47-88.

Blau, Peter M. and Joseph E. Schwartz (1984) Crosscutting Social Circles: Testing a Macrostructural Theory of Intergroup Relations. Orlando, FL: Academic Press.

Braithwaite, John (1989) Crime, shame, and reintegration. New York. Cambridge University Press.

Cohen, Lawrence E. and Marcus Felson (1979) Social Change and Crime Rate Trends: A Routine Activity Approach. American Sociological Review 44:588-608.

Easterlin, Richard A. (1987) Birth and Fortune. Chicago: University of Chicago Press.

Elliott, Delbert S., Suzanne S. Ageton, and R. J. Canter (1979) An Integrated Theoretical Perspective on Delinquent Behavior. Journal of Research in Crime and Delinquency, 16:3.

Farrington, David P. (1986) Stepping stones to adult criminal careers, in Dan Olweus, Jack Block, and Marian Radke-Yarrow, eds., Development of antisocial and prosocial behaviour: research, theories, and issues. New York: Academic Press, pp. 359-384.

Fishbein, Diana H. (1990) Biological Perspectives in Criminology. Criminology 28:27-72.

Gates, Darryl F. (1992) Chief: My life in the LAPD. New York: Bantam.

Hirschi, Travis (1969) Causes of Delinquency. Berkeley, CA: University of California Press.

Hirschi, Travis and Gottfredson, Michael (1983) Age and the Explanation of Crime. American Journal of Sociology 89:552-584

Katz, Jack (1988) Seductions of Crime: Moral and Sensual Attractions in Doing Evil. New York: Basic Books

Land, Kenneth C., Patricia L. McCall, and Lawrence E. Cohen (1990) Structural Covariates of Homicide Rates: Are There Any Invariances Across time and Social Space? American Journal of Sociology 95:922-963.

Lemert, Edwin M. (1972) Human Deviance, Social Problems, and Social Control. Englewood Cliffs, NJ: Prentice-Hall.

Pearson, Frank S. and Neil A. Weiner (1985) Toward an Integration of Criminological Theories. Journal of Criminal Law and Criminology 76:116-150.

Reiss, Albert J. Jr. and Jeffrey A. Roth (1993) Understanding and Preventing Violence. Washington, DC: National Academy Press.

Sampson, Robert J. and W. Byron Groves (1989) Community Structure and Crime: Testing Social-Disorganization Theory. American Journal of Sociology 94:774-802.

Tonry, Michael L., Lloyd E. Ohlin, and David P. Farrington (1991) Human Development and Criminal Behavior. New York: Springer-Verlag.

Widom, Cathy S. (1992) The Cycle of Violence. National Institute of Justice Research in Brief, NCJ 136607.Wilson, James Q. and Richard J. Herrnstein (1985) Crime and Human Nature, New York: Simon and Schuster.

Wilson, James Q. and Richard J. Herrnstein (1985) Crime and Human Nature, New York: Simon and Schuster.

Wilson, William J. (1987) The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy. Chicago: University of Chicago Press.

Chapter 17. COMMERCE AND TRADE

I. Introduction

A. The General Division of Labor Problem

Recall from Chapter 13 on the evolution of social organization that division of labor and trade are unusual in animals, especially among the "higher" vertebrates. We have to go to "lower" animals like the social insects to find analogs of human behavior in this regard. It is also striking that humans engage in division of labor and trade on a variety of scales ranging from the family (division of labor by age and sex) to the societal (the standard economic roles of complex societies[1]) to international (e.g. U.S. specialties in agriculture, computers, and finance, Japanese specialties in smaller autos and consumer electronics). We can take time to consider only one of these scales, cross-cultural and international trade. However, the same general principles ought to apply to all forms of division of labor and trade. All forms give rise to several very interesting and unsolved theoretical problems.

The economic advantages of the division of labor are quite large. Adam Smith used the example of specialization in the manufacture of pins. If individual workers had to find the iron ore, mine it, smelt it, manufacture it into wire, solder on heads, sharpen the pins, and package and market them, their productivity would be abysmal. The dozen or so specialists involved in 18th Century pin making were much more efficient even for this extremely simple item. Species like humans and ants that make extensive use of division of labor are quite successful. Yet, relatively few species have evolved a division of labor and the human expansion of the division of labor to create modern economies is a very late process. The key question is *"Why is it so hard to achieve a division of labor?"*

There must be some serious impediments in the way of a free evolution of a division of labor. We argue that the primary problem is one of cooperation. A division of labor generally requires that partners be able to resist taking unfair short-term advantages. Empirically, divisions of labor seem to be supported either by kin selection (insect colonies, the clones of cells that make up the bodies of complex organisms), or by reciprocal altruism (the standard 2-species mutualism like the fungal-algal association that makes up lichens). However, for all the ink spilled since Adam Smith, this is a phenomenon of which we have only an incomplete understanding. Even in biology, the examples of mutualism between species are just coming under serious theoretical study, and the answers are confusing.

---

[1] such as farmer, teacher, public servant, banker, factory hand soldier, politician, etc.

B. International Trade

As within-society division of labor, our example of the phenomenon of trade between major social groups is important in humans, and there is no close analog in other animals. If the general level of exchange of resources *within* human societies is unusual, the existence of cross-cultural exchanges is even more so.

The motivation for international trade is simple and obvious: societies can specialize based on their special skills and resource attributes and exchange with others, potentially to the net benefit of everyone. The absence of trade in the animal world suggests that successful trade relations might not the easiest thing to achieve. Indeed, tensions between modern trade partners who are on reasonably good terms politically, such as conflicts over trade policy between Western Europe, Japan, and the USA, testify that trade is indeed problematical. Trade rivalries, charges of unfair competition and rigged prices, and the like are common in trade relations.

Although trade is undertaken by merchants for quite mundane economic reasons, it has important evolutionary side effects. First, traders carry ideas from one society to another; trade thus provides an avenue for the diffusion of innovations. Second, trade is often a competitive business, and competition acts as a stimulus to invention. Thus, active international commerce tends to be an important force driving cultural evolution, particularly the basic technical aspects of culture. We'll return to the evolutionary implications of trade in Chapter 28.

II. Basic Theoretical Concepts

Four basic theoretical concepts will serve us as a foundation for understanding systems of trade: a) the idea of absolute and comparative advantage, b) the economic theory of free markets vs. monopoly, c) the costs of transport, and d) the idea of protection rents.

A. Absolute vs. Comparative Advantage

If one nation is simply better than its trade partner at producing one good and another at another, we say that there is an absolute advantage to trade. Some societies will be favorably endowed with certain raw materials, and others with an abundance of skills of certain kinds, etc. It makes economic sense for those societies that can produce a particular commodity more cheaply than others to produce it in surplus of local needs and offer the remainder for sale to another society in exchange for their specialized products. This absolute advantage is an obvious stimulus to trade.

The idea of comparative advantage is less obvious and therefore more interesting.

Even if one nation is only relating better at providing a product, but, absolutely worse at both, it makes sense to trade. This idea is one of the classics of economic reasoning, and is attributed to David Ricardo, whose theory of capitalist stagnation we met in Chapter 15.

For example, it might make sense for Japan to import large cars from the U.S. and the U.S. small cars from Japan, even though the Japanese can make both kinds of cars more cheaply than we can. How does this work?

> Let us suppose that the U.S. can produce 10 million large cars or 12 million small cars per 100 million person-days of labor per year. Let us suppose that the equivalent production per 100 million person-days in Japan is 12 million large cars and 25 million small ones. This difference might arise because each country has accumulated different skills and manufacturing facilities due to differences in past automobile manufacturing experiences. It might also arise because of different relative costs for the resources that go into the two types of cars.
>
> Now suppose that the demand for cars is 8 million large cars and 6 million small cars per year in the U.S. and 4 million large and 6 million small cars in Japan. If the U.S. makes both large and small cars to satisfy its domestic market, it will need 130 million person-days to manufacture them. The Japanese will need 57 million person-days to do the same, for a total of 187 million person-days to meet the joint demand. But suppose the two nations specialize and trade. The U.S. can make 12 million large cars for 120 million person-days and the Japanese can make 12 million small ones for a total of 168 million person-days. This provides a net saving of 19.3 million person-days if they trade, about 10% of total costs. Even though Japan is altogether better at making cars, it is better off buying its large cars from the U.S., if it can, say, share the labor savings 50-50 with the U.S. Table 17-1 summarizes the example.

Even with powerful reasons to trade, dividing the spoils is an impediment. Relative and absolute advantage together suggest that there will frequently be, at least in the abstract, powerful reasons to trade. However, as table 17-1 illustrates, a number of complexities that might rise. For trade to take place, American large cars will have to be sold in Japan at lower prices than home-produced Japanese cars. In order to accomplish this, U.S. wages will probably have to be lower since Americans are less efficient workers. Moreover, total employment is going to go up in Japan and fall in the U.S. if trade is opened. Although the U.S. *as a whole* is better off with trade, the auto sector will suffer from foreign competition. Since the general public's interest is relatively diffuse and the auto industry's is concentrated, it may be hard for politicians, even ones who are well aware of Ricardo's reasoning, to resist the well organized auto lobby. We see examples of this phenomenon every election year when one or more politicians argue for trade restrictions. Recent debates over NAFTA and GATT were tolerable victories for free trade, but intense efforts by groups like French farmers nearly derailed the process, and certainly warped it.

Table 17-1. An Illustration of the concept of Comparative Advantage.
(Note: Demand is given in millions of autos and costs are given in millions of person-days of labor.)

	JAPAN			**UNITED STATES**			**GRAND TOTAL**
Demand for Autos	4 large	6 small	*total costs*	8 large	6 small	*total costs*	
Costs *Without* Trade	33.3	24	*57.3*	80	50	*130*	*187.3*
Costs *With* Trade	40	24	*64*	80	24	*104*	*168*

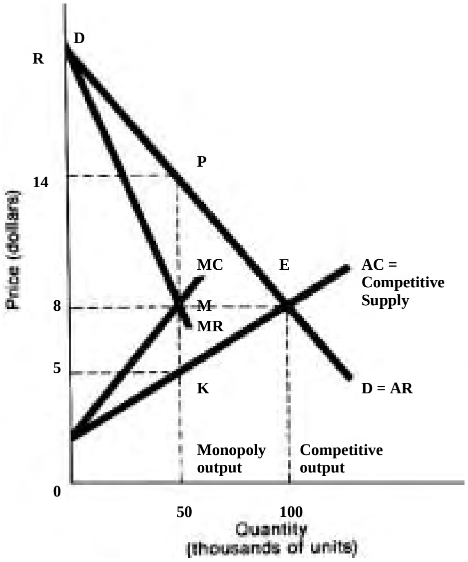
Thus, the opening of trade is liable to have "distributional" effects (some people will become worse off and some better) even as it increases "efficiency" (makes both trade partners better off on average). For example, organized labor in the US tends to oppose free trade. Labor unions suspect that one effect of trade is to force all labor to compete on the world market, driving wages in first world countries toward third world levels. Even as efficiency of the world economic system increases, business is managing to get a larger and larger share of the total benefits, at the expense of labor. It would be naive *not* to expect a political struggle over how the free trade pie is divided, and for people who think they will lose not to resist its temptations.

B. Free Markets (Free Trade) vs. Monopolies

It is notorious among economists that when there is only one seller or one buyer in a market, those who trade with the monopolist will be less well off than if markets are free. The reason is the following: (see Baumol and Blinder, 1979:434-440 or any good basic economics text for a more technical discussion.) In a free market, each seller has only a tiny effect on the market. A selling firm sees only a price "out there" in the world determined by the aggregate of all transactions in the marketplace. If sellers can make a profit producing at the present price, they do so up to the point that price falls to their average costs. Each seller competes with every other to drive the price down. As the price drops, the less efficient sellers drop out, but more efficient sellers survive. The classic equilibrium in such a situation is the point where supply and demand balance. At this point the price equals the average costs of production for sellers.

In a monopoly market, one seller sells all or most of the goods. As this seller increases production, it watches the price go down, as prices have to be lowered to attract new customers. It isn't other producers over whom one has no control who are affecting price, it is the actions of our dominant seller that drive prices down. At some point, the seller will have to spend more than one dollar to produce an additional dollar of revenue. At this point, the monopoly seller will stop producing more because its marginal return will equal its marginal cost. However, its average cost of production will still be quite a bit lower than the price, and it will earn monopoly profits.[2] Figure 17-1 illustrates these ideas:

Figure 17-1 Equilibria of competitive and monopolistic industries. Competitive equilibrium *E* occurs at price $8 and quantity 100,000 units, which is where the supply and demand curves intersect. The smaller monopoly output (50,000 units) occurs where the marginal cost and revenue curves meet (point *M*). The monopoly price, $14, is given by point *P* on the demand curve at the monopoly output (Baumol and Blinder, 1979:439)."



Under most circumstances, it will pay producers to try to create monopolies, or to try to engage in quasi-monopolistic practices like cartel arrangements that fix prices and share market. Perhaps a firm can create a monopoly by driving all others out of business by fair means or foul, and then raising prices to the monopoly level. If a competing firm can't be prevented from entering the market when the price is higher than average production costs, perhaps a little agreement can be arranged. If producers can do so, it will pay them collude to fix prices at the monopoly price, and not engage in competition. This is

---

[2] Notice that this argument depends mainly on marginal cost of production *rising* with volume. This may not be true of goods with large economies of scale. In these cases, costs per unit decline as production increases—a situation that may lead to "natural monopolies" such as electric utilities.

fraught with political problems, as they will have to share the market by agreement. OPEC has tried to behave as a cartel, but was only briefly successful. In the US this is generally illegal. In the section on protection rents we will consider some of the ways cartels and monopolies can be accomplished.

C. Costs of Transport

The total volume of trade, the distance over which trade can be carried, and the kinds of goods that can be carried depend on the costs of transport, measured in units like dollars per ton-mile. When transport is cheap, bulk goods that are big, heavy, and low priced per unit of weight can be moved to respond to the advantages of trade. When such costs are high, only expensive goods can be moved, and these only short distances. The price of transport must obviously be added to the price of goods, and the volume of trade is likely to respond quite strongly to transport costs.

Thus, the volume of inter-society trade has grown in direct proportion to advances in transportation technology. These advances have come in many forms, from the evolution of human hands down to the container ship and supertanker. There is a hypothesis that upright posture and hands first arose to take advantage of a division of labor by age and sex. Men hunted and women gathered, and then carried their specialized products back to a camp to exchange. In known hunter-gatherer societies, baskets, slings, carrying nets, and the like allow people to move 10s of kilos tens of kilometers, an impressive feat by animal standards. Recall the key role attributed to the 100 ton ship in the early modern period in permitting the first very long distance direct trade, initially for fairly valuable and light cargoes like spices.

A by-product of cheap transportation and the expansion of trade is that societies can become highly dependent on trade in essentials and customary luxuries. Food, clothing, building materials, industrial raw materials, and the like tend to be bulky and heavy in proportion to value. The division of labor advantage here is plain, but so are the risks. Nations heavily dependent on trade are quite vulnerable to disruptions of trade, as for example Germany was in WWI and WWII due to British naval superiority. Germans attempted and failed to use submarine warfare in both wars to counter-blockade the British. A few ancient societies, like Rome and China, were dependent on long-distant trade in food and other essentials when transportation was unusually easy and well organized. There are political risks in trade that often figure in trade policy. Famine and food riots in Rome when the grain supply was interrupted shook the Empire. Actual risks aside, the argument of vulnerability is a good one for political groups adversely affected by trade. For example, in the U.S., the government until recently subsidized key agricultural, energy, mineral, industrial, and manufacturing industries as part of our strategic (i.e., national defense) preparedness programs.

D. Protection "Rents"

"Protection rents" is a bit of economist's jargon that refers to the price international traders must pay to avoid having their goods seized by bandits, generals, and government functionaries. This important problem (Curten, 1984) is related to the political vulnerability issues discussed above. Cross-cultural trade between different societies typically takes place between politically autonomous units. A trader carrying goods from one society to another has to deal with two political jurisdictions, at least one of which is likely to be a foreign country. Further, trade routes over water or across lightly populated country are vulnerable to piracy and banditry. Successful traders have to have some way of ensuring that their goods are safely transported to a distant market, and that the foreign society will not plunder instead of buy the goods. In modern societies, and in some historical cases such as the Mediterranean routes under the domination of the Roman empire, this is accomplished by an international system of laws, regulations, and law enforcement supported by ordinary taxes. Historically however, and to some extent today, traders had to purchase their protection directly.

> *Many methods were used*:
>
> *Self-help violence.*Traders could arm themselves, especially for protection along the route, but also possibly to deal with local customers at the foreign terminus. The trouble here is that armed merchants are a recipe for trouble; the difference between an honest armed merchant and a bandit gets a bit thin if the weapons are powerful enough to be effective—and if some temptation arises. A classic example was the armed trade/piracy that English, Dutch and French merchants carried on with Spanish America in the 16th century. Drake and Hawkins brought cargoes of slaves and other products to the New World to sell illegally (the Spanish Government wanted to monopolize trade with its colonies to gain revenue for the Crown). If the colonists were slow to buy, the English ran out their cannon, and threatened to shoot up the town in order to grease the wheels of commerce. Or so the "reluctant" buyers, whose alternate market was the Crown monopoly, claimed anyway. Drake and Hawkins claimed it was merely a convenient charade. Of course, if the ship was light on the way home, and relations with Spain were bad, as usual, the English captains engaged in a little outright robbery, secure that the profits would cover their protection rents to Queen Elizabeth, who would then turn a deaf ear to the Spanish ambassador's complaints (which he pursued energetically, by the way). (See Morrison (1974) and Thompson (1972) for entertaining histories of this period.) Dealers in illegal goods often arm themselves to protect their businesses today. The Cali and Medellin cocaine cartels are notorious examples armed international businessmen.
>
> *Hire protection.* A common strategy was to hired armed private guards to deter small-scale banditry during the trip, and pay protection rents to the societies at

both termini of the trip, and any major ports or trade towns along the way. Local political figures and the governments of large states were often well organized to provide local protection and regular access to local markets—for a protection fee. The magnitude of the fee was likely to depend partly on the degree of monopoly the local officials could exercise on violence as well as market forces. Similarly, local tribesmen between towns were often for hire as private guards. Of course the problem here is that if you are known to be willing to hire protection because you are not sufficiently well armed to help yourself, your hired protection can prove troublesome. Often the people who are for hire are bandits or pirates on their own account, if the opportunity offers. A protection racket is a frequent activity of criminal conspiracies. First the gang breaks a few windows, then is sells protection from window breakers. In practice, on many trade routes infested with pirates and bandits, it is not always clear when you are buying protection and when you are the victim of a protection racket! Today, privately purchased protection, like self-help protection, is commonest in international trade in illegal goods like drugs. It is also very common within and among states with a poor rule of law, such as the former Soviet Union, where mafias are extremely important.)

Dane-Geld

It is always a temptation to a rich and lazy nation,
    To puff and look important and to say:-
“Though we know we should defeat you, we have not the time to meet you.
    We will therefore pay you cash to go away.”

And that is called paying the Dane-geld;
But we've proved it again and again,
That if once you have paid him the Dane-geld
You never get rid of the Dane.
(Rudyard Kipling 1865—1936)
Dane-Geld

Government monopoly. Often, the protection of trade is organized as a government monopoly. Honest, competent governments can greatly favor trade and increase wealth by offering cheap, effective protection. By contrast, “kleptocratic” governments offer expensive, incompetent, and thieving protection, often wrecking the economy and providing fertile grounds for the development of mafias. The most effective governments can even engage in diplomacy that extents substantial protection across international boundaries, as in the modern world trade system.

Trade was often most extensive when there were just enough providers of protected ports of entry to ensure a bit of competition, but not too many. On the one hand, if each trade expedition had to pass through many jurisdictions, each wanting a payment, the total protection rents became exorbitant and trade declined.The great caravan routes across Central Asia were only intermittently open from China to Europe because these long land routes usually had too many petty chieftains/bandits demanding protection money to make them competitive with the Southern Indian Ocean-Suez (or Lebanon)-Mediterranean routes. On the other, state monopolies over wide areas, such as in Spanish America, inhibited trade via government monopoly.

III. Types of Cross-Cultural Trade

Historically, several different variants of systems for organizing cross-cultural trade have been important (Curten, 1984, McNeill, 1982). Each of these variants has been influenced by the four major theoretical considerations discussed above. Of course, an infinite variety of local circumstances also affected their operation.

A. Trade Systems in Hunter Gatherer and Simple Horticultural Societies

Trade systems in hunter gatherer and simple horticultural societies are generally limited by the rather high cost of transportation. Usually also hunting and gathering societies are politically autonomous on a quite small scale. Thus, it is difficult to move heavy goods *far enough* to cross cultural boundaries; there is seldom a large ecological difference between societies to create major comparative or absolute advantages to trade, and protection costs are high per unit of distance moved due to the number of independent polities involved.

Most trade in these societies is between immediate neighbors, and is restricted to high value goods, such as ornaments, obsidian for tools and the like. Nevertheless, some high value goods could move surprising distances by what is called *relay trade* in such societies. For example, stingray spines (for use as spearpoints) from the Northern Australian coast were traded for stone axeheads from far in the Australian interior. These goods moved from the coast to the interior of Australia by relay trade, passing through many hands along the way. Similarly, *Dentalium* shell (used as a kind of money) was moved down the U.S. West Coast from the Puget Sound area to Northern California, abalone shell moved inland, and obsidian spread widely from sources like the Clear Lake area in Northern California. Often, the increase in value with distance is recorded in the increase of trade value of shell money by ethnologists, or in the tendency for finished or semi-finished obsidian to move much farther than large chunks and crude tools since the value to weight ratio had to be improved as transport distance and thus costs increased.

Trade between societies was often organized on a ceremonial and expeditionary basis in order to cope with the risks of theft in cross-cultural trade. Large groups of people would travel to a host society at an agreed upon time, chiefs would exchange gifts, negotiate prices, settle disputes that threatened to erupt, and generally supervise trade. The ceremonial *Kula* trade system was a spectacular and famous example. The Trobriand Islanders, studied by the famous ethnographer Bronislaw Malinowski, participated in this trade which involved a large area along the northeastern coast of New Guinea. The ceremonial centerpiece of the trade was a circular flow of valuable necklaces and arm bands in opposite directions in a rough ring of societies. The system involved canoe voyages of up to several hundred kilometers for such trading episodes. The exchanges of valuables among long-established trade partners in pairs of societies served as a "cover" for the exchange of more mundane products such as food, raw materials, etc. that were quantitatively more important.

Elements of ceremonial trade survived until quite late, even among more sophisticated societies. For example, the tribute exchanges between China and her Asian neighbors went on until early in this century. The North American fur trade with the Indians had an aspect like this. Political leaders and their followers would bring goods to a trading post, where gifts would be exchanged with the post agent before trade began. Early Agrarian states often had elaborate "diplomatic trade," with exchanges of gifts between monarchs serving as the ceremonial cover for more mundane trade.

One school of thought has been that these systems of exchange had a very different character than market exchanges. Karl Polanyi (in Dalton, 1974) argued that such trade was centrally organized by political leaders, and was conducted at traditional, fixed prices, rather than market prices which responded to supply and demand. More recently, students of these systems like Curten have argued that the gift exchanges were incidental to trade between followers, and that the fixed prices were mostly a fictional by-product of a lack of a reliable monetary system. In fact, adjustments were made to reflect supply and demand.

B. Systems of Advanced Horticultural and Agrarian Societies

Port of entry trade. Agrarian states commonly opened a few ports of entry for highly regulated trade. Motivations for this system included monopoly controls on the trade of imports or exports, protection of domestic industry from foreign competition, and a desire to prevent foreign ideas from entering a country. For example, China restricted early Portuguese trade to one port of entry, Macao, and the Japanese long restricted all foreigners to Nagasaki. Substantial departures from this pattern did not occur until the 19th century—and only under intense European pressure.

Entrepot trade. States with a stronger interests in trade often set out to create trade entrepots (specialized trade centers) with open access to all traders at modest protection fees. They aimed to make markets, provide transshipment points, offer supplies, and attract as much trade as they could handle. Many such states might have few of their own citizens involved in long-distance trading, and merely specialize in services for a fee. Examples include some of the Spice Islands ports like Malaka (Malay Peninsula) before the time of European dominance, and Venice in the later period after about 1500 when Venetian citizens themselves withdrew from trade.

Ports-of-trade and entrepot towns were often neutral points as far as regional conflicts were concerned. Even warring polities had an interest in recognizing this neutrality so trade could proceed. A grand version of this sort of thing operated in Western Europe in the commercial period. Wars in Europe were often settled by treaties that guaranteed naval peace only in home waters. Unrestrained, violent commercial rivalries were carried out in American, African and Asian waters. “No peace beyond the line” was the aphorism to express this situation, where the “line” was drawn down the Mid Atlantic and across to Africa near the Equator. Here, Europeans were tending to treat their whole continent as a giant entrepot for the many national trade systems.

Diaspora trade. During most of the agrarian period, and in many situations dominated by horticulturists (especially Africa during the last 2000 years) most trade was carried on by what have been termed “trade diasporas,” composed of a farflung ethnic group specializing in international trade. Trade diasporas are a response to the organizational complexities of cross-cultural trade when laws, literacy, communication, and transportation are poorly developed, but transport technology makes a fair volume of long-distance trade possible. In the classic cases an ethnic group spreads outward to a series of port towns and entrepots and organizes the trade between them by becoming experts in cross-cultural exchange. Usually, the original homeland of the ethnic group is important in trade, so there is a natural way for people to develop this specialization, but as the diaspora grows, the original homeland often becomes relatively insignificant. Often, the diaspora merchants are foreigners in the host countries at both ends of the trade routes. Participants in the diaspora are usually subdivided into people who remain resident in the host country and specialize in services for traders, and those who actually travel and conduct the trade. In some cases, for example the Jews, the home country disappeared entirely, and only the diaspora traders remain.

The diaspora residents usually go to some lengths to organize the protection rents with the host country, provide translation services and other local knowledge, and regulate the affairs of the merchant community. Frequently, the local representatives are married into the host culture, and thus have access to valuable local knowledge and influence. A chain or network of such communities constitute a *trade diaspora* and trade between such communities could cover great distances.

Often diaspora peoples were able to cultivate close relationships with local rulers, and came to serve as advisors or bureaucratic staff. The Ottoman court in Istanbul often made use of diaspora peoples in such roles. The Mongol dynasty in China recruited many trade diaspora personnel into its bureaucracy so as not to have to rely too much on the native Chinese. Such people are typically easier for kings and emperors to control than local politicians with independent power bases, and they may bring useful expertise as well. A diaspora community is often small and unpopularly foreign. This puts them at the king's mercy and makes them appreciate his protection[3].

Host countries usually granted diaspora communities the right to regulate their own internal affairs, and the community was often residentially segregated. Local rulers were often reasonably sympathetic to diaspora communities because having them was the only way to take advantage of the opportunities of trade. Big entrepot towns like Alexandria on the Nile Delta, an important way point on a major Far East-Orient route, played host to a large number of these diaspora communities from quite distant localities.

You are perhaps familiar with some ethnic groups who were important participants in classic diasporas. Jews (Europe and Western Asia), Armenians (South Asia), and Chinese (Southeast Asia) are well known examples. But the list is very long. A number of African trade diasporas are also known; for example the peoples who organized the Sahelian and Saharan trade routes. Indians from various groups created diasporas along the Indian Ocean routes, for example Klings and Gujeratis. Southeast Asian islanders created several, for example the South Sulawesi people. Literally dozens of long-distance diasporas are reviewed in Curtin's book.

There were two main reasons for organizing trade around an ethnic group. First, before the advent of specialized educational institutions, such an exotic specialization on cross-cultural affairs could be most efficiently organized within a single ethnic group. At that time, the only way to major in international relations was to learn the trade from your parents[4].

Second, the dangers and risks of trade are multiplied when one has to deal with for-

---

[3] For example,the ethnic Chinese trade diaspora in the Philippines dominated both external and internal trade. They were also an important source of loans for the Spanish aristocracy. When the aristocrats became overburdened with debt, they regularly incited ethnic Filipinos to massacre Chinese. The same tactic was used for centuries in Western Europe against Jews.

[4] Remember the earlier discussion about whether to treat occupational specialties as cultural analogues of species.

eigners, especially powerful foreigners who can loot or extort at a whim. Bonds of kinship and ethnic solidarity help ensure cooperation in the absence of effective legal systems. Diaspora communities did have effective customs and codes of conduct that made business on a handshake and a merchant's word of honor possible in the face of lavish temptations to take unfair advantage of a brother merchant. There are a host of ways for unscrupulous merchants to take advantage of one another. They can welsh on debts, debase the quality of goods or coinage, cut side deals with pirates to steal goods of known location and shipment date. Trust is an essential ingredient of extensive trade, and coethnics are more trustworthy than foreigners. From the host country's point of view, merchants are potential thieves and cheats. The local representatives of a diaspora were known quantities, and could be held to account for the misbehavior of their coethnic traveling traders. In a sense, the local residents were hostages for the honest behavior of their coethnics and were accordingly given the right to regulate their behavior. One might hesitate to leave ones coethnics at the mercy of a local mob by cheating the natives.

In this connection, recall the advantages of cultural transmission for creating the opportunity for local specializations and cooperation on an ethnic basis. The trade diaspora system appears to be a good example of how a fairly large group can evolve a system of cooperation. That cross-cultural trade should have so long been dominated by ethnic specialists is some confirmation of the cultural group selection hypothesis. Note further how important trust and cooperation are in all aspects of a system of the division of labor, and the manifold threats to trade from those who would take advantage in one way or another.

Perhaps the most interesting surviving trade diasporas are those involved in illegal trade. International law now protects legitimate traders, but smugglers of drugs, arms, and the like still face complex political problems. As we have already noted, such businesses still provide their own protection or hire private protection. Smuggling rings generally have a strong ethnic component; the Sicilian Mafia, the French Connection, the Medellin and Cali Colombian cocaine cartel are examples. In the former Soviet Union, "Mafias" from the Muslim republics are said to be quite active.

C. Trade and Commercial Societies

The mercantile empires of the commercial era of Europe were an interesting special type of trade diaspora. Here, the home state took an active role in organizing, promoting, and protecting the trade of its nationals. The model for this type of state-supported trade was Venice and the other Italian trading states like Genoa.

The home country did not just establish enclaves in terminus cities, it also set up a series of fortified trading and supply posts at convenient locations along the route which *sometimes acted as termini in their own right*. Venice's chain of forts stretched down the east coast of the Adriatic and usually included forts in Greece, Cyprus, Crete, and other Mediterranean Islands as well as more typical diaspora communities in the Levant and Asia Minor. The Portuguese trade empire was a chain of fortified "factories" that stretched down the African coast and across the Indian Ocean to the Spice Islands in Indonesia. The main Indian Ocean center was Goa, on the West Coast of India. The Dutch and English East India companies were state-sponsored corporations with a similar structure and inspiration. Spain carried on a transpacific trade with Asia from a main base in Manila and a intermediate terminus on the way to Spain in her American colonies (Acapulco, and the Panamanian Isthmus).

Unlike a typical diaspora, these Western European enterprises were backed by a considerable naval force, and advanced land military techniques. To pay for all of this, and to try to earn some extra profits, the European diasporas usually went into the business of selling protection and creating monopolies. The Portuguese and Dutch both tried at various times and with varying success to monopolize the whole of the East Indian trade, both the long-distance trade with Europe and the internal trade in the area. Usually, they tried to monopolize local trade by selling licenses to local traders, and seizing the cargoes of "smugglers" who refused to buy them. This was nothing but a bald protection racket of course, although to whatever extent the Europeans were more efficient at suppressing piracy and increasing the volume of trade, honest native traders might have benefited. One big protection racket is perhaps preferable to many small ones.

Rivalries between the Europeans and the high cost of supporting naval forces so far from home meant that these tactics were effective only for short periods of time. For example, the Dutch East India Company went broke from the expense of trying to monopolize trade and protection.

In the New World, the disease die-off (see Chapter 20), the relatively short sea voyages involved, and the Europeans' vastly superior military technology allowed full-scale colonial empires to emerge quickly after 1500. In the rest of the world, colonial empires only emerged in the 18th and 19th centuries as transportation technology advanced, the military disparity between Europe and the rest of the world increased, and medical developments reduced the disease risks to Europeans. All this, combined with the trade possibilities inherent in the industrial revolution's cheap manufactures and high demand for raw materials made a brief episode of Old World colonialism possible. Thus, the factory style trade empire lasted longer than the full-fledged colonial empire, the New World excepted.

The full economic and political history of this episode remains to be written. Was the

European thrust for monopoly control of trade with, for example, India ever economically sensible? Were the terms of trade so distorted by monopoly and forced extractions that the development of the economies of the colonized countries was grossly distorted and handicapped? Are the present inequities between nations a function of past colonialism and present neocolonialism? The latter case is made by neo-Marxist Dependency Theorists (e.g. Wilber, 1979; Wallerstein, 1974). Conventional economic historians picture the situation as one in which the costs of empire always made the enterprise marginal at best, and that, while elements of monopoly, plunder and protection rackets were clearly important, trade on net benefited the colony or ex colony. Along these same lines, there is a dispute about the costs and benefits of the former Soviet Empire in Eastern Europe. Today, the US is the only superpower (read main imperial power), and Congress is very reluctant to fund the foreign aid, UN dues, and military costs that Presidents tend to see as necessary to excercise imperial power. Similar political debates took place in the British Parliament during the period when the British Empire was growing.

Of course, the benefits and costs of empire both to the mother country and the colony are likely to be variously distributed so that some groups win and others lose. Thus empire generates complex political reactions in both societies. Displaced elites, and victims of monopoly and shifting markets in the colony, are not at all favorably disposed, for example. British colonialism in India destroyed the local cloth industry via competition with machine made cloth, displaced the governing elite, and spread British institutions—not the least of which was the ideology of representative government. As a result, perhaps aided by ethnocentrism, native elites (e.g. Gandhi, Nehru) were able to run the costs of Empire up to unacceptable levels for most European countries after only a hundred years or so of domination. The U.S. set the pattern in 1776; although in this and many other cases, the pattern of trade changed only marginally as a result of decolonization, leading to the controversy over neo-colonialism. In the current regime of intense global international trade supervised by the US and our allies, American labor unions feel victimized by the drift of manufacturing jobs to overseas locales, and the Anglo middle class is restless over the immigration of ambitious people from overseas.

D. Trade and Industrialization: Ecumenical Trade

One result of intense trade is that expertise in cross-cultural contacts tends to spread. Even the classic trade diasporas tend to work themselves out of business, as the cultural diffusion they engender spreads knowledge of foreign languages and customs. The trend has been for trade to become ecumenical, meaning that individual merchants and their representatives can organize trade with a wide variety of foreign nations. For example, multinational firms can organize world-wide business empires by drawing on an international staff of managers. No longer must a merchant sell to the ethnic specialists of a diaspora. This pattern is not entirely novel; the giant cross-cultural empire of the Roman period allowed a similar development in the Mediterranean in antiquity. Often, a sort of international culture with a lingua franca grows up under such circumstances; the English-speaking international business community of today and the Roman/Greek ecumenical culture of antiquity are examples.

IV. Consequences of Cross-Cultural Trade

A. Increased Economic Efficiency

Regional specialization and improvements of economic efficiency are the classic results of trade. A society can overcome the ecological limitations of its own territory and the historical differences in technical skills to a significant extent via trade. The negative side of this consequence is an exposure to political and social risks. A dependency on the world market and other nations is created. Political conflicts between the beneficiaries and victims of trade within a country are likely to create internal political strife, as noted above.

B. Flow of Ideas

Trade is one of the most important channels for the flow of innovations from society to society. For example, Europeans acquired many key technical innovations from China via trade from 1000-1500 AD. Nowadays the flow of innovations is back to the Orient. Other aspects of culture flow as well, for example religious and political ideas. Islam spread to Indonesia, to Central Asia, and across Northern Sub-Saharan Africa along trade routes from the central area of Moslem conquest conversion in Western Asia.

The spread of liberal political ideas from Western Europe and Communist ones from Eastern Europe are a more modern example. Because of the political and economic risks of trade mentioned above and the ideological ones noted here, many nations have greatly restricted trade. The close regulation of European trade by China and Japan are older examples. Pre-Gorbachev Soviet restrictions on cross-cultural communication provide a more recent example of this attempt. Of course, such restrictions tend to be difficult to enforce without restricting the flow of useful innovations and foregoing the economic advantages of trade. The recent partial opening of China to the West is a result of elites trying juggle these costs and benefits.

C. Biological Contact

Ideas are not the only things that spread with trade, so do genes and diseases. We cover the case of diseases in Chapter 20. Genetic mixing between trade partners is probably not ordinarily too effective at long distance. Permanent migrants and long-term conquest are presumably more effective. However, diaspora traders often intermarried extensively with local communities, and some important mixed-race neoethnic groups have arisen in as a result. For example, mixed Indian-French people were an important part of the Western fur trade, and Portuguese-Africans were important in the Portuguese colonies of Mozambique and Angola. In both cases, the disease resistance of the mixed race as well as their abilities to communicate with both parent cultures gave them an important role in the economy.

V. Conclusion

Cross-cultural trade has played an important and gradually increasing role in the ecology of the human species. The economic advantages of trade are directly important in finessing ecological limitations and taking advantage of specialized opportunities. However, the political consequences of a dependence on trade, the by-products of having to organize protection, the cultural evolutionary consequences of increased diffusion of ideas, and the demographic and genetic impact of large-scale population movements are at least as important.

VI. Bibliographic Notes

References:

Curtin, P.D. 1984. *Cross-cultural Trade in World History*. Cambridge: Cambridge University Press.

Dalton, G. (ed). 1971. *Economic Development and Social Change*. New York: Natural History Press.

Morrison, S.E. 1974. *The European Discovery of America*. New York:Cambridge University Press.

Thompson, G. M. 1972. *Sir Francis Drake*. New York: Morrow

Wallerstein, I. 1974. *The Modern World System*. New York:

Wilber, Charles K. 1979. *The Political Economy of Development and Underdevelopment*. New York: Random House.

Chapter 18. WARFARE AND POPULATION DISPLACEMENT

> The present book has the...purpose of straightening thought about war and peace.... [I]t seemed best to refrain from condemnation altogether. For indignation is so easy and satisfying a mood that it is apt to prevent one from attending to any facts that oppose it. If the reader should object that I have abandoned ethics for the false doctrine that “to understand everything is to pardon everything”, I can reply that it is only a temporary suspense of ethical judgment, made because “to condemn too much is to understand little.”
>
> L. F. Richardson, 1960
>
> Statistics of Deadly Quarrels

I. Introduction

War is one of the most dramatic types of interactions between human groups. Indeed, it is one of the most dramatic types of human behavior. It is also arguably one of the most important types of interactions in terms of its effects on the sizes and distribution of human populations and on the human evolutionary process in general. It is also one of the most characteristically human kinds of behavior. Other animals often fight, but very few of them fight in large, organized groups against other large, organized groups the way humans do. Only humans have the requisite levels of cooperation, coordination and division of labor.

Thinking about war arouses mixed feelings of horror and fascination. As the quote from L.F. Richardson in the epigraph suggests, war is hard to think about analytically. People tend to have highly charged but highly ambivalent feelings about war. On the one hand, war is a frightening, dangerous, and destructive phenomenon. We are horrified by the prospect and actuality of it. On the other hand, the actions of individuals in war often exemplify admirable human tendencies to bravery, honor, loyalty, and lack of self-regard. We tend to condemn war, but glorify warriors.

Richardson’s own feelings were typically ambivalent. Despite his being a pacifist Quaker and a conscientious objector, he served as an ambulance driver with a French division on the Western Front during WWI. He writes of the motives for volunteering, but for one phrase, much as any other patriotic volunteer might: “In August 1914 I was torn between an intense curiosity to see war at close quarters, an intense objection to killing people, both mixed with ideas of public duty, and doubt as to whether I could endure danger.” Richardson was a pioneering student of turbulent flow in fluids (some of you may have heard of the Richardson number) and weather forecasting (Richardson pioneered the computer-based weather prediction methods that are now the basis for the T.V. weatherperson's forecast). After the war, and until his death in 1953 (his book is posthumous) he devoted a large proportion of his effort to the scientific study of war. *Statistics of Deadly Quarrels* is based on the statistical study of some 600+ wars of various sizes between 1820 and 1952. This book, along with a somewhat similar effort by Quincy Wright (*A Study of War*, 1965) are counted as the classics in the field of attempts to understand war from a scientific point of view.

Why do people fight at all? In this chapter, we will examine the theories proposed to explain war, and review some of Richardson's and other's data about the phenomenon. Why does violent conflict have the pattern it does in humans? Given that they do fight, why do they so often fight in groups, rather than as individuals? Then we will look at some of the ecological and evolutionary consequences of war. War has a substantial impact on the movements of people, diseases, and ideas, and is a stimulus for technical improvement. We will try to follow Richardson's advice to be dispassionate; let us understand clearly the nature of the beast, the better to avoid his bite perhaps.

Warfare is an extreme example of outgroup conflict & ingroup cooperation. In addition to an interest in war per se in this chapter, we want to use war as an example of intergroup conflict and within group cooperation. All societies are full of conflicts between individuals, kin groups, tribelets, ethnic groups, classes, interest groups, etc. Societies compete among themselves for markets, political influence, etc. Usually these conflicts involve little violence, although the spoken or unspoken threat of violence is present in the background as a coercive tactic and/or as a motive for diplomatic and political efforts to resolve disputes by agreed upon legitimate means. Legal systems depend ultimately on the ability to use violence, if necessary, to ensure compliance. Generalizations about war apply in some part to all types of human conflict. Because the costs of violent conflict are so high, and because violence has attracted so much attention by evolutionary biologists, social scientists, and historians, it ought to be a good phenomenon against which to test general explanations of patterns of conflict and cooperation. Many of the same considerations will apply to more mundane conflicts, for example between interest groups and political parties in a democracy.

Violent conflict is one of nature's dirty tricks, according to the main hypothesis of this chapter. Violent conflict is an example of something that can plausibly arise by evolutionary processes like selection without being adaptive, at least in the usual sense of the word. At several points in this class, we have met similar cases. Evolution tends to adjust sex ratio to 1:1 despite the fact that this leads to too many males, female choice sexual selection can lead to maladaptive exaggeration of display characters, and cultural evolution can lead to reductions in fertility. We argue that the logic inherent in violent conflict and threats of violence can be favored by evolutionary processes even though we all become worse off because of the existence of the capability to wage war.:

> **Violent conflict may be one of nature's dirty tricks. Even though the possibility of large scale war leaves us all worse off, the logical dynamics associated with violent conflict and threats of violence can be favored by evolutionary processes.**

II. Classical Models Of War

A. Definitional Matters

Wars are large-scale human conflicts in which deaths occur. The line of division between wars, feuds, and simple murder is not easy to draw, hence Richardson's general term "deadly quarrels". Much of the theory will apply to any kind of use of force or threat of force to gain one's ends at the expense of someone else's, so the exact place we draw the distinction is not important in the first instance. However, to understand the peculiarly human tendency toward modest amounts of small-scale fighting and large amounts of large-scale fighting, we need to account for war specifically. Let us define war proper as fights between social units larger than kin groups that are conducted with the intent to kill or capture opponents.

B. Yanomamo Warfare

The anthropologist Napoleon Chagnon's (1988) studies of violent conflict among the Yanomamo, a group of hunter-horticulturalists living in the (until very recently) remote tropical forest on the border between southern Venezuela and northern Brazil, is a classic study of warfare in politically societies. The Yanomamo live in villages of about 100 people, each of which is politically independent. There is a very considerable amount of violence between communities because there are no supra-village leaders to referee disputes. The whole Yanomamo population numbers about 15,000. The root motive for most fights between groups is over women: sexual jealousy, suspicions of infidelity, forcible kidnap of women, and failure to give a promised girl in marriage. However, revenge for earlier killings is a source of continued friction after the original fight. An offended village can nurse a grudge for a decade or more before getting the opportunity for a revenge killing. Typically, 10-20 warriors from a village sneak through the forest to the vicinity of the village where the past killer of one of their people lives. They try to kill the killer, but any adult male will do. Killers become *unokai*, a special, high-prestige status. About 35% of adult males are *unokais*, but of men over 40, about 60% have killed. About 30% of all adult male deaths are due to violent conflict. The Yanomamo are polygynous, and *unokais* tend to have more wives and more children than those who haven't killed. In addition to deadly fights, the Yanomamo have a graded series of non-lethal conflicts, including shouting matches, club fights and fights with axes and machetes. In lethal fights bows and arrows are the preferred weapons. The non-lethal fights often occur during visits between groups and also between men within villages. Yanomamo males cultivate a reputation for ferocity. Men who fail to do so may find that other men begin to attempt to seduce their wives and carry off their daughters. Men are especially likely to loose their women if they patrilineage as a whole gets a reputation for cowardice.

The Yanomamo pattern of warfare is just on the boundary of our distinction between warfare and feud. Yanomamo villages are organized around patrilineal kin groups, and most people in ay given village are related. When villages split they generally do so along kin group lines. The average relatedness of individuals in the villages is 0.06-.12 (recall that full sibs and parents and offspring have a relatedness of 0.5). Thus, when a war party of 10-20 leaves on a mission of revenge, it will include mainly genetic kin, albeit some of rather distant relatedness.

Chagnon argues that his data are typical of violent conflict in the small-scale societies that all humans lived in until improvements in crop production made larger and denser settlements possible in the last few thousand years. He also argues that the reproductive advantages of *unokais* may explain, with the help of kin selection, the scale and pattern of conflict among the Yanomamo. Others think that the Yanomamo are unusual in the amount of small-scale cooperative violence, and that most past peoples had more sophisticated political institutions limiting feuds but organizing proper wars (Price and Brown, 1985, cited in chapter 3). It is interesting that when most vertebrates cooperate in dangerous fights that it is in very small groups, such as pair of brothers. A well-organized war party of 20 or larger is not known for any animal organization of combat, the social insects excepted.

Chagnon reports that a Yanomamo man sent to the territorial capital for nursing training was very excited by the concepts of police and laws. It is not clear what fraction of hunting and gathering and simple horticultural societies had at least rudimentary political institutions of law and policing, but it is interesting that a Yanomamo would think this a good idea. (In highland New Guinea many people welcomed Dutch and Australian police after World War II because it is no fun to live under a permanent regime of feud and small-scale warfare.) It would seem that peace-making institutions might readily spread if invented among groups like the Yanomamo.

C. A Simple Game-Theoretic Analysis

The most basic theory of war has been developed using game theory. Recall how game theory works: The idea is that all kinds of situations in which there are interactions between individuals leading to gains and losses have something in common. In particular, “players” typically employ “strategies” designed to guess how another player will respond and then play the game so as to maximize returns to themselves. There are two general types of games, zero sum and variable sum games. “Zero sum” games are those in which a fixed set of resources have to be divided between players. Many games of skill and chance are of this type; only one team can win the ball game or a particular hand of cards. Although people often think of economic competition and the like as zero sum games, they are probably rare in real life.

Most real-life “games” are variable sum games. In variable sum games, the total payoffs to players depend on the strategies they choose. War is an example of this last type. If a war is conducted, both sides will typically suffer casualties and losses of resources. War is like playing poker while burning much of the money that might be won to keep warm. As long as the war goes on lives and resources are being destroyed, usually at a significantly higher rate than capture of resources even by the winner. The winners may sometimes be better off due to booty and so forth, but the total losses will most often exceed total gains of resources because war is wastefully destructive. On average, we can all expect to be worse off at the conclusion of a war. In modern wars at least, and probably all but those relative handful of situations where the winning side is overwhelmingly powerful or lucky, warfare will result in losses in excess of gains for *both* sides, even the “winner.”

The paradox of war is that everybody looses, yet everybody still arms themselves. From this perspective, understanding war means understanding why people engage in such apparently maladaptive behavior. The very nature of war seems to make some form of pacifism the only sensible strategy, yet warfare and the preparation for war is nearly universal. Why? Are people just stupid?

Simple game theory analysis helps clarify the paradox. Game theorists (e.g. Schelling, 1966; Maynard Smith, 1984; Zagare, 1987) have thought a lot about games that roughly capture the nature of violent conflict. Here is a prototypical “war game” (if you think about it you will see that many kinds of ordinary bargaining situations have the same structure):

Game 1

Player 2	Player 1	
	fight	*don't fight*
fight	P1 gets -100 P2 gets -100	P1 gets -25 P2 gets +25
don't fight	P1 gets +25 P2 gets -25	P1 gets 0 P2 gets 0

> We imagine that the game starts in a time of peace. After that at each time step each player can choose to send and army to seize a bit of territory (fight strategy). In the next time step the other player responds with a fight or don't fight strategy and then the payoffs are collected. Then, the next time step starts and the players keep fighting, surrender, or make peace.

In the end, pacifists lose. Game theorists argue that games like this capture the general property of warfare. Forced seizure of another's resources pays off handsomely, but only if the other party does not resist. If there is resistance both sides lose a lot. Notice that this is an inherently nasty game. Neither player can afford to be a pacifist, even though neither player really wants to go to war, unless the other is a pacifist. A pacifist has no choice but to lose any fights another player wishes to impose upon him. And evolutionary considerations suggest that if we start out with a world full of pacifists, fighters can invade if something like game 1 obtains. Therefore, one cannot expect the other player to be a pacifist; pacifism is not an Evolutionarily Stable Strategy. (Recall that an ESS is a strategy that can resist invasion by another strategy when it is very common. If pacifists are very common, a rare fighter mutant will easily victimize them, be favored by selection, and increase rapidly on the evolutionary time scale.)

Maynard Smith illustrated the problem with what he called the "hawk-dove" game. He was thinking of birds defending territories for nesting. In the hawk-dove game, individuals can adopt either the hawk strategy, "fight for any territory you want, and fight to defend one if you have it," or the dove strategy, "occupy any open territory, but never fight." In this game, neither strategy is generally an ESS. When doves are rare, it pays to be a hawk, but when hawks are very common, it pays to play dove because the hawks spend a lot of time in costly fights with each other. Maynard Smith also investigated a strategy he call "bourgeois." Bourgeois strategists follow the rule "never fight to take a territory, but always fight to defend it." This strategy is an ESS, and cannot be invade by either hawk or dove. The war game, by allowing for partial seizure of territory by surprise attack, at no cost to the attacker unless the victim launches the mutually costly counter attack, is a rather nastier game than the one Maynard Smith studied, but even in his game pure pacifism (all dove) certainly isn't an ESS.

Most perversely, in our war game both players have an incentive to attack first. Notice that whoever goes first confronts the victims of attack with a nasty dilemma. The victims have already lost 25 units, and if they decide to fight, will lose 75 more. A rational victim will swallow the loss it seems. This game turns the pacifism intuition on its head. Now it seems as if the world should be full of hair-trigger fighters who grab any opportunity to execute a preemptive first strike against any other player, for fear of being the victims if they don't strike first. Now we have to explain why the real situation is usually better that this, if a long ways from pure pacifism, or even Maynard Smith's Bourgeois ESS.

War can be deterred by credible threats to retaliate. Schelling stresses the importance of communication in games like this. Suppose we can communicate effectively a willingness to go to war in the above game even if the cost is -100 if the other fellows strike first. We might invoke some principle of territorial integrity and try to convince our antagonist that we'll play a bourgeois style strategy, promising to retaliate if attacked, while assuring one and all that we ourselves have no territorial ambitions. If our threat and promise is believed, the other fellows will not strike first. It would be foolish to try to gain an advantage of 25, if you know that the next thing will be a -100 war, especially if you believe that the other guys will not strike first. As the theorists say "a credible threat will deter attack." So far so good. If both sides adopt this strategy and are believed, then we have "stable deterrence," and war will not occur. This is how the situation that prevailed between the U.S. and the USSR from 1950-1990 was often characterized. There is a hook here, however.

We have to be a bit irrational to accept the -100 rather than the -25 loss when confronted with a first strike, say the Warsaw Pact seizure of West Germany, to use the case that worried military planners in the Cold War period. "Better Red than Dead" people sometimes said. Especially in the case of nuclear war where the cost of a full-scale war is unimaginably large, the threat is not very credible if the players are rational[1]. Our threat

---

[1] Former President Ronald Reagan's famous (or infamous depending upon one's politics) "Evil Empire" speech is a case in point. At a time when most U.S. political leaders were attempting to tone down warlike rhetoric, Reagan lambasted the USSR as an "evil empire" that must be stopped at any cost. According to the logic described in this chapter, Reagan's speech may have helped motivate the Soviets to bow out of the arms race over the following several years. Many of us believed that Reagan was a doddering old zealot who really believed his militant rhetoric. More importantly it seems that Soviet policy makers really believed it, decided they couldn't win the Cold War, and, in essence, surrendered! Did he really believe it? We'll never know because no one called his "bluff".

will be credible if we can (irrationally) convince ourselves and our enemies that we are really playing the following game instead of the prototypical war game (Game 1 above):

Game 2

Player 2	**Player 1**	
	fight	*don't fight*
fight	P1 gets -20 P2 gets -20	P1 gets -25 P2 gets +25
don't fight	P1 gets +25 P2 gets -25	P1 gets 0 P2 gets 0

In this game, our threat is quite credible. If player 2 attempts to get +25 from us by fighting, we will surely fight as well, robbing him/her of the gain, because it is better to lose -20 than -25. Here there is no first-strike temptation, and deterrence is much more effective than in the case of game 1. Note that we are all better off if we *believe* this is the game we are playing, even if we actually are in the game 1 situation. It seems as if we are all better off if we are a little bit crazy, believing that war is much less dangerous than it actually is. On a small scale the Yanomamo man's dramatic displays of his fierceness, or the modern American street gang members demands for respect lest violence ensue, can be interpreted as mechanisms to try to make threats credible.

Irrational strategies lead to plausible coercion. However, if we admit irrational strategies, it is not clear we can make any gains. For example, suppose there is reason to believe that one player in this game is a bit crazy. A crazy player, or even just a bold gambler of the stripe of Napoleon or Hitler, can take advantage of the -100 (negative) payoff to coerce the other player rather than to deter. Suppose that the militaristic leader of a neighboring society is player one in the game above. Suppose he gives a speech in which he demands a bit of our territory (worth 25 units) or he will go to war. He brags that his army is so potent that he can whip us easily if we resist. At worst, it will only cost him -20. Our military chiefs say this is nonsense, the payoff is as in Game 1, not Game 2; war will cost both sides about -100. We may even know that our enemy's military chiefs are telling him the same thing. Hitler's military planners were much more rational than he was, and greatly feared his reckless course of aggression. But if our enemy persists in this irrational belief he will go to war and cost us both -100. If we are rational, at this point we should give up the territory, that will only cost us -25. This is essentially what the British and French "appeasement" strategists did when giving Hitler the German speaking areas of Czechoslovakia.

But if there are other rational leaders out there, they may observe our action and decide to pretend to be irrational to victimize us for another 25. Or the original militarist may come back for more, as Hitler kept doing. Or the militarist may just be bluffing. In communicating an apparently irrational willingness to fight, the militarist has put us on the horns of an exquisite dilemma. To win this game, not only must one be crazy, you must try to convince the craziest "statesman" around that you are crazier than he is. So the theory seems to say. Eventually, you may have to appeal to a sacred principle and call the crazy man's bluff, as the French and British finally did when Hitler invaded Poland in 1939. Of course, Hitler wasn't bluffing, he was a genuine megalomaniac!

Even the weak can be strong if their threats are credible. For example, let's take another situation. Suppose we are a powerful but rational aggressor. We can easily impose a disproportionate cost on a neighbor if he chooses to resist, say four times as many casualties as we will take. Let us say we want a bit of territory worth a 1000 casualties. We demand the territory, and threaten our victims with 4000 casualties unless we get it. Suppose our victims respond that this is territory sacred to their nation, that their sense of honor is completely outraged by such a demand, and that they will fight to the last soldier (say they have 10,000). (This situation corresponds roughly to Polish responses to the demands of Nazi Germany in 1939.) If they are not bluffing, it is going to take 2,500 casualties of ours for a territory worth only 1,000, so we will be deterred. Do we attack in hopes that they are bluffing? Do we attack for fear that some of our previous victims will contemplate revolt if we do not follow through? Will the threats of the weak to fight irrationally be credible? In recent decades, the North Vietnamese and the Afghans showed the US and the USSR that they were willing to accept huge casualty rates in apparently very asymmetrical contests with Great Powers. The Somali warlord Mohammed Aidid has recently showed how a objectively weak but determined group can take on the UN, backed by world opinion and excellent US infantry, and win. George Washington strategy to win the American War of Independence is another example of the power of the determined weak against the strong. The Americans were hardly ever strong enough to win battles. But by demonstrating that they were capable of fighting on indefinitely, we eventually convinced the British the cost of winning was too high. Evidently, we should take the threats of the weak seriously.

No combination of strategies will solve the problem. The message seems to be that the rational player will always lose to irrational players in a world like this. Some game theorists have reached just this pessimistic conclusion. But if everyone is really irrational, then wars are likely to break out by accident. There is plenty of evidence that irrational players existed during WWII, such as Hitler, and for different reasons Japan. Plenty of wars do seem to have broken out by accident and through gross miscalculation, like WWI. Thus, no combination of rational and irrational strategies seems to solve the problems caused by the game of war. This, combined with the commonness of wars, suggests that simple game theory analysis has something to say for it. But the fact that war is usually not perpetual—even between hereditary enemies—suggests that it is incomplete. Like the model of malthusian growth, the simplest game theory seems to tap a major underlying part of the problem of war, but needs some refinement.

D. More Complex Strategies

Schelling argues that humans have developed very elaborate strategies to avoid the worst consequences of "games" like war. For example, conflicts are typically escalated slowly, as the contenders assess each other's resolve and explore compromises that might avoid the -100, -100 type payoff. Given the great advantage of surprise attack in war, it is remarkable how few wars start without extensive threats and negotiation. For example in the WWII case, only the German attack on Russia was a real political surprise. All the other international attacks that built up into this conflict were proceeded by extensive exchanges of threats, diplomatic maneuvering, etc. Pearl Harbor was a strategic surprise attack, but the outbreak of war between Japan and the US had been considered likely for months and virtually certain for weeks before hostilities opened, as intense diplomacy and active sabre-rattling resulted in no compromises. Schelling imagines that these activities are an attempt to resolve the conflict short of war (or to make peace after a war has begun) by communication about intention, resolve, etc. The following two sections are examples of the arguments he developed.

One very general strategy is to try to arrange to convey a mixture of rationality and irrationality to opponents. Let us suppose we define our "sacred principles" so that we tell any potential enemies that we are nice reasonable fellows; we'll suffer a certain amount of insult without going to war. However, the boundaries of our nation itself are sacred, and our honor can be trampled upon only just so much. As enemies start to insult us with their demands and seizures, we'll remain calm for a while (because we know we're strong, but we certainly don't want to start a fight if it can be avoided, especially over trifling mistakes you might have made, or over reasonable disagreements and grievances we may have). Nevertheless, if you press our principles at some point we'll get mad, and then, no matter how irrational it is, we'll fight. None of us can be just sure when the restraints of reason will leave us. The best thing for potential enemies to do is to tread lightly around us and not risk challenging our honor. We all recognize this strategy. It is the image of heroic characters of fiction, and of the image that modern states try to project in their foreign policy.

Ronald Reagan played the roles in the movies, and then played them for real as President. This is a nearly universal strategy in "game" situations of the type we are considering.

Such strategies are reminiscent of the Bourgeois strategy in Maynard Smiths game. The reason such rules are work so well is roughly this. If natural selection can settle upon some random rule to decide the game without a fight, players who follow the rule will do much better against each other than pure hawks who fight all the time. When playing against each other, Bourgeois players avoid the losses suffered from fighting another hawk. At the same time, however, they impose a penalty on any hawks who try to take an occupied territory. Strategies that take advantage of some asymmetry in the situation to resolve the conflict don't pay the costs of fighting. If some such strategy becomes reasonably common everyone who plays it against a fellow player will win the rewards of peace. But anyone who violates the rule with get sure retribution.

In this model, ownership is just an arbitrary rule, chance determines who gets there first. In fact, the owner probably has some investment in learning the territory not possessed by a potential invader that gives an additional reason for this particular rule to evolve. In any case, if all players agree on some sacred principles, like the principle of ownership being special, we may often be able to avoid wars. Indeed, the sanctity of borders is one of the key concepts we use to try to avoid war; violating another nation's frontier is typically the act that initiates hostilities.

Ritualization of conflict is very common. It may pay to advertise intentions, willingness to fight. If you are operating with some rule like Bourgeois, it often pays to let all potential contestants know precisely what will make you mad enough to fight. It may pay to advertize your fighting ability so weaker opponents do attack you by mistake. The idea is that each player would like to know the fighting ability of the opponent. Of course, each player is motivated to exaggerate its own ability and willingness to fight, especially if relatively weak. It is valuable to try to detect who is bluffing and who is not. Thus two contestants dance about and shout, trying to figure just how strong an opponent is. If he is clearly stronger and appears to know it, it is time to cut and run. And this is what animals often do; birds sing and engage in ritualized conflicts that are usually short of all-out fights.

In very general terms, people use the same strategies as birds. We articulate our principles in long speeches, send diplomats to explain the speeches, deliver ultimatums, rattle sabers, have military parades, conduct "maneuvers", etc., apparently in an effort to assess resolve and strength so as to avoid all-out fights whenever possible. If all signals were honest communications of intentions and capabilities, we (and animals) would perhaps never actually fight. However, as we've seen bluff and deception can also be tempting strategies.

(There is a myth that animal fighting is so well ritualized that real injury is rare. In fact, as with humans, ritualization often succeeds, but also often fails.) Do our German opponents believe that we (the English) believe that they believe that our ally (France) is really only bluffing, and that we'll (Britain and France) all back down if they attack? If so what should we do about it? The British and French were fully resolved to go to war in 1939 if the Germans invaded Poland, but they couldn't get Hitler to believe them. It is practically impossible to play such intricate games perfectly, so disasters like World War II happen.

D. Fighting in Groups

The main way that human conflict differs from animal conflict is that humans commonly fight in groups. Animal fighting by contrast is almost always between two contending individuals. The exceptions are that close kin sometimes collaborate in fights. For example, Jane Goodall (1986) has described an example of "war" between two troops of chimpanzees, in which parties of two or three related males attacked and killed members of another troop. The social insects sometimes have organized fights between whole colonies. As we saw, even very simple human societies like the Yanomamo can do considerably better than this.

Humans are much more like the social insects than typical mammals in this regard. Even the simplest human societies can usually assemble war parties numbering in the 10s to 100s. Only a few societies, such as the Gebusi studied by Knauft(1985) appear to lack the ability to cooperate in fairly large numbers for war with neighbors. Very frequently, societies can mobilize all the adult males that it is logistically feasible to assemble for fights, although there are other cases in which fighting between groups within easy walking distance is common, such as Highland New Guinea.

Cooperation in war can be rewarding, but the public goods/altruism problem returns. The benefits of fighting collectively are very great. All other things being roughly equal, it is large armies that win wars, as Clauswitz (1830 [1976]) observed. Two-against-one is the classic recipe for an easy victory. An early 20th Century theorist of war, F.W. Lanchester (Jones, 1987), developed a theory that the superiority of a larger army relative to the smaller is in proportion to the ratio of the square of numbers, not the linear ratio. Doubling your force relative to your enemy multiplies your power by 4. His reasoning is simple. Suppose a force of 100 confronts a force of 50, and that 10% casualties are caused by each volley of fire. In the first volley, the larger force is reduced to 95, and the smaller to 40. In the second round, the large falls to 91, and the smaller to 30, while in the third the numbers are 87 and 21. The larger force will soon annihilate the weaker, and still have most of its strength intact. Thus there is a great advantage to assembling the largest possible fighting force. The problem is that fighting produces public goods. Defense and booty are collectively acquired, and the risk to the soldier for doing his share is very large. It will require powerful kin selection, reciprocity, or group selection mechanism to get collective fighting. Not surprisingly, only a few animals have managed to solve this problem. Humans are one of them, and it is of great theoretical interest to know the reason. It is also of practical interest, since this is one problem we would probably be better off not having solved. It would be nice to unsolve it, so long as we can avoid unsolving other public goods problems, such as peace within groups. *It definitely will not do to go back to being typical mammals.*

III. The Natural History of Warfare

A. Basic Data

Nearly all societies known have wars. A reasonable amount of work has been devoted by anthropologists to the study of "deadly quarrels" among primitive peoples. Unlike what you may have read, there are very few completely peaceful societies. K. F. Otterbien (1985) a student of the evolution of warfare, found that 92% of the societies in his cross-cultural sample of mostly primitive societies engaged in warfare. The ones that did not were exceptions for obvious reasons (small societies alone on distant islands, or relict hunting groups dominated by an overwhelmingly more powerful group). However, there are substantial variations in military organization, the size of groups that commonly cooperate in violent conflict, the prevalence of inter-society vs. between society violence, the magnitude of casualties in fights, and the frequency of fights.

B. Andreski's Three-Dimensional Taxonomy of Military Institutions

The anthropologist Stanislav Andreski (1968) developed a useful scheme for classifying military structure, and discussed its relationship to other culture core factors. Essentially, he systematically assembled the data from the discovery of human diversity as it pertains to military matters. He used three variables to classify military institutions:

> (a) *The military participation ratio (MPR),* is the proportion of able-bodied males enrolled in the warrior class. This varies as a function of military technology. How costly it is to train and equip an effective warrior determines whether this is a specialized or general occupation. When the best technology is expensive metal armor, and the training period long, the MPR is low. Mass armies are a product of simple or cheap technology, stone-tipped spears or mass produced rifles.

> (b) *The degree of subordination*: A hierarchical command structure is militarily most effective, but in many egalitarian societies, people will not tolerate such structures. This is supposed, for example, to be one of the disadvantages of democracies in military competition with more command oriented states, though the democracies may compensate with higher morale, more individual

> initiative, and other advantages.
>
> (c) *The cohesiveness of the military organization*: To what extent will the separate parts of the military organization of a society come together to act in concert? Subordination implies cohesiveness but not the other way round. In some societies, a common bond of sentiment may cause the assembly of large armies, without there being any overall command structure. The tribal segmentary lineage systems separate substantial cohesiveness with little subordination.

Andreski scored various feasible combinations of these three dimensions on a high-low scale to get an ideal-type taxonomy for analytical purposes. We'll adopt his convention of using capitals for High on the dimension and lower case for low.

*1. The **M-s-c** type (many simple hunting and gathering, and horticultural societies)*: This characterizes societies with high participation, but low subordination and cohesion. This type is characteristic of hunters and gatherers and simple horticulturalists. Dispersed residence, egalitarian norms, and simple weapons seem to favor this type. Some such societies are characterized by very active feuding and small-scale warfare, but large-scale military operations are inhibited. The warfare among simple horticulturalists in New Guinea and Amazonia is often close to the extreme of this pole and is relatively well-studied. Settlers expanding on a frontier often exhibit this type, as in the self-help military activity of Anglo settlers against the Indians.

*2. The **M-s-C** type (many horticultural and pastoral societies)*: This is the same as discussed above, but with high cohesion added. The Plains Indian tribes and other pastoral societies furnish examples. Here a bond of sentiment and norms of within group peace make the whole tribe an effective fighting unit despite weak subordination. According to Otterbein (1968), cross-cultural evidence shows that type one societies are characterized by patrilineal residence, whereas type two societies are characterized by matrilineal residence or other institutions, such as men's societies, that cross-cut the loyalties of closely related males. Recall here the discussion in Chapter 13 on conformist transmission and the evolution of altruism, where we discuss another study with the same general result. The key idea is that the size of the unit that cooperates should be determined by the size of the unit that is socialized together, and subject to conformist transmission.

*3. The **m-s-c** type (feudal anarchy)*: In this type low military participation is combined with low cohesiveness and subordination. This is the pattern of feudal anarchy. When weapons are expensive, as the equipment of medieval knights was, single heroic warriors and small collaborative groups of warriors may be the dominant pattern. This pattern seems most common on frontiers (e.g., the areas of militarized Germanic expansion east into country dominated by the Slavs during the Middle Ages), or in central areas after a breakdown of central authority. There is a disproportion between the sophistication of weapons and the sophistication of political institutions.

*4. The **m-S-C** type (small professional armies)*: The existence of a small, cohesive, disciplined military elite is a common pattern for agrarian states. When weapons are expensive, and/or the mass of people cannot be trusted with weapons, this type will arise.

*5. The **m-s-C** type (warrior conquest societies):* This is a relatively rare one. It usually occurs as a transitional type when an M-s-C society imposes itself by conquest on a host population. Ancient Sparta was an example of a society that managed to institutionalize this type for a long period after the Dorian conquest of Greece. Usually, after a period of consolidation, these mature into agrarian states of the m-S-C type.

*6. The **M-S-C** type (modern armies)*: Mass, disciplined, cohesive armies are the type we are mainly familiar with in the industrial world. Industrial improvements in weapons and transportation, plus the rise of nationalistic sentiments has made such armies *de rigueur* ever since the French Revolutionaries showed how effective this pattern could be. Napoleon's conquests were possible because the French got a head start on this type using the mass enthusiasms of the 1792 revolution as a basis for expanding military recruitment to the whole male population, and the rationalism of the period as a basis for organizing, equipping and supplying the huge armies that resulted. Historically, a few agrarian states used this style of organization when they could depend on the loyalty of the majority, and weapons were cheap enough to equip such armies. Alexander the Great used such an army of Greeks for his conquests, and the Venicians developed their navy on this principle in the early period of her dominance. Normally, however, the expense of arms and the narrow power base of agrarian societies made arming the mass of subjects unattractive to rulers.

Andreski was much interested in the evolutionary transformations from one type to another. You can duplicate his reasoning for yourself, following the hints given above about weapons costs and political evolution.

IV. Hypotheses

A number of hypotheses have been advanced to account for the existence of warfare and to explain the variations in scale and frequency we know to exist. This area is rather confused and controversial. Perhaps warfare has confused most scholars except the game theorists because most people have hunted for an adaptive explanation for war, or have considered it merely stupid and evil. The game theory models are not nearly as well appreciated by anthropologists, at least, as they should be. Few have considered the possibility that evolutionary processes can favor behaviors that are so pathological (relative to common-sense ideas of adaptation) as violent conflict. Even smart and well-meaning folk get trapped by the logic of the war game; ***it is the situation that is fiendish more than the individuals***[2]. The following discussion hits some of the high points.

A. Evolutionary Mistake Hypotheses

Robert Ardrey and some other popularizers of animal behavior studies have argued that humans are innately aggressive. In the distant past we were selected for abilities to defend territories and mates, and in recent times this tendency finds a pathological outlet in war. The problem here is that first we need to understand why any animal would engage in games of the negative sum type, and specifically why, if the vestigial instinct exists, it gets expressed as large scale conflict. Why aren't we satisfied with barroom brawls and ritualized equivalents such as football, hockey, etc.?

Warfare could also be a cultural rather than a genetic vestige. This is a cultural variant of the Ardrey hypothesis. Warriors are often motivated by cultural notions of honor and prestige to fight. It seems possible that these notions were once adaptive but no longer are. Or it is possible that they are maladaptive outcomes of the runaway indirect bias process, and never were adaptive in the usual sense of the word. The anthropologist C. R. Hallpike has defended a hypothesis like this.

B. Individual Advantage Hypotheses

The anthropologist W. Durham (1976) gives a sort of sociobiological explanation for war. He thinks that wars enhance the individual fitness of participants through acquisition of booty by winners, and through effects on inclusive fitness of those who lose their lives, say defending their kin. This hypothesis will clearly fit some kinds of small-scale fighting well. Selection should favor selfish seizure of others resources if the benefits exceed the losses.

This hypothesis begs the problem of war, if not of violent conflict more generally. First, the destructive nature of violent conflict seems to guarantee that fighters on average must lose resources. Fighting consumes resources, but doesn't produce any, seemingly guaranteeing the negative sum game analysis. The lucky few may find temporary conditions where the acquisition of resources by violent seizure pays dividends but how could this be the general case? Even primitive war seems to give examples of negative sum games

---

[2] This is not to say that we count Hitler, Napoleon, and Ghengis Khan among the world's basically well-meaning citizens!

in which neither party can expect a net positive payoff. In the beginning, the more militarily able groups may prosper on booty, but the destructive nature of war means that losers are likely to disappear or acquire the means to defend themselves. Second, when the groups fighting are much larger than a kin group, selection ought to favor cowards and slackers, those that expose themselves to minimum risks to acquire booty or provide defense. Both booty and defense are public goods, and subject to all the problems we have already examined.

C. Group Advantage Hypothesis

Several anthropologists have advanced the hypothesis that warfare serves group-functional purposes. We have met group selection mechanisms that might be used to explain how all this works. Either the conformist transmission effect (frequency dependent bias), or the tendency of the runaway process to generate group variation, might lead to the large scale of war as well as individual sacrifices for the production of public goods we observe. A convincing hypothesis should be able to account for both of these factors.

This hypothesis is so common in anthropology that we might think of it as the orthodox view although it often is difficult to imagine how such behavior could have evolved. In particular, the hypothesis is defended by A.P. Vayda, R.A. Rappaport, and Marvin Harris, among others. Vayda (1960) started things off by arguing that Iban and Maori warfare were adaptive because war in those cases functioned to redistribute populations relative to space. Warfare evened out resources and optimized population growth.

It was not clear, however, how warfare was adaptive when land became scarce. Rappaport (l968) tried to deal with that problem by arguing that warfare also was a means of population regulation—a way of removing enough persons from the population to prevent overuse of resources and environmental degradation. He argues that the population control system of the Tsembaga Maring of New Guinea is embedded in a cycle of rituals that involve the slaughter of pigs. These belligerents may resume hostilities only after the climax ritual has been completed and this is possible only when there are many pigs available to slaughter. Foin and Davis (1987) used mathematical models to test several alternative hypotheses about the stability of Maring ecosystems. They summarized the pig ceremony/warfare dynamics as follows:

> Rappaport proposed that the key epideictic [ceremonial] signal for the Tsembaga Maring is the intensity of female labor. In the Maring division of labor, females are principally responsible for pig husbandry. Women tend the gardens, prepare the food, and feed the pigs. These are labor-consuming tasks; Rappaport estimated that immediately before the ceremonial pig slaughter that he witnessed, pigs were consuming…[more than half of the main carbohydrate source foods]. Gardens were 36% larger before the pig sacrifice than after-

> wards. The intensity of female labor is directly proportional to pig density and thus is an attractively simple index of environmental quality. Rappaport argued that as labor devoted to pig husbandry increased, complaints about the workload would also, thus triggering a *kaiko* [ritual festival] as the only response that could relieve the workload. An incidental, but crucial, consequence of the *kaiko* is that warfare usually resumes shortly thereafter (Foin and Davis, 1987:12).

As the timing of the ritual is dependent on the size of the pig herd, rituals (and warfare) usually occur in l0-l2 year intervals. Thus, occasional warfare runs the population and regulates it well under carrying capacity, but does not occur so frequently that too many people are removed.

Marvin Harris (in Ferguson, 1984) also thinks that primitive warfare is a population regulator, but is unconvinced by Rappaport's argument; his own is both more clever and more contrived. He notes that primitive warfare is in general unlikely to be an effective means of regulating population growth, as only males are likely to be killed. Killing males has little effect on population growth, especially where polygyny is practiced (e.g., combat deaths in World War II had little effect on European population growth rates; an awful lot of males have to be killed before there are too few to get the essential business of sexual reproduction accomplished!). Thus, if we wish to marshal a convincing argument for the regulation properties of warfare, it must somehow be connected with the removal of females, too. Harris claims it is, but in a circuitous way.

In Harris' view that happens through a connection that war has with female infanticide; he thinks that female infanticide is much more common than it is reported to be, since it more often takes the form of benign neglect rather than overt homicide. But the question that rises is how are parents motivated to overcome their reluctance to remove their own children? The answer is that warfare provides the incentive. Consistent warfare implies that group survival is dependent on males. That, in turn, encourages development of a male-centered ideology that exalts males and denigrates females; thus, female infants have no cultural value and are slaughtered for the welfare of the larger population.

Warfare also helps limit population is a less direct way, according to Harris. When groups fight consistently, they are likely to leave some intervening space between belligerents unoccupied. That limits the amount of territory available for exploitation and limits population, although it simultaneously provides refuges for wild life and seed dispersal. The main conclusion, however, is that female infanticide and warfare are the price that primitive peoples pay for population regulation. (The problem, of course, is that most of the reported cases of female infanticide occur among foraging populations that rarely practice extensive warfare at all, seems unrelated to warfare, and occurs for reasons that benefit individual parents rather than social groups).

You should all be able to spot the problem with these hypotheses; selection on groups ought to favor increases of those groups! The typical anthropological argument seems to produce population regulation among a group of groups, all Maring, not just the units like the Tsembaga that compete. This seems more likely to be a by-product of warfare, not something that a group selection process would favor directly.

In the case of the war-like forest horticulturalists of the Amazon, like the Yanomamo, population densities are very low indeed. Here it can be argued that the variable-sum nature of chronic warfare has reduced human populations far below carrying capacity as an unintended consequence of war. The Yanomamo move frequently and keep large spaces between themselves and hostile neighbors, much larger than resource conservation seems to require. In addition to the group selection mechanism, the more perverse processes outlined by the game theorists seem to be operating. Conflict over resources does seem to be an important underlying motive for warfare, but this is likely to favor groups that can expand using military superiority. In a highly competitive situation like that faced by the Yanomamo, the size of population depends upon maximizing security against attack, and the tropical forest makes surprise easy, and first strike the strategy of choice. Irrespective of subsistence carrying capacity you've got to be so distant from hostile neighbors as to make attack unlikely.

In other words, the typical group-functional hypotheses miss the perversity of the evolutionary situation set up by the war "game" analysis. Warfare is liable to evolve even if makes everybody worse off. From this perspective it is vain to look for ordinary adaptive arguments for warfare.

D. Deterrence/Coercion Hypothesis (Evolutionary Tragedy Hypotheses)

This theory follows from the conclusion of the last paragraph. The game theorists' analysis seems to suggest that it is an error to treat the 'evolutionary mistake' hypotheses and the functional hypotheses as if they were opposites. To the extent that evolution under war "game" conditions leads to a certain irrationality and to a rather pathological result, it may be that the two hypotheses are really the same. The proud, touchy, boastful warrior, who loves war and fighting for its own sake may in whole or in part be the evolutionary result of the peculiarities of the situation of the potential use of violent conflict for coercion. Thus, a hypothesis like Hallpike's may be quite consistent with functional evolutionary explanations in the context of the overall perversity of the problem of war. We might call this the "evolutionary tragedy" hypothesis; the only practical way to avoid victimization by aggressors and to avoid most wars is to be conspicuously prepared to fight. The penalty here is that mistakes will be made, in part because of the underlying first strike logic of the war game. It is functional to prepare for war in a world of pacifists, because they are so easily taken advantage of. In a world full of warriors, one must be prepared to fight to defend oneself. To prepare for war is sort of an irrational necessity. How would *you* characterize it?

> ***Evolutionary Tragedy Hypothesis:***
> **Preparing for war is an irrational necessity. The only practical way to avoid being victimized by aggressors and to prevent most wars is to be conspicuously prepared to fight. The penalty here is that mistakes will be made, in part because of the underlying first strike logic of the war game. In a pacifist world it is still functional to prepare for war because pacifists are so easily taken advantage of. In a world full of warriors, one must be prepared to fight to defend oneself.**

E. Group Selection Hypothesis

An element of group selection seems necessary to explain the scale that war reaches, at least in advanced agrarian and other more complex societies. The deterrence hypothesis seems to be necessary to explain the apparent tendency of societies to engage in wars, or at least be armed and ready to engage in them, even though on average they result in a net loss to all participants, but the same theory applies at any scale of conflict. As we argued in Chapter 13 as well as here, warfare is an example of the extreme degree of cooperation, and human cooperation is hard to explain using conventional evolutionary mechanisms.

A compound hypothesis, combining the basic deterrence game theory model of violent conflict with the hypothesis that cultural group selection provides the mechanism to account for the large scale of human warfare, is plausible on deductive grounds.

V. Test of Hypotheses

If the compound hypothesis is correct, and the evolutionary mistake, individual advantage, and simple group selection hypotheses are less correct or partial explanations, the data should show the following kinds of patterns.

A. Pattern 1: Conflict Should Have a Tendency to Be Ritualized

Societies should have a tendency to use displays of power and saber-rattling much more frequently than actual wars breaking out. Wars should result from miscalculations, where compromise failed or where the eventual losers miscalculated their chances.

Primitive war, especially among horticulturalists, is notoriously highly ritualized. Many battles take place at set times, and are broken off after a few casualties. Often, there are various contests short of deadly fights that seem to be tests of strength, such as the club fights of the Yanomamo, the singing insult fights of Inuits, etc.

In the modern period, showing the flag in troubled waters, diplomatic threats, and the like are much more common than actual wars. And little wars, perhaps to demonstrate intent to bigger enemies (e.g. the U.S. invasions of Grenada and Panama) are much more common than big wars, which however, are responsible for a very disproportionate share of casualties (Richardson's data). Impressionistically, errors seem to be a common cause of costly wars.

Actual wars should tend to result from miscalculation, when ritualized communication of strength and intent fails for some reason. We have already considered examples from WWII. Consider a completely different scale of organized violence, gang warfare in American urban areas. Normally gangs are deterred from entering the territory of other gangs and other major aggressive acts by the threat of retribution. Low level scuffles maintain the credibility of deterrence by ritual demonstrations. Occasionally, the impulsiveness and touchiness of gang members leads to unpredictable outbreaks of drive-bys, and retaliation for same. Incidently, successful gangs are neighborhood institutions of fairly considerable sophistication. The element of cooperation involved is often underestimated (Sanchez, 1991).

Societies should also take great pains to display and make credible their willingness to go to war if pressed too hard, even though they also attempt to leave open avenues for compromise. Perhaps the most clear cases in support of this hypothesis are the polices of small neutral countries like Switzerland and Sweden. They are too small to provide a credible offensive threat to their neighbors, but spend large sums on defensive weapons and training. Any of their neighbors could defeat them, but none have tried recently, perhaps because the threat is credible and the neutralism believed. These countries can play "bourgeois" to the hilt. Note that large countries cannot adopt this strategy too freely, because their military preparations are too easily viewed as posing a first strike offensive threat. The Soviets worry about US military preparations, but can afford to ignore the Swedes and the Swiss in most calculations.

Similarly, the warrior complex of many horticultural and pastoral societies might be interpreted as an attempt to convince neighbors of their fierceness. Headhunting, reckless displays of courage, a touchy sense of honor, and the like, combined with an active diplomacy via marriage exchanges, ceremonies and the like seem to fit this expectation. The Yanomamo certainly cultivate their violent reputations, as we saw. Urban gangs have institutions rather resembling these.

B. Pattern 2: Most Wars Fought Between, Rather than Within, Societies

If a group selection processes is operating, wars should be fought disproportionately between societies, rather than within them. According to L. F. Richardson's data, internal war is scarce relative to war between distantly related groups. That is, the social units that are group-selected should provide domestic tranquility, but wars between such units should be fairly common. Richardson's data on recent wars support this hypothesis. International conflicts are much more common than civil wars, and most civil wars involve major cultural differences between the participants (e.g., class differences as in the Russian Civil War, sectional differences as in the American, or religious differences, as in the case of the 350 year-long Irish rebellion against Great Britain). Also, Richardson's data show a marked tendency for culturally similar countries not to be involved in wars against each other, despite a tendency for neighboring countries to fight each other. Similarly, ideological differences are often important in wars. An alternative hypothesis here is that miscalculations are less likely between ethnically and ideologically similar people, who are less likely to misjudge each other's intentions.

The segmentary principle works in highly war-like pastoral and horticultural peoples and in modern contexts. Even though there is much small scale fighting, distinctions are made along ethnic lines. War with co-ethnics tends to be rarer, and more highly ritualized. War with true foreigners usually lacks the casualty-limiting prohibitions that characterize intra-ethnic fights[3]. John Dower's *War Without Mercy: Race and Power in the Pacific War* (1986) examines the effect of racism on the way the war between the U.S. and Japan was conducted. Dower draws upon American and Japanese songs, slogans, cartoons, propaganda films,and secret reports. to study how and why each side characterized the other as subhuman—and the effects of those characterizations on how the war was fought. Figure 18-1 illustrates how conflict between nations with very different cultures can be exacerbated by the perception of opponents as inhuman.

Historically, the group selection process might result in a steady escalation of the scale of cooperation over time. That is, all other things being equal, large societies can mobilize more resources for defense and offense than small ones. Also, large societies can perhaps provide more domestic peace and prosperity than small ones through solving public goods problems. One might argue that the tendency for social and political units to increase

---

[3] Recall here the segmentary principle that is most clearly exhibited in the case of pastoral societies.

Figure 18-1. War between peoples whose cultures are truly “foreign” often lacks the casualty-limiting prohibitions that characterize intra-ethnic fights. Here cartoons from U.S. popular media during WWII are compared with similar Japanese cartoons. (Source Dower 1986:184-193.)

a) “Exterminationist sentiment… was reinforced by depicting the Japanese as vermin.” The following cartoon appeared in *Leatherneck Magazine* in March 1945, the same month that the U.S. began incendiary bombing of Japanese cities (Dower 1986:184).

Louseous Japanicas

The first serious outbreak of this lice epidemic was officially noted on December 7, 1941, at Honolulu, T.H. To the Marine Corps, especially trained in combating this type of pestilence, was assigned the gigantic task of extermination. Extensive experiments on Guadalcanal, Tarawa, and Saipan have shown that this louse inhabits coral atolls in the South Pacific, particularly pill boxes, palm trees, caves, swamps, and jungles. Flame throwers, mortars, grenades, and bayonets have proven to be an effective remedy. But before a complete cure may be effected the origin of the plague, the breeding grounds around the Tokyo area, must be completely annihilated.

b) In this folkloric rendering by Sugiura Yukio, “Japan’s wartime mission is associated with the divinely born Momotaro… who, with the aid of a dog, pheasant, and monkey subdued threatening demons from a distant land (Dower 1986:198).”

in size over time during the last 10,000 years supports this prediction.

C. Pattern 3: Wars Tend to Cost Both Sides More Than They Gain

If wars mostly result from failures of deterrence, rather than from rational use of military power to take advantage, wars ought to commonly cost both sides more than they gain. This seems to be impressionistically correct for major recent wars at any rate. L. F. Richardson reports that economic causes cannot account well for wars, but he did not make any analyses that test this prediction exactly.

IV. Consequences of Warfare

Wars have winners and losers, and losers often have to flee. The society with the better resource-use strategy and that is able to maintain a higher population, will generally outcompete a technically less sophisticated society. Appeals to violent conflict are likely to speed up this process.

Weaker societies may adopt the military and subsistence techniques of stronger ones as a defensive measure, more or less conscious of the fact that failure to keep up will leave them vulnerable to conquest or eviction.

The anthropologists Naroll and Wirsting (1976) attempted to calculate the relative importance of population migration and borrowing in cultural evolution. They compared long lists of traits in 78 triads of societies, a “base” society, a distant society with a similar language, and a neighboring society with a different language. The neighbors with dissimilar languages tended to be more similar than the distant ones with similar ones. However, this comparison does not control for environmental similarities and differences. It is clear that population movements and expansions have been important in cultural evolution but relatively how important is difficult to say on present evidence.

Epidemic diseases often accompany conquerors, as we will see in a later chapter. Also, prolonged campaigning in a given region has lead to drastic depopulation as a result of direct deaths of civilians, famines, and disease. For example, the 100 Years War in France was very destructive, as were the wars of religion in Germany, and the prolonged civil wars in Chinese history. As was mentioned above, chronic warfare among stateless people may keep populations far below carrying capacity, though the case is controversial.

VII. Conclusion

Compared to the scale of the problem, we know surprisingly little about why war exists. To our way of thinking, the evolutionary tragedy that derives from the nature of conflict is part of the explanation. The other part derives from the human propensity to cooperate. This last part gets us from murder to war. This is a highly unpleasant conclusion, because it leaves us with only the clumsy, error-prone process of deterrence due to an irrational willingness to fight to avoid fighting and victimization by coercion. If anybody has a good idea for getting out of this mess, they should speak up!

Note that we have now assembled a considerable fund of examples where selective forces on culture and genes will not result in adaptations in the usual sense. Although we can *conceive of* a peaceful society—one that does not have excessive males, and is free of exaggerated, maladaptive traits arising from runaway processes—evolutionary forces may well tend to lead us away from such a state! Understanding that much of the problem of large-scale conflict arises from the dynamics inherent in use of force situations gives us important clues about how to manage conflict on this scale. These clues are hidden by many contemporary social science approaches that tend to assume that the intentional actions of individuals and groups are the *sole* source of social problems.

VIII. Bibliographic Notes

References:

Andreski, S. 1968. *Military Organization and Society*. Berkeley: UC Press.

Ardrey, Robert. 1976. *The hunting hypothesis: a personal conclusion concerning the evolutionary nature of man*. New York: Atheneum.

Chagnon, N.A. 1988. Life histories, Blood revenge, and warfare in a tribal population. *Science* 239: 985-992.

Dower, John W. 1988. *War Without Mercy: Race and Power in the Pacific War*. New York: Pantheon Books.

Durham, W. 1976. Resources, competition and human aggression. Part I: A review of primitive war. *Quart. Rev. Biol.* 51: 385-415.

Ferguson, R.B. (ed.). 1984. *Warfare, Culture, and Environment*. Orlando: Academic Press. (This an excellent collection of papers, mostly by anthropologists of the Harris style of cultural materialism.)

Foin, Theodore C. and William Davis. 1987. Equilibrium and Non-Equilibrium Models in Ecological Anthropology: An Evaluation of “Stability” in Maring Ecosystems in New Guinea. *American Anthropologist* 89:9-31.

Goodall, J. 1979. Life and Death at Gombe. *National Geographic* 155: 592-621.

Hallpike, C.R. 1973. Functionalist interpretations of primitive warfare. *Man* 8: 451-470.

Jones, A. 1987. *The Art of War in the Western World*. Urbana: Univ. Illinois Press.

Maynard Smith, J. 1982. *Evolution and the Theory of Games*. Cambridge: Cambridge University Press.

Naroll, R. and R. Wirsing. 1976. Borrowing Versus Migration as Selective factors in Cultural evolution. *J. Conflict Resolution* 20:187-212.

Otterbein, K.F. 1985. *The Evolution of War*. New Haven: HRAF Press.

Otterbein, K.F. 1968. Internal War; A cross-cultural study. *Amer. Anthro*. 70:277-289

Rappaport, P.A. 1984. *Pigs for the Ancestors*, 2nd Edition. New Haven: Yale Univ. Press.

Richardson, L. F. 1960. *Statistics of Deadly Quarrels*. Pittsburgh: The Boxwood Press.

Sanchez Jankowski, M. 1991. *Islands in the Street: Gangs and American Urban Society*. Berkeley: Univ. Califoornia Press.

Schelling, T.C. 1966. *Arms and Influence*. New Haven: Yale Univ. Press.

von Clausewitz, C. 1976. *On War*. Edited and translated by M. Howard and P. Paret. Princeton, NJ: Princeton Univ. Press.

Vayda, A.P. 1960. *Maori Warfare*. Polynesian Society Maori Monographs, No. 2. The Polynesian Society Incorporated: Wellington, New Zealand.

Wright, Q. 1942 (1965). *A Study of War. 2nd Ed*. Univ. Chicago Press: Chicago

Zagare, F.C. 1987. *The Dynamics of Deterrence*. Chicago: University of Chicago Press.

Chapter 19. DIFFUSION OF INNOVATIONS

> "I have never learned to accustom myself to innovations, and I fear that above everything else, for I know full well that in making innovations, safety can in no way be preserved."
>
> Proctus—Advisor to Roman Emperor Anastasius

I. Introduction

A. Definition

The concept of diffusion of innovations usually refers to the spread of ideas from one society to another or from a focus or institution within a society to other parts of that society. As is typical in this series of lectures, we will concentrate on particularly dramatic cases of diffusion between societies to illustrate the main processes. Many of the same principles will apply to the spread of ideas within a society. The value of extreme examples is that they often reveal processes in more pure and stark form than less extreme cases.

B. Importance

Recall the costly information hypothesis from Chapterss 11-14. Diffusion of innovations between societies is one of the most important processes in cultural evolution. The diffusion of innovations is important because it is relatively hard to invent (or develop) many kinds of useful knowledge. Complex techniques (e.g. maize farming) are combinations of many skills, and develop over a long period of time. It is usually difficult to invent all the requisite parts in the right order, foresee the advantage of nascent new technology, etc. It may also require a special environment or a historical/cultural preadaptation to make the earliest steps of an invention possible. It is usually much easier to acquire all but the simplest skills from someone else than it is to try to invent them for yourself. The possibility of non-parental transmission, combined with the existence of various types of biases, means that humans can selectively borrow ideas from other societies—we can attempt to guide the evolution of our culture. As a consequence, societies trade ideas and techniques, as well as disease organisms, genes, and commodities. Elements of the costly information hypothesis are well exemplified by the diffusion of innovations process.

Most societies have undoubtedly acquired most of their cultural repertoire by diffusion. For example, Europeans acquired the following basic technical innovations from foreign sources during the Medieval period: "Arabic" numerals (Indians), compass (Chinese), astrolabe[1] (Arabs), paper (Chinese), astronomical tables (Arabs), mechanical clock (Chinese), algebra (Persians), printing (Chinese), and explosives (Chinese).

There is even some evidence, referred to in the first chapter on cultural evolution, that isolated societies sometimes lose cultural traits (Diamond, 1978). In small, isolated societies, skills that are known only to specialists or are practiced rarely are liable to be lost by accident. Everyone must be a bit of a generalist, but that limits the sophistication that specialization makes possible. Reacquisition by diffusion may be necessary to maintain some skills in small populations.

C. Diffusion of Innovation Studies

Several independent research traditions have studied the diffusion of innovations: *Anthropology, geography, and sociology* have a long tradition of trying to understand present behavior in terms of patterns of diffusion of techniques and ideas from source societies to their present distributions. Critics charge that this tradition has tended to focus on descriptive history as inferred by patterns of similarity (diffusionism) and to neglect causal processes. Rather implausible links were often postulated by extreme diffusionists[2].

Rural Sociologists pioneered the quantitative study of the diffusion of innovations. Classic studies include the diffusion of hybrid corn and 2-4-D weedkiller in the American Midwest. The largest number of studies come from this field, including many studies of attempts to diffuse modern techniques to Third World peasants.

Similarly, students of *educational reform* have studied the spread of kindergardens, drivers training and modern math. Someone right now is probably studying the spread of General Education requirements in U.S. universities! *Medical Sociologists* have studied how the use of new drugs spreads among communities of physicians. *Communications and marketing* experts study how propaganda and advertising work to persuade people to adopt new ideas and products.

Rogers and Shoemaker's (1971) classic study reviewed l,500 diffusion of innovation studies. Their book is notable for its content analysis of all these studies in order to make quantitative tests of general hypotheses about diffusion processes. Virtually all of these are studies of situations where change agents (often but not always foreigners) are trying to diffuse scientific or technical innovations to a clientele. What is notable about this literature is that most of the innovations studied are the products of relatively careful technical development. They ought, on average, to be objectively much better than typical foreign traits that people usually have decided whether or not to adopt. As we shall see, even under these

---

[1] a compact navigational instrument used (before the invention of the sextant) to observe and calculate the position of celestial bodies

[2] Thor Heyerdahl's ideas about contacts between Polynesia and South America are a famous example.

relatively favorable circumstances, the decision of whether or not to adopt an innovation is a tricky one. We can use the studies of the diffusion of innovations as a "laboratory" to examine the effects of the decision-making forces of cultural evolution. ***Which hypothesis best explains the data on diffusion of information, the costly information hypothesis or the sociobiology hypothesis?***

II. An Example, the Plains Indians' Horse Hunting

A. Acquisition of Horse Technology from the Spanish (1650-1750 AD)

Paleo Indians had hunted horses, never domesticated them. In fact, as we shall see in Chapter 21, the Paleo Indians may have been responsible for the extinction of horses in North America ca 10,000 BP. As far as is known, horses were domesticated only once somewhere in the Eurasian steppe ~5,000 BP. Initially, horses, onagers, and donkeys were used as draft animals, to pull plows, carts, and chariots. Riding astride was apparently a late innovation. Interestingly enough, the horticultural/hunting and gathering frontier where horses were domesticated was ecologically and culturally analogous to the Great Plains ca 1700 AD.

Horse riding diffused from Mexico after the Spanish conquest; most of the development of Plains adaptation of the Western-movie/Custer's-Last-Stand type occurred in the l8th Century and 19th centuries. According to Roe's classic account (1955), the timing of the diffusion of horses is difficult to date. Probably the Apaches of New Mexico had horses by the 1660s at the latest. Some of the Northern Plains tribes, such as the Sioux and the Blackfeet probably did not have horses until a century or so later.

According to Roe, Indians almost certainly acquired the horse technology directly from the Spanish settlers in Mexico, not from independently domesticating stray feral horses. On the frontier in Northern Mexico, some Indians learned how to ride, probably by working as wranglers for settlers. Subsequently these Indians taught others, and horse riding diffused away from the frontier. The saddles and bridles used by Indian horsemen are based on Spanish patterns, for example, suggesting diffusion rather than reinvention. Later, the fur trade played a very important role in stimulating the adoption of complex pastoralist technologies by diffusing the use of guns and other manufactured items in return for skins. The fully developed Plains horse culture was very much like pastoralism in the Old World, a system basically derived from an agrarian technology applied in a semi-arid grassland environment, and with complex relations between the agrarian states and the pastoralists.

B. Local Innovations Were Still Required

One should not underestimate the amount of local innovation that went into the evolution of the Plains societies. Use of the horse set in train a vast array of technical and social innovations.

New hunting technology made it possible to follow bison herds: Foot hunters on the Plains had long hunted bison, but rather inefficiently because they could not reliably find and follow herds. With the mobility provided by the horse, an almost complete reliance on this rich resource could be achieved. The Plains Indians became a peculiar kind of pastoralists whose efficient use of the bison as a source of food and many other implements is legendary.

The Plains warfare pattern was also essentially a pastoral one. The herds of valuable horses, in classic pastoral fashion, gave rise to raiding, horse-stealing and defense against same. The military effectiveness of horse mobility was turned to account in the raiding of settled peoples; Northern Mexico suffered from fierce raids by Southern and Central Plains groups who traveled long distances to steal horses, women, children, and other booty. It was also turned to account to try to defend the Plains against Anglo-American encroachment, but with only local success. The application of industrial technology (rifles, light steel cannon, steamship, and railroad transportation), and the masses of Whites prepared to move West, overmatched the pastoral mobility advantage.

New social institutions were developed to make use of the new technology. Bison hunts were large, collective affairs in the summer, when the animals gathered into vast herds. Allies in war were required to defend oneself on the Plains, and small groups with no friends to help would likely suffer severe defeats. The Western hunting and gathering groups that moved onto the Plains had previously been ordinary food foragers. Now they had to acquire more sophisticated political forms in order to effectively exploit the resource and to provide some deterrent to attack. Recall Steward's argument regarding composite bands and migratory, big game herds. In Winter, bison broke up into small herds. The Eastern settled, sedentary horticultural societies that took up hunting on the Plains had to become more flexible and opportunistic in order to cope with the unpredictable contingencies of buffalo hunting. Among other things, rigidly unilineal kinship systems were abandoned to allow more flexible principles for kin-based cooperation. It is said that the Cheyenne, a formerly settled horticultural tribe, once tried to spend the whole year hunting as a tribal unit and suffered considerable starvation as a result. Historic Cheyenne social and political adaptations were suited for farming and had to be modified for life on the Plains. ***Note that this example of cultural evolution is decidedly not consistent with progressivist notions***

of evolution.

The convergence in social organization between the more highly organized groups of horticultural ancestry and the simpler ones of hunting and gathering background was not complete by contact times (1830-50s). Despite a great similarity among the Plains tribes, their social and political organization still betrayed their horticultural or hunting/ gathering cultural background, according to Oliver (1962). Societies that derived from a hunting and gathering background, such as the Comanche, had much more informal leadership than those of horticultural ancestry, such as the Cheyenne and Sioux.

No one group appears to have invented the whole complex of adaptive traits. Instead, elements invented in one group diffused to others. The horses themselves and knowledge about them spread from group to group over the period of a century or more. Other techniques, and social organization principles likely spread along the same routes. The involvement of Plains peoples in trade, and the great mobility the horse made possible made communication and observation easy.

C. Diffusion Was Necessary

Without diffusion from outside the Plains—and within the Plains among the various tribes— it is difficult to believe that so novel and sophisticated a strategy could have developed in 1 or 2 centuries. Think what might have happened if these people had been able to acquire innovations from full-blown pastoral nomads like the Mongols! The Plains peoples never did become fully pastoral cattle-herding people. Perhaps because they had no models. The Western ranching tradition was Spanish an inspiration, and was tied to a fixed headquarters, quite unlike nomadic pastoralism. The Navaho are an interesting example of a Native American group that became highly pastoral, but on the Spanish, not the Central Asian model. The Navaho lived just across the Spanish American frontier, and perhaps had an extra increment of time and more access to Hispanic models of migratory sheep-raising, an important tradition in Spain. They did adopt the fixed residence headquarters, not the mobile tent.

On the Plains, the penalty for failure to acquire innovations was extreme. Horticultural groups were raided persistently until they adopted horse hunting (Cheyenne) or left the Plains (Apache). The Apache clung to corn cultivation, and were virtually excluded from the Southern Plains about the time of regular contact with Whites (1820s) by persistent raiding by Comanches, who poured out onto the Southern Plains from the Upper Colorado River country. In the North, a few horticultural groups, the Arikara and the Hidatsa, still cultivated corn along the Upper Missouri in the 1830s, but they played an important role in trade for agricultural staples and furs that was perhaps not so important in the south.

When more invention is necessary, cultural change is slower than if innovations can be copied. The Plains Indians obtained much of their basic toolkit from the Europeans, a toolkit that had required thousands of years to evolve in the Old World. Nonetheless, the rate of evolution of novel traits on the Plains was indeed striking. By contrast, agriculture took about 4,000 years to diffuse from the Middle East to Britain. Presumably, much more independent invention was required in the latter case. The lesson of the Plains case seems to be that the diffusion of innovations can greatly accelerate cultural evolution, but even then there are real limits to how fast societies can absorb and modify new ideas to develop a new economy.

The diffusion of innovations can greatly accelerate cultural evolution, but even then there are real limits to how fast societies can absorb and modify new ideas to develop a new economy.

III. Theory of the Innovation Decision

A. A Decision-Making Model

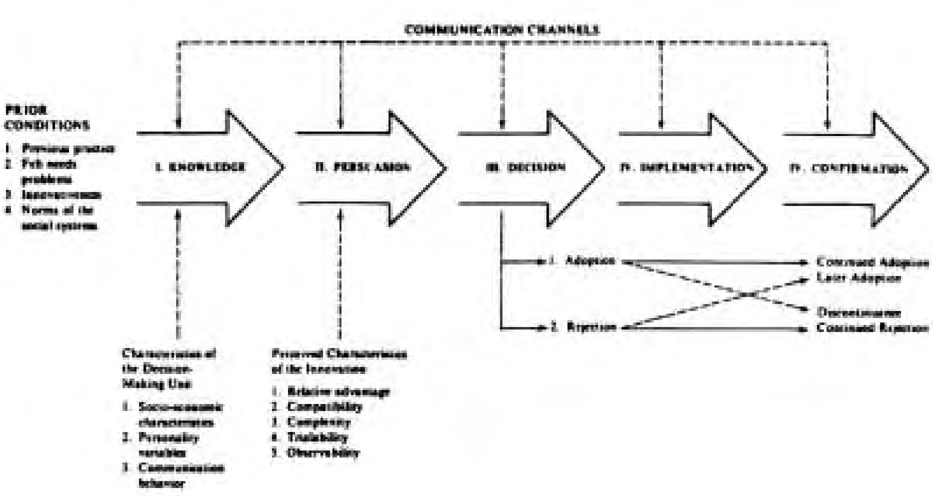
A complex series of influences affect decisions to adopt innovations. They include: (a) *individual attributes* (e.g. income); (b) *attributes of the social system* (e.g. the innovation may be perceived as violating ethical norms or the privileges of elites); (c) *perceived attributes of the innovation* (e.g. whether a new crop variety looks better in a test plot). Figure 19-1 presents Rogers' (1983) model of the stages involved in deciding whether or not to adopt an innovation.

B. Expectations from Cultural Evolution Theory

Information on the value of an innovation is costly to acquire. On the one hand, there are certainly innovations "out there" that would be beneficial to the potential adopter. On the other hand, there are plenty of bad ideas out there, or at least ideas not suited to a particular decision-maker's situation. There are often shady salesmen and overenthusiastic entrepreneurs that one has to worry about. Recall Proctus' lament from the epigraph. The trick is to use appropriate decision-making rules that increase one's chances of adopting good innovations and rejecting bad ones—always remembering that making decisions is a costly business.

The theory we developed in Chapters 11-14 suggests several rules, derived from the costly information hypothesis, that might be used depending upon circumstances:

Figure 19-1. A model of stages in the innovation decision-making process. “The *innovation-decision process* is the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision (figure and text from Rogers 1983:166).” Note that the consequences of the innovation are not shown in this diagram for the sake of simplicity.



a. Be highly suspicious of innovations, *trust tradition*, use culture as a stable inheritance system (recall from Chapter 11 that in a relatively stable situation, the past is often a very good guide, and this is the cheapest rule). However, the use of this rule must be balanced against the possibility that the environment has changed recently (e.g., your neighbors have recently acquired horses and guns).

b. Rely on your own learning (*guided variation*). If highly sophisticated complex information must be discovered, invention for oneself is very costly, but many innovations will require a certain amount of fine-tuning to suit an individual’s circumstances. Those who would invent, or even adopt most proffered innovations, have to be prepared to pay some learning costs. Rogers refers to this requirement for at least minimal individual learning in order to adapt new practices to local conditions as “re-invention”.

c. Evaluate innovations carefully on their merits (*direct bias*). This is a less costly rule than individual learning, but will still require trials (and the evaluation of trials) that are costly, particularly if the innovation turns out not to work. It may also require substantial modifications for local circumstances.

> d. Adopt innovations modelled by people who are thought to be generally trustworthy (*indirect bias*). Using those who seem to be successful, those who have prestige, and so forth as guides for what to adopt and what to reject is a relatively easy rule to apply—at least once trust is successfully established. Students of the diffusion of innovations apply the term “opinion leadership” to the results of this rule. However, traditional standards of prestige or success may be poor guide in a changing situation.
>
> e. Go along with the majority (*frequency dependent bias*). Once most other people have adopted an innovation, it is probably the right thing to do. This is a very cheap rule to use, but in a competitive situation where many good innovations are available, an individual using it is liable to suffer, at least relatively speaking.

Based on the Costly Information Hypothesis, we would expect people to be sophisticated managers of information costs. The decision to adopt or not will depend on the cost of evaluating the innovation (and the cost of learning any required modifications of details) and the ability of the decisionmaker to bear those costs. The lower the ability to bear information acquisition costs, the more likely it is the person will rely on low-cost rules. When decision costs are very high, people will be very conservative, relying on tradition and adopting few innovations. In general, people will, balance the costs of applying high information acquisition rules against the probability of making a mistake by using traditional behaviors or a cheap but inaccurate rule. Now let us see what people actually do.

IV. Empirical Evidence

A. Typical Pattern of a Successful Innovation[3]

The rate at which people adopt innovations appears to be normally distributed. Figure 20-2a illustrates this pattern. Note that over time the cumulative total describes a sigmoid[4] curve that is very similar in shape to the logistic growth and frequency-dependent curves. This pattern could be explained by a simple contagion theory (a disease spread by individual contact in a uniformly and totally susceptible population would look exactly like the innovation in Figure 19-2). However, the data are considerably more complex. Rogers categorized adopters as is shown in Figure 19-2b. In most studies, these categories are correlated with sociological variables:

> (1) *Innovators*—well-educated, risk loving. In Third World situations they are often the well-connected outsiders as far as the local community is concerned.
>
> (2) *Early adopters*—local leaders and people of high prestige in a community

---

[3] Note that there is very little data available on *failed* innovations.

[4] S-shaped

Figures 19-2. (a) “The bell-shaped frequency curve and the S-shaped cumulative curve for an adopter distribution.” (b) “Adopter categorization on the basis of innovativeness.” (Both figures copied from Rogers 1983:247.)

(a)

Pasted in in 1994. Is your copy clear enough to use?

(b)

but not outside it. In the Third World, such people often have marginally more land, education and income than the average farmer or worker, but they are still the same class. Soviets called farmers in this category Kulaks, which became a term of denigration. Such people usually strongly subscribe to general local norms, even as they adopt innovations. These people are very frequently the most effective opinion leaders. If people in this social category adopt innovations, the rest follow. If they do not adopt, the innovation typically does not spread.

(3) *Early majority*—deliberate, more tradition-bound, less educated, less likely to be leaders, etc. than early adopters, but likely to follow opinion leaders.

(4) *Late majority and laggards*—still more traditional. Often poorer, lower status individuals for whom peer pressure is required to motivate adoption.

Table 19-1 summarizes some of the information developed by Rogers and Shoemaker from their large 900 + sample of studies of the diffusion of innovations. They developed a large series of hypotheses about the effects of many variables on innovativeness or the probability of adopting an innovation. Here we present only a small sample of their data to give you an idea of how it worked. Their basic method was simply to read all the studies and score the ones that mentioned a particular variable as either in support or not in support of a given hypothesis. This is a crude version of what has since come to be called meta-analysis.

TABLE 19-1. Summary of evidence from studies of Rogers and Shoemaker on innovations. Positive means hypothesis predicts variable to have positive effect on innovativeness or adoption.

GENERALIZATION	NUMBER OF STUDIES		PERCENTAGE
	Supporting	Not Supporting	
Socioeconomic Characteristics			
Education (positive)	203	72	
Literacy (positive)	24	14	63
High social status (positive)	275	127	68
Personality Variables			
Dogmatism (negative)	17	19	47
Rationality (positive)	11	3	79
Favorable to education (positive)	25	6	81
High aspirations (positive)	29	10	74
Communication Behavior			
Social participation (positive)	109	40	73
Change agent contact (positive)	135	21	87
Mass media exposure (positive)	80	36	69
Opinion leadership	42	13	76
Innovation Characteristics			
Perceived relative advantage (positive)	29	14	67
Trialability (positive)	9	4	69
Observability (positive)	7	2	78
Compatibility (positive)	18	9	67

B. Conformance With the Costly Information Hypothesis

Notice how Rogers' generalizations conform to the costly information prediction of *cultural inheritance theory.* People with less wealth and less education, and thus on higher relative information costs, tend to be later adopters and to use the example of higher prestige people or the majority, rather than learning or direct bias, to evaluate innovations. (We are presuming here that literacy and general knowledge make information costs lower; think of the trouble an illiterate person would have comparison shopping in catalogs, reading reports, evaluating advertisements, etc.) Innovators and early adopters have the skills to evaluate innovations more easily, to bear the costs of adopting the innovation to local circumstances, and to tolerate the risks involved. The people who can less well bear decision-making costs rely on higher status "opinion leaders" and use the cheaper indirect bias decision-making rule. It is interesting in this context that the microevolution of dialects (Southern U.S. speech, Brooklyn accents, and the like) has many parallels with the diffusion of ordinary innovations, especially in that the role of opinion leaders is important (Labov, 1972). Recall our discussion of dialect evolution in Chapter 14.

Indirect bias is used in a sophisticated way. People in the "innovator" category are usually not opinion leaders. Their status is so high that no one imitates them. It seems that people judge that those who are too different from them in status are probably so different as to be unreliable models. Also, the innovation-prone are often pathologically so. Thomas Jefferson invented and adopted many innovations, but went broke as a farmer. Local people judge, perhaps correctly, in the main, that the circumstances of life of people much higher in status is so likely to be different that they are not useful models. They tend to see the local person, who is like themselves—but just a *little* more successful as the best model. In the Third World, the diffusion of innovations often fails because the extension agents and foreign experts are very different in status from peasant farmers. (Contrast with the U.S.A., where agricultural extension agents have roughly the same status as their early adopters.) Diffusion is generally successful only if "change agents" can reach key people in the "early adopters" category; they are likely to be the opinion leaders. Oftentimes, change agents who do not learn enough about local conditions to make some friends are not likely to know which innovations are useful anyway.

The cost of evaluating an innovation has a direct impact on the rate of adoption. Innovations with obvious advantages usually diffuse quickly. For example, hybrid corn has a three-fold yield advantage over open pollinated varieties; its use is quite easy to diffused. Innovations with small advantages (e.g., a l0% increase in yield) tend to spread more slowly. Hard-to-evaluate advantages such as sanitary practices also tend to spread rather slowly. (Sanitary practices are hard to evaluate because people cannot see disease microbes and because improvements in health are not immediately manifest.)

When information costs are high people often do simply depend upon tradition. Rogers and Shoemaker give the example of a case in which a folk theory of disease inhibited the diffusion of boiling water in Peru. People can't see the microbes that cause disease, and distrust public health workers. They cling to apparently irrational traditions. Modern Western people tend to invert this tendency. We are now innovation-adopters by tradition so to speak, and often adopt the latest technical fads as a matter of course. Many of them do work, and we can usually afford the cost when they go wrong[5]. This trust of traditions when decision-making costs (and the risks due to erroneous adoptions) are high may explain some otherwise puzzling features of cultural evolution.

Complex social organizational innovations are often very difficult to acquire. It may be very difficult to understand what gives another society its advantages. For example in New Guinea some peoples have acquired many technical innovations and have become moderately successful entrepreneurs. However, they use the big-man system to pool capital to buy trucks and other costly goods. The big-man system is preadapted for this role. The trouble comes when the big-man retires. This system is not geared to long-lasting capital goods. Each of the people from whom the big-man has obtained capital has an interest in his enterprise, but the big-man system has no provision for the transfer to a new leader of the business. He can't will it to his son, because the role is not hereditary. There is no custom of electing a new leader. Thus the business tends to be broken up among the big-man's clients or allowed to languish. These budding New Guinea capitalists can acquire many innovations, but the idea of a corporation has never spread to them. It is presumably more difficult to see the advantage of a corporation compared to the advantage of truck transport, so the New Guinea native relies on a traditional, short run serviceable, but ultimately flawed, social-organizational form (Finney, 1972).

There is a school of thought (see Chapter 23) that maintains that technical innovation per se is relatively easy, and that in the long run it is the difficulty of acquiring new social institutions that limits the rate of evolution of human societies. Social innovations are complex and hard to observe. Foreigners do so many things differently, and it is not easy to see how the whole pattern works. They require the simultaneous agreement of many people and are hard to try out. Yet social organization is a culture core feature; new tech-

---

[5] Why have people in the U.S. become such avid adopters of innovations? Perhaps part of the answer lies in the fact that, until very recently, we continued to have a growing frontier. As you have seen from this course, life (i.e., the environment) is often quite unpredictable on the frontier. Thus innovations tend to be favored more often than is the case in more well settled environments. Perhaps another reason we can afford to be such avid adopters of innovations is that on average we use 30 times more resources per capita that people in nonindustrial societies.

nology cannot be properly deployed without it. A new technology may set off a wave rapid change, based on a modest reworking of existing institutions, then rates slow down as more fundamental social-organizational innovations are required.

C. Effects of patterns of innovation on distribution of income

Students of diffusion have noted that it is usually the wealthier people in a village, the most prosperous doctor, the upper middle class school district, etc., that adopt innovations first. If innovations are successful, this tends to make the rich richer, at least temporarily. In a developing or growing country, this will lead to *relative* worsening of the distribution of income.

Thus, even when development is proceeding so that incomes and well-being are generally rising, relative and absolute losses by some groups are common. This can generate very substantial social strains. It seems a hypothesis worth exploring that the political turbulence in developing countries today is as much a product of generally rapid growth as it is of underdevelopment per se. Countries like Brazil have a very poor distribution of income and rapid growth rates. The East Asian countries (e.g. Taiwan, Korea) seem impressionistically to have less poor distributions of income despite rapid growth than is the case in Latin America. They also seem to be somewhat less turbulent politically. (Recall the graph from Chapter 8; many underdeveloped nations have been growing at very rapid rates by historical standards since WWII.)

Lindert and Williamson (1985) conclude that effects like this may account for the rise in income inequality that accompanied the industrial revolution in Europe and the USA. Interestingly, for all the heat generated on this subject, they claim that good data are available only for these countries. By and large we don’t know much about how the distribution of income actually varies as modernization and other economic changes occur.

There may also be regional or occupational effects due to the spreading of innovations. Some occupations disappear entirely. For example, craftsmen and peasants may be displaced by factories and commercial agriculture. Or new classes may arise, such as when factory workers and middle-class professionals gain power and challenge old elites. Moreover, particular ethnic groups may gain ascendancy because they were preadapted in some way that allowed them to take advantage of innovations. This occurred with the Ibo who came to dominate government and business in Nigeria, exciting much resentment on the part of formerly dominant groups, leading to a bloody civil war in the 1970s.

V. Conclusions

A. The Importance of Diffusion

Diffusion of innovations permits culture to evolve more rapidly than would be possible if each society had to evolve their own innovations. The acquisition of ideas from other societies is extremely important to the evolution of *complex* adaptive strategies. All the evidence is that key technical innovations are usually invented far more rarely than they are acquired by diffusion from other societies. (It would be a mistake to think that multiple independent invention never occurs, however. There is every indication that the Americas before Columbus were entirely uninfluenced by the Old World, and that parallels between the Old and New World in technology, social organization, politics, art, etc. were the result of independent developments.) Even in simpler societies, trade, population movements, warfare, and inter-marriage provided a steady flow of innovations from one society to another. The result is that the landscape of, for example Native North America, can be divided into “culture areas” in which similar adaptations to similar environments have been achieved, despite the fact that linguistic evidence suggests that many of the peoples in such areas had very different ancestry.

B. Complexity of the Adoption Process—Costly Culture Idea

Adopting innovations is by no means a simple process. The practices of foreigners (or of a different social class or occupation within a society) may or may not be useful to those who live in a different environment, practice a different craft, etc. Theory and evidence suggest that individuals use various bias strategies in a fairly sophisticated way to increase their chances of adopting useful practices while avoiding as much as possible the information costs attendant on adoption decisions. The human system of separate cultures with leaky barriers to diffusion is unique in the animal world; the barriers to gene flow between species are much more extreme. The decision-making forces and non-parental transmission that differentiate culture from genes have proven to be a powerful device for allowing humans to adapt quickly to new environments while providing a tolerable protection from the diffusion of inappropriate ideas from other environments.

VI. Summary

A. *Concept*: diffusion of innovations

B. *Model*: Socially-structured adoption curve for desirable innovations

C. *Discoveries*: importance of opinion leaders in successful adoption; importance of diffusion of innovations in long-term cultural evolution

D. *Hypothesis*: The costly information hypothesis explains the socially structured adoption curve, especially what sort of people are opinion leaders and what sort are not.

VI. Bibliographic notes

References:

Finney, B.R. 1972. Big-men, half-men, and trader-chiefs: Entrepreneurial styles in New Guinea and Polynesia. In: *Opportunity and Response*, T.S. Epstein and D.H. Penny (eds). London: Hurst.

Labov, W. 1972. *Sociolinguistic Patterns*. Philadelphia: Univ. Of Pennsylvania Press.

Larson, Gary. 1991. *A Far Side Collection: Unnatural Selections*. Kansas City: Andrews & McMeel.

Lindert, P.H. and J.G. Williamson. 1985. Growth, Equality, and History. *Explorations in Economic History* 22: 341-377.

Oliver, S.M. 1962. Ecology and cultural continuity as contributing factors in the social organization of the Plains Indians. *UC Publ. Archeol. Ethnol.* 48:1-90.

Roe, F.G. 1955. *The Indian and the Horse*. Norman: Univ. of Oklahoma Press.

Rogers, E.M., with F.F. Shoemaker. 1971. *Communication of Innovations: A Cross-Cultural Approach*. New York: Free Press.

Chapter 20. DISEASE EXCHANGES

> Soldiers have rarely won wars. They more often mop up after the barrages of epidemics. And typhus, with its brothers and sisters—plague, cholera, typhoid, dysentery—has decided more campaigns than Cæsar, Hannibal, Napoleon and all the generals of history.
>
> Hans Zinsser (1935)

I. Introduction

A. Disease as an Example of Links Between Environment, Technology, & Biology

We might say that disease is part of an "environment core," defined by analogy with the culture core as those features of the environment most closely connected with subsistence and technology. What diseases a population gets depends on the technology it employs in a given environment. This effect is mostly through population density, but other factors also play a role. At the same time, disease has effects on social organization. In the case of catastrophic epidemics, episodes of disease can completely disrupt a society. In the case of chronic diseases, population densities may be regulated at quite low levels compared to what we would otherwise expect from technology and environment. As we shall see, disease is also a result of population contact, and influences relationships between societies.

Disease organisms and their relations with human populations exemplify the coevolutionary and demographic interactions between humans and other species. In the past, interactions with predators might have been significant. We also have to cope with a host of weeds and pests that attack our domestic animals and crops. On the other hand, we also have more positive interactions with the domesticated plants and animals, with a suite of "friendly" gut bacteria, and so on. This chapter, and Chapter 25 on plant domestication, give examples of the coevolution of humans with other species.

B. Plagues and Peoples

Much of this chapter is based on the work of the ecologically oriented historian, William McNeill (1976) whose book ***Plagues and Peoples*** *was a pioneering discussion of the impact of disease on human history using an interdisciplinary approach*. McNeill imagines that the average person of history (a peasant in the case of recorded history) can be viewed as subject to two kinds of parasites, microparasites and macroparasites. Microparasites for McNeill are disease organisms, bacteria, viruses, parasitic worms, and the like, that live at humanity's expense. Macroparasites are lords, kings, soldiers, and priests, the burden of other humanity that lives at the expense of farmers. This is an interesting association of the "highest" and "lowest" types of critters in the same general category, parasites on the primary producers of human societies! If you know any farmers, you may have caught them using the term "parasite" for all us city folk. They *do* put us in the same general category as plant pests and diseases!

Some other classics in this genre include Hans Zinsser's (1935) *Rats, Lice and History* and Rene Dubos (1965) *Man Adapting*. More recently, Gottfried's (1983) *Black Death,* Crosby's (1986) *Ecological Imperialism,* McKeown's (1988) *The Origins of Human Disease, and* Preston's (1994) *The Hot Zone* have added to this literature. There is also now an excellent summary of how evolutionary theory should apply to disease, Randolph Nesse and George Williams' (1994) *Why We Get Sick.* All of these books are "good reads;" they are not too technical and are written in lively fashion.

II. Theory of Disease

A. Dimensions of Variation in Communicable Diseases

The evolutionary ecology of disease has been the subject of an excellent body of work by Robert May and Roy Anderson. A few references to their papers are included in the references. May is an outspoken exponent of simple models by the way. His mathematics are usually quite trivial, and yet the conclusions quite powerful. He and Anderson have had a major impact on debates about many important disease problems, including AIDS.

We begin with basic terminology:

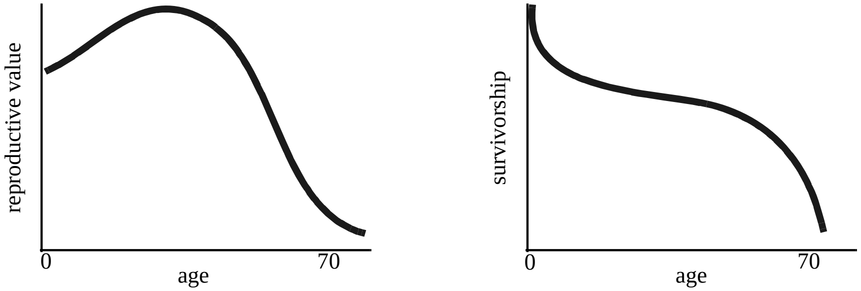
> *Virulent vs. avirulent diseases:* Virulent disease rapidly kills a substantial fraction of those who are infected. Avirulent diseases don't kill, or kill very slowly or merely cause chronic illness. For example, smallpox was virulent, particularly in populations without a history of exposure, malaria is relatively avirulent in adapted populations.
>
> *Endemic vs. epidemic (and pandemic) disease:* Endemic diseases are those that are always present in a population. Epidemic diseases appear, cause mortality and disappear from a population, at least temporarily. *Pandemics* are very large-scale epidemics involving large fractions of the world.

B. Evolution of Disease Systems

Selection on both the disease organism and the host very often seems to result in initially virulent diseases becoming less virulent with time. The essential idea is that host will be selected for ability to resist disease, while the disease will come under selection to remain infectious, but to do as little harm to the host as is consistent with being transmitted. From the diseases' point of view, the healthier the host the better, insofar as healthy hosts can make more new disease organisms and transport it further than sick ones. The trade-off is that a parasite must rob a host of energy and resources to reproduce itself, and so usually cannot become completely harmless. Sometimes a former disease may evolve into a mutualist that actually helps its host. But vice versa too!

R. A. Fisher developed the theory of ***reproductive value*** *to explain some of the details about how hosts ought to respond to selection to resist diseases*. It explains why children and the old are especially susceptible to diseases. The sensitivity of social organization to disease outbreaks follows a similar logic, as we shall see. Figure 20-1 provides a sketch of Fisher's argument. Fisher characterized the reproductive value of the young as being low because they are small, subject to high mortality and not yet reproductively competent. Moreover, the young may die before they reproduce, and a family's investment in them is small. Similarly, the reproductive value of old individuals is low because the younger that an animal reproduces, the earlier its own offspring can begin to contribute to reproduction. Older individuals will have tended to have used themselves up[1] to reproduce when younger.

Figure 20-1. Fisher explained the differential mortality of very young and very old humans in terms of their reproductive value. Reproductive value is an organism's expected future contribution to the size of the population, relative to its own present contribution to its size. Survivorship measures the proportion of an age cohort that is living at a particular age.



Because of trade-offs, selection will act to increase survival of organisms with high reproductive value and tolerate more mortality among the very young and very old. Selection falls hardest on individuals that have the biggest expected contribution to future generations, and thus emphasizes protection of adults near maximum reproductive value, at the expense of juvenile and old age mortality. If there is some trade-off between mortality at

---

[1] Consider the applicability of this statement in the context of traditional human environments and pre-industrial cultural patterns.

different ages, all else being equal, selection will favor taking risks with the young and the old in order to let the reproductively valuable survive. For example, young children put practically everything they can find in their mouths. Selection might have favored this behavior because it is important for children to acquire immunities to many common bacteria before adulthood. If a child has an incompetent immune system, it is as well for this fact to be manifest at an early age. If the child dies young, parents will have wasted few resources, but if it dies at 20, they will have wasted much. The main tests of the immune system should occur while people are children. These reasons presumably explain why the mortality curves of humans are so steep during infancy, and again after about 50. Note also, the social value of young and middle-aged adults is high relative to the very old and very young. It is people 18-60 that provide the productive work force and leaders. Epidemics that kill people in this age group can be devastating to social organization as well as to population. Fisher's theory appears to give a good account of why there is excess juvenile mortality and for the existence of senescence (collapse of health in old age).

The existence of true senescence is a still-controversial prediction of Fisher's theory. To the extent that selection acts adaptively to crowd threats to death into old age, we should expect that many biological systems should break down more or less simultaneously. There should not be one cause or a few causes of old age infirmity, but a swarm of postponed debts all coming due together as selection loses its grip as reproductive value falls. Most but not all evolutionary biologists think Fisher was right, but much expensive biomedical research effort is predicated on the assumption that cures for old age can be found.

Virulent diseases tend to die out in a population, as all hosts either die, become genetically resistant or phenotypically immune. Therefore avirulent strains that kill slowly or not at all are more likely to persist, become a successful endemic disease (e.g. worm parasites, common cold virus, etc.). Diseases that remain relatively virulent, such as smallpox, may either have a strong trade-off between their own reproductive rate and the damage they do to their host for some biological reason, or they may have peculiar ecology that prevents the evolution of avirulence. Often selection favors intermediate virulence rather than completely avirulent strains of pathogen. The following example of myxomatosis illustrates this idea.

C. Evolution of Myxomatosis in Rabbits

This classic study demonstrated the decline in virulence of the virus, and an increase in resistance in the rabbit. The virus disease that was introduced into populations of European rabbits in Australia as a measure to control them. When rabbits were introduced to Australia, they lacked diseases or predators to control their populations and they became serious pests. After it was introduced, the myxomatosis virus seemed to stabilize at intermediate virulence in several populations in Europe as well as Australia (see Table 20-1). At the same time, the rabbit populations evolved higher resistance to the disease. As a result, myxomatosis became endemic. This pattern is consistent with much evidence regarding the history and geographical distribution of humans and their diseases. However, as is discussed in section V.A.1 of this chapter, hard evidence is lacking for any human disease.

Table 20-1. Frequency of field-collected strains of myxoma virus of different grades of virulence, collected in different years from rabbits in Australia Grade I is highest virulence, Grade V the lowest. Adapted, from May and Anderson, 1983..

Virulence Grade						
	I	II	IIIA	IIIB	IV	V
1950-51	100	--	--	--	--	--
1958-59	0	25	29	27	14	5
1963-64	0	<1	26	34	31	8

D. Influenza: A disease that remains virulent

Influenza is an example of a disease that retains its virulence. In this case, the tendency for virulent strains to arise from time to time (the “Spanish” flu of 1918 is a famous example) is apparently due to the rapid evolution of new strains of the disease from animal viruses. The ancestral viruses are fowl diseases that people acquire from pigs after pigs acquire them from ducks and chickens. (The biology of parasites is full of fascinating twists like this.) The strain is briefly virulent in humans before populations acquire immunities, then that strain just dies out in humans. There is no possibility of a stable long term evolutionary adjustment. The destructive diseases of the past, such as smallpox, plague, cholera, and so forth often had human or animal foci where they were endemic and avirulent. If human populations are infected from these foci at irregular intervals, the diseases similarly may never become endemic and avirulent in the populations into which they are “accidentally” introduced. Each time a major new disease adapts to attack humans, there is a chance that it will be briefly epidemic and virulent before the evolution of endemic, avirulent strains can take place. Influenza is an extreme example because the frequency with which new epidemic strains are acquired from pigs.

E. Dynamics of Classic Pandemic Outbreaks

The influenza pattern appears to be a common pattern for really destructive epidem-

ics. Pandemic diseases persisted in endemic foci in some population somewhere, often a nonhuman alternate host. In the case of the Black Death, the original focus was infected wild rodents some place in the Himalayan region. Other frequent alternate hosts are domesticated animals and wild animals such as rats or monkeys that live in close proximity to human settlements.

For some diseases, human populations were often too small to sustain the disease as an endemic infection, but large enough to carry epidemics. For example, in populations smaller than 300,000 measles cannot persist as an endemic disease. Too few non-immune children are born to sustain the disease population after an initial attack. There is a *threshold population size* below which a disease dies out in an isolated society. However, these societies may be dense enough to spread the disease *if it is introduced*. Once an epidemic passes through a population and dies out, the number of people with acquired immunities drops until there are once again enough susceptible individuals to carry an epidemic. Then the society is primed to explode if the disease is again introduced from the outside. Table 20-2 from Harrison et al. (1988) shows how, in a series of island populations, only Hawaii is large enough to sustain measles on its own. In the other cases, measles dies out and must be reintroduced by travelers. Note that percent of months with measles seems to be a function of both island size and frequency of visitation. Guam and Bermuda, with lots of visitors, have high rates for their size.

Table 20-2. “Endemicity of measles in islands with populations of 500,000 or less, all of which had at least four exposures to measles during 1949-1964 (from Harrison et al., 1988:520).”

Islands	Population	Annual Population Input	% Months With Measles
Hawaii	550,000	16,700	100
Fiji	346,000	13,400	64
Samoa	118,000	4,440	28
Solomon	110,000	4,060	32
French Polynesia	75,000	2,690	8
Guam	63,000	2,200	80
Bermuda	41,000	1130	51
Falkland	2500	43	0

Thus, the most virulent epidemics occur in situations where the disease spreads from an endemic focus to poorly adapted populations, who suffer great mortality, but do not sus-

tain the disease. The disease may recur at irregular intervals due to chance contact with the endemic focus. The intermediate-sized population will carry an *epidemic*, but will not sustain the disease as an *endemic* infection.

If the population is larger still, the disease becomes endemic, strikes mostly children and old people, and is much less of a burden on the population than one that strikes people near maximum reproductive and social value. From the point of view of the disease, the important variable is the rate of generation of new susceptible people relative to the rate at which people die or are cured of the disease. For the most serious infectious diseases, such as smallpox, people die or recover fairly quickly. In small populations, such diseases tend to die out pretty quickly after an epidemic is introduced because so many people are cured or become immune that the chain of infections is broken. These diseases can be sustained in larger populations because enough new children lacking immunity are born to continue the train of infections within the population. As diseases become endemic in this fashion, the coevolution of disease and host populations will ensue, inherited immunities will build up, and the disease may become less virulent. Thus, populations with intermediate densities are most vulnerable because infectious diseases do not become endemic. Instead, these diseases attack *irregularly* after a large enough number of susceptibles has built up to carry the disease, and some chance event reintroduces the microbe.

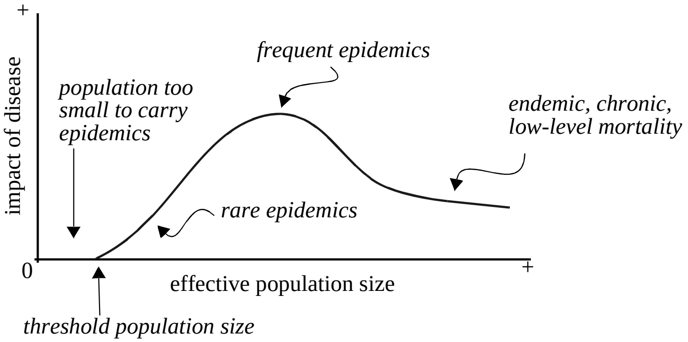
Effective population size is population size measured in terms of probability of contact of one sick person with another. It is therefore a function of **both** density *and* mobility.

Effective population size **is a function of** ***both*** **density and mobility. This means that the rate of contact between people and sub-populations is important, not so much the population's actual size and density.**

The literal population size and density important, but mainly operates by affecting the rate of contact between potentially infected subpopulations and individuals. Frequent, long-distance travel increases effective population size, sedentarism reduces it. The impact of disease on the demography and sociology of a population is of course low when it is too small to suffer the disease at all. It is usually tolerable when the disease is endemic. The worst impacts occur at intermediate effective population sizes that are large enough to carry the epidemic, frequently make contact with endemic foci, but are too small to allow the evolution of endemism and avirulence. Figure 21-2 illustrates the biology behind this idea.

The evolution of resistance to infectious disease amounts to reducing the effective population size of susceptibles. In the case of viruses, histocompatibility antigens are the first line of defense. Each human genetic variant at such loci is resistant to some diseases and disease strains, but not others. There is a coevolutionary merry-go-round between selection increasing the frequency of disease genotypes that can attack currently common antigen types, and the human population response of increasing frequencies of those antigen genotypes that are most difficult to attack. In human populations exposed to repeated attack by many viruses, there are many genotypes. Each disease strain can attack only a minority of the population. For example, it is estimated that in African populations, the effective population size is only 1/200th the raw numbers due to antigen diversity, at least for a virus that can attack only one genotype. In contrast, isolated island populations are as large as 1/3 of their raw numbers. As we will see below, the consequences of low antigen diversity are dramatic when isolated populations are exposed to the full spectrum of disease variants..:

Figure 20-2. Impact of disease on population growth rate or size according to McNeill's (1976) hypothesis.

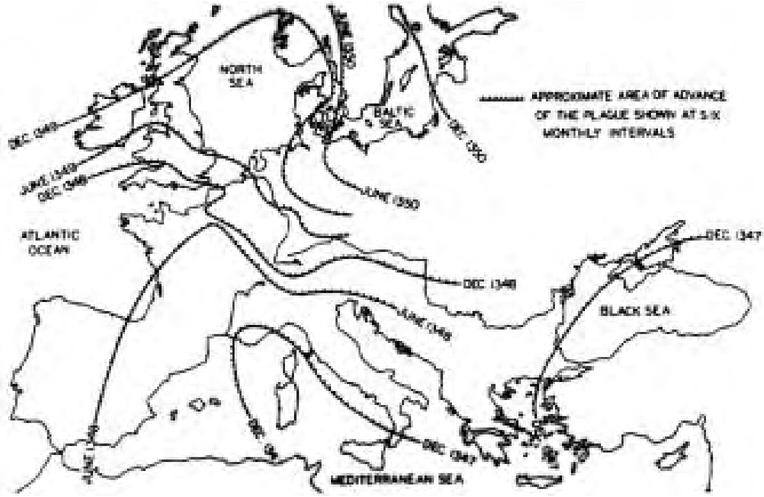


III. Disease, Technology, and Technical Change

A. Importance of transport, technology, and the like:

Changes in technology sharply affect the diseases humans get because they lead to changes in the effective size and density of our populations. Technological progress over the last 10,000 years has tended to move populations from below threshold to the endemic size for a large spectrum of diseases. McNeill (1976) argues that the classical period from 500 B.C. to 1500 AD brought densities and travel rates up to the point that effective population sizes were around the peak of severity for disease impacts for many classic epidemic diseases like smallpox and plague. This was the Era of the Plagues. The Black Plague struck Europe at least twice 542-3 AD, and again in 1347-50 (see figure 20-3). Other lesser outbreaks occurred and other severe outbreaks that might have been Black Plague occurred at earlier times. It seems that open trade routes across Central Asia, such as the Mongols supervised in the 14th century, linked Europe to the Black Plague focus in Central Asia at irregular intervals, initiating the outbreaks. Mortality over wide areas could reach 50%. Many other diseases of great severity swept Europe as each society acquired a tenuous contact with the disease pools of the others.

Figure 21-3. Spread of the Black Plague in fourteenth-century Europe (modified by Harrison et al. (1988:524) from McNeill (1976).



After 1500, contact by ship became so regular that the whole civilized world essentially became a single population for many purposes. Now, for most diseases, the world population began to move down the right shoulder of the curve, and most diseases became endemic and less virulent childhood diseases. Mortality was still high until the advent of scientific public health, but was concentrated among those who were reproductively less valuable and/or less advantaged socially.

The AIDS epidemic is testimony to how cultural changes can still expose human populations to new diseases. The current AIDS pandemic reminds us that we may still be vulnerable to new plagues, despite scientific public health. Relaxed sexual mores, alas, are still dangerous. Another example is polio, which was a dreaded disease in the 1950s. The polio virus had apparently long been common, but few people had the disease, because most children were infected very young when the course of the disease was normally mild. As sanitation *improved* in the 20th Century many children got the disease at later ages when infection caused severe paralysis or death. More generally, a new technology may alter the habitat so as to favor a disease (e.g. irrigation favors waterborne and mosquito-born diseases). Similarly, technology may determine which habitats can be occupied, and different habitats may have different disease profiles. For example, the introduction of the American sweet potato to New Guinea allowed people to push cultivation to higher altitudes, and thus to escape malaria; population densities are much higher in the healthier highlands.

B. Historically small importance of medical technology

Curing was an early occupational specialization; people have always tried to find technical solutions to disease. Even hunting and gathering societies have people who specialize in curing the sick. Even in the absence of proper specialists, all human societies have some curative techniques. The so-called "secondary compounds" of plants are a rich source of drugs. These compounds are usually chemical defenses against herbivores and parasites, but sometimes have useful pharmacological properties for humans. Quinine, morphine, digitalis, and cocaine are examples of drugs discovered by folk healers and later brought into scientific medicine. Also, people often have customs regarding disposal of feces and other traditions that have sanitary implications. Finally, unlike most other animals, humans nurse the sick. This is a tremendous help in surviving seriously debilitating illnesses such as many epidemic diseases. In really severe epidemics, significant mortality is thought to occur just because so many people are sick there are not enough left healthy to nurse them.

However, prescientific doctoring seems to have depended largely on the placebo effect. The placebo effect is the psychological effect that treatment has even if treatment is nothing but a sugar pill. All good medical experiments control carefully for the placebo effect, because for many diseases, it is actually quite effective. People really do get better faster if they take a cure they believe in, even if the non-psychological effects of the treatment are nil. Not until the development of scientific medicine does medical treatment seem to have been generally efficacious. Although folk pharmacopoeia have yielded many important drugs, the vast bulk of folk cures appear to be "medically" ineffective. Not a few treatments are plainly magical and aimed at improving the patient's morale. In many cultures people go both to traditional practitioners and to modern doctors. This is presumably the best approach in practice, getting the maximum placebo effect as well as whatever real cures the proper doctor can provide! Of course, it may be hard to optimize this strategy. The witch doctor's treatment only works if you believe in it, but if you believe in the witch doctor, you may not make proper use of the scientific practitioner.

C. Generalized Result

Long-stabilized conditions seem to result in genetic and cultural adaptations to disease. Sudden changes often lead to increased burdens of micro-parasitism, as human populations come into contact with new organisms for which neither genetic nor cultural means of adaptation exist. New or insufficiently regular contact with foreign populations is a troublesome source of exposure to diseases for which populations are ill-adapted. Because technology plays such an important role in regulating human population density and mobility, each of the technological types of society we have studied in this class tends to have a characteristic disease profile. However, environmental variation also plays an important role. The following sections document these generalizations. Table 21-3 summarizes the relationship between cultural characteristics and population size.

Table 21-3. "Cultural characteristics in relation to the number of human generations and population aggregation (modified from Harrison et al., 1988:515)."

Years bp	Generations	Cultural Type	Community Size & Type
1,000,000	50,000	Hunter Gatherer	nomadic bands <100
10,000	500	Early Agriculture	relatively settled villages <300
5,500	220	Irrigated Agriculture	few cities ~100,000, mostly villages <300
250	10	Industrial & Commercial	some cities 500,000+, many cities ~100,000, many villages ~1,000
130	6	(introduction of sanitary reforms)	—
0	—	—	some cities 5,000,000+, many cities 500,000, fewer villages ~1,000

IV. Diseases of Hunter Gatherer Societies[2]

A. Ecological Circumstances and Types of Diseases

Hunter gatherers had a far different disease profile than we experience. They have low population densities and are intimately involved in local ecological processes. These circumstances make them particularly vulnerable to diseases with alternate hosts such as malaria[3] and intestinal parasites (e.g., tapeworms, round worms, etc.). Most of the diseases

---

[2] Taken largely from Dunn (1968).

[3] See The end of this chapter for a recent article about contemporary problems with a new strain of malaria.

suffered by hunter gatherers are relatively mild and are passed by intimate contact (e.g., T.B. & herpes). Population sizes are far too low to carry virulent epidemics or to support endemic infections of moderate virulence. Food foragers probably lacked most microbial diseases that are either virulent or cause only a short infectious period, or survive a short time outside the host (e.g. everything from smallpox to colds, to intestinal bacterial diseases).

B. Great Geographical Differences

There are high micro-parasite loads in the Old World tropics where humans have a long history, primate relatives are present, and disease organisms tend to survive for a long time outside hosts[4]. Micro-parasite loads are generally lower in temperate and arid zones. There, cold seasons and/or dry conditions limit populations of insect vectors and reduce lifetimes of disease organisms outside the body. There are also fewer primate relatives of humans or other animals to act as reservoirs and evolutionary sources of infections.

In rain forests in Malaysia and Africa, hunters and gatherers carry ~20 worm and protozoa parasites, in the African and Australian deserts from 1 to 9 (Dunn, 1968). Dunn argues that this range is in rough proportion to biotic diversity generally, implying that places with many species of animals have many alternate hosts, many species to enable them to complete complex life cycles, and many species to act as the evolutionary sources for human infestations.

Micro-parasite loads are lowest in New World because of the Arctic barrier and the fact that humans have no close New World relatives, even in tropics. The diseases that the original migrants brought to America must have been only those that small groups of sub-arctic hunters and gatherers could carry. Once across, Americans were almost completely isolated from any possibility of acquiring Old World diseases, except perhaps infections that were filtered through sub-Arctic hunters like the Eskimo. Australia and the Oceanic Islands were similarly isolated and nearly disease free (Crosby, 1986).

The main form of human adaptation to disease is via biological resistance. However, some cultural customs and curative practices are also important. For example, as we discussed previously, simple nursing is quite effective for saving the seriously, but not catastrophically, ill.

---

[4] because conditions more closely approximate the warm moist environment within the human body

V. Diseases of Simple Horticultural Societies

A. Ecological Circumstances and Types of Diseases

Use of domestic plants and animals usually greatly increases population densities and substantially modifies environments. Virulent endemic childhood disease such as smallpox were probably first experienced in these types of societies. Higher rates of infestation of specialized parasites (e.g. bilharzia from irrigation water, *Anopheles,* the malarial mosquito) are found around settlements because of higher population density and poor sanitation. Until the last few hundred years, there was still a great deal of geographical variation in the amount and type of disease suffered by horticulturists.

B. Biological and Cultural Adaptations

Increased densities and expansion into new habitats exposed horticultural people to new diseases and set in train evolutionary responses, most importantly genetic responses. Diseases were, until the last few decades, features of the environment to which people adapted very substantially genetically as well as culturally. Human populations vary considerably in their abilities to resist various diseases.

Classic, well-studied examples include the various hemoglobin variants, e.g. sickling trait for malaria[5] *resistance in West Africa*. Sickle cell anemia is a disease caused by being homozygous for a particular gene coding for a non-standard hemoglobin. When one is heterozygous for this gene, the anemia is very mild, and the individual is protected from malaria. The heterozygous sickling person's red blood cells are prone to become distorted and leak nutrients when stressed by the malaria parasite, which multiplies inside red blood cells. The multiplication rate of malaria in the host is thus reduced. With a double, homozygous dose, the blood cells distort and leak in such high frequency as to cause anemia and usually premature death of the carrier. Selection favored a fairly high frequency of this gene in the more malarial parts of West Africa, despite high mortality among homozygotes. At the same time, individuals homozygous for the normal gene are unprotected from malaria.

Malarial parasites evade the immune system better than bacteria and viruses, and other means of resisting them have to be run up. The costly sickle cell system is a result. In some African populations heavily exposed to malaria, the proportion of the sickling gene reaches around 15%. This will provide malaria protection for about 26% of the population (the heterozygotes), leave 72% unprotected (homozygous normals), and sacrifice about 2% of the homozygous sicklers. Protected heterozygotes have about a 20% fitness advantage homozygote normals, and the homozygous state causes a fitness reduction of 80% relative

---

[5] Malaria is a human disease caused by parasitic protozoans in the red blood cells. It is transmitted by the bite of *Anopheles* mosquitoes, and is characterized by periodic attacks of chills and fever.

to the protected heterozygotes. The crudity of this anemia producing mechanisms betrays a recent evolution; selection may not yet have “discovered” the appropriate adjusting modifier genes to permit the anemia genes to go to fixation without causing fatal anemias. There is some suspicion that people avoided the most malarial parts of Africa until the advent of horticulture there ca. 3,000 BP. DNA sequencing data suggests that the sickling gene evolved independently 3 times, a remarkable example of convergent evolution.

Even more remarkably, other functionally equivalent systems for malaria resistance have evolved. One of these, G-6-P-D deficiency, has an interesting coevolution with a cultural mechanism for malaria resistance, fava bean consumption. Genes for G-6-P-D deficiency confer resistance to malaria, but based on a different biochemical mechanism from sickling. The gene is in high frequency in the Mediterranean region where the disease was common in the past, for example in Sardinia. These genes also have the effect of making red blood cells less good places for malaria plasmodia to live, at the cost of making them somewhat less good at carrying oxygen and having other problems.

Fava beans have been widely cultivated around the Mediterranean Region for centuries in spite of the fact that they cause a deadly disease called favism in people who are G-6-P-D deficient. In such susceptible people, eating the beans causes red blood cells to break, and the victims die as the capacity of their blood to carry oxygen collapses. Fava beans (also called broad beans) are large flat beans about the size of the end of your thumb. They are very similar to a number of other legume crops in terms of ease of cultivation and nutritional value. Solomon Katz et al. (1979), who studied fava consumption in this region originally hypothesized that populations with the highest proportions of this gene would exhibit the lowest use of fava beans. However, what they found was that fava bean consumption was actually *highest* in those populations with the highest proportions of the gene.

According to Katz and his colleagues, fava consumption is adaptive in malarial regions because some of the compounds in the bean confer malarial resistance in individuals who do not have the favism gene. Unfortunately, having G-6-P-D and eating fava beans is analogous to being a sickling homozygote.

This example may provide a good example of natural selection acting on a cultural—rather than biological—trait. A great variety of cultural beliefs have developed regarding fava beans during the long period of their use in this region. Despite some recognition that they can have harmful effects, fava beans continue to be eaten. There is no evidence that those who eat fava beans understand the biological complexities involved or have specific genetic biases (e.g. a distaste for the beans among individuals genetically vulnerable to favism). Using cultural evolutionary concepts, we can construct a plausible hypothesis that natural selection is acting on a *cultural trait* (eating fava beans) much as it is acting on the *gene* that causes favism. Individuals characterized by beliefs that lead them to consume fava beans had a higher probability of surviving to adulthood and becoming cultural parents for the next generation that individuals who did not consume fava beans. Selection would also favor the spread of folk medical beliefs that helped G-6-P-D deficienct people avoid fava beans. The use of plant foods high in secondary compounds of presently unknown or poorly understood effects is widespread in human cuisines. Natural selection for such preferences could be an important phenomenon.

Many other cultural practices have been hypothesized to have evolved to protect human populations from disease. Hill tribes of North Vietnam live in raised huts to avoid malaria mosquitoes. The nocturnal mosquitoes that carry malaria in this habitat apparently fly close to the ground, and prefer to bite cattle rather than people. By stabling cattle on the ground floor and living above them, one can largely avoid bites. To give another example, Mongols living in areas with endemic Plague avoid rodents, especially sick ones. Since rodents are reservoirs of Plague, this is probably an effective means of avoiding outbreaks of this dreaded disease. Adjustments such as these, supplementing biological resistance, were apparently relatively successful in converting most of the new virulent diseases into the relatively harmless endemic ones, so long as sufficient time, perhaps a few thousand years, were available to evolve the appropriate mechanisms. In the case of the crude sickling resistance gene and the dangers of combining G-6-P-D deficiency with fava bean consumption, it would seem that 3,000 years is too short to *perfect* an adaptation to malaria.

V. Diseases of Classic and Renaissance Agrarian Societies

A. Ecological Circumstances and Types of Diseases

Agrarian societies tended to be around the maximum impact part of the effective population size curve for many diseases, according to McNeill's hypothesis. As table 21-2 showed, early agricultural societies brought about increases in population and settlement density (cities). Trade was greatly expanded due to political consolidation, improved transportation, and expanded warfare. By about 500 B.C. the stage was set for the various urban civilizations to start exchanging diseases all over the Old World as noted above. During this era, local epidemic diseases spread with trade and military adventures due to a confluence of disease pools.

A variety of diseases, many of which cannot be reliably identified, swept through the ancient Old World civilizations. Most probably became avirulent or died out after initial attacks. Note that historical epidemiology is a difficult business. Only a few diseases leave traces on skeletons for the archaeologist to find. Mummies make the best material for paleopathology (Armelagos, 1969), but are relatively uncommon. Diseases tend to evolve, and old chroniclers were not always the most acute observers. Hence, there is a great deal of uncertainty about the identity of many ancient diseases.

The demographic and political consequences of disease epidemics were very important. For instance, the spread of invaders into India and Southern China may have been slowed by diseases. Similarly, bubonic plague is associated with the fall of the Roman Empire. Plague was renewed in Europe with the Mongolian invasions and led to major political upsets in Western Europe in the 14th century. The demographic collapse of Europe due to the 14th Century bubonic plague raised wages for a century or more due to labor shortages (see Chapters 7 and 15).

B. Colombian Catastrophe

The most catastrophic disease epidemics in human history were associated with the voyages of discovery ca 1500 AD which ended of the isolation of the Americas. Every other demographic holocaust we know of pales by comparison. According to the summary of evidence by Henry Dobyns (1993), roughly 80-95% of the precontact populations of the Americas was killed as wave after wave of new diseases decimated New World natives for 50-125 years after contact. Native Americans have much less variability at the key histocompatibility antigen loci that protect against virus infections. Epidemic diseases that reach such unprotected populations are called *virgin soil* diseases. Unlike endemic diseases among well-adapted peoples, these epidemics struck people in the prime of life, as well as children. Social disorganization was extreme, even in comparison with the plague in classical Old World civilizations, where the analogous situation was horrifying enough. The following series of passages from historical sources quoted by Crosby (1972) provide a graphic example:

> Thomas Hariot [a member of the 1587 English colony at Roanoke Island in what is now Virginia] wrote that there was no Indian village where hostility, open or hidden, had been shown,
>
> > but that within a few dayes after our departure from everies such townes, that people began to die very fast, and many in short space; in some townes about twentie, in some fourtie, in some sixtie, & in one sixe score, which in trueth was very manie in respect to their numbers…. The disease also was so strange that they neither knew what it was, nor how to cure it; the like by report of the oldest men in the countrey never happened before, time out of mind (Crosby, 1972:41).
>
> Similarly, French settlers in what is now Canada in 1616 reported that the Indians:
>
> > are astonished and often complain that, since the French mingle

> with and carry on trade with them, they are dying fast and the population is thinning out. For they assert that, before this association and intercourse, all their countries were very populous and they tell how one by one [different areas] have been more reduced by disease (Crosby 1972:41).

A European who lived in [the Boston Bay] area in 1622 wrote that the Indians had

> died on heapes, as they lay in their houses; and the living, that were able to shift for themselves, would runne away and let them dy, and let there Carkases ly above the ground without burial….. And the bones and skulls upon the severall places of their habitations made such a spectacle after my coming into those partes, that, as I travailed in the Forrest nere the Massachusetts, it seemed to be a new found Golgotha (Crosby, 1972:42).

…The Cakchiquel Mayas [of South America]… kept a chronicle of the tragedy for their posterity…. Their words speak for all the Indians touched by Old World disease in the sixteenth century:

> Great was the stench of the dead. After our fathers and grandfathers succumbed, half of the people fled to the fields. The dogs and vultures devoured the bodies. The mortality was terrible. Your grandfathers died, and with them died the son of the king and his brothers and kinsmen. So it was that we became orphans, oh, my sons! So we became when we were young. All of us were thus. We were born to die! (Crosby, 1972:58)

C. Disease and Imperialism

Patterns of disease appear to have strongly channeled European colonial practices from 1500 to about 1850 (Crosby, 1986). European conquest of places like the Americas and New Zealand was comparatively swift because diseases were flowing from Europeans to the Natives. In Africa, which was so convenient to Europe, white presence was very thin until the advent of antimalarial drugs in the mid-19th century. Then Europeans were able to effectively colonize Africa. Throughout most of the Old World, disease flows were more or less balanced, and Europeans remained a small minority. Even today, whites are scarce in tropical countries, and in cases like Brazil tend to be restricted to the temperate end of the country. Crosby attributes this pattern to diseases and subsistence techniques. Europeans are biologically and culturally temperate-zone animals and cannot compete with other populations nearer the equator. Nor were they able to really displace native populations anywhere without the aid of a sharp disease gradient in their favor.

D. The Confluence of Disease Pools

In the European Era, long-distance travel became so routine that many human populations passed to sizes that maintained formerly epidemic diseases in the endemic state. Thus smallpox tended towards a routine childhood disease, which perhaps favored the evolution of less virulent strains and host resistance. And at any rate, young people were disproportionately victims, compared to the more valuable adults. Thus the Era of Plagues (big pandemics) was essentially ended by most formerly epidemic diseases becoming endemic. The catastrophes in the New World were the last of the truly horrific epidemics. Native Americans turned the corner of exposure to Old World diseases, and began to increase again.

VI. Diseases of Industrial Society

A. Ecological Circumstances and Types of Diseases

Industrialization brought about further increases in population size, density, and rates of communication. Effective population size took another dramatic jump. This meant more people were exposed to old virulent infections. It also meant that more people were exposed to old urban sanitary diseases such as cholera and typhoid. Even if immunities from the late agrarian confluence of the disease pools was high, chronic mortality was probably an increasing problem in early industrial cities as densities increased. (See Knauft's 1987 article on pre-industrial cities for a vivid description.) Transportation improvements probably were responsible for influenza becoming pandemic during that time. Even in the best 19th century cities, disease problems were severe due to massive exposure to poor nutrition, environmental pollutants, and noninfectious diseases such as scurvy, beri-beri, etc.

B. Adaptations

Biological adaptations to disease were rather slow compared to the variety and rate of spread of infectious disease during the 19th century. The most effective adaptations were *cultural*. Scientific medical technology, primarily public health adaptations, were especially effective. Vaccines were developed for smallpox; chemotherapies were developed to treat venereal diseases and the like; insecticides were developed to combat insect borne diseases like malaria and yellow fever; and nutritional supplements (e.g. citrus, vitamin C, for scurvy) began to be used. Moreover, the development of sewer systems began to improve both the health and general appearance of the cities. Pedestrians no longer had to divide their attention between where they were stepping and the 'night soil' being thrown out of upper-story windows.

Modern industrial life absolutely requires high quality public health measures. Quite grim new diseases, like AIDS, and old ones like malaria, continue to threaten modern societies. Public health organizations, such as County Mosquito Abatement Districts and the U.S. Communicable Disease Center in Atlanta probably save more lives in this country every year than all the work of all the practicing physicians.

Let us give credit to a couple of the relatively uncelebrated public health pioneers to *whom we owe so much*:

> (a) John Snow and the Broad Street Pump organization, working on a London cholera outbreak, developed methods of tracing the source of polluted water by appropriate statistical studies.
>
> (b) Thomas Crapper and Edwin Chadwick developed the flush toilet[6] and sanitary sewers. The very deadly water-transmitted diseases of industrial cities (e.g. typhoid, cholera) were almost eliminated by piped and treated pressurized[7] water, an efficient buried sewer system, and flush toilets. Pressurization is important; otherwise pollutants and disease organisms can enter the water supply through cracks. In many water-short 3rd World cities, the water is still dangerous because the supply system is frequently shut down, allowing contamination.

In industrial societies, the epidemic disease situation would probably have been intolerable without these public health innovations. In the event, scientific innovations have protected us despite the awesome run-up of effective population size. It is hard for us to even imagine how bad it must have been.

It is interesting to note that most classic diseases of the early industrial period began to decline well before modern medical advances came up with "cures." Figure 20-4 McKeown's shows such an example for tuberculosis. Such declines are not well understood. Improved nutrition, larger, cleaner dwellings, improved sanitation—all a result of increased prosperity—are the leading candidate explanations.

Complacency is unwarranted. The AIDs epidemic is on everyone's mind, and could turn out to be a major "virgin soil" epidemic, as it seems from experience in some parts of Africa. Other old diseases, such as tuberculosis and malaria, have evolved resistances to drugs and insecticides used to control vectors, and are on the rise. The coevolutionary race between disease and host tips back and forth, and permanent, total victory is not on the horizon.

VI. Conclusion

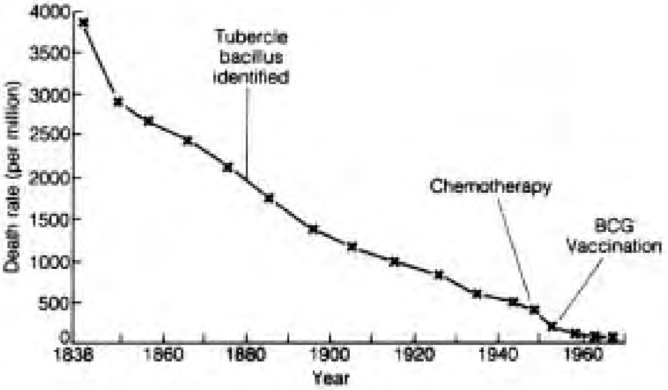
Infectious disease might seem mainly like an interaction between a human population and a non-human one. *In this chapter, we've emphasized the extent to which disease depends on the way populations interact with each other, as well as the way disease populations interact with any given human population*. If hypotheses like those developed by McNeill and Crosby and others are correct, disease and disease exchanges have been important determinants of the expansion and contraction of societies. Note that until the ad-

---

[6] Honest!

[7] .

Figure 20-4. Decline of tuberculosis in Western Europe. Mean annual death rates from respiratory tuberculosis in England and Wales from 1838 to 1969 standardized to 1901 population. (Copied from McKeown, 1988:79.)



vent of scientific medicine, disease-ridden societies may have had an advantage in intersocietal competition. Crosby's case that Africa resisted European domination until the development of effective antimalarial drugs in 19th century, whereas the Americas fell quickly beginning in the 15th century seems reasonably compelling.

This chapter also serves as an example of biological adaptations to environmental variation. We stressed the importance of culture in human adaptations in this course, but the case of disease illustrates that genetic adaptations *still* play a quite significant role. Until recently, medical technology was too primitive to be very effective, and the evolution of immunities seems to have played an important role in human abilities to cope with parasite burdens. Physical anthropologists believe that some other genetic variations between human populations have adaptive significance, for example body build differences and skin color, and disease serves as our example of the wider importance of genetic adaptations.

Note also how cultural and genetic adaptations have interacted in intimate ways in the case of disease. This too is presumed to be a general phenomenon. We have stressed the importance of gene-culture coevolution in this class, and disease-genetics-culture interactions furnish some nice, albeit specialized, examples.

VII. Summary

A. *Concepts*: reproductive value, virulence vs. avirulence, endemic vs. epidemic

B. *Discoveries*: placebo effect, patterns of disease as a function of technology

C. *Models*: Evolution of avirulence

D. *Hypothesis*: McNeill's ideas about the relation of epidemic disease to effective population density

VII. Bibliographic notes

References:

Black, F.L. 1975. Infectious diseases in primitive societies. *Science* 187: 515-518.

Crosby, A.W. 1986. *Ecological Imperialism: the Biological Expansion of Europe 900-1900*. Cambridge: Cambridge University Press.

Dubos, R. 1965. *Man Adapting*. New Haven: Yale Univ. Press.

Dobyns, H.F. 1993. Disease transfer at contact. *Ann. Rev. Ecol. Syst*. 22:273-91.

Dunn, F.L. 1968. Epidemiological factors: health and disease in hunter-gatherers. In R.B. Lee and I. DeVore (eds). *Man the Hunter*. Chicago: Aldine.

Gottfried, R.S. 1983. *The Black Death: Natural and Human DIsaster in Medieval Europe*. New York: Free Press.

Harrison, G. A., J. M. Tanner, D. R. Pilbeam, and P. T. Baker. 1988. *Human Biology: An Introduction to Human Evolution, Variation, Growth, and Adaptability*. Oxford: Oxford University Press.

Katz, Solomon H. and J. Schall. 1979. Fava bean consumption and biocultural evolution. *Medical Anthropology* 3:459-476.

Katz, Solomon H., M. L. Hediger, and L. A. Valleroy. 1974. Traditional maize processing techniques in the New World. *Science* 184:765-773.

Knauft, Bruce. 1987. Divergence between Cultural Success and Reproductive Fitness in Preindustrial Cities. *Cultural Anthropology* 2:1:94-114.

McKeown, T. 1988. *The Origins of Human Disease*. Oxford: Basil Blackwell.

McNeill, W.H. 1976. *Plagues and Peoples*. New York: Anchor Doubleday.

May, R.M. 1983. Parasitic infections as regulators of animal populations. *Amer Scient*. 71: 36-45.

May, R.M. and R.M. Anderson. 1983. Parasite-host Coevolution. In D.J. Futuyma and M. Slatkin (eds) *Coevolution*. Sunderland Mass.: Sinauer.

Nesse, R.M. and G.C. Williams. 1994. *Why We Get Sick: The New Science of Darwinian Medicine*. New York: Random House.

Preston, Richard. 1994. *The Hot Zone*. New York: Anchor-Doubleday.

[8]Zinsser, H. 1935. *Rats, Lice, and History*. New York: Little, Brown.

---

[8] This is a classic of science writing for the general public. It is a "study in biography, which after twelve preliminary chapters indispensable for the preparation of the lay reader, deals with the life history of TYPHUS FEVER." You get the idea; it has been extensively reprinted as late as the early 70s at least.

Deadly Malaria Comes Back With a Vengeance[1]

Do we want to do these or no?

---

[1] Drogan, Bob. 1992. Los Angeles Times 7/28:H2.

Chapter 21. TECHNOLOGY AND ENVIRONMENTAL DETERIORATION IN PRE-INDUSTRIAL SOCIETIES

> One assumption made by most... [is that] until about 5,000 years ago the earth retained its pristine form, and any modifications of its physiography, fauna or flora are ascribable to natural causes. This view is one with which I do not agree...
>
> Robert Heizer 1955

> More than one half [of the extent of the Roman Empire] is either deserted by civilized man and surrendered to hopeless desolation, or at least greatly reduced in both productiveness and population.
>
> George P. Marsh 1874

I. Introduction

A. What Impacts Have Non-Industrial Societies Had on Environment?

We tend to think that small, simple, technically unsophisticated societies have had less impact on the earth's environment than modern industrial societies. Relatively speaking this may turn out to be true, but it is not necessarily the case that the impacts of past societies were insignificant. In this chapter, we will review some of the important proposed impacts of hunting and gathering, horticultural, pastoral, and agrarian types of societies.

B. Three Theoretical Tools

Garrett Hardin, (1968) described the tendency of people to over exploit and damage their environment as the "Tragedy of the Commons." The situation he had in mind for illustrative purposes was the Medieval European Common Pasture. Suppose the pasture produced maximum meat and milk when stocked with 100 cows. Each cow over that cuts the yield per cow. Each of 50 peasant families in the village can keep 2 cows on the common without over exploiting it. But consider the motivation of a particular family to add a 3rd cow. They get all the benefits of the meat and milk from the 3rd beast, but the cost is borne equally by all 100 cows, 97 of which belong to others, from a selfish point of view it makes sense for each family to add a 3rd or 4th cow, even though that degrades the commons for everyone, and all become worse off. Hardin suggested that we can avoid the tragedy only by creating private property or making laws and enforcing them. Otherwise common property resources are very vulnerable to over exploitation. While this somewhat depressing picture of the use of common resources has come in for much attack from empiricists, it is an important theoretical model. Note its close links to the postulate of natural selection theory - the selfish individual.

R. A. Fisher first described the concept of "environmental deterioration." He pointed out that very generally the adaptive improvement of one species deteriorates the environment for other organisms that interact with it. For example, if predators become swifter or more cunning, the environment of the prey has deteriorated. This is "inter-specific environmental deterioration".

Another form of environmental deterioration is the impact that a population's own adaptations have on the environment, as they feed back on the population, mediated by effects on other species or the physical environment. If human impacts are serious, the environment will "deteriorate" with regard to prevailing technology (*intraspecific deterioration*[1]*)*. Dense populations can do serious physical and biological damage: they can overexploit prey species, damage resources by spreading onto marginal lands, shortening fallow cycles, or cause deliberate damage as a by-product of violent conflict, etc[2]. This may provide a selective or decision-making pressure for new technology, or it may merely result in lower human populations on a given deteriorated site. In other words one of the significant causes of human evolution might be that we have to continually adapt to our own environmental damage. We might have to adapt to our own poisons, in much the same way that we have to continually adapt as our prey get warier when our hunting skills and technology improve.

Evolutionary biologist Leigh van Valen proposed the "Red Queen" hypothesis in her discussion of evolution in deteriorating environments. The hypothesis is named after the part in Alice in Wonderland where the Red Queen tells Alice that she is running merely to stay in the same place. As prey get warier, evolutionary pressures force us to become better hunters, then the prey get warier still, and so (perhaps ad infinitum?). In this world, evolution continues, but populations do not really become any fitter. We will discuss this hypothesis in the evolutionary transformations section of the course beginning in Chapter 23. Suffice it to say here that humans coevolve with other species—prey, pests, diseases, competitors—and with the physical environment. This sort of evolution can lead to the most perverse conclusions, as we have already seen in the case of warfare. Improvement in the short run may mean no progress or sliding backward in the long run. But since even decision-making forces are often not very forward-looking, short-run adaptation may rule,

---

[1] Note that current ecological thinking generally favors the idea that *intra*specific competition tends to be much more important in most environments than *inter*specific competition. In other words, we tend to experience much more competition from those who are most like us—because similar organisms exploit similar environmental niches.

[2] For example, the Romans literally sowed the fields of conquered Carthage with salt to deny them the ability to produce food. More recently, we saw Iraq's Saddam Hussein torch Kuwaiti oil fields and open crude oil valves into the Persian Gulf.

whatever the long-term consequences.

Of course, not all impacts need be negative in terms of making it ever more difficult for humans to make a living in a particular environment. People may invest in the construction of long-lived capital facilities, such as roads, irrigation works, terraces, hedgerows, scientific knowledge, plant and animal domestication, and other things that make life easier for future generations. This we might call “positive deterioration”. Thus, Great Britain’s economic performance is so tattered these days that some of the advancing developing nations can equal her GNP per capita. However, life in Britain at the same level of per capita income is relatively more comfortable because of large past investments in roads, railroads, housing, cultural amenities, etc., compared to the newly industrialized nations. The Brits have paid their dues and can kick back!

C. Levels of Selection - A Reminder

The balance of positive and negative instances of environmental deterioration provides a clue about the level at which selection works. It also provides insight into the level at which different types of decision-making are effective. **Group selection**[3] leads to adapted societies and some measure of conservation of natural resources. **Individual selection**[4] tends to lead to over-exploitation of resources—the tragedy of the commons effect. Cooperation allows for mutual coersion, mutually agreed upon strategies can prevent ‘tragedies of the common’. Thus the kinds and degree of resource damage and improvement are indices of: (a) the degree of cooperation possible in a social system, (b) the organizational level at which such cooperation is most effective, and (c) the quality of decisions being made[5].

II. Environmental Relations of Hunters and Gatherers

A. Could Hunter-Gatherers Have a Substantial Impact on Their Environment?

Hunter gatherer societies typically have a relatively modest ability to affect their environments. This is because they have small populations and relatively low-powered technology. Consequently they are often portrayed as having harmonious, functional relationships with nature. However, we also have to remember that hunters and gatherers have an extensive life style (inefficient with respect to people supported per unit land area). Their per capita impact could be high just because they cover so much territory in their for-

---

[3] or effective group decision-making evolved by other means

[4] or individual rational choices, or selection or decision-making rational at the level of smaller as opposed to larger groups

[5] Note that even the most cooperative people cannot make decisions about things of which they are ignorant, although natural selection can still be effective.

aging for the best resources. Also, perhaps, hunters and gatherers have relatively modest decision-making powers (no science, not even literacy) and very modest political institutions. If something does go wrong, they may have difficulty discovering the cause and effecting a correction.

B. Impacts of the Use Of Fire

Even the earliest hominids made extensive use of fire. Fire use is one way that even simple societies can release a lot of energy and cause a lot of destruction of vegetation. It is not entirely clear when humans started using fire, but the Zhoukuodian Cave in Northern China, with *Homo erectus* remains dating back to about 450,000 bp shows evidence of fire use. Human use of fire probably increased the frequency of wildfire due to accidental escapes of campfires and deliberately set fires. Historically, hunters and gatherers are known to have set fires to open dense vegetation for travel, to renew browse, to attract game, and to drive animals for hunts.

Major vegetation changes would often be caused by human set fires (Stewart 1956). The open savanna and prairie vegetation of many areas of the world may at least be expanded by this activity. His data came from the Wisconsin Prairie, where fire was controlled by Whites, soon after settlement began. They indicated that the prairie vegetation type shrank by 60% between the onset of agricultural development in 1829 and 1854 due to shrub and tree invasion of the grasslands. If you've ever lived in the Eastern Deciduous Forest, you may have gained an impression of just how fast trees will invade an abandoned field or a neglected lawn. In a extreme summer-dry climate like California, trees have a tough time and tend to need encouragement. In summer-wet climates, they are much more aggressive.

It is possible that other major grassland formations, such as the East African savanna and the Central Asian steppe are at least in part anthropogenic vegetations; the boundary of the forest and the grass may well have been pushed back by increases in fire frequency caused by human activity.

C. Direct Impacts of Hunting—

Were megafaunal[6] *extinctions caused by humans?* At various times and places in the relatively recent past, the earth's large mammal biota underwent a drastic reduction, known as the Pleistocene Megafaunal Extinction. Beginning in the Miocene Epoch 25 million years ago, the earth began drying and cooling. This led to the development of open plant communities that in turn favored the evolution of large grazing mammals and their predators. This trend reached its height during the Pleistocene Epoch, the epoch of cyclical gla-

---

[6] literally "large animal"

ciations, the last 2 million years. Then, quite suddenly, in the last few tens of thousands of years, most of the large mammal assemblages were virtually wiped out. Only in Africa does a reasonable approximation of Pleistocene big game survive. As late as about 12,000 years ago the Central Valley of California had assemblage of game that were fully as spectacular as the game preserves at Amboseli or Ngorongoro in Africa do today.

Extinctions in the terminal Pleistocene extinction in North America included many Genera[7]. Figure 21-4 (appended at the end of this chapter) provides some illustrations of the species lost in the North American and other megafaunal extinctions. Think of Yellowstone Park full of these things, instead of just a few elk, deer and bears! Here is a list of generic extinctions during the late Pleistocene (* indicates genera with living species in Eurasia or South America):

(1) Mastodons (2 genera), Mammoths
(2) Ground sloths (4 genera)
(3) Camels and llamas (2 genera)
(4) Peccaries (2 genera)
(5) Pronghorn antelopes (2 genera)
(6)* Horses
(7) Giant beavers
(8) Giant shortfaced bears
(9) Giant armadillos
(10) Sabertoothed cats (2 genera)
(11)* Capybaras (also an additional totally extinct genus)
(12) Shrub oxen (2 genera)
(13)* Tapirs
(14)* Spectacled bears
(15) Extinct bovids (2 genera)
(16)* Yaks
(17)* Saiga antelope
(18) Extinct moose
(19) Gylptodonts (2 genera)

Interestingly the timing of extinctions on various continents was quite variable. This

---

[7] This term is used in the biological sense to mean extinctions of an entire Genus. Recall that organisms are classified in descending order by Kingdom, Phylum, Class, Order, Family, Genus, and Species. Generic extinctions therefore refer to the extinction of entire groups of species.

rules out simple climatic effects as causes of the extinctions because climate changes are roughly synchronous over the entire globe. However, the extinctions *do* appear to be closely related to the arrival of modern humans with more efficient hunting technology.

Geographic Region	**Timing of Extinctions**
Africa, Southern Asia	> 40,000 BP
Australia	13,000 BP
Europe, Northern Asia	11,000-13,000 BP (4 genera only)
North America	11,000 BP
South America	10,000 BP
New Zealand & Madagascar	800-700 BP

The sudden simultaneous demise of many genera, at least in North and South America, is consistent with the hypothesis that early humans were at least partially responsible for these extinctions. Mosiman and Martin's mathematical models and illustrations of the wave-like nature of the spread (see below) indicate that rapid demise could be accomplished quite quickly by relatively few hunters.

Extinctions were least severe in Africa (30% of genera) and Europe. This is because these areas had had long, gradual exposure to evolving humans, and Red Queen - like evolutionary arms races had occurred over millennia.

Martin's idea is that large, highly desirable game that have no experience with skilled Late Pleistocene hunters will be very vulnerable. In the Americas and on oceanic islands like New Zealand and Madagascar, human hunters arrived suddenly and very late. Where the extinction was less severe, as in Europe, the fauna had time to coevolve with human predators. The extinction was least severe in Africa, where human populations existed the longest and were longest held in check by disease.

Most of the extinct species were large herbivores and their predators (e.g., mammoths, ground sloths, big ungulates, saber-tooth tigers, giant condors). There was no sudden extinction of smaller mammals. Moreover, these were extinctions without replacements; in the earlier of the Pleistocene speciation kept up with extinction and no empty niches were left.

Since there is so little archaeological evidence critics have doubted that human pop-

ulations could have actually removed the mass of animals. Why don't we find a better fossil record in, especially, North America, which is well-explored archeologically? There are a few mammoth kill sites in the proper period, ca 11,000bp, but not many. Mosiman and Martin (1975) countered with a simulation model showing how a front-like wave of people could build up in Northern Canada, just south of the ice, and sweep to the Gulf of Mexico in roughly 300-1100 years, depending on details of the simulation. Figure 21-1 will give you some feeling for the simulation. The essential elements of it are exponential human population growth, and a considerable vulnerability of prey to human hunting. We did the essential arithmetic, less the wave-like spread and the complementary dynamics of the prey, in the chapter on demography (Chapter 8).

The concept of the "front" is an essential feature of Mosiman and Martin's paleolithic overkill model. As they describe the Figure 21:1:

> Upon reaching a certain critical density, the population of hunters, newly arrived in the New World, expands southward in a quarter circle whose center is represented by Edmonton, Alberta. As long as some prey remains in the area of human occupation, the front advances smoothly. When the local herds are exhausted, it advances in a jump. The range available to the hunted is steadily reduced. The width of the front prevents survivors from "leaking" back into unoccupied areas behind the front. In the position shown, 1,000 miles from Edmonton, the front has begun to sweep through the region of radiocarbon-dated Paleoindian mammoth kill sites. Depending on the simulation strategy, these sites will be overrun in 40-170 years. By the time the front has reached the gulfs of Mexico and of California (radius of the circle = 1,954 mi) the herds of North America have been hunted to extinction (Mosiman and Martin, 1975:305).

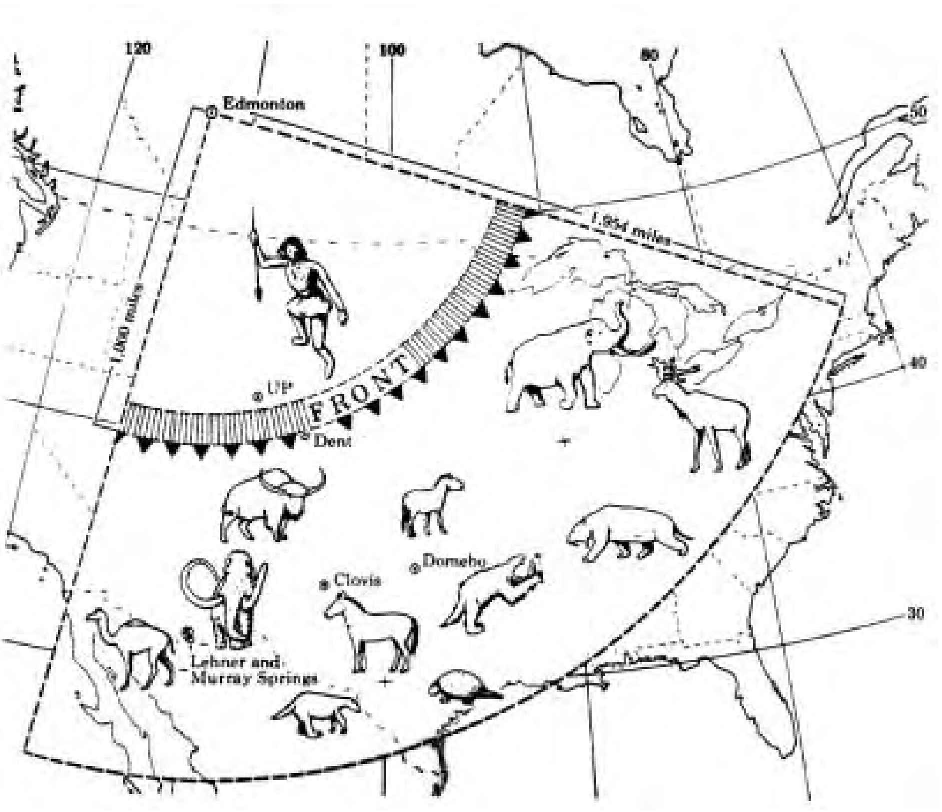
Alternative hypotheses and challenges to the data have been raised. Krantz (1970) argues that direct human hunting pressure could not have been sufficient to cause extinctions. He makes a case for more subtle effects of human activities, suggesting that fire might heavily impact plant communities and indirectly the big game. Of course, the big game is adapted primarily to open grassland anyway, so more of it shouldn't hurt. (We don't buy this argument).

Climate-related hypotheses have also been suggested as alternatives to Mosiman and Martin's hypothesis. The climate argument goes like this. If people were not responsible, then some potent natural force must have been involved. The simplest possibility is environmental change resulting from the fluctuating Pleistocene climate[8]. Some researchers have questioned Martin's dates and the direct association of extinction with humans. Others have also noted that there is some evidence of a wave of bird extinctions in North America.

---

[8] See several of the papers in Martin (1984) for a thorough discussion of this hypothesis.

Figure 21-1. An illustration from Mosiman and Martin's (1975:305) Paleolithic Overkill model.



Climate stress hypotheses are viable. The best data are from North America, where extinctions, humans, and major climatic change all came at the same time. Humans may have been only *part* of the cause (Butzer, 1971). However, the problem with this hypothesis is explaining differential extinction on different continents. Also, it is hard to see why extinctions due to climatic effects should have been so extreme at the end of the last glacial episode when the same fauna had either survived many previous glaciations and deglaciations or at least had been replaced by other, similar species.

What conclusions can we draw about environmental degradation in hunter-gatherers? If Martin's case holds, as we think it very well might, food foragers of the Pleistocene probably were not natural conservationists. Selfishness ruled. Individuals and small groups (bands) were the operational decision-making units and killed megafauna whenever they were hungry. Especially with respect to migratory big game, where herds must have been accessible to many bands, we might well expect that the tragedy of the commons problem would remain unsolved[9].

The actual extent of food forager conservation practices is controversial (Heizer, 1955). The sudden reduction of big game may have led to specialized food foraging, which rapidly led in turn to agriculture. This idea provides a possible model of the origins of agriculture—environmental deterioration!

III. Environmental Relations of Agricultural Societies

A. Substantial Increases in Potential Impacts

The environmental relations of agricultural societies were first studied in the classic book by George Perkins Marsh (l874), *The Earth as Modified by Human Action*. Essentially, these societies are characterized by more dense populations that were more efficient[10] food producers per unit land than hunter-gatherers. Agricultural technology also required more resources per capita (e.g., ore, fuel, forage). This makes more potent impacts possible since there are tools for clearing forests, civil engineering projects, etc.

B. Classic Environmental Degradation Problems of Agriculturalists

The classic effects of farming in habitats that are the least bit sensitive are deforestation, soil erosion, and (in the tropics) soil laterization[11]. Marsh noted these effects in the Mediterranean Basin by comparing ancient Greek and Roman sources with 19th century conditions as he observed them. Where the ancient texts described forests of oak, pine, and other trees, only barren, rocky hills with a bit of goat-chewed scrub were visible.

Kirch (1984) provides clear documentation for several examples of marked environmental deterioration due to impacts of human horticulture in Polynesia. Typically, Polynesian populations greatly reduced fish and game populations in the first centuries after contact, on the overkill model. The first signs of impact are declines in the sizes of shells of exploited mollusks, and the vanishing of flightless bird-bones (many species of vulnerable birds disappeared from the islands a few centuries after humans arrived). Population expansions a few centuries after colonization often caused people to expand cultivation onto sensitive upland soils, where erosion and nutrient loss converted them to degraded fernland savanna. In some cases, there is clear evidence of population decline; the number

---

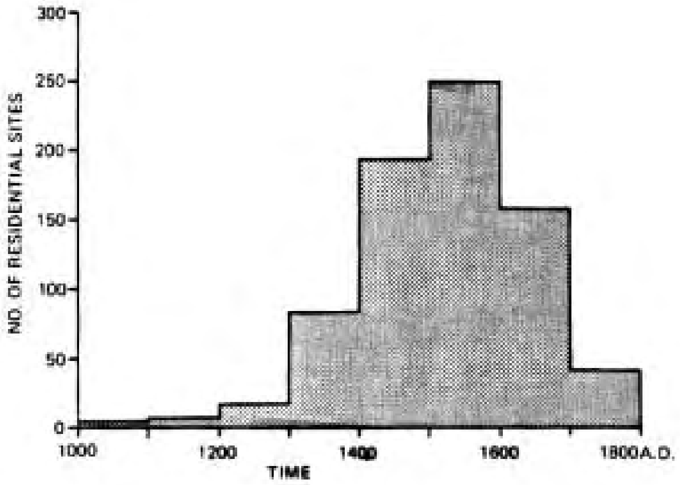
[9] i.e. they hunted the herds to extinction

[10] in terms of per capita productivity

[11] a hardening and mineralization of the soil that leaves it hard and unsuitable as a medium for growing most food crops

of house sites falls after a peak in what looks like an overshoot-and-crash population trajectory. Figure 21-2 shows data from leeward (dry) Kaho'olawe, one of the smaller Hawaiian islands. In other areas, the accumulation of eroded sediment along river flats apparently compensated for loss of upland fields to erosion. Thus, deterioration caused by farmers is less than expected from theory. The Polynesian chiefly system did serve as an effective decision-making system for many purposes, including resource use and conservation. For example, chiefs on many islands supervised the storage of staples against the hazard of typhoons and droughts. Perhaps the degradation of uplands was too slow for the chiefs to understand what was happening, or perhaps the intense competition between chiefs forced them to take a short-run view.

Figure 21-2. Site frequency histogram for Kaho'olawe Island (copied from Kirch, 1984:109).



Did the depletion of England's wood lead to coal use, and in turn to the industrial revolution? It has been argued that this form of "environmental deterioration" was the key to many of the initial industrial innovations (Wilkinson, 1973). This argument is reminiscent of the data from Polynesia. Environmental deterioration provides an impulse to develop new technology to prevent living standards from declining as old resources are exhausted. Usually this results in the running-to-stay-in-place of the Red Queen hypothesis. However, occasionally, there may be a lucky breakthrough that allows a burst of real getting ahead. The shift from wood to coal as a fuel may have set off the industrial revolution as one of these lucky accidents.

Grazing animals kept by horticulturalists and pastoralists can also cause severe environmental damage. The loss of vegetation from overgrazing decreases recycling of water via evapotranspiration[12] and increases the reflectivity of the ground, leading to less total heat absorbed by the ground. Both of these effects may contribute to less thundershower activity in marginal semiarid areas. In this manner, overgrazed dry grass and shrublands may be converted to actual desert, although this mechanism is still a bit controversial.

Under horticultural, pastoral and agricultural subsistence modes, pressures on huntable animals continue to increase, often becoming extreme. Hunting pressure on game animals increases as human populations become larger and more dense. When, as is often the case, humans and game compete for similar habitats, games are also squeezed into more marginal environments. As a result, game populations often decline dramatically—as the Kaho'olawe case illustrates.

C. The Special Case of Hydraulic Societies

Despite their strong governments, hydraulic societies were unable to effectively solve soil salinization and food control. Large-scale “hydraulic” societies based on flood control and irrigation such as arose in around the Tigris and Euphrates Rivers in Classical Mesopotamia tend to have strong central administrations. Under this type of political system we might expect centralized decision-making and planning to lead to effective conservation, at least if decision-makers have the right motives and reasonable information. However, there are two problems that hydraulic societies almost never solve effectively: soil salinization and flood control.

Soil salinization is particularly problematic in arid irrigated areas. This is because plants transpire about 2/3 of the water that is applied to them and concentrate salts in the remainder. These salts must be leached[13] from below the root zone with extra water if they are not to poison the plants. As water percolates through the soil salts build up in the ground water. Consequently if a water catchment basin is not drained, the water table rises, carrying salty water to surface and large areas are therefore gradually lost to production due to soil salinization.

Classical Mesopotamian civilization suffered this problem beginning 2,500 B.C. (Jacobsen and Adams, 1958). The expensive drainage projects required to avoid salinization are often postponed by governments until it is too late. The present situation in California's Southern San Joaquin Valley is extremely serious. The selenium problem you have read

---

[12] loss of water from the soil both by evaporation and by transpiration from the plants growing thereon

[13] washed away by repeated application of water

about in the last few years is only one manifestation of the salt balance problem in this area.

Flood control is also a very difficult problem for hydraulic societies to solve. The problem is that flood waters carry silt which builds up in water channels. The best solution is to dig deep narrow channels so that water flows fast and carries the silt away. A second best, but cheap solution is to build wide floodways with shallow dikes. The problem with wide floodways, however, is that they silt up. This causes the river to gradually rise above its flood plain on its own silt. Eventually, catastrophic floods result when the river overflows into the flood plain. The silt-laden Yellow River of China is especially prone to this problem. A catastrophic flood in 1194 caused the Yellow River to switch its mouth about 300 km south, so that it flowed on the opposite side of the Shantung Peninsula. Then in 1852 it switched back. All of this switching took place in one of the most densely settled parts of China and was responsible for many thousands of deaths[14]. Figure 22-3 illustrates these phenomena.

IV. Conclusion

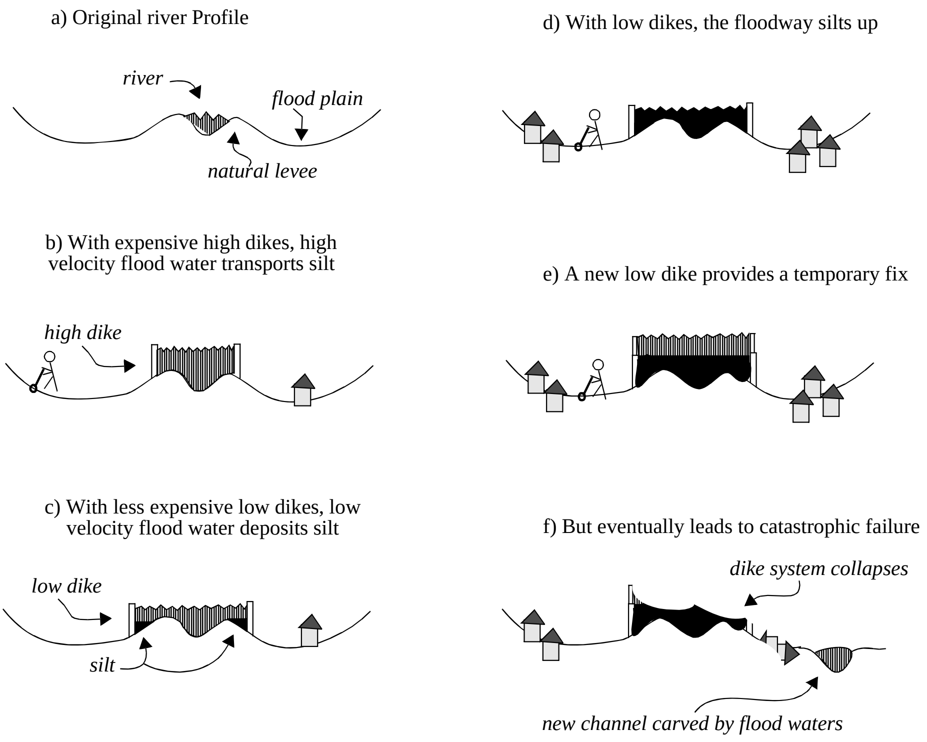
Modern hominids are something of a pest from the perspective of the rest of the Earth's biota. The environmental movement has made us all aware of the problems caused by modern human populations. However, it is quite common to romanticize food foragers and village agriculturalists by assuming that they interacted more harmoniously with nature. If Martin's hypothesis is correct, this assumption is wrong; the first hunters in the Americas and on oceanic islands were perhaps responsible for an even more spectacular wave of mammalian extinctions than even industrial societies have accomplished—thus far at least. Even in the Old World, their impact on game was apparently dramatic. Of course, some human societies presumably cause much less environmental impact than others, and modern industrial societies are certainly unprecedented in the rate they can cause damage, and the exotic forms of damage of which they are capable. On the other hand we have an unprecedented knowledge of environmental matters and sophisticated institutions to reach collective decisions. It seems that ancient hunters might hold the dubious record of most species driven to extinction. Let's hope we don't beat it!

Human (or anthropogenic) modifications of environments are also interesting from a theoretical perspective. Environmental deterioration (and improvement) affects future evolutionary forces on a population by putting new pressures on other individuals, popula-

---

[14] Note that the PRC government is currently planning to build one of the largest hydroelectric dams in the world in this area to provide electricity and flood control. Unfortunately, however, it will also put some of the most striking terrain in East Asia under water.

Figure 21-3. Dynamics of the flood control problem faced by hydraulic societies.



tions and species (the Red Queen again). Also, to the extent that environmental effects are public goods (or 'bads'), their incidence is indicative of human societies' abilities (and limitations) in solving such problems. We will return to this topic in the next chapter.

VI. Bibliographic Notes

References:

Butzer, K.W. 1971. *Environment and Archeology: An Ecological Approach to Prehistory*. Chicago: Aldine.

Hardin, G. 1968. The tragedy of the commons. *Science* 162: 1243-1248.

Heizer, R.F. 1955. Primitive man as an ecological factor. *Kroeber Anthropological Society Papers* 13: 1-31.

Jacobsen, T. and R. M. Adams. 1958. Salt and silt in ancient mesopotamian agriculture. *Science* 128: 1251-1258.

Kirch, P. 1984. *The Evolution of Polynesian Chiefdoms*. Cambridge: Cambridge Univ. Press.

Krantz, G.S. 1970. Human activities and megafaunal extinctions. *Amer. Scient*. 58: 164-70.

[15]Marsh, G. P. 1874. *The Earth As Modified By Human Action*. New York: Scribner, Armstrong.

Martin, Paul S. and H.E. Wright (eds). 1967. *Pleistocene Extinctions*. New Haven: Yale Univ. Press.

Martin, Paul S. and Richard G. Klein, eds*. 1984. Quaternary extinctions: a prehistoric revolution*. Tucson, AZ: University of Arizona Press.

Mosiman, J.E., and P.S. Martin. 1975. Simulating overkill by Paleoindians. *Amer. Scient.* 63: 304-313.

[16]Stewart, O.C. 1956. Fire as the first great force employed by man. In: W.L. Thomas, Jr. (ed.) *Man's Role in Changing the Face of the Earth*, pp. 115-33. Chicago: Univ. of Chicago Press.

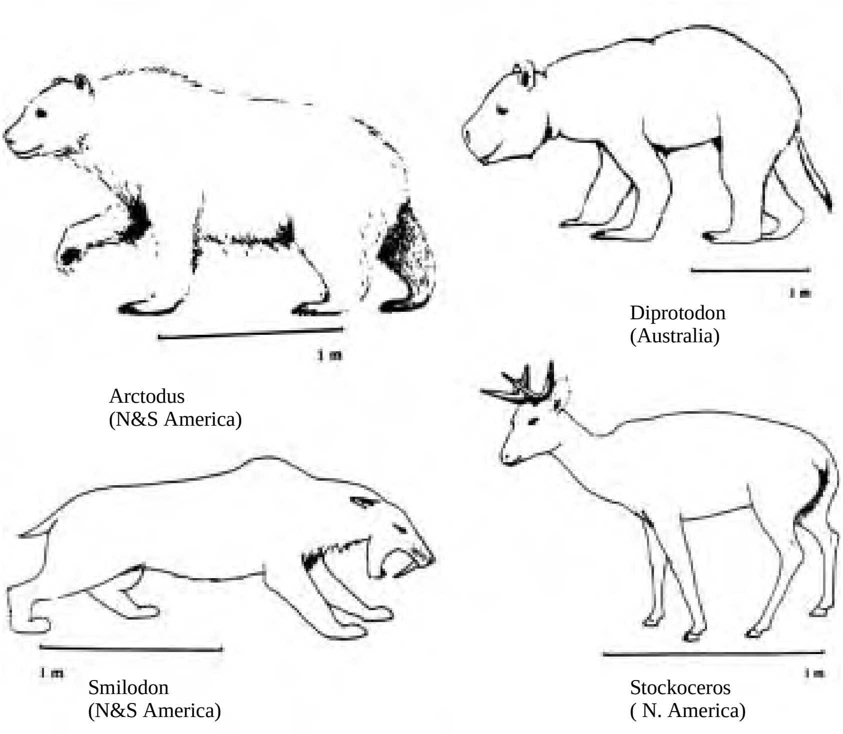
Wilkinson, R.C. 1973. *Poverty and Progress: an evolutionary model of economic development*. London: Methuen.

---

15. There is also an Arno Press Reprint edition; this book is a classic of the environmental impact genre. Marsh was a New England congressman and later US ambassador to Turkey and Italy. He was able to compare old, careworn Europe with relatively pristine America.

16. This book is a classic; it contains 30-40 papers summarizing various impacts. Many of the historical chapters are still useful.

Figure 21-4. Some of the species lost during megafaunal extinctions in North America and elsewhere. (Illustrations copied from Martin and Wright 1967)



Arctodus
(N&S America)

Diprotodon
(Australia)

Smilodon
(N&S America)

Stockoceros
(N. America)

Figure 21-4. (continued)

Need to scan in 2 pages of figures from last year's text

Figure 22-4. (continued)

Chapter 22. TECHNOLOGY AND ENVIRONMENTAL DETERIORATION: INDUSTRIAL SOCIETIES

> "The benefits of projects, to whomsoever they may accrue, must exceed the costs."
>
> U. S. Bureau of the Budget Circular, 1937
>
> "What [Arrow's Impossibility Theorem] shows... is that there is no way of aggregating individual preferences for societies into a social preference that does not infringe on one of a number of perfectly reasonable requirements, for example that no one person be a dictator....
>
> David Collingridge, 1982

I. Introduction

As we saw in the last chapter, a good case can be made that human impacts on, and enhancements of, ecological processes are ancient problems and possibilities. How are contemporary industrial societies different? The argument in this chapter is that industrial societies have escalated both our abilities to solve environmental problems and our abilities to create them. The jury is still out on whether on net industrial societies are better or worse environmental deteriorates than pre-industrial ones.

People from the long-civilized Old World are said to tend to view Americans as naive. American political culture is deeply affected by a 19th century idea, utilitarianism. Roughly speaking, this idea holds that if individuals are rational they can create collective institutions that, using scientifically based techniques, can solve virtually any problem. When rational means to solve problems fail, Americans tend to fall back on an even older traditional strain of thought, "fundamentalism." We tend to blame the failure on people with selfish or evil motives. In other words, we tend to act as though any failure must be due to the malicious and intentional behavior of a person or group; seldom recognizing that even the 'pure of heart and analytical of mind' are sometimes wrong. Whether unique to Americans or not, this view is naive.

In this chapter, we'll review the theory that suggests that things are nowhere near this simple. We'll see that contemporary societies exemplify two inescapable difficulties in attempting to solve problems, what I'll call the "***problem of information***" and the "***problem of values***". This does not mean that contemporary societies cannot solve their problems, only that they can only do so if they take account of these difficulties and find ways around them. In other words, there is no need to adopt a pessimistic fatalism about the contemporary problems of the world, but there is good reason to abandon fatuous optimism and the tendency to view all problems as the result of evil intentions.

II. Specific Adaptive Challenges of Contemporary World[1]

A. Modern Societies Confront Serious New Variants of Old Problems

You know the standard laundry list:

Food Production: People in many parts of the world are chronically near subsistence disaster. When economic, political, or natural catastrophes occur, massive numbers of them are often pushed over the brink.

Energy and raw materials: Maintaining and expanding industrial production requires stable access to affordable energy and raw materials. This threat has receded dramatically since the 1970s as commodity prices from oil to silver to wheat have plunged, but it will no doubt return. (As of today OPEC is failing to hold the line on oil prices. Before one gets too optimistic about the long-run availability of cheap gasoline, remember that something like half the oil left in the world is in the politically unstable and militarily vulnerable Persian Gulf region—Iraq’s 1991 invasion of Kuwait vividly demonstrated this point.)

Population: Our very high and rapidly growing world population is approaching malthusian and/or ricardian limits. While some nations are terrified by the implications of this growth, others are dedicated to population growth.

Pollution: Threats from by-products of intense industrial and agricultural production appear to be worsening. Perhaps the most pernicious of these problems are the climatic changes that atmospheric scientists project will flow from fossil fuel combustion. The carbon dioxide released by fossil fuel combustion will double its concentration in the atmosphere over the next century or so. Since carbon dioxide is a “greenhouse gas”, slowing the rate at which heat is radiated away from the earth without much affecting heat gain from the sun, this is likely to lead to climatic changes, including a temperature rise of several degrees, and a concomitant rise in sea level of many feet. The disruption to present settlement patterns and agricultural systems is liable to be massive.

Similarly, it appears that damage to the Earth’s ozone layer by pollutants such as chlorofluorocarbons (CFCs)[2] may expose people to much larger doses of carcinogenic ul-

---

[1] This is essentially a laundry list of problems about which most of you are reasonably familiar. We therefore will not go into them in great detail. The purpose of listing these problems here is to set the stage for the general analysis which follows.

[2] any of a group of compounds that contain carbon, chlorine, fluorine, and sometimes hydrogen and are used as refrigerants, cleaning solvents, and aerosol propellants and in the manufacture of plastic foams

traviolet radiation from the sun.

Violent international conflict: The world is presently experiencing a reduction in the "normal" level of violence; the Iran/Iraq and Afghan/USSR conflicts are over and the threat of nuclear war between imperial superpowers seems to be substantially diminished. However, the risk of nuclear devices being used by a small group or nation appears to have increased with the loss of centralized control over the former USSR's nuclear arsenal. Moreover, as the devastation of the Persian Gulf region showed, even conventional warfare can have catastrophic environmental consequences.

Poverty: In many countries, the per capita production of wealth is extremely low[3]. In even the richest nations, maldistribution of wealth between classes creates problems and maldistribution of wealth *between* nations is even more striking.

Race, ethnic, class, and national prejudices: Even the most economically advanced and pluralistic industrial states have serious problems with prejudice and conflicts between different racial, ethnic, and national groups. Ones serious enough to make the newspaper lately include the Catholic/Protestant conflict in Northern Ireland, Tamil/Sinhalese violence in Sri Lanka, the Intifada in Israel/Palestine, Basque terrorism in Spain, Latin American leftist revolts and terrorism countered by state "dirty war" tactics in Chile, Argentina, Peru, and Guatemala, Sikh/Indian conflicts, Armenian/Azerbaijan riots in the former USSR, conflicts between several ethnic and religious groups in Yugoslavia, fighting between Mujahadeen groups from East, South, and Northern Afghanistan, and the atrocity-ridden civil wars in Liberia, Lebanon and Angola. You can extend this list yourself. Of course, conflicts between whites, blacks, and "coloureds" in South Africa in many ways exemplifies this entire genre of problems.

Strong international interdependence, but weak international institutions: Even putting aside war-and-peace issues, international institutions are not very effective, and international affairs often tremble on the brink of catastrophe. Trade, debt, and monetary issues threaten economic collapse from time to time, and often catch particular nations and subgroups within nations in a cruel economic plight. American wheat growers and Latin Americans in general are recent victims. Perhaps the most dramatic recent example involves the collapse of the former USSR's economic institutions. Perhaps the best positive note here is the recent growth in the United Nations' stature following large-scale international cooperation during the Persian Gulf War.

---

[3] Some examples of annual per capita Gross National Product in 1983: Switzerland=$15,552; U.S.=$13,492; Canada=$11,535; Japan=$9,149; Spain=$4,774; South Korea=$1,870; Turkey=$1,125; Nepal=$153; Ethopia=$147; Bangladesh=$124.

In sum, a large number of problems of great scale face us at the close of the twentieth century. The inset on the following page is an essay written by Britain's Prince Charles regarding the 1992 Earth Summit. It illustrates many of the problems with which we are dealing in this chapter.

B. Modern Societies Have Unprecedented Means With Which to Solve Problems

We have access to more institutional, organizational, economic, and cooperative resources on a larger scale than at any time in the past. For example we have:

a. Institutions for the development of science and technology such as universities.

b. Rational government and private industry bureaucracies to apply science and technology.

c. Rationalized markets with carefully administered flows of information and cheap transportation of people and goods.

d. People with broader loyalties than in the past.

This latter point bears explication. Most modern states can normally count on a reasonable level of sentiment in favor of reasonable solutions to national problems. This was much less true a few centuries ago before nationalism became a powerful ideology. In Europe, loyalties remained primarily to one's village, city or district until the last few hundred years. In many places rather narrow loyalties are still the rule. "Tribalism" is much more important than nationalism in most contemporary African states, for example. And there is no guarantee that political loyalties will remain at the nation-state level, much less will expand; witness the various ethnic separatist movements in Europe and the West-Asia. Essentially, it seems that the scale at which we are able to solve public goods problems is limited by the scale of our loyalties.

The scale at which we are able to solve public goods problems appears to be limited by the scale of our loyalties.

C. Given Such Powerful Means, Why are Our Problems Not Easily Solved?

Bad motives and stupidity do not create the world's problems. The frequent refrain of editorial writers that "If mankind can send a person to the moon, why can't we solve ________(fill the blank with any modern problem)_______?" is instructive. But questions of this form are rooted in fundamental problems. As is the case with warfare, it is not just simple bad motives and stupidity that create these problems. Rather the difficulty in solving these problems arise from (1) discrepant values; and (2) limited information.

Problems arise from differences in values between individuals and between groups. The essence of the “value problem” is that individual preferences vary according to each person’s system of values. This means that the **value** we place on a particular good or service reflects our own preferences and group loyalties—not necessarily what is best for humanity. In other words, even though humans engage in a great deal of cooperative activity, the scale at which they are willing to subordinate their personal desires in favor of group needs tends to be quite limited.

“Mankind” does not solve its problems[4]. Individuals and groups of various sizes and levels of cohesion solve their own problems, and in so doing often create problems for others. For example, the U.S.’s high interest rate policies of the 1980s were designed to correct our inflation; but they had a savage effect on countries that had borrowed too much money[5] at high nominal interest rates. The idea here is that conflicts between people usually stem from deep causes, not from mere easily-corrected mistakes or simple evil intentions. Recall the problem of the evolution of cooperation in this context. The logic of the tragedy of the commons or of arms races is “out there” in the real world, not just a result of a few bad people's selfishness. If our theory is correct, even if we begin with societies of saints, these kinds of dynamics would tend to bring us right back to the present set of problems after a few generations of cultural evolution. This not to say that there are no people who are just plain rotten. Rather, it is important to remember that the worst of us are only a small part of the problem, compared to more deep-seated problems associated with living on a limited planet.

Problems arise from limited information. It is hard to predict the future. Even the best science is limited. Climate modeler Steven Schneider describes the best attempts to predict the effects of CO_2 increase on climate as “a dirty crystal ball.” One reason many developing countries (and their bankers) got in such a desperate debt jam is that 10 years ago almost everyone expected commodity prices to keep on rising, and inflation to remain high. Borrowing billions of dollars at real interest rates of zero or less, against expected oil revenues at $30/bbl and rising, seemed sophisticated to Mexican policy makers (for example). Take the ‘First World’ bank depositors for a ride, they could afford it! Then Paul Volker slammed on the brakes and OPEC lost control of oil prices and the potential value of Mex-

---

[4] This is known as the fallacy of the collective singular.

[5] which seemed like a quite sensible thing to do during the inflationary times in which the debts were contracted

ico’s resources slumped. How can effective long term goals be achieved when unpredictable decisions can upset the most carefully thought out plans?

III. Two Fundamental Problems for Rational Problem-Solving

The problems of large-scale cooperation and environmental limits and the information problem challenge the ability of even the most sophisticated rational problem-solving institution. Let’s examine them in more detail now:

A. The Problem of Values—It’s Human to Fight

As an individual, family member, community member and national all humans hold somewhat unique values and expectations. We have already discussed this problem from the perspective of the evolutionary theory of cooperation and the game theory analysis of war. Social scientists often refer to a theoretical position, conflict theory, derived from Karl Marx in this context (Dahrendorf 1974). The main difference between the Darwinian approach and that of traditional conflict theory is that conflict theorists tend to take as given that conflicts occur mainly between groups, whereas **D**arwinians focus more on conflicts among individuals**.**

The basic problem is that because people all want the same scarce resources they cannot all be happy[6]. They want to satisfy their basic subsistence needs. They want love, respect, and social interaction. And they also want status and power.

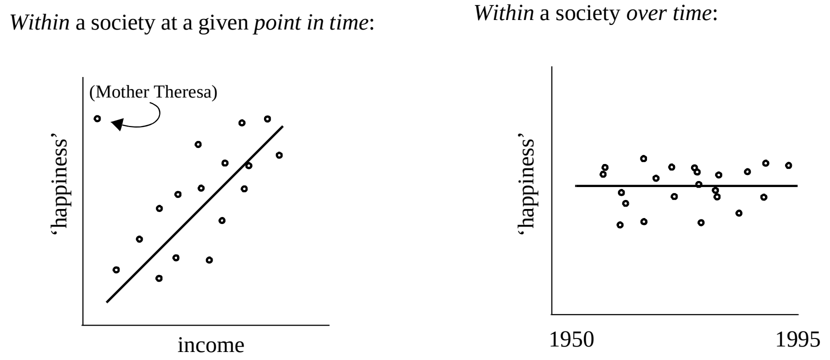
Status, wealth and power are rather pathological if what we enjoy about them is having more relative *to others*. What is crucial to understand is that these needs are in part inherently impossible to satisfy for everyone because satisfaction comes from the degree to which one has *more* than one’s fellows. Economist Richard Easterlin's (1976, 1995) empirical case that relative wants are just as real and perverse as in theory is illustrated in figure 22-1. What Easterlin did was to collect data on happiness in many countries at many points in time, as collected by standard polling techniques. It is quite typical in these surveys to find that wealthier people are happier. Modern industrial economies are growing rapidly, and making us all wealthier year by year. To the extent that industrial economies are mainly satisfying real desires for personally useful things, economic growth per capita should make us happier on average. But to the extent that it is merely satisfying relative wants, the rising tide will lift all boats equally, and on average no one will feel any better off. The data strongly support the relative wants hypothesis. A dramatic example is Japan. Since 1958, the Japanese income level per capita has expanded five-fold, from 1/8 of that in the US in

---

[6] W.D. Hamilton referred to this problem as one of the main reasons to expect little cooperation in nature.

1958 to 2/3 of that in the US in 1987. Over that time the measured level of happiness in Japan has been dead flat! Other advanced countries in which many surveys are taken tend to have more ups and downs than Japan, but no evidence of any upward trend..

Figure 22-1. The problem of relative wants and relative satisfaction is illustrated by hypothetical plots. Here we compare the relationship between 'happiness' and wealth *within* societies at a particular point in time with the same relationship *within* societies or within a society *over time*. (Adapted from Easterlin 1976, 1995.)



This relativity of satisfactions hypothesis proposed by Easterlin may even extend to international comparisons (e.g., the "revolution of rising expectations" in Third World countries due to mass communications). People may not get much satisfaction from being absolutely better off, if people in other countries are still relatively better off. In other words, as we saw in an earlier chapter, people in many Third World countries are getting rich faster than the now-advanced countries ever did—largely because of the rapid diffusion of innovations. But they are also becoming literate, getting TVs, and finding how much worse off they are than Americans and Europeans[7] The data as of about 1960 showed no significant trend as a function of GNP per capita. Nigerians were about as happy as West Germans, for example. However, by 1984, significant cross-cultural trends had appeared. People seem to have begun to make comparisons not just within their own society, but across all societies. When Nigerians start to watch television, they discover from movies and the like just how much better off Europeans really are, and perhaps vice versa. The Nigerians become less happy and the Germans more.

Another economist, Robert Frank (1985, personal communication), speculates that the communication revolution is having the effect of making most people in the world more

---

[7] See footnote 3.

systematically *unhappier*. Suppose that the effect of cheap mass communication is to make everyone more aware of how well off, talented, beautiful, respected and so forth other people are. Even those of us who are quite comfortable will be reminded daily by celebrity stories and video images that there are people a lot more comfortable, talented, beautiful, and respected than we are. Before mass media, those of us in comfortable circumstances were happy big frogs in small ponds. Now we realize how relatively small our pond is. It could be possible that the mass communications revolution has had the effect of massively deflating relative wants.

Note that the Easterlin-Frank hypothesis is an exceedingly radical challenge to the very foundations of modern industrial society. President Jimmy Carter discovered the danger of tampering even marginally with the sacred principle of modern politics that economic growth is good. Virtually every world leader promises economic growth, and attempts to deliver. The Soviet Empire fell because Communism couldn't deliver economic growth. Only the Pope and a few other old-fashioned and hippy-environmentalist romantics have dared to question economic growth. Yet the argument of Easterlin and Frank is from the hard-headed school of modern economics. Above some apparently rather low threshold, all economic growth appears to do is to give individuals temporary satisfactions of envious desires. When I get my new car it gives me great pleasure to have the nicest one among my friends and gloat on their envy. But then it fades a bit, and one day Jones comes home with a shiny new one and it is my turn to suffer the pangs of envy. This makes economic growth much like the Red Queen idea, or like an addiction. We feel each increase in our paycheck as a pleasure, not understanding that the rising tide of economic growth will soon cause us to demand another fix. The economy must run faster and faster but all it does is keep us all at the same level of happiness. Or we can fall behind merely by knowing more about the bigger fixes of others.

Partly because of intense competition, groups of people specialize with respect to how they satisfy goals. To some extent, they even specialize in *which* goals they select. These groups are sometimes culturally endogamous units, and therefore might be subject to some measure group selection. At any rate, they seem to be foci of cooperation[8]. This tendency is particularly marked in modern societies where we have many interest groups. Conflict between these groups becomes highly organized, and is often highly rationalized as well. These groups often employ some type of technology (e.g., armies; opinion polls) in their conflicts.

---

8. For a solid introduction to this suite of problems, see Olson's (1982) *The rise and decline of nations: economic growth, stagflation, and social rigidities*.

What we see is humans using rational means and the tendency to cooperate to solve problems at the individual, group, and sometimes even national scale. Seldom however, do we find humans using their potential to solve the problems of humanity. Our loyalties to nations, ethnic groups, co-religionists, etc. shift the scale of conflict, but do not eliminate it. As we saw in the case of war, conflict can arise in certain situations for quite sensible but perverse reasons. The logic of arms races can lure us forward—in spite of our attempts to behave in an objectively rational manner. This, of course, is problematic because we are moving rapidly toward a global community; increases in population, improved transportation and communications technology, and the emergence of a global economy all cause 'local' problems to be felt by more people than ever before.

B. Problem of Information—It's Human to Err

Rational calculation has clear limits. Fundamentally *unpredictable* events such as the random nature of weather, earthquakes, stock markets, wars, and whims of important political figures have important consequences. Even events that are potentially predictable may not yet be scientifically understood; this sometimes makes them hard to separate from the last category. Moreover, information is costly—almost all decisions are made with less than the maximum conceivable amount. You are quite familiar with this argument by now; the high cost of learning (or scientific research, to take a more sophisticated example) is quite fundamental to explaining human behavior. Problems associated with informational deficits are aggravated by intentional deception on the part of governments, businesses, and various interest groups (e.g., "disinformation" campaigns by government intelligence agencies, misleading advertising, political campaign propaganda, etc.).

IV. Organizing Rational Solutions to Social Problems

There are two fundamentally different rational approaches to solving large-scale social problems, market rationality and plan rationality. Each approach uses a different scheme for organizing critical social interactions[9].

A. Market Rationality

Markets are organized around an institutionalized set of rules that govern interactions between individual rational actors, allowing them to collaborate in exchange transactions for their mutual benefit. Much of American and British economics deals with the workings of (idealized) markets. Although we generally associate the concept of "market" with financial and business transactions, market models of the political process in democratic legislatures have also been extensively analyzed. Liberal democracies, at least, create

---

[9] discussion borrowed from Dahrendorf (1968:ch. 8)

a “market” in which the commodities are votes and influence. Economic and voting markets have in common that society's decisions are the aggregated outcome of individuals’ expressions of their preferences.

One of the key advantages of markets is that individuals get to express their own preferences (which are based upon personal value systems) directly. Markets enable very elaborate and efficient flows of information between producers and consumers via price signals. No one person needs to know very much about the details of what is going on, just the price. Anarchy works.

One of the important disadvantages of markets has to do with the values upon which market rules are based; fair rules are hard to agree upon. In extreme cases, there is a systematic distortion of price by powerful interest groups. Moreover, people may create and participate in “black markets” in sex, drugs, slaves, guns, etc. that are inimical to the common good. In fact, this is the public goods problem in another disguise. Here public health and well-being is the ‘good’. As the “tragedy of the commons” illustrates, people or groups expressing their individual rational preferences can cause collective catastrophes.

Public goods problems are one of the best-studied examples of market failure. As we've seen before, this problem is closely related to the problem of cooperation and altruism. The benefits and/or costs of some goods inherently accrue to the group rather than individuals. In these situations where everyone enjoys what one person buys (union dues, military service, air pollution control), people tend to hang back, hoping someone else will pay. As the selective service (draft) records of several recent Presidential candidates indicate, cheating is hard to control in these situations. As a result, public goods are under-provided by markets and require us to employ strategies such as coercive collection of payments (taxes, dues) and collective provision of benefits.

Markets also have information problems. It is hard to set up markets for goods that individuals use in very small quantities. For example, it is difficult to negotiate the opportunity to fish in a river once in awhile vs. the opportunity to pollute it all the time. In these cases, the bargaining costs are too high since every polluter cannot bargain with every fisherman. Perhaps even more important, it is hard to represent future generations; we are uncertain about their preferences, and they are not around to bargain for themselves.

B. Plan Rationality

Non-market economies attempt to organize a collective, rational attack on problems, rather than depend on the individualist anarchy of markets. As was just discussed, markets clearly fail to solve many kinds of public goods problems. Collective, plan-organized solutions clearly prove superior in certain cases. Under plan rationality, collective bureaucratic institutions are created that identify goals, collect information, develop and evaluate plans, then choose and implement those plans that provide the greatest benefit for the most people. At least this is usually their initial intent.

Plan rationality has the obvious advantage of being theoretically able to escape the kinds of selfish rationality that can lead to obvious disaster. We can organize ourselves to make collective decisions on behalf of the whole group and evade the problems caused by the myopic rationality of individual decision-makers in markets. The problem of free riders or cheaters can be controlled by legitimate coercion (taxes, dues, fines), so long as we can decide what is legitimate. This approach is also more efficient for organizing and processing information on a larger scale that allows the rational consideration of problems that effect many individuals slightly.

One of the key disadvantages of plan rationality has to do with the valuation of individual preferences. It is very hard to aggregate value preferences in order to arrive at general goals. In welfare economics this is referred to as the Social Decision problem. For example, is it fair to compare anyone's values with anyone else's? How can we say l0,000 white water kayakers do or don't enjoy their sport more than l,000 farmers enjoy cheaper water? How do we make such policy decisions? The Italian economist and sociologist Vilfredo Pareto (1848-1923) examined this problem and developed the concept of “Pareto optimality” which refers to the point at which an increase in public goods for one person or group would make another worse off. His idea was that we should do anything that will make someone better off without making anyone else worse off. This is a nice, but impractical, idea since many of the most pressing problems with which we are faced require that some bite a bigger bullet than others. The essay by Prince Charles of Britain provides several examples of this problem.

The problem with plans is that they must almost always conflict with someone's values. Plans are therefore likely to be made in the interest of the stronger party, unless political power is equally distributed (and it never is). Even if goals can be developed, planners may not try to achieve them, as the USSR’s central planning demonstrated, they often pursue their own interests instead[10]. Utopian goals can easily lead to tyranny. Economist and Nobel prize winner Kenneth Arrow showed that rational dictators lead to *formally* rational societies. Plato proposed a similar rationalist solution long ago. The obvious trouble is that benevolent, rational dictators are hard to come by. If we try too hard for rational societies,

---

[10] In this putatively most equal of all societies, *aparatchicks* (bureaucrats) became the new aristocracy with their own stores, schools, resorts, and even traffic lanes in major cities.

dictatorships may be the result[11]. Arrow also showed that social decision-making could be rational if everyone has the same preferences.

The problem of formulating acceptable rules for aggregating individual preferences to reach social decisions was also analyzed by Arrow -- he termed it the "Voting Paradox".

Table 22-1. An example of a public goods problem about what, if any, type of dam should be built on a currently pristine river. The preferences of three different interest groups are given.

preferences	**Fishermen & River Runners**	**Wild River Enthusiasts**	**Farmers**
A. Small Dam	1st	3rd	2nd
B. No Dams	2nd	1st	3rd
C. Big Dam	3rd	2nd	1st

As you can see from Table 22-1, there is no happy middle ground that will please all three interest groups. If all three were equally influential[12], it would be difficult to identify a compromise position at all. Now, suppose we use voting to determine what society prefers (see Table 22-2).

Table 22-2. The problem of ranking preferences.

Society Prefers	**Should Therefore Logically Prefer**	**But Society Actually Prefers**
A to B & B to C	A to C	C to A

What does Society prefer??? In this case society is irrational, and intransitive[13]. Arrow demonstrated that this is a general theoretical problem (e.g., markets have the same general problem); in general it is not possible to find a decision-making rule to aggregate the rational preferences of individuals and still maintain standards of rationality with regard to social choice. Arrow (1963) argued that there is no ethically acceptable way to anticipate and prevent this problem. For example, the problem can be solved if we allow a dictator to make decisions for society, but this, says Arrow, seems like a solution that is worse than the problem. No successful challenge to Arrow's reasoning has yet been found (Collin-

---

[11] Or is it that societies are prone to the rise of dictators when the irrationality of social decision-making becomes too extreme?

[12] Fat chance in California with the powerful agricultural lobby!

[13] Remember the transitive rule from algebra? "A binary relation ~ on a set *S* is **transitive** if, for all *a, b,* and *c* in *S*, whenever $a \sim b$ and $b \sim c$ then $a \sim c$ (Clapham 1990:177)."

gridge, 1982). So much for the optimality of Vilfredo Pareto!

For an empirical example of how voting on the basis of individual rationality can lead to collectively irrational results see Ferejohn's (1974) analysis of porkbarrel politics in rivers and harbors legislation, especially his last chapter. Interestingly, the direct empirical work on Arrow’s paradox is very thin. Perhaps because few economists stoop to collecting data and few political scientists are comfortable with Arrow's level of abstraction, no one has been attracted to the problem.

V. Conclusion

The improvements in rationality developed in the course of the rise of industrial civilizations are indeed revolutionary. They have proven excellent tools for solving *some* of the problems that plague commercial-industrial societies, such as epidemic disease. However, industrial societies have also exacerbated old problems, for example by applying science and industrial techniques to warfare, by becoming extremely dependent on non-renewable mineral resources, by generating geochemically significant amounts of trace gases like CFCs and carbon dioxide as pollutants, and so forth.

If the theory reviewed in this chapter is correct, there is a fundamental continuity in the problems of modern and ancient societies. There is no obvious “solution” to the value and information problems. The limitations of cooperation and social decision-making seem to be quite fundamental arising, as they do, from selfishness at the level of the individual, family, community, nation or even species[14].

If markets and market-like political mechanisms (“democracy”), and planned solutions (“socialism”) do solve the particular problems of the modern world it will be because of hard, careful, scientific, managerial and political efforts that *finesse* the fundamental problems rather than “solve” them. That is, by careful attention to detail and a little luck we can probably evade the worst consequences of value and information problems in most particular cases. Furthermore, conformist effects that make individuals more homogenous in terms of their basic values (see Chapters 11 & 12) can perhaps help in reducing conflict and stalemate. But there is not likely to be a scientific or moral breakthrough that will allow us to solve them in principle.

---

[14] Species included, because we do things to other species (experiment on them, eat them) that we cannot countenance doing to our own species.

VI. Bibliographic Notes

References:

Arrow, K J. 1951 (1963, 2nd edition). *Social Choice and Individual Values*. New York: Wiley.

Collingridge, David. 1982. *Critical Decision Making*. London: Frances Pinter.

Clapham, Christopher. 1990. *A Concise Oxford Dictionary of Mathematics*. Oxford: Oxford University Press.

Dahrendorf, R. 1959. *Class and Class Conflict in Industrial Societies*. Stanford: Stanford University Press.

Dahrendorf, R. 1968. *Essays in the Theory of Society*. Stanford: Stanford Univ. Press.

Easterlin, R.A. 1976. The conflict between aspirations and resources. *Pop. Dev. Rev.* 2: 417-25.

Easterlin, R.A. 1995. Will raising incomes of all increase the happiness of all? *J. Econ. Behav. Org.* 27: 12-29.

Frank, R. H. 1985. *Choosing the Right Pond* New York: Oxford University Press.

Ferejohn, J.A. 1974. *Pork Barrel Politics*. Stanford: Stanford Univ. Press.

Olson, Mancur 1982. *The rise and decline of nations: economic growth, stagflation, and social rigidities*. New Haven: Yale University Press.

Chapter 23. MACROEVOLUTION: MICROEVOLUTIONARY PROCESSES AND THE HISTORY OF THE HUMAN SPECIES

> We view *Homo* as an evolving genus that beat the odds. It overcame the resistance to advanced cognitive evolution by the cosmic good fortune of being in the right place at the right time."
>
> C. Lumsden and E.O. Wilson
> *Genes, Mind, and Culture* (1981)

O. Introduction to part IV of the course, "Evolutionary Transformations of Human Ecological Patterns"

Human evolution is a great saga: How did the human species and our component cultures arise from a chimp-like ape to become, ultimately, modern humans? The first three parts of the course have described the ecological/evolutionary typology of human societies, the basic evolutionary mechanisms that operate on human populations, and some of the systemic environmental interactions of human populations. In the last part of the course, we want to turn back to the main types of human societies and ask how each one might have evolved. That is, how and why might humans have evolved from apes in the first place? Why did hunting societies eventually give rise to horticultural ones, etc.? Can we use the science we have described in the previous chapters to inform our understanding of human history?

This last, seemingly innocent, question gives rise to the fascinating, fiercely debated issue of the relationship between historical and scientific explanation. Both evolutionary biologists and social scientists are confused and uncertain about what kind of answer we can give to these most interesting questions. Recall the discussion of Steward's failure to connect his ecology and evolution described in Chapter 2. Problems like his are still important. This is one of those easy-to-visit frontier areas of science where you can see fairly clearly for yourself how we scholars struggle for new knowledge on the edge of the sea of ignorance!

Part of the problem is conceptual. Science is about general "laws," explanations that cover many cases. But humans are members of one, unique, historical lineage. Can science say much of anything about solitary cases? Are historical and scientific explanations either conflicting or even opposed modes of explanation?

Part of the problem is practical. Historical events happened a long time ago, and most of the evidence is lost. A powerful theory would help us fill in the gaps of incomplete data. Students of biological and cultural evolution do indeed have a a fairly powerful set of theoretical tools derived from observation and experiment. However, of course the best data come from short-term experiments and observations in the lab and field. Thus we understand *microevolution* (events on the time scale of a few years) fairly well. *Macroevolution* is a more problematic phenomenon. Large-scale historical changes take place on time scales of thousands to millions of years, far beyond the direct reach of experiments and observation. If there are any macroevolutionary phenomena that are hard to detect with microevolutionary experiments, we are in trouble with gaps.

In this chapter, we outline the issues involved in trying to extrapolate from a micro theory to a macro account. We tentatively conclude that a scientific micro-based account of macroevolutionary historical phenomena is probably possible, but that scientists have to admit that history offers real and special problems.

In the subsequent chapters, we will apply the basic models developed in the course to explanations of the basic macroevolutionary transformations in human history. You will see that there are some fascinating hypotheses around, though none that meet demanding tests. On the other hand, many hypotheses can be eliminated using current theory and data.

***Microevolution*: The processes of evolution as observed through direct observation and experiment. The microevolutionary time scale is from one to a few generations or cycles of cultural transmission.**

***Macroevolution*: The process of evolution as observed through paleontology, archaeology, and history. The more dramatic events of evolution (new species, new technological systems) occur rarely and slowly and are not directly observable in the present. The time scales involved are tens to hundreds or many more generations or cycles of cultural transmission.**

I. Conflict Between Scientific and Historical Explanation

The conflict between "scientists" and "historians" has a long tradition in the social sciences. Two of the most important founding documents in human ecology, Peter Vayda and Roy Rappaport (1968) and Donald Campbell (1975) are explicitly critical of merely descriptive historical approaches to human history. Other very prominent social scientists, such as Marshall Sahlins (1976) and Clifford Geertz (1973), started their careers as "scientific" human ecologists, but later wrote very critical accounts of such studies from the historical side. More recently, Misia Landau (1991) has analyzed scientists attempts to give an account of human origins and argues that all the classical accounts have the structure of folk hero myths. Attempts to do "science" seems to have resulted in mere mythologizing; a very tart accusation as you can appreciate from our standard scientists' condemnation of mythologizing in Chapter 2!

Historians ask: Aren't explanations of human social life necessarily interpretive and particularistic? Any given unique evolutionary trajectory has to be explained by events unique to that trajectory, not by general laws that apply to every case. Aren't present phenomena are best explained mainly in terms of past contingencies, not ahistorical processes like function or adaptation that would erase the trace of history if they really were important? Like other "scientific," antihistorical explanations of human cultures, the argument goes, Darwinian models cannot account for the lack of exact, complete correlation of environmental and cultural variation, nor the long term trends in cultural change.

The "scientists'" answer is classically that when one ignores scientific theory, all that is left is a descriptive narration of historical events using informal folk categories. Each case of an evolutionary history may be unique, but the cases as a whole fall into patterns underlain by understandable processes. The patterns and common processes then tell us much about why each case behaved as it did. Certainly, many historical patterns are complex and the facts are few, but to give up on science is to give up on the only truly powerful set of investigative tools we have. No matter how difficult the problem is, we can always do better using science than if we don't. To the "scientist," the "historians'" arguments are just a disguised way of avoiding the hard task of real understanding in favor of easy but completely unsatisfactory story-telling that is hardly different from writing fiction.

In this chapter we argue that the attempt to make a fight out of "history" versus "science" is a mistake. (1) The historians are correct to point out that there are many examples of real historical change in human macroevolution. Scientific human ecologists have sometimes tried to ignore historical patterns of change, and have been guilty of oversimplifying the connection between micro and macroevolution. (2) Modern evolutionary models in fact have several basic mechanisms that can generate historical macroevolutionary patterns. "Historians" cannot claim that observed historical patterns are inexplicable from the "scientific" point of view.

If these points are correct, when we remove the quotes science and history really are one approach. Darwinian theory is both scientific and historical. The history of any evolving lineage or culture is a sequence of unique, contingent events. Similar environments often give rise to different evolutionary trajectories, even among initially similar societies. Anglo-Americans travelling abroad find the British somewhat strange and the Germans decidedly foreign, and not just in matters of language either. Somtimes very long run trends in features such as size occur. Human societies have tended to increase in size in a more or less steady manner for the past 10,000 years. Nonetheless, these historical features of organic and cultural evolution can result from a few microevolutionary processes.

Our aim is to catalog the kinds of microevolutionary processes that can give rise to historical patterns of change in both the organic and cultural cases. There are number of microevolutionary processes that can generate historical macroevolutionary patterns that can bridge the conceptual gap between scientists and historians. Once the conceptual gap is gone, the harder task of using scant data to infer the causes of macroevolutionary events is a doable enterprise.

II. What Makes Change Historical?

Our first problem is give an usable definition of "history." The above debate is pretty abstract until the we describe more precisely that makes historical change is. The historians' argument is (e.g., Trigger 1978) that history involves unique, contingent pathways from the past to the future that are strongly influenced by unpredictable, chance events. For example, as we'll discuss in Chapter 28, capitalism arose in Europe rather than China, perhaps because Medieval and Early Modern statesmen failed to create a unified empire in the West (McNeill 1980). Several times popes and kings almost succeeded in taming the politically fractious West, but they never quite did it. If one of these "almost" initiatives had been implemented, Europe might have become a continent-wide, conservative, Catholic, Empire, dominated by a rural landed elite. Such an empire would have sharply controlled merchants and manufacturers. Thus Europe after the Middle Ages could have moved into something like the later Austro-Hungarian Empire on a large scale. The rise of capitalism and the industrial revolution might not have happened at all, or might have happened in another place at another time.

In contrast, it is argued, scientific explanations involve universally applicable laws.

In evolutionary biology and in anthropology, these often take the form of functional explanations, in which only knowledge of present circumstances and general physical laws (e.g. the principles of mechanics) are necessary to explain present behavior (Mitchell and Valone 1990). For example, long fallow horticulture is commonly used in tropical forest environments, presumably because it is the most efficient subsistence technology in such environments (Conklin 1969; Chapter 5). The fact that similar subsistence techniques are used in similar environments is an example of the sort of patterns that scientists invokd in the face of historians' claims that everything is the accident of history.

It has often been argued that this dichotomy is false. Eldredge (1989:9) forcefully defends a common objection: all material entities have properties that can change through time. Even the simple entities like molecules are characterized by position, momentum, charge, and so on. If we could follow a particular water molecule, we would see that these properties changed through time -- even the water molecule has a history according to Eldredge. Yet, everyone agrees that we can achieve a satisfactory scientific theory of water. Historical explanations, Eldredge argues, are just scientific explanations applied to systems that change through time. We are misled because chemists tend to study the average properties of very large numbers of water molecules.

Eldredge's argument explains too much. Not all change with time is history in the sense that historically oriented biologists and social scientists intend. To see this consider an electrical circuit composed of a voltage source, a capacitor and an fluorescent light. Under the right conditions, the voltage will oscillate through time, and these changes can be described by simple laws. Are these oscillations historical? On Eldredge's view they are; the circuit has a history, a quite boring one, but a history nonetheless. Yet such a system does not generate unique and contingent trajectories. After the system settles down one oscillation is just like the previous one. The period and amplitude of the oscillations are not contingent on initial conditions. They are not historical in the sense of "one damn thing after another" (Elton 1967:40) leading to cumulative and divergent, if haphazard, change.

What then makes change truly historical? We think that two requirements capture much of what is meant by "history," and that they pose an interesting and serious challenge for reconciling history with a scientific approach to explanation. A pattern of change is historical if:

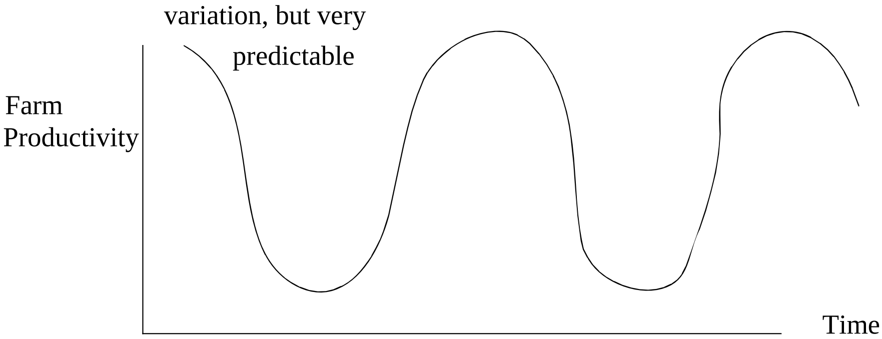
A. Trajectories are not stationary on the time scales of interest.

History is change that does not repeat itself. On long enough time scales, the oscillations in the circuit become statistically monotonous or "stationary" (see definition box for a discussion of this important but simple and little known concept). Similarly, random day-to-day fluctuations in the weather do not constitute historical change if one is interested in organic evolution because on long evolutionary time scales the there will be so many days of rain, so many days of sun and so on. By choosing a suitably long period of time, we can construct a scientific theory of stationary processes using a statistical rather than strictly deterministic approach. In the case of nonstationary historical trajectories, a society or biotic lineage tends to gradually become more and more different as time goes by. There is no possibility of basing explanation on, say, a long-run mean about which the historical entity fluctuates in some at least statistically predictable way, because the mean calculated over longer and longer runs of data continues to change significantly. One of the most characteristic statistical signatures of nonstationary processes is that the variance they produce grows with time rather than converging on a finite value as time increases. The definition box and Figure 23-1 elaborate the concept of stationarity.

.

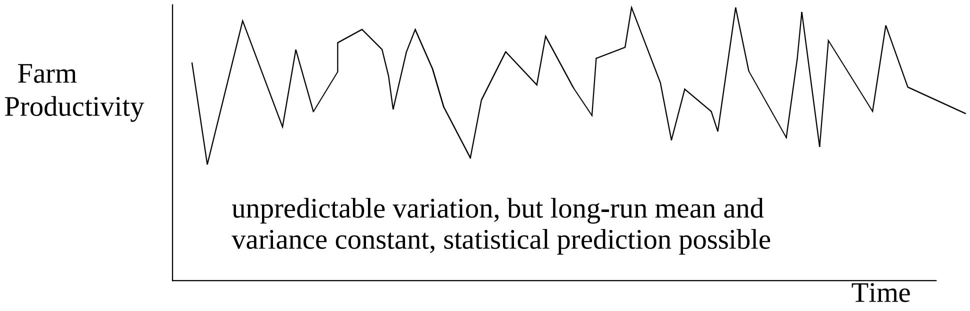
Figure 23-1. Illustrations of (a) deterministic, (b) noisy, but stationary, and (c) non-stationary change with time.

(a) Deterministic change

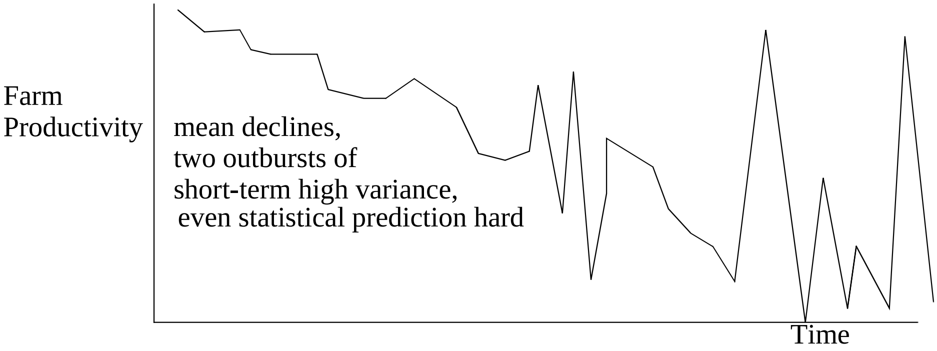


Exact prediction possible if we know the law describing the process of change

(b) Random, but stationary, change



(c) Non-stationary change



B. Similar initial conditions give rise to qualitatively different trajectories.

Historical change is strongly influenced by happenstance. This requires that the dynamics of the system must be path dependent; isolated populations or societies must tend to diverge even when they start from the same initial condition and evolve in similar environments. Thus, for example, the spread of a favored allele in a series of large populations is not historical. Once the allele becomes sufficiently common it will increase at first exponentially, and then slowly, asymptotically approaching fixation. Small changes in the initial frequencies, population size, or even degree of dominance will not lead to qualitative changes in this pattern. In separate but similar environments, populations will converge on the favored allele. Examples of convergence in similar environments are common--witness the general similarity in tropical forest trees and many of the behaviors of the long fallow cultivators who live among them the world over. On the other hand, there are also striking failures of convergence--witness the many unique features of Australian plants, animals, and human cultures. The peculiar hanging leaves of eucalypts, the bipedal gait of kangaroos, and the gerontocratic structure of Australian Aboriginal societies make them distinctively different from the inhabitants of similar temperate and subtropical dry environments on other continents.

***Time Scales*:**

This term refers to some characteristic measure of how fast or slow a process normally is. To use the term formally, we have to define a measure of the speed of the process. For exponential processes like malthusian growth, the doubling (or halving) time is a convenient measure. For more complex processes, with large changes in rate in different parts of the curve, a more complex measure is required. For example, for the increase of a favorable innovation due to natural selection or bias, the time to get from 5% to 95% of the population would be a good formal measure (refer back to fig. 9-1). If, historically, the time scale for the malthusian growth of populations far from carrying capacity is has a time scale of a two or three generations, and the time scale for the spread of a favorable innovation is a few tens of generations, we would say that malthusian growth has a shorter time scale than the diffusion of innovations.

Note that a process that is historical in one spatio-temporal frame may not be in another. If we are not too interested in a specific species or societies in given time periods, we can often average over longer periods of time or many historical units to extract ahistorical generalizations. Any given water molecule has a history, but it is easy--necessary without a Maxwell's demon--to average over many of them and ignore this fact.

It is important not to blur the distinction between simple trajectories and true historical change. it is easy to see how evolutionary processes like natural selection give rise to simple, regular change like the spread of a favored allele or subsistence practice. However, it is not so easy to see how such processes give rise to unique, contingent pathways. Scientists take the approach to steady states and convergence in similar situations as evidence for the operation of natural “laws,” so it *seems* natural to conclude that failures of stationarity

***Stationary vs. nonstationary processes*:**

This is an important conceptual distinction in the statistical study of "time series" (historical data). A stationary process is one that is varies in a statistically predictable way. Even if there is change, the statistical variables that describe the pattern of change don't themselves change with time. If we record the number of "heads" in 10 fair- coin flips for many such sets of flips, the mean and variance that characterize the number of heads we expect don't change in time even thought the number of heads in each 10-flip set will vary a considerable amount. This time series is stationary. Now suppose that the coin is wearing unevenly, so that on average the number of heads is gradually going down, but that the tendency to runs of both heads and tails is increasing. Now, the mean and variance of the coinflip process are changing with time, and we will generate a simple non-stationary data set. Technically then, a stationary process is one in which at least the statistics of fluctuation, like the mean and variance, don't change with time. If the mean, variance, or other statistics change with time, we've got a non-stationary process.

and convergence are evidence of processes that cannot be subsumed in the standard conceptions of science, or at least be explained by adaptive processes. The argument we are about to advance is that things are not at all that simple. There is every reason to expect that perfectly ordinary scientific processes, ordinary in the sense that they result from natural causes and are easily understood by conventional methods, regularly generate history in the sense defined by these two criteria

III. How Do Microevolutionary Processes Give Rise to History?

A. History is Often Caused by External Environmental Factors

It is likely that historical change is at least sometimes generated by abiotic environmental change with historical properties (Valentine and Moores 1972). Long term trends in evolution could result from the accurate tracking of a slowly changing environment. For example, during the last hundred million years there has been a long, slow increase in the degree of armoring of many marine invertebrates living on rocky substrates and a parallel increase in the size and strength of feeding organs among their predators (Vermeij 1987; Jackson 1988). It is possible that these biotic trends have been caused by long-run environmental changes over the same period -- for example, an increase in the carbonate content of the ocean (Holland 1984), which might make it easier to construct bulky skeletons of calcium carbonate.

Similarly, human history is highly historical. Figure 23-1c might almost describe the last 30,000 years of human dependence upon meat in Europe. We began a shift from migratory big game hunting to sedentary, broad spectrum, more labor-intensive foraging beginning about 17,000 year ago, finally developing agriculture about 7,000 years ago (Henry 1989). Some farm systems still support high meat consumption, but others very little. Many authors (e.g., Reed 1977) have argued that the transition from glacial to interglacial climate that occurred during the same period is somehow responsible for the big shift toward increasing dependence on plant foods and eventually to agriculture (see Chapter 25).

Differences among populations in similar environments may result from the environments really being different in some subtle but important way. For example, Westoby (1989) argues that some of the unusual features of the Australian biota result from the continent-wide predominance of highly weathered, impoverished soils on this relatively undisturbed continental platform. Perhaps the failure of horticulture to develop in or diffuse to Aboriginal Australia merely reflects poor soils. It is interesting that New Guinea, the steep, uplifting, good soils edge of the Australian continental platform had horticulturalists rather early.

Historically, the "externalist" or "equilibrist" move in discussions of history is an important one. For the "scientific" evolutionary biologists and social scientists, it gets history out of their court and into the court of the geologists and ecologists. Charles Lyell, Darwin's friend and famous geologist, espoused a non-historical, cyclical stationary theory of geological history. He was very jumpy about Darwin's theory because he could see history in the paleontological record of extinctions and speciation as read by Darwin. He knew "scientific" geologists would get stuck with "unscientific" history if they weren't careful! By imagining that natural selection produced populations in near equilibrium with external environmental conditions, Darwin could have a nice, "scientific" theory of evolution, and pin the awkward problem of "history" on Lyell!

Historical causes from the physical environment are empirically very plausible.The use of "environmental determinism" and climate change arguments by people interested in human history has always been controversial. Modern geology and paleoclimatology have developed irrefutable evidence of a dynamic Earth that changes in all sorts of ways on every imaginable time scale. Continents drift, the heat output of the sun rises, day-length declines, atmospheric gasses fluctuate, etc. Externalist, equilibrist environmental hypotheses to explain historical change in general have to be taken quite seriously. In Appendix 24-A we have provided a discussion of the geological record of climate change over Earth history as but one example of this dynamism. The hominid lineage's tenure on the planet coincides with dramatic climate changes attending the onset of the Ice Ages, and climate history will figure large in externalist hypotheses we'll discuss in the next chapters.

B. History Is Caused by Processes Internal to Evolutionary Mechanisms

It is possible that evolutionary processes themselves can generate non-stationary, diverging historical patterns of change on their own even in a stationary environment. Traditionally, many social and biological scientists have assumed that much of the evolutionary record can be read as a slow improvement and gradual perfection of species and societies by evolutionary processes like natural selection. This idea is often called "*progressivism.*" Gradually, over the whole history of the earth, evolution has been replacing "primitive" organisms with more "advanced" species.

Naive progressivism is unsupportable. As we have seen, microevolutionary studies have shown that natural selection and the decision-making forces of cultural evolution can produce rapid, usually adaptive, change to local conditions. *There are no known foresighted processes in evolution that seek long term goals*. On this account, there is an embarrassingly large amount of time available for internal processes to account for historical trends. Natural selection and similar processes seem to be able to get to equilibrium rather quickly, and hence seem unable to account for much history. Darwin was always worried that the Earth was old enough to account for all the evolution he saw, but then he faced Lord Kelvin's calculation indicating that the planet is only about 50 million years old. Now that we know that life has existed on Earth for a few billion years, the shoe is on the other foot. It is easy to imagine that an immense amount of evolution can occur due to internal processes on the millions of years time scale. A progressive, internal process that took billions of years to get from bacteria to Queen Victoria is not completely plausible, and, at least on these long time scales, some version of external equilibrist hypothesis seems required. (All progressivist schemes, following the 19th Century evolutionists like Spencer, also had a suspiciously ethnocentric and anthropocentric tendency to put their own society at the pinnacle of evolutionary progress, and are also suspicious on the grounds of ethnocentrism.)

On the other hand, certainly, the overall trajectory of human evolution has at least the appearance of long term historical "progress" of some sort. We began as narrowly distributed East African upright apes 4 million years ago. We have gradually enlarged our brains, expanded our range, increased the diversity and sophistication of our cultural adaptations, increased the size of our social units, and burgeoned in numbers to become the most dominant single vertebrate species the Earth has ever experienced. Whether "progress" has to go inside or outside quotes, this historical trajectory itself is something we have to account for. Progress or not, such long term, non-stationary trends demand some sort of explanation.

What is required to escape the externalist objection to naive progressivism are historical mechanisms internal to the evolutionary processes of genes and culture that could produce a modified, more plausible, less ethnocentric form progressivism. The historical patterns generated by these processes might well have time scales somewhat to much shorter than billions of years, and so have to share the long-term explanatory stage with external, equilibrist, environmental hypotheses. Still, on the 100 year to million year time scales of human history, internal, reformed progressivist accounts of various kinds may be quite correct. Let us count the ways that a reformed progressivism might be constructed from plausible internal contraints on the rate of evolutionary change!

1. Random Processes

Mutation and drift and their cultural analogs can create history by random walks. We begin with the simplest internal process that could generate history (though not much that you'd care to call progress). It could be that most evolutionary change is random. Much change in organic evolution may be the result of drift and mutation, and much change in cultural evolution may result from analogous processes. Evolution by mutation and drift is slow compared to simple adaptive change. Raup (1977) and others argue that random-walk models produce phylogenies that are remarkably similar to real ones. To the extent that cultural and genetic evolutionary change is random, populations in similar environments will diverge from each other.

It seems likely that some variation in genes and culture evolves mainly under the influence of nonadaptive forces -- for example, much of the eukaryotic genome does not code for genes and might well evolve entirely under the influence of drift and mutation (Futuyma 1986:447). Similarly, the arbitrary character of symbolic variation suggests that nonadaptive processes are likely to be important in linguistic change and similar aspects of culture. In both cases, isolated populations diverge at an approximately constant rate on the average. However, to understand why a particular species is characterized by a particular DNA sequence, or why a particular people use a particular word for mother, one must investigate the sequence of historical events that led to the current state.

Indirect bias can create historical patterns. Some evolutionary processes give rise to dynamic processes that are sensitive to initial conditions, and have no stable equilibria. In Chapter 14 we discussed the evolution of symbolic characters under the influence of indirect bias. Recall that in this case (like mate choice sexual selection in biology) runaway dynamics, strongly dependent on initial conditions, can lead to unique, exaggerated display traits in a population. These symbolic traits may come to serve functions like ethnic boundary marking, but non- adaptive, random effects may determine how a particular trait is developed into a symbolic system. Also recall that in the case of expressive symbolic systems like art that neophilia (boredom with old stimuli, the little thrill of seeing something a bit new) can drive an endless wandering in "style space." Language apparently evolves under the influence indirect bias, and language evolution is a classic example of continuous long term *change and divergence of ancestral societies.*

Most defenders of "scientific" approaches are quite willing to accept that random processes like drift and indirect bias operating on symbolic systems like language generate history, but they often want to be able to divide problems into those that are purely, random- historical and others that are purely, causal-scientific. The most pointed controversy comes over whether the history that can't be attributed to geology can be attributed to afunctional style, leaving all the important (e.g. adaptation producing) internal processes purely universal general laws free of historical residues, as many "scientists" and "historians" both seem to want. (Both sides seem to want this distinction to hold up to make their subjects easier, and to disputes with their colleagues fewer by dividing the intellectual labor so neatly. If the main argument of this chapter is correct, these very human desires to make life easy have to be foregone.)

2. Adaptive Processes Can Give Rise to History.

It is more difficult to understand how adaptive processes like natural selection can give rise to historical trajectories. There are two hurdles: *First*, there is the problem of too much time referred to above. Theory, observation, and experiment suggest that natural selection can lead to change that is much more rapid than any observed in the fossil record (Levinton 1988:342-347). For example, the African Great Lakes have been the locus of spectacular adaptive radiations of fishes amounting to hundreds of highly divergent forms from a few ancestors in the larger lakes (Lowe-McConnell 1975). The maximum time scales for these radiations, set by the ages of the lakes and not counting that they may have dried up during the Pleistocene, are only a few million years. The radiation in Lake Victoria (200+ endemic species) seems to have required only a few hundred thousand years.

Adaptive cultural change driven by decision-making forces can be very fast indeed as is evidenced by the spread of innovations (Rogers 1983) and by the rapid evolution of new adaptations, such as the case of the Plains Indians' development of horse nomadism in a century and a half or so. It is not immediately clear how very short time-scale processes such as these can give rise to longer term change of the kind observed in both fossil and archaeological record unless the pace of change is regulated by environmental change. In the absence of continuing, long-term, nonstationary environmental change, adaptive processes seem quite capable of reaching equilibria in relatively short order. In other words, both cultural and organic evolution seem, at first glance, to be classic scientific processes that produce functional adjustments too rapidly to account for the slow historical trajectories we actually observe.

Second, it is not obvious why adaptive processes should be sensitive to initial conditions. Within anthropology the view that adaptive processes are ahistorical in this sense underpins many anthropological critiques of adaptive explanations. Many anthropologists claim that it is self-evident that cultural evolution is historical, and that therefore adaptive explanations (being intrinsically equilibrist and ahistorical) must be wrong (Hallpike, 1986). Again, it seems to suit the arguments of both "historians" as well as "scientists" if adaptive processes are ahistorical.

Sahlins' (1963) contrast of Melanesia and Polynesia is a classic example of the "historians" argument. Sahlins notes that Melanesians and Polynesians each live on a a very diverse set of Tropical Pacific Islands, using the same basic technology. There are many ecological differences within these two large cultural groups, but each covers the whole range from very large Islands (New Zealand, New Guinea) to tiny atolls. If adaptation and convergence were all, the main cultural variation should be governed by environment and be replicated within each group. What struck Sahlins is some striking similarities shared within each group and not replicated between them. His main example was in the realm of social organization. Polynesians have an ideology of ranked lineages and sacred chiefs, which on large islands leads to the formation of large chiefdoms and even small-scale states. Hawaii is a good example; societies there were just either very advanced chiefdoms or small states, depending on your definitional preferences. The Melanesians lack the idea of ranked lineages, and typically have the bigman style of political organization. They lack big chiefdoms and states even on large islands with dense populations. History seems to make a big difference in a telling case where a natural experiment helps us control for environment, and provide plenty of replication to boot.

Is there any way that path dependence and long-term change can be consequences of any adaptive process analogous to natural selection? Sahlins himself (1976) argued that such facts require abandoning adaptive accounts in favor of a vague historical process he called "cultural reason." Let's use for discussion the adaptive topography model of genetical or cultural evolution under the influence of a basic adaptation producing force like natural selection or direct bias with and adaptive decision rule. As noted in the chapters on evolutionary processes, we often model evolution as acting on quantitative character like height or political conservatism. Under many assumptions, the evolutionary response of such systems is for the population to “climb” the fitness “topography” until the mean phenotype of the population is optimally adapted at a peak on the topography, whereupon stabilizing selection keeps it there.

I*n this simple model the evolutionary trajectory of the population will be completely governed by the shape of average fitness as a function of mean phenotype*. If the adaptive topography has a unique maximum then every population will evolve to the same equilibrium mean phenotype, independent of its starting position, and once there be maintained by stabilizing selection. On the other hand if there is more than one local maximum, different equilibrium outcomes are possible depending on initial condition. The larger the number of local maxima, the more path dependent the resulting trajectories will be (see fig. 23-2).

You can imagine that natural selection and adaptive decision making forces make populations act like blind mountain climbers. They can sense which way is up in their immediate vicinity, but they cannot see what the overall topography is like. They have to search for the overall fitness maximum by climbing upwards wherever they are. Put three independent Darwinian climbers anywhere on 23-2a and they will all soon arrive at the fitness maximum. Start the same three off even close together on 23-2b and they will drift apart and end up stuck on different local maxima. If search capabilities are limited, it will be exceedingly difficult for our climbers on 23-2b to get off these local peaks and begin climbing toward the highest point in the topography.

Indeed, we might imagine that it would take geological processes or some similar rare big change to create a new ridge or slope to get a stuck population started again, something that would happen very rarely. Theoretical studies of genetic drift confirm an old intuition of pioneering evolutionist Sewall Wright that drift can jump populations from one adaptive peak to another, but the process is very slow relative to the rate selection can drive a population up a simple slope. In short, even a very efficient local hill climber will be able to climb a rough topography slowly and inefficiently, creating the conditions for a long, slow, divergent, progressive, historical pattern of adaptive improvement.

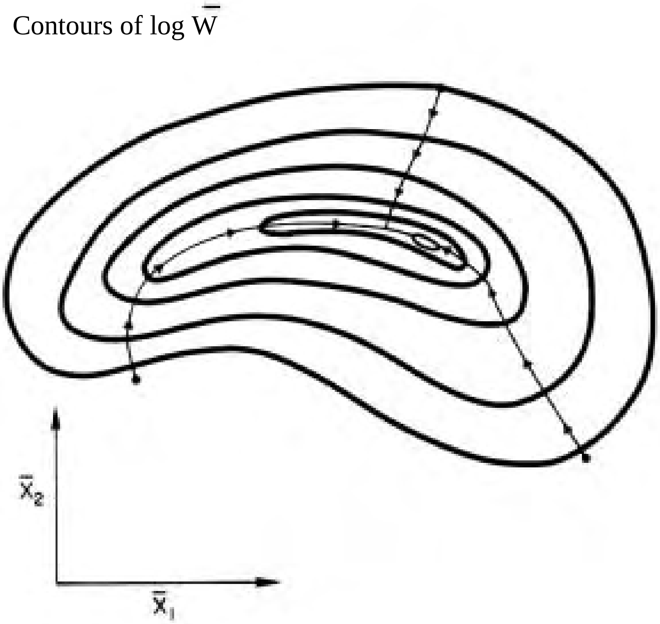
The questions are: (1) Are adaptive topographies mostly like the simple hill portrayed in figure 23-2a or more like the real mountain used in 23-2b? (2) If they are rough, exactly what makes them so? If simple topographies are common, we'd better look for the causes of history mostly in external equilibrist environmental changes or random processes, except perhaps at very short, out-of-equilibrium time scales. On the other hand, any tendency for complex topographies to be realistic will make internal “progressivist” patterns easy to imagine, even on long time scales.

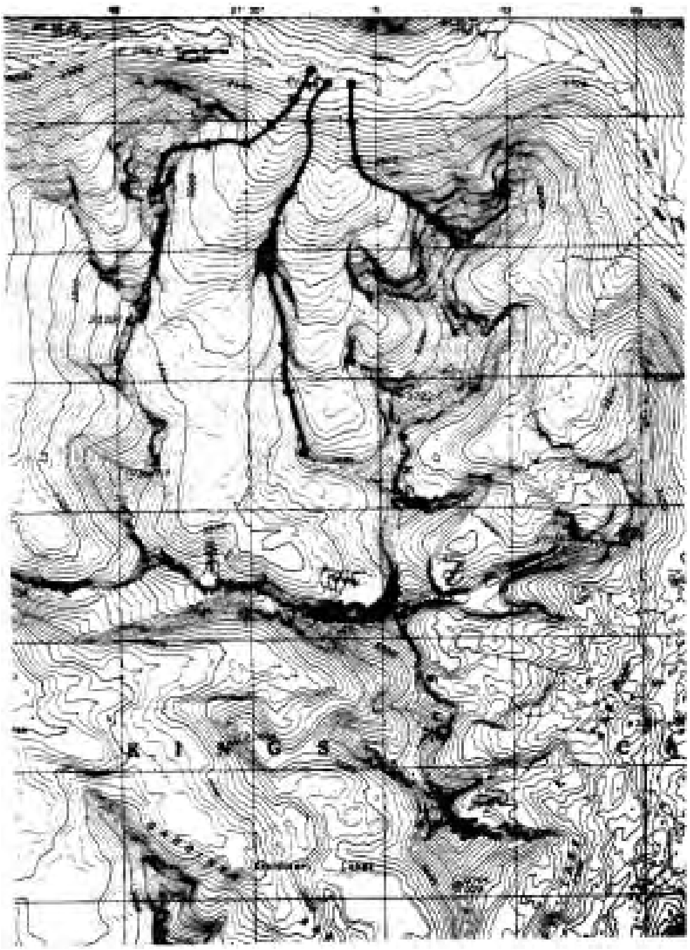
There are a number of internal processes that are good candidates for producing rough adaptive topographies for cultural or genetic evolution:

(1.) Complex design problems have multiple solutions. The character of most biological or cultural evolutionary “design” problems has not been worked out, but multiple solutions is a notorious complexity of human engineering design. A computer design problem discussed by Kirkpatrick et al. (1983) provides an excellent example. Computers are constructed from large numbers of interconnected circuits each with some logical function. Because the size of chips is limited, circuits must be divided among different chips. Because signals between chips travel more slowly and require more power than signals within chips, designers want to apportion circuits among chips so as to minimize the number of connections between them. For even moderate numbers of circuits, there is an astronomical number of solutions to this problem. Kirkpatrick et al. present an example in which the 5000 circuits which make up the IBM 370 microprocessor were to be divided between two chips. Here there are about 10^{1503} possible solutions!

t.

Figure 23-2. This figure shows two adaptive topographies. The axes are the mean genetic value in a population for two characters. The contour lines give contours of equal mean fitness. Populations beginning at different initial states all achieve the same equilibrium state. Part a shows a simple unimodal adaptive topography. Part b (next page) shows a complex, multimodal topography. Initially similar populations diverge owing only to the influence of selection (Boyd & Richerson 1992:190-191).





This design problem has two important qualitative properties:

A. *It has a very large number of local optima*. That is, there is a large number of arrangements of circuits with the property that any simple rearrangement increases the number of connections between chips. This means that any search process that simply goes up hill (like our model of adaptive evolution) can end up at any one of a very large number of configurations. An unsophisticated optimizing scheme will improve the design only until it reaches one of the many local optima, which one depending upon starting conditions. For example, for the 370 design problem several runs of a simple hill climbing algorithm produced between 677 and 730 interconnections. The best design found (using a more sophisticated algorithm) required only 183 connections.

B. *There is a smaller, though still substantial, number of arrangements with close to the globally optimal number of interconnections*. That is, there are many qualitatively different designs that have close to the best payoff. In the numerical example discussed above there are on the order of 70 such arrangements.

These results are quite typical. To quote from the introduction of a classic textbook on optimization "...many common design problems, from reservoirs to refrigerators, have multiple local optima, as well as false optima, that make conventional [meaning simple, blind, hill-climbing] optimization schemes risky" (Wilde 1978). Thus, if the analogy is correct, small differences in initial conditions will commonly launch different populations on different evolutionary trajectories which end with qualitatively different equilibrium phenotypes. Populations will commonly get stuck on local peaks for varying lengths of time. Many evolutionary changes will be progressive jumps to improved technology, not simple tracking of environmental change Just as in figure 23-2b, evolutionary change due to attempts to make better tools should be demonstrate our two criteria for being historical.

(2.) "Developmental" constraints may impose history. Developmental constraints could play a major role in confining lineages to historically determined "bauplane," as many biologists have argued (e.g. Seilacher 1970). "Bauplan" is German and means something like "building plan." Development proceeds in a hierarchical fashion, so that events early in development have a large influence on events later in development. Thus, the basic number of limbs that vertebrates have is manifest very early in development, and many subsequent developmental episodes appear to depend on there being four limbs. Developmental anomalies, such as calves with six legs, sometimes occur, but the resulting individuals are almost always inviable. So many developmental pathways in later development are keyed to events early in development that it is almost impossible to alter early events without merely messing everything up. Adaptive changes are usually possible only by tinkering with events late in development.Thus, there might be many circumstances where selection might try to favor an insect with four or eight legs or a vertebrate with six, or a bird with wings converted back to legs, etc. However, such things very rarely happen. Once a lineage establishes a basic bauplan, it seems to be essentially fixed for geologic time.

Perhaps culture has become part of the human bauplan. In the case of humans, it would seem that culture has come to play an essential role in our development; children without proper socialization are pathological basket cases. Our species and any descendent species we have for the indefinite future will probably be culture bearing, so matter how modified we are in other ways. We probably depend upon cultural transmission for basic essentials that other animals inherit genetically.

In terms of our adaptive topography picture, we might view developmental constraints as like impenetrable thickets on the adaptive landscape. The terrain may sometimes be smoothly uphill in the direction of acultural hominids or four-legged plus two arms centaur hominids, but there may be no useful genetic variation that can penetrate the adaptive constraint thicket in these directions.

A similar argument has been made for cultural variation itself. Social scientists at least since Freud have tended to believe that events early in childhood strongly and permanently influence personality, and that societies with different child rearing practices come to have different average personality types. The kind of psychological anthropology associated with Margaret Mead and like minded mid-century types advocated this hypothesis. To the extent that such structure exists, path dependence is likely to be important. Basic personality types will have a big influence on basic values that people hold, and basic value orientations in turn will affect what sorts of economic organizations people can manage, and what sorts of occupations that they will find rewarding. Changing fundamental attributes of a culture underpinned by a set of personality types will tend to undermine values and economic activity in complex, hard to predict and control fashion. Therefore, once a society is committed to a certain personality profile (cold Germanic, warm Latin, disciplined Asian), it is very hard to change it with catastrophic disruption of the shallower parts of psychology and social institutions that depend on such psychology.

There is much skepticism in both biology and social science over the importance of developmental constraints as a cause of complex evolutionary topography, notwithstanding the arguments and examples above. Constraints on major morphological evolution seem to break down in cases like the adaptive radiations of tropical fishes when the environment is essentially empty, and many new designs come into being in short order. Bandura (1977), a pioneering student of the processes of social learning, argues that there is relatively little complexly embedded structuring of socially learned behavior. He stoutly defends a “bean bag” theory of culture. People may have a lot of cultural traits, but they are not tightly structured or linked. The tendency of cultures to readily adopt revolutionary innovations from quite foreign sources (such as the Japanese adoption of European industrial technology in the mid 19th Century) might make us wonder that personality type constraints are very constraining. Religious conversion to new sets of apparently quite basic values is also fairly common, often quite apart from other changes, for example in economy.

(3.) Games of coordination and similar phenomena can cause history. “Games” of coordination are those kinds of social interactions in which at least part of the payoff de-

pends upon doing what everyone else does. Recently, game theorists (Sugden, 1986) have come to suspect that an element of coordination is very common in the kinds of complex cooperative societies in which humans live. Which side of the road to drive on is a simple example. You are barreling down a dirt road and round a curve to find an oncoming car. Do you veer left or right? Either right or left is equally good in the abstract, but it is quite important that you and the oncoming driver "agree" to conform to one convention or the other. Now the shape of our adaptive topography is no longer fixed, it also depends upon where the population is. In America you should swerve right, but in Australia left. In this simple case, the adaptive topography is flat until some consensus begins to form, and then a hill and valley emerge. In general, games of coordination have many solutions, many more than two for more complex ones. Moreover, games of coordination can be mixed with other games, like games of cooperation, and the total payoff of some coordination equilibria may be higher than others, generating once more the complex, lumpy evolutionary topography that can generate history.

Arthur (1990) shows how locational decisions of industrial enterprises could give rise to historical patterns due to coordination effects. It is often advantageous for firms to locate near other firms in the same industry because specialized labor and suppliers have been attracted by preexisting firms. The chance decisions of the first few firms in an emerging industry can establish one as opposed to another area as the Silicon Valley of that industry. More generally, historical patterns can arise in the many situations where there are increasing returns to scale in the production of a given product or technology. Merely because the QWERTY keyboard is common, it is sensible to adopt it despite its inefficiencies.

If you have ever spent any time in a foreign culture, you know that there are a host of petty, annoying differences between the ways you are used to and those of your hosts. If your hosts have ever lived here, you can trade stories all night about whose customs are more odd than whose. These are mostly issues of games of coordination, and point up their pervasive and important role in regulating behavior in complex societies.

Once a culture has reached a particular solution to a coordination game, changing to another solution, even if the other solution is better, can be a very difficult task. Everyone has to change at the same time, and it is a big production. Take the US conversion to the metric system. It is obviously a benefit for the US to coordinate with the world standard system, but so far we cling to the English system because of the immense costs of the transition.

We might hypothesize that one problem that the former Soviet Block societies now face is that they must abandon many old norms of coordination, and negotiate new ones. If we suppose that a functioning society is made to work by a vast array of interlocking "games" of coordination, this extensive renegotiation will make adopting the metric system seem like child's play. Even if the capitalist system is absolutely better than the Communist in all ways, it is liable to be extremely costly to make the transition. If Yeltsin's fast transition strategy fails but the Chinese slow strategy succeeds we might have a test of the importance the stickiness of games of coordination to creating history in cultural evolution. If both fail, it would seem likely that they are even more important.

(4.) The existence of socially approved sanctions and punishment creates a special kind of coordination problem. Take basic social norms and customs that are enforced by public opinion (or stronger sanctions). Scandinavians are rather law abiding, and even economic crimes like tax evasion are viewed as serious offenses. People who cheat on their taxes are liable to be turned in by anyone who knows about the evasion, and even knowing about such a crime and not reporting it would be viewed askance. On the other hand Scandinavians are very liberal on matters of sexual conduct. Few parents seriously object to or interfere with their teenagers active sexuality beyond basic emotional support, safe sex advice, and the like. Parents who do more are viewed as narrow-minded prudes even by other parents. In Italy, by contrast, tax evasion is very widespread and no friend is likely to turn you in for cheating on your taxes. But the Italian concept of family honor that requires males to closely control the sexuality of "their" women. In many Mediterranean cultures men are quite prepared to murder men who seduce their wives, sisters and daughters, and to deal very harshly with any signs that the women concerned were willing participants in illicit affairs. What is adaptive to do in each place differs substantially merely because what the community is prepared to tolerate and punish differs.

Theoretical models suggest that any behavior that a community is generally prepared to sanction can be stabilized by punishment if the punishment is harsh enough but not too costly to impose, even if the behavior sanctioned is not particularly adaptive (Boyd and Richerson, 1992). Punishment is something that can stabilize a virtually infinite variety of quite amazingly non-adaptive behaviors. Wearing ties to work in business and English spelling (why not "speling"???) are a couple of mild homegrown examples. Many other conventions enforced by punishment are undoubtedly functional, along the lines of the drive on the right rule. The point is that punishment exaggerates the already large tendency for games of coordination to generate protected local optima. Many protected optima mean diversification. It is likely that some local optima are better than others (there has got to be something better than wearing ties and krazee spelling), so we have another mechanism to produce topographies like fig. 23-2b.

(5.) Interactions between populations and societies (or interacting internal elements like classes) can result in multiple equilibria. Models of the coevolution of multiple populations have many of the same properties as games of coordination within populations, although the theory is less well developed (Slatkin and Maynard Smith 1979). The evolution of one population or society depends upon the properties of others that interact with it, and many different systems of adjusting the relationships between the populations may be possible. For example, Cody (1974:201) noted that competing birds replace each other along an altitudinal gradient in California, but latitudinally in Chile. Given the rather similar environments of these two places, it is plausible that both systems of competitive replacement are stable and which one occurs is due to accidents of history.

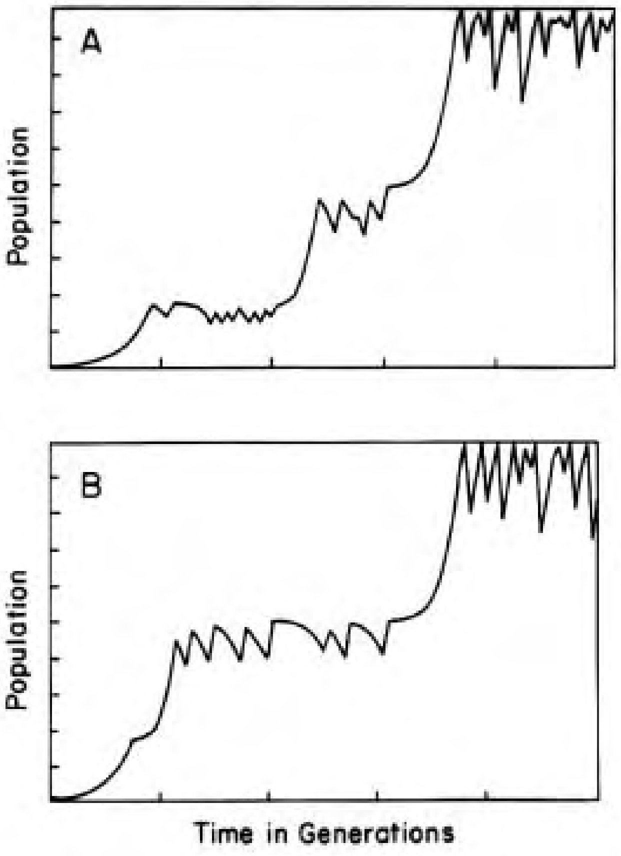
The stratification of human societies into privileged elites and disadvantaged commoners derives from the ability of elites to control high- quality resources and/or to exploit commoners using strategies that are similar to competitive and predatory strategies in nature. We will examine some experiments by Insko et al (1983) in Chapter 26 that seem to show that both an exploitative or a more legitimate form of stratification could arise and stabilize in the same environment. It seems plausible that the diversity of political forms of complex societies could result from many arrangements of relations between constituent interest groups being locally stable. The distinctive differences between the Japanese, American, and Scandinavian strategies for operating technologically advanced societies could well derive from historic differences in social organization that have led to different, stable arrangements between interest groups, in spite of similar revolutionary changes in production techniques of the last century or two.

(6.) Chaotic dynamics can create history. An understanding of “chaos” is one of the most important scientific achievements of the last 20 years. Some of you have undoubtedly been exposed to at least popular treatments of the subject (e.g. Gleick, 1987). Chaotic dynamics are completely deterministic; there is no random element. Yet, in many cases, even fairly simple dynamic systems wander about in a very random-like way. If we start of two systems exactly alike, they will move exactly in parallel forever. However, if we start them off just a little bit differently, the differences will grow.

Chaotic dynamics were first discovered meteorologist Edward Lorenz, who was doing simple numerical simulations on a primitive computer. He discovered that nearly identical runs of his equations diverged in the most surprising manner in just a few “days” of simulated weather. Today numerical meteorologists believe that chaos causes the frustrating unpredictability of the weather due to the “butterfly's wing” effect of chaotic dynamics. If a butterfly beats its wing just so in Japan, the tiny eddy created will tip atmospheric processes slightly and launch the North Pacific on a trajectory that will grow into a storm that hits California a week later. A flick in a different direction, and it will be dry. Thus, weather forecasts of even four or five days in the future are very difficult. Given that it is impractical to know exactly where the system is starting from at this moment down to the last butterfly's wingbeat, we could be on any one of many chaotic paths to five days from now, and these paths diverge pretty fast in the case of weather. The 24 hour forecast is pretty fair, but the 96 hour is already only a little better than a guess based on long term averages.

It is not surprising that chaotic dynamics appear models of social systems. For example Day and Walter (1989) have analyzed an extremely interesting model of social evolution in which population growth leads to reduced productivity, social stratification, and eventually to a shift from one subsistence technology to a more productive one. Examples of the resulting trajectories of population size are shown in figure 23-3. Population grows, is limited by resource constraints, and eventually technical substitution occurs, allowing population to grow once more. The only difference between figures 23-3a and 23-3b is a very small difference in initial population size. Nonetheless, this seemingly insignificant difference leads to qualitatively different trajectories -- one society shows three separate evolutionary stages, and the second only two.

Figure 23-3. Both parts show the trajectories of population growth generated by the same model of social evolution for two slightly different initial population sizes. In part a, the society goes through three distinct phase of growth, while in part b, there are only two (Boyd & Richerson 1992:199).



Thus, it seems that there are many candidates for creating rough topography for adaptive evolutionary processes. History is easily accounted for by a number of well-specified Darwinian mechanisms. At the same time, we know little about the relative importance of each process in the actual generation of human evolutionary history.

IV. Conclusion

Scientific and historical explanations are not alternatives. Contingent, diverging pathways of evolution and long-term secular trends can result from processes that differ only slightly from those that produce rapid, ahistorical convergence to universal equilibria. Late 19th and early 20th Century scientists gave up restricting the term “scientific” for deterministic, mechanistic explanation and began to admit “merely” statistical laws into fundamental corpus of even physics (very reluctantly in some cases, recall Einstein's famous complaint about God not playing dice with the universe to express his distaste for the essential probabilistic indeterminacy of quantum mechanics).

Similarly, historical explanations cannot be distinguished from other kinds of scientific explanations except that some models (and, presumably, the phenomena they represent) generate trajectories that meet our definition of being historical. These history-generating processes do not depend on exotic forces or immaterial causes that ought to excite a scientist's skepticism; perfectly mundane things will do.

There are challenging complexities in historical processes. For example, even well understood processes will not allow precise predictions of future behavior when change is historical. However, all the tools of conventional scientific methods can be brought to bear on them. For example, it should be possible to use measurement or experiment to determine if a process is in a region of parameter values where chaotic behavior is expected or not. At the same time, the historian's traditional concern for critically dissecting the contingencies that contribute to each unique historical path is well taken. Process oriented “scientific” analyses help us understand how history works, and “historical” data are essential to test scientific hypotheses about how populations and societies change.

If the arguments in this chapter are correct, the ***conceptual*** *problem of linking macro and microevolution in a way that should satisfy both “scientists” and “historians” is solved.* In fact we have a rather large number of hypotheses that will do the work. The problem of the complexity of historical processes and gaps in the historical record means that the far harder *empirical* problem still gives future generations of scientific historians, perhaps you, plenty of most excellent work to do!

In the final chapters in this course, we'll examine some of the major historical transformations of human societies in order to see if we can make this synthesis between history and science seem reasonable in these concrete cases.

V. Bibliographic Notes

This chapter is based on:

Boyd, R. and P.J. Richerson. 1992. How microevolutionary processes give rise to history. In: M.H. and D.V. Nitecki (eds.) *History and Evolution*. Albany: SUNY Press.

References:

Arthur, W. B. 1990. Positive Feedbacks in the Economy. *Scientific American* February: 92-9.

Bandura, A. 1977. *Social learning theory*. Englewood Cliffs, NJ: Prentice Hall.

Boyd, R. and P.J. Richerson. 1992. Punishment allows the evolution of cooperation (or anything else) in sizable groups. *Ethology and Sociobiology* 13: 171-195.

Campbell, D. T. l975. On the Conflicts Between Biological and Social Evolution and Between Psychology and Moral Tradition. *American Psychologist* **30**:1103-26.

Cody, M. L. 1974. *Competition and the structure of bird communities*. Princeton: Princeton University Press.

Conklin, H. C. 1969. An Ethnoecological Approach to Shifting Agriculture. In *Environment and cultural behavior*, ed. A. P. Vayda. Garden City, NY: Natural History Press.

Day, R. H., and X. Walter. 1989. Economic Growth in the Very Long Run: On the Multiple Phase Interaction of Population, Technology, and Social Infrastructure. In *Economic complexity: Chaos, sunspots, bubbles, and nonlinearity*, ed. W.A. Barnett, J. Geweke, and K. Schell. Cambridge: Cambridge University Press.

Eldredge, N. 1989. *Macroevolutionary dynamics*. New York: McGraw-Hill.

Elton, G. R. 1967. *The practice of history*. London: Methuen.

Futuyma, D. J. 1986. *Evolutionary biology,* 2d. ed. Sunderland MA: Sinauer.

Geertz. C. 1973. *The Interpretation of Cultures*. New York: Basic Books.

Gleick, J. 1987. *Chaos: Making a New Science*. New York: Penguin.

Hallpike, C. R. 1986. *Principles of social evolution*. Oxford: Clarendon.

Henry, D. O. 1989. *From foraging to agriculture: The Levant at the end of the Ice Age*. Philadelphia: University of Pennsylvania Press.

Holland, H.D. 1984. *The chemical evolution of the atmosphere and oceans*. Princeton: Princeton University Press.

Insko, C. A., R. Gilmore, S. Drenan, A. Lipsitz, D. Moehle, and J. Thibaut. 1983. Trade Versus Expropriation in Open Groups: A Comparison of Two Types of Social Power. *Journal of Personality and Social Psychology* **44**:977-99.

Jackson, J. B. C. 1988. Does Ecology Matter? *Paleobiology* **14**:307-12.

Kirkpatrick, S., C. D. Gelatt, and M. P. Vecchi. 1983. Optimization By Simulated Annealing. *Science* **220**:671-80.

Landau, M. 1991. *Narratives of Human Evolution*. New Haven: Yale University Press.

Levinton, J. 1988. *Genetics, paleontology, and macroevolution*. Cambridge: Cambridge University Press.

Lowe-McConnell, R. H. 1975. *Fish communities in tropical freshwaters*. London: Longmann.

Lumsden, C.J., and E.O. Wilson. 1981. *Genes, mind and culture*. Cambridge: Harvard University Press.

McNeill, W.H. 1980. *The human condition: An ecological and historical view*. Princeton: Princeton University Press.

Mitchell, W. A., and T. J. Valone. 1990. The Optimization Research Program - Studying Adaptations by Their Function. *Quarterly Review of Biology* **65**:43-52.

Raup, D. M. 1977. Probabilistic Models in Evolutionary Paleobiology. *American Scientist* **65**:50-57.

Reed, C.A. 1977. Origins of Agriculture: Discussion and Some Conclusions, pp. 879-953. In *Origins of agriculture,* ed. C.A. Reed. The Hague: Mouton.

Richerson, P.J. and R. Boyd. 1992.

Rogers, E. M. 1983. *The diffusion of innovations*. 3d. ed. New York: The Free Press.

Sahlins, M. 1963. Poor man, rich man, big-man, chief: Political types in Melanesia and Polynesia. *Comp. Stud. Soc. Hist.* 5: 285-303.

Sahlins, M. 1976. *Culture and practical reason*. Chicago: University of Chicago Press.

Seilacher, A. 1970. Arbeitskonzept zur Konstruktions-morphologie. *Lethaia* 3:393-6.

Slatkin, M., and J. Maynard Smith. 1979. Models of Coevolution. *Quarterly Review of Biology* **54**:233-63.

Sugden, R. 1986. *The economics of rights, co-operation and welfare*. Oxford: Basil Blackwell.

Trigger, B. 1978. *Time and traditions*. Edinburgh: Edinburgh University Press.

Valentine, J. W., and E.M. Moores. 1972. Global Tectonics and the Fossil Record. *J. Geol.* **80**:167-84.

Vermeij, G. J. 1987. *Evolution and escalation: an ecological history of life*. Princeton: Princeton University Press.

Westoby, M. 1989. Australia's High Lizard Density: A New Hypothesis. *Trends in Ecology and Evolution* **4**:38.

Wilde, D. J. 1978. *Globally optimal design*. New York: John Wiley & Sons.

Chapter 24. ORIGIN OF THE HUMAN ADAPTIVE PATTERN

Contrast the title of this book by Charles Darwin:

*The **Descent** of Man and Selection in Relation to Sex*

with this book by Jacob Bronowski:

*The **Ascent** of Man*

I. Introduction

Over the span of time from about 5.5 million BP until about 50,000 BP the hominid line evolved from something very like a chimpanzee to a biologically modern species essentially like ourselves. The objectives of this chapter are to describe the basic differences between humans and our primate relatives, and to introduce you to the data and hypotheses that are available to explain the origin of the human species. In essence, we would like to be able to explain the hunting and gathering "revolution"—the emergence of a (presumably adaptive) pattern of human behavior that is rather distinctively different from that of apes. Even the simplest human societies we can study today are sharply different from the societies of our closest primate relatives. What sort of micro- and macro-evolutionary processes can we use to account for this development that began perhaps 6 million years ago?

With quite some anatomical data on our ancestors, but barely any behavioral data, there is plenty of room to mythologize. The work of the Leakey family, Donald Johanson, Tim White, Henry McHenry and many others have made the bones and stone tools of these people fairly well known. Roger Lewin (1987b) and Richard Klein (1989) survey the main findings. We have a fairly good outline of how our bodies evolved, although new fossil discoveries require major rewrites of parts of the story every year. There is much less certainty about soft parts and behavior. When did we lose our fur? When did estrous become cryptic? When did food sharing and male contributions to provisioning of females and offspring begin? When did male cooperation in hunting and warfare begin?

We don't know the answers to these questions. The history of ideas about human origins is fascinating because we are simultaneously so interested in the answer and free of constraints from the data. Scientists seem to have had an almost irresistible tendency to mythologize about our origins. Lewin reports on the work of paleontologist/historian of science Misia Landau who discovered in "scientific" accounts of human origins a structure remarkably like the heroic stories of mythology. Humans were set terrible trials (the shrinkage of tropical forest), which they met with risky quests (descent from the trees and exploration of the new habitat). Ultimately, through great exertion and devotion to the principle of evolutionary advance, we triumphed and became modern people. Books like Bronowski's *The Ascent of Man* are recent, charming examples of such quaint stories in modern pseudoscientific dress. It is quite embarrassing that scientists have often written such stuff. We'll try to stick to the descent of humans not the Ascent of Man in these pages.

II. The Basic Adaptation of Modern Humans

The basic adaptation that differentiates modern humans from other primates is cooperative food foraging using cultural adaptations (technology). The genetic resemblance between humans and the great apes is quite striking. However, there are substantial differences in terms of anatomy, behavior, and social organization. In the next few sections we will briefly examine the possible adaptive significance of these differences in an effort to understand how the human adaptive pattern—foraging cooperatively using cultural adaptations—evolved.

A. Humans Closely Resemble Great Apes

Using modern biochemical techniques it is now known that the human line must have split from the ape line only 6 million years or so ago. Modern laboratory techniques such as sequencing proteins allow biochemists to estimate the average rate of change of proteins during the course of evolution. They do this by calibrating known divergences of lineages in the fossil record with protein differences. Humans are rather closely related to chimps and gorillas by these measures (Sarich, 1980). Modern biochemical methods are very accurate. They indicate that humans share a very high proportion of their genes with the African great apes (gorillas, chimps, and bonobos). This idea was once very controversial, but has gradually become well accepted as the evidence from different molecular evolution measurement techniques has accumulated.

Biochemical evidence is more reliable than morphological evidence for trying to sort out which species are human ancestors and which are not. There are many apes known from the Miocene period, ca 22 to 7 million years ago. Some fossil apes of this period have large grinding molar teeth rather like those of hominids. Paleontologists once were fairly confident that these were human ancestors. Now the biochemical evidence suggests that these were independent radiations of apes able to eat lots of coarse plant matter. It seems that measures of biochemical distance are not too well correlated with amounts of morphological difference. When evolution is rapid, form can change faster than gene sequences; the biochemical change is rather clock-like, giving good estimates of phylogenetic trees and times of divergence. The fossil record is very sparse, and hence unreliable when evolution is rapid.

Almost every element of human anatomy and behavior is at least foreshadowed by apes and monkeys. Take tool use. Not too long ago, scholars would have confidently asserted that apes don't use tools. Now, chimpanzees are known to use a variety of tools, some requiring substantial preparation to use. There is quite suggestive evidence that chimpanzee tool use is based upon cultural traditions (McGrew, 1992). Elements of human forms of social organization are found among other animals, especially apes (Harcourt and de Wall, 1992; Maryanski and Turner, 1992). Some bonobos (pigmy chimpanzees) can apparently comprehend human language to a surprisingly sophisticated standard (Savage-Rumbaugh, et al, 1993). To be completely accurate, the following lists of differences would have to be qualified with a rather technical discussion of the exact capabilities of apes in comparison to humans. This is as it should be. 6 million years is a fairly short period of time, and it stands to reason that human capabilities will have evolved by shaping, modifying, and exaggerating capabilities present in the last common ancestor we shared with the apes, most probably an animal not very different from the living chimpanzees and bonobos.

B. Anatomical/Physiological Differences

There are six particularly important anatomical/physiological differences between humans and other apes. Each of these differences has important adaptive consequences:

1. *Humans are bipedal.* This frees the hands from locomotion, facilitating an increase in manual skills, tool use, and carrying things.

2. *Humans mature very slowly* and have a long life. This enhances enculturation via vertical transmission; a long childhood allows for lots of opportunities for parents to teach their children cultural knowledge. The disadvantage is that slow maturation lowers potential reproductive rates.

3. Humans have *small canine teeth and large flat cheek teeth.* We use tools to substitute for canines. Our big cheek teeth are well-suited for eating coarse vegetable foods, such as seeds and roots instead of fruit. This is a dietary *generalization* rather than a specialization. Small canines may also be related to relatively low levels of intra-group aggression in human societies—the long canines of primates are mostly used for displays and acts of within-group aggression.

4. Humans have very *large brains* which enhance/facilitate the storage of cultural information, calculating abilities, rapid evolution via culture, and flexible behavior. The disadvantage is that large brains are energetically expensive and fragile. Perhaps equally important, large heads cause birthing problems[1]; thus, brain size comes under stabilizing

natural selection (Chapter 9). This is an example of how cultural evolution may not always favor genetic fitness.

5. Humans also have *cryptic estrous and perennial sexual activity*. This may be important in that it provides the psychological motivation for pair bonding. In turn, the tendency to pair bond tends to protect genetic fitness from divergent cultural evolution by making sex pleasurable and the rhythm method unreliable. If you can't immediately see the disadvantages of cryptic estrous and perennial sexual activity, see any soap opera (Burley, 1979).

6. Unlike other apes, humans have a *two part vocal tract* that makes it possible to speak complex languages. It also makes the likelihood of choking to death fairly high (Lieberman, 1975).

C. Psychological-Behavioral Differences (Possible Adaptive Significance)

There are also some clear psychological-behavioral differences between humans and the other apes, that may also have evolutionary consequences for cultural transmission.

1. *Low intra-group aggression* enables co-operation and division of labor—males can work together instead of fighting. Females gain husbands who make a major economic contribution to the rearing of offspring. Males lose the ability to compete freely for mates; and females lose the ability to observe male fitness displayed clearly in fights and choose to mate with the winner.

2. *Humans transmit subsistence strategies and ideas about social organization by means of cultural traditions.* We have discussed the advantages and disadvantages of this difference at length in Chapters 11 and 12, and elsewhere.

3. *Language and other symbolic capacities* such as art, dance, and ritual characterize humans. These capacities facilitate communication, provide an organizing memory with which to store culture, and make us more efficient at discerning ingroup/outgroup distinctions. The key disadvantages to this ability may be the results of runaway and handicap cultural processes involving indirect bias.

D. Social-Organizational Differences (Possible Adaptive Significance)

Finally we list the primary social-organizational difference between humans and the other apes, and their consequences for evolutionary processes.

---

1. In other words under natural selection individuals with large but not extra-large brains will come to predominate in the population. Under cultural selection alone ever increasing brain size is favored.

1. Humans live in *large well-organized groups* that enable them to acquire and defend resources cooperatively. The disadvantages that arise from living in large groups such as these are cheating and similar public goods problems, as discussed in Chapters 21 and 22.

2. By *sharing resources* a division of labor can be reached, between mates, parents and offspring, and other kin. This was probably especially important for hunting large game, and for sharing resources in times of drought, defeat in war, etc. Hunter-gatherer bands and ethnolinguistic units seem to act like insurance pools, enabling people to adopt strategies with high average rewards, but high variation in success. An active, able hunter will often go many days without making a significant kill, but he can depend upon meat for himself and his family because other hunters will get lucky and share the meat from their kills. When gathering resources fail in one band's territory, they will usually receive permission to use the territories of coethnic neighbors. Such arrangements increase work efficiencies but the disadvantages are the same as for #1 above.

3. *Home-base settlement pattern*s facilitate co-operative resource acquisition, division of labor, and sharing. They also permit environmental modifications like house building. Perhaps the greatest disadvantage of this settlement pattern is that it is unsanitary, and can be dangerous if enemies know the location of one's residence.

E. Summary

Modern humans are quite odd in comparison with other mammals. While no single feature is particularly striking by itself, all of them together present quite an evolutionary leap. The most important differences are presumably our large brains, extreme dependence on cultural traditions, and large scale cooperation. The question we now want to address is how evolutionary processes caused these differences to arise.

III. Basic Paleontological Data

A. Basic Macroevolutionary Pattern

Table 24-1. An Overview of the Basic Human Macroevolutionary Pattern

Time Scale (years bp)	**$20x10^6$**	**$3.3x10^6$**	**$2x10^6$**	**$1x10^6$**		**$0.15x10^6$**	**$0.05x10^6$**
Organisms	Miocene apes	*Australopithecus afarensis, africanus*	*Homo habilis*	*Homo erectus*	*Archaic Homo sapiens*	*Homo sapiens neanderthalensis*	*Homo sapiens sapiens*
Basic Anatomical Characteristics	small brains (basic apes?)	bipedal, small brain, big sex dimorphism, big cheek teeth	*Homo* increasing brain size, modest sex dimorphism, declining tooth size			big brains	two-part vocal tract (basic modern humans)
Tool Traditions	?	small-scale use of temporary tools like *Pan* (chimps)	Oldowan pebble tools	Acheulean basic flake		Mousterian medium fancy	very fancy tools
Adaptations	?	tropical savannah/ dry woodland. Misc. forager?	tropical savannah/ dry woodland. Misc. forager?	tropical savannah/subtropical forager/ hunter.		tropical-subboretic (cold climate) hunter-forager.	tropical-arctic hunter-forager

The basic human macroevolutionary pattern (Table 24-1) shows a discrete or mosaic-like accumulation of traits. As far as can be judged from the fossil record, the evolution of one part of the trait complex is more or less complete before others even start. It appears that the complex suite of human adaptive traits developed in pieces—much as one develops a mosaic pattern by laying down first one piece, then another. For example, bipedality developed before big brains.

Art and possibly even good language only appeared very late, long after brains were quite large. Lieberman and coworkers (1975) have studied the physics of speaking and tried to reconstruct the vocal tracts of fossil hominids from the morphology of the bottom of the skull. He argues that even Neanderthals, who were replaced by modern humans in Europe only about 40,000 years ago, could not speak, at least not anywhere near so well as modern people[2]. Marshak (1976) notes that, until the advent of modern humans, evidence for art is very scarce in the archaeological record, and that the art that has been found is

---

[2] This is highly controversial.

quite modest. Perhaps the extensive use of symbols is a very late development in human history. Isaac (1981) makes the same point about the arbitrary imposition of pattern on tools, and the development of non-functional stylistic variation from site to site in tools. Until very late in the record, tool traditions lasted a long time, were not very fancy, and did not vary much from place to place. As anatomically modern people arrived, tools got much fancier and started evolving stylistically at a much more rapid pace. This event was probably accompanied by a revolution in social organization; perhaps the symbolically marked ethnic group level of social organization arose at this time, but we have essentially no information about the social organization of Neanderthallers and earlier hominids. The arrival of anatomically modern, symbol using humans in Europe about 35,000 BP is called the Upper Paleolithic Transition. The moderns replaced the Neanderthallers there and caused an abrupt modernization that was complete by about 33,000 BP. On the other hand, skeletally modern people are known from South Africa and the Middle East dating back to about 100,000 BP, but they were using Mousterian tool kits much like those of the European Neanderthals. Just when and where modern symbol-rich behavior patterns arose is currently unknown. The transitionally modern people are still hiding from archaeologists!

Early adaptations may have prepared our neuro-physiological system for highly complex cerebral tasks. In his book *The Cerebral Symphony* (1990), neurophysiologist William Calvin argues that the neural machinery that initially evolved because of selection for the ability to throw now enables us to use language, plan for events far in the future, and make music. Calvin argues that ballistic motions such as throwing a rock or stick, hammering, or kicking are extremely hard to perform because they occur too quickly for us to make corrections as we progress from wind-up, propulsion, release, and follow-through. For example, when you carry a full cup of hot coffee, your hands are constantly making corrections based upon information from your eyes and inner ear: “Wups! A little to the left. Steady. Look out! Level, level; that’s it. Now set it down. Don’t slop!…” When you throw something slowly, there is still time for a bit of correction as the process unfolds. However, slow throwing lacks both the distance and speed that will put a prehistoric rabbit over the cooking fire for dinner. Thus, over time, Calvin thinks that natural selection would have favored those who were more able to throw accurately—or hit a flint nodule accurately to make spear points.

The neurological machinery needed to accomplish this task is quite complex. Once humans evolved the machinery necessary for ballistic motion, however, a whole new set of behavioral options became possible. High speed ballistic motions require us to store a large and complex set of movement instructions in our brains before the motion begins. Instead of correcting our movement as we proceed as is done carrying a cup of coffee, we have to have all the instructions for a ballistic motion entered in our cerebral computer before we initiate the throw. Essentially, Calvin argues that when we are not throwing, we can use the same neurological capacity that allows us to store ballistic instructions to manage other activities requiring large sets of complex instructions such as playing a Beethoven concerto or planning a college education. This is the ability that allows *real* conversation where you are simultaneously thinking about what someone else is saying, what you are going to say in response, and what you are saying now.

In short, the evolutionary consequences of preadaptations such as those that coordinate our symbolic capacities can be profound. The fact that traits designed for one purpose may hundreds of thousands of years later kick in as useful for an entirely different task may contribute, in part, to the mosaic pattern of human evolution.

B. Relationship Between Cultural Complexity and Environmental Variation

Change in cultural complexity does not appear to have been smooth, and its relationship with environmental shifts is inconsistent. Figure 24-1a illustrates changes in cultural complexity found in the archeological record. Although the significance of the pattern is presently obscure, it does not seem as though the data are consistent with a smooth acceleration. During the Acheulean period[3] of nearly 1 million years, culture changed very little to judge from stone tool form. A smoother pattern of technical development began around 100,000 years ago with the appearance of Homo sapiens, but the association of this development with any environmental change is presently unsupported. Conversely figure 24-1b illustrates the dramatic shift in climatic fluctuation associated with the onset of the Pleistocene epoch ~ 1.6 million years ago. Notice how *Homo* emerges about the same time as the change to the Pleistocene climate.

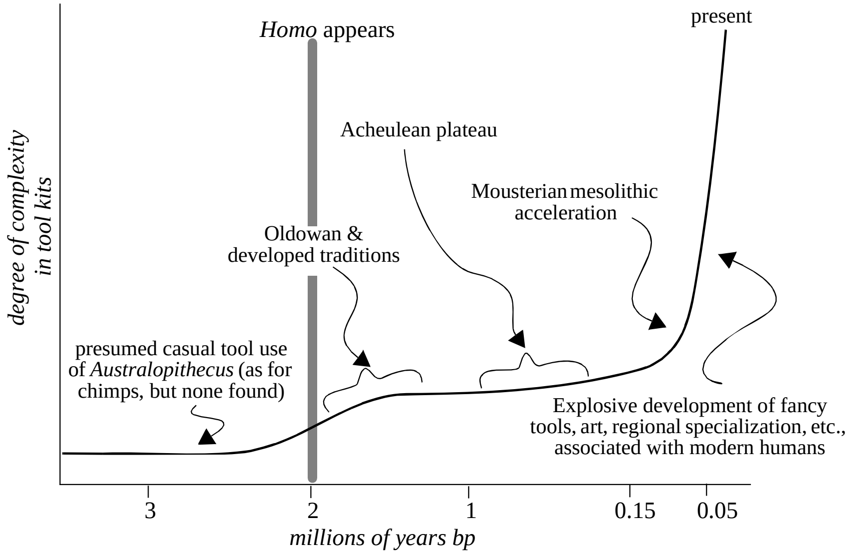
Note that we cannot really say too much about the development of many elements of the modern human adaptive complex. Did the early Pleistocene "humans" hunt or merely scavenge game? This is a controversial area where some bits of evidence can be developed based on bone assemblages, evidence from cut-marks, etc. (e.g., Behrensmeyer et al., 1986). When did humans start to share food, live in base camps, lose indicators of ovulation, and so forth? Isaac and others interpret some early tool concentrations as home bases, but this interpretation has recently become quite controversial. The social organization and other behaviors of early hominids may have been very different from that of modern people. At what point in hominid evolution would we really want to call these creatures hu-

---

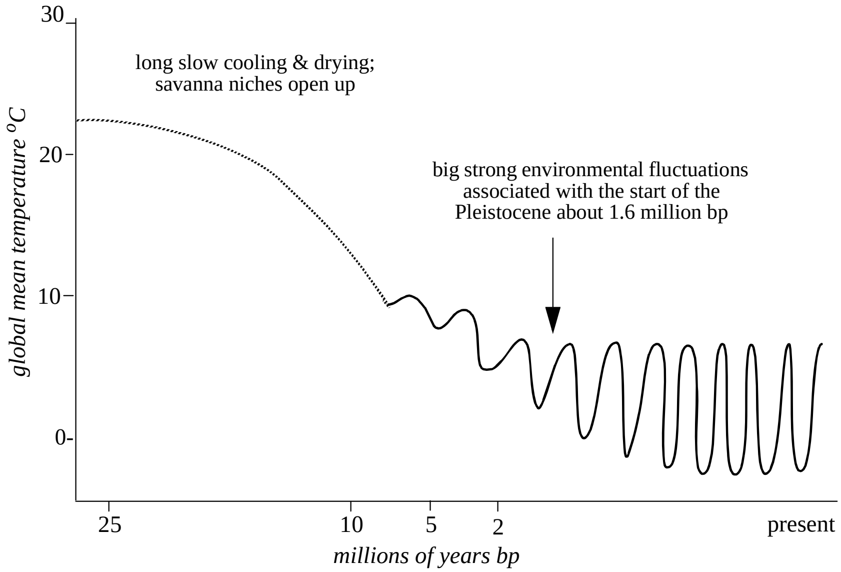
[3] roughly corresponding to *Homo erectus* level humans, although perhaps also with biologically more advanced forms as well

Figure 25-1. Changes in the degree of cultural complexity among hominids and their ancestors appear to correlate with changes in the level of climatic fluctuation. Note that the time line in graph **b)** is strongly exaggerated for illustrative purposes.

a) Cultural Complexity



b) Environmental Change



man? This depends much more on behavior than on anatomy. Humans sometimes attempt to raise apes as if they were children and incorporate them into human families. This always fails because apes cannot be sufficiently socialized. As they become adult they become much too rough and wild to live free in a human household. It is presently impossible to say at just what point in human evolution we would feel comfortable with one of these ancestors of ours as a room-mate!

IV. Types of Hypotheses

A. Internalist Hypotheses:

Internalist hypotheses, of which there are many, usually envision some sort of adaptive breakthrough, after which a positive feedback of some type sends hominids off on a relatively smooth evolutionary trajectory towards modern humans. Thus, some sort of chance evolutionary event set up the necessary preadaptation, after which the environment for each stage in the trajectory was susceptible to “deterioration” by competition with types that had the more perfected version of the human adaptive complex (e.g., each improvement in weapons technology reduced game densities and made neighbors more dangerous; selection continued to favor better weapons makers and users).

Upright posture frees hand, and free hands are seen as the key preadaptation to subsequent social evolution. Tobias (1981) argued that as the climate cooled and dried our quadrupedal ancestors moved out onto the expanding savanna, because savanna living favored bipedal locomotion. There are various speculations on why bipedal posture evolved. Perhaps early hominids had to carry primitive weapons to protect themselves on the open plains, perhaps they used hands to harvest seeds, or to carry resources back to a home base. Bipedal walking may also simply be the most direct route to an efficient gait for an arboreal lineage evolving to exploit the savanna. Apes are quite inefficient walkers, but humans are about as efficient as typical quadrupeds (McHenry, 1982). This adaptation set up a positive feedback process that drew out the other parts of the trait complex -- a smoothly accelerating evolutionary trajectory.

Although hypotheses such as these make good sense, they have serious problems. First, hypotheses that depend too much on internal feedbacks (there are, for example, scenarios linking bipedal gait to pairbonding to monogamy to extended offspring dependence to the division of labor, etc. (see also figure 24-2) have real difficulty in accounting for the mosaicism of the paleontological record. Why did our major traits (Table 24-1, see also Figure 24-3) come in bits and bobs, and not in the kind of smooth trajectory envisaged by proponents of internalist hypotheses? The internalists would respond by proposing a

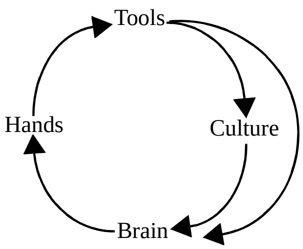


Figure 25-2. An example of the role played by positive feedback processes in progressivist explanations of the evolution of human culture (from Washburn, 1960).

“rough adaptive topography” (see Chapter 23), such that innovations were retarded by deep chasms that took a few hundred thousand to a couple of a million years for adaptations to evolve around.

Second, these hypotheses don’t account for the specifics of the hominid adaptive break-throughs. Why did hominids only start having large brains ca. 2 and not 5-15 million years ago? Why did the breakthroughs permitting cultural adaptations occur only in the hominid lineage? Why did they occur among our African ancestors, and not elsewhere in the world? Internalist hypotheses are poor at answering these “big questions”.

Third, they rely often implicitly on the notion that somehow hominids were preordained to move inexorably up to our currently dominant position in relation to most, if not all others animal life forms [4]. As evolutionist we must always be suspicious of “explanations” that rely on “causes” that are more ideological than scientific.

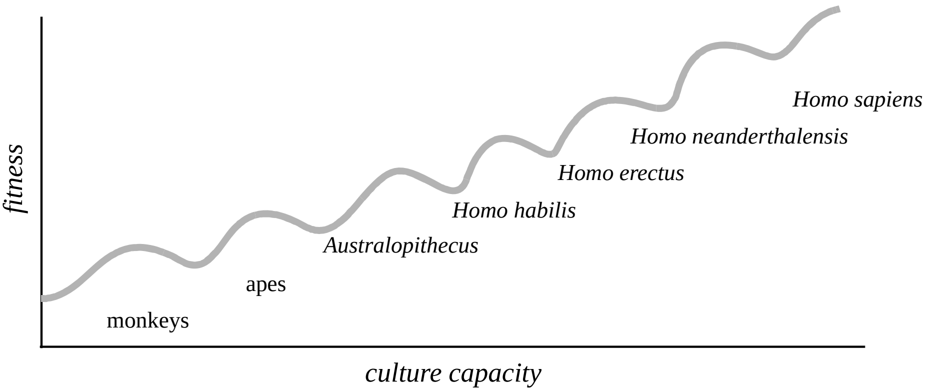
In sum, while internalists hypotheses are particularly useful in generating explanations for fine scale historical changes (see Chapters 26 and 27) their application to large scale events (such as hominid evolution and the neolithic revolution (Chapter 25) is problematic. This is because they are often strongly tainted with the view “onward and upward to Natures’s crowning jewel - Man”, and because external influences on the timing and specifics of evolutionary change receive scant attention.

---

[4] Daily we drive species to extinction, encroach on the remaining habitat of others, and spend millions of dollars on controlling pathogenic organisms.

.

Figure 25-3. The adaptive topography encountered by hominids and their ancestors was quite irregular. This meant that adaptive innovations often were subject to substantial counter selection when they first began to emerge.



B. Externalist Hypotheses

Externalist hypotheses attempt to explain the human trait complex as an ordinary adaptation brought about by a change in environment[5]. The most obvious environmental correlates are the gradual drying and cooling of the earth's climates since the Miocene. The Miocene epoch began 25 million years ago as Antarctica drifted over the South Pole and glaciations began. The Miocene was a period of revolution in mammalian adaptations generally, as animals adapted to cooler and more variable climates (see the graph of climate variation in Appendix 24A) and more open, less forested habitats arose. These animals included a number of apes with resemblances to hominids. Mammals also, on average, got brainier during this period. According to Jerison (1973), early tertiary mammals showed no signs of increase in brain size over Mesozoic mammals. We all know about the stupidity (or at least relatively small brain size) of the dinosaurs, the most famous Mesozoic animals. All animals remained pretty stupid until the last 25 million years or so, when a fair proportion of them began to develop conspicuously large neocortexes.

Then a new spurt in brain size came with the onset of the Pleistocene glaciations. Beginning about 2 million years ago, glaciation began in the Northern Hemisphere too, and the pattern of conspicuous fluctuations of climate began, or got stronger. As the Pleistocene

---

5. Recall from Chapter 24 that externalist hypotheses hold that most populations are usually very well adapted. However, populations are seldom, if ever, perfectly adapted because of environmental fluctuation; i.e., evolutionary processes are tracking a moving environmental target.

advanced, the pattern of fluctuations changed from shorter- to longer-term (see Appendix 24A). Perhaps hominid adaptations are just part of the general mammalian response to climatic change.

If the patterns of variation in the climate record sketched in the appendix are correct, more brains to cope with the demands of more learning and eventually culture may be a response to an increasingly variable climate[6] (look back to Chapters 11 and 12 for the rationale behind this). In this view, small simple brains do not so much indicate “primitive” animals, as simple, invariant climates that do not put much of a premium on costly processes like individual and social learning. The increasing variability of climate looks like the right kind of environmental change to favor increasingly sophisticated individual and social learning abilities.

This externalist hypothesis has become the major alternative to internalist feedback hypotheses for the origins of the hominids. It seems more reasonable to look for a direct adaptive response to environmental change, not just an accidental trigger + positive feedback story, to explain each mosaic bit in the human adaptive complex. For example, a bipedal gait might have arisen in response to the spread of savannas. Just what primates may have been doing on the savanna is still a bit puzzling. Hunting or scavenging animal carcasses has been suggested, but the large cheek teeth of *Australopithecus* suggest that they were initially foraging for bulbs, seeds, and other relatively high-quality plant resources. This would have been a marginal adaptation to the savanna, as forests are probably a better source of this kind of plant resource. The bipedal gait would have allowed large territories to be gleaned for these resources. Then later, as the climate deteriorated still further and began to fluctuate more strongly (at the beginning of the Pleistocene 1.6 million years ago), culture capacities and the employment of hands to manipulate technology may have arisen (see Lewin, 1987a).

The externalist hypothesis nevertheless fails to account for several important details. For example, there is not much correlation between climatic shifts and the evolutionary **details** such as the Acheulean Plateau, and the recent explosion of first biological then cultural evolution. With the availability of new ocean core data yielding information on the paleoclimate, externalist hypotheses are likely to be strongly refined (or perhaps rejected?) in the near future.

---

[6] These climatic fluctuations affected the whole world, though the details differ in each location. The tropics were affected by cycles of aridity as the temperate and arctic regions were exposed to cycles of glaciation and cold climates.

C. Non-Adaptive Diversification

Does the evolution of hominids show any signs of generating non-adaptive variation? Humans only evolved once, in Africa, despite the existence of similar habitats on all the continents. The *Australopithecus* niche was filled on the other land masses before the migration of *Homo,* with a combination of other animals, but no other group converged on our lineage. Why didn't this happen? Some element of historical accident must have been important on a fairly long time scale. Either the apes of Africa were the only animals with the preadaptations to become culture-bearing bipeds[7]. Or they were the only ones to break down a previously adapted complex of traits, or the African environment was the only one that offered opportunities to move from local peak to local peak (e.g., figure 24-3), or something else. If some evolutionary accident had befallen the Australopithecines, probably humans would never have arisen at all. Thus, to some extent at least, each major biogeographic region seems to be a unique evolutionary experiment with at least some non-convergent differences.

V. Conclusion

Neither extreme externalism nor extreme internalism seem to fit the existing human data perfectly. Recalling that the differences between these two hypotheses are all a matter of the time scale and mode of innovation limitation (see Chapter 23), we are free to adjust time scales, and mix these hypotheses in other ways. On the grand scale, it seems that an externalist hypothesis fits quite well; humans are basically a weedy generalist well adapted to take advantage of the rapidly changing Pleistocene climate. On a smaller time scale, some form of internalism seems required to account for the increases of culture capacity within the Pleistocene period. Given that only one lineage responded to the climatic deterioration with a spectacular increase in culture capacity (and that one was ultimately very successful and able to spread to all continents), convergence was clearly imperfect, indicating a role for non-adaptive variation in evolutionary processes. If early humans were at some sort of adaptive peak, lineages from the New World and Australia showed no signs of converging on it. Hominids remained an African lineage for a long time before they even spread to Eurasia, but once they arrived they were successful. An element of historical accident seems well demonstrated in this evolutionary record.

The data still allow much room for interpretation. Every major new hominid fossil discovery seems to generate a significant reevaluation of hypotheses. Perhaps we will never

---

[7] William Calvin's discussion of the neuro-physiological complex permitting complex cognitive operations was an example of a "preadaptation". (Stephen Gould calls them exaptions).

get an uncontroversial explanation of this problem. On the other hand, our knowledge of the fossil and climatic record is still steadily improving, and tests of hypotheses are possible; at least the *range* of sensible hypotheses might eventually be narrowed. In the meantime, depending on your taste, this problem is either fun to think about or quite frustrating.

VI. Bibliographic Notes

References:

Behrensmeyer, A.K., K.D. Gordon, and G.T. Young. 1986. Trampling as a cause of bone surface damage and pseudo-cutmarks. *Nature* 319: 768-71.

Burley, N. 1979. The evolution of concealed ovulation. *Am. Nat.* 114: 835-58.

Butzer, K.W. 1971. *Environment and Archeology. An Introduction to Prehistory*. Chicago: Aldine.

Calvin, William H. *The Cerebral Symphony: Seashore Reflections on the Structure of Consciousness*. New York: Bantam Books.

Harcourt, A.H. and F. de Waal. 1992. *Us Against Them: Coalitions and Alliances in Animals and Humans. Oxford: Oxford University Press.*

Isaac, G. L. 1976. States of cultural elaboration in the Pleistocene: possible archeological indicators of the development of language capabilities. *Ann. N.Y. Acad. Sci.* 280: 275-288.

Isaac, G.L. 1981. Emergence of human behavior patterns. *Phil. Trans. R. Soc. Lond.* B 292: 177-88.

Jerison, H.J. 1973. *Thee Evolution of Brain and Intelligence*. New York: Academic Press.

Klein, R. G. 1989. *The Human Career: Human Biological and Cultural Origins*. Chicago: University of Chicago Press.

Lieberman, P. 1975. *On the Origins of Language: An Introduction to the Evolution of Human Speech*. New York: Macmillan.

Lewin, R. 1987a. Four legs bad, two legs good. Research News. *Science* 235: 969-70.

Lewin, R. 1987b. *Bones of Contention: Controversies in the Search for Human Origins*. New York: Simon and Schuster.

Maryanski, A. and J.H. Turner, 1992. *The Social Cage: Human Nature and the Evolution of Society.* Stanford: Stanford University Press.

McGrew, W.C. 1992. *Chimpanzee Material Culture: Implication for Human Evolution.* Cambridge: Cambridge University Press.

McHenry, H. 1982. The pattern of human evolution: studies on bipedalism, mastication, and encephalization. *Ann. Rev. Anthrop.* 11: 151-173.

Marshak, A. 1976. Implications of the paleolithic symbolic evidence for the origin of language. *Am. Sci.* 64: 136-45.

Sarich, V.M. 1980. Molecular clocks and human evolution after 12 years. *Am. J. Phys. Anthrop.* 52: 275-6.

Savage-Rumbaugh, S, J. Murphy, R. Seveik, D. Brakke, S. Williams, and D. Rumbaugh. 1993. Language comprehension in the ape and child. *Monographs of the Society for*

Research in Child Development 58.

Tobias, P. 1981. The emergence of man in Africa and beyond. *Phil. Trans. R. Soc.* Lond. B. 292: 43-56.

Washburn, S. 1960. Tools and human evolution. *Scientific American* (Sept.) pp 2-15.

For good reads by the bone guys see:

Johanson, D. and M. Edey. 1981. *Lucy, The Beginnings of Humankind*. New York: Simon & Schuster

Leakey, R. E. and R. Lewin. 1977. *Origins*. New York: Dutton.

Appendix 24-A: Note on the Climatic Record

A number of different methods are used to reconstruct past climates. They fall into three classes, physical methods, biological methods, and human historical documents.

An example of physical methods is the use of oxygen isotope ratios. Most oxygen on earth is O^{16}, the isotope with an atomic weight of 16. Some, however, is the heavier O^{18} isotope. For most purposes the isotopes are essentially identical. However, water molecules containing O^{18} are heavier enough than O^{16} water to have a slightly lower evaporation rate. When large amounts of ice accumulate during ice ages, the water in the ice tends to be relatively depleted in O^{18}, whereas the ocean waters become somewhat richer in ^{18}O. By using a mass spectrometer to measure O^{18}/O^{16} ratios in samples from ice or bottom sediment cores, the fluctuations from glacial to interglacial conditions can be estimated. One of the longest deep sea core O^{18}/O^{16} records is illustrated on the attached figure.

Biological indicators use the idea that the ranges or behavior of organisms change with temperature or other features of climate. The pollen record from Macedonia in the figure for the next chapter is an example, as is the foraminifera abundance curve attached. (Foraminifera are marine amoebas that live in little calcium carbonate shells. The shells are abundant in marine sediments, and so they have been favorites for both physical and biological measurements of climate change.) Tree-ring width estimation—rings in the Western U.S. are closely correlated with rainfall in some localities—is another example.

Human historical records include accounts of famines, freezes, and other unusual events, and a few fairly long runs of data on dates of wine harvests and the like. The instrument record only began even in crude form only in the 17th Century. Lamb (1977) discusses these early records in some detail.

Figures 24A-1 through 24A-3 illustrate Pleistocene environmental fluctuations. Figure 24A-1a gives estimates of historical temperature trends based upon data from a number of sources. Figure 24A-1b provides similar data based upon tree ring data. Figure 24A-2a presents data from deep sea cores and figure 24A-2b presents similar data based upon ice core samples. Figure 24A-3 from Lamb (1977) shows analysis of an equatorial deep sea core covering the last 2 million years.

Figure 24A-1.

(A) "Generalized surface temperature changes of the earth over its geological history. Only relative departures from today's conditions are suggested; particularly for Precambrian times (copied from Schneider & Londer (1984:15)."

(B) "One of the best methods of reconstructing paleoclimatic conditions is to compare the proxy evidence from independent lines of evidence. This figure compares tree ring widths in the White Mountains of California against an analysis of mountain glacier expansions and contractions in the Holocene as inferred from debris left behind from these events (copied from Schneider & Londer (1984:104)."

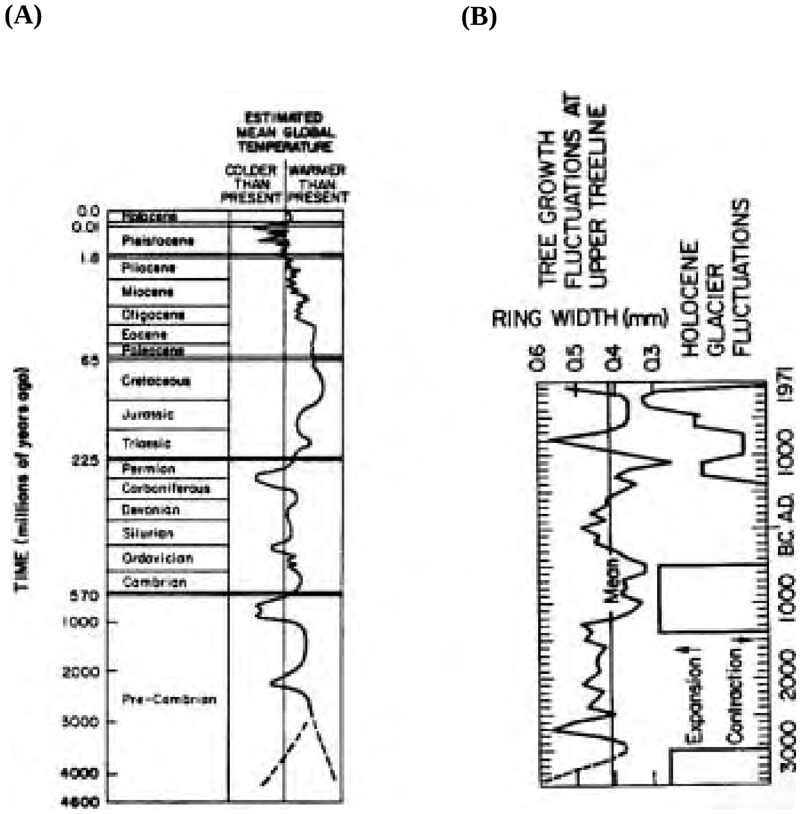


Figure 24A-2.

(A) "Variation in the oxygen isotope ratios in the shells of fossil forams [relatively large marine organisms whose shells form the bulk of chalk and common limestone deposits] living near the ocean floor taken from a deep sea core in the Pacific Ocean. If all other factors are constant, less negative values of this oxygen isotope ratio index ($\delta 0^{18}$) indicate colder climates corresponding to increased ice volumes. …Each major change of direction in the oxygen isotope ratio curve is called a stage, as indicated on the figure. Inasmuch as similar stages are found from deep sea cores taken all over the world, many paleoclimatologists believe that these major shifts in …[the] index indicate a record of global climatic change over the past million years or so (copied from Schneider & Londer (1984)."

(B) "An ice core taken at Camp Century, Greenland provides a climatic record back some 120,000 years or so. When the oxygen isotope ratio index ($\delta 0^{18}$) is large and negative, it suggests a relative absence of the isotope $\delta 0^{18}$, indicating relatively cold conditions (copied from Schneider &

(A) **(B)**

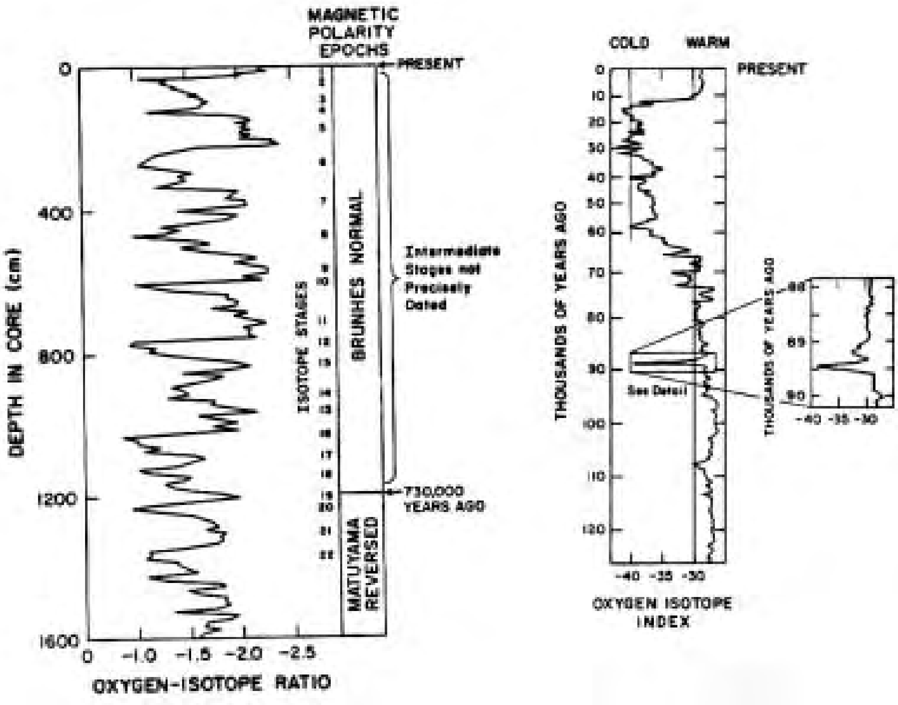
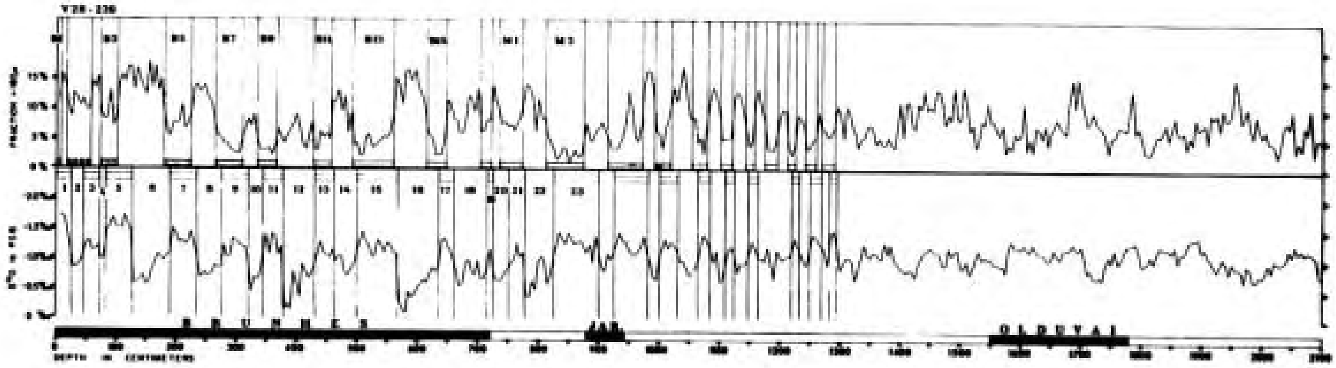


Figure 24A-3. “Analysis of a deep sea core… from the equatorial Pacific at 3º15'N 159º11'E at a water depth of 3490 m covering the last 2 million years. The geomagnetic stratigraphy indicates a time scale (shown in units of thousands of years at the bottom of the diagram) which implies that the sediment here examined was laid down over the last 2 million years.

“The upper curve registers the percentage of the sediment made up of coarse particles (>180mm cross-measurement). The coarse fraction of the sediment consists largely of the shells of foraminifera and therefore increases with the productivity of these creatures, increasing with increasing water temperature.

“The lower curve plots the variations of the 18O/16O ratio in the species *Globeriginoides sacculifera*. The variations of oxygen isotope ratio provide another indicator of the swings between glacial and interglacial regimes, the ratio increasing as the Earth goes into a glacial regime. The numbers above the lower curve identify the stages of the Quaternary climatic sequence according to Emiliani’s system. (Text and figure copied from Lamb, 1977:fig 15.1).”



Chapter 25. ORIGIN OF FOOD PRODUCTION

> "While observing the barbarous inhabitants of Tierra del Fuego, it struck me that the possession of some property, a fixed abode, and the union of many families under a chief, were the indispensable requisites for civilization. Such habits almost necessitate the cultivation of the ground; and the first steps would probably result… from some such accident as the seeds of a fruit tree falling on a heap of refuse, and producing some unusually fine variety. The problem, however, of the first advance of savages toward civilization is at present much too difficult to be solved."
>
> C. Darwin, *Descent of Man* (1874)

I. Introduction

This change in subsistence patterns from hunting and gathering to agriculture was the first unambiguously CULTURAL "revolution" in human technology and ecology. It constitutes an interesting and important macro-evolutionary phenomenon. All previous changes, as we saw in the last chapter, entailed genetic changes insofar as modifications in morphology were involved. Humans seem to have become biologically modern in Southern Africa by perhaps 100,000 years ago, and fully modern people had replaced Neanderthals by ca 40,000 bp in the remote outpost of glacial Europe. The agricultural revolution, by contrast, was primarily technological, behavioral and social. Any associated genetic changes are likely to have been an insignificant part of the food production revolution.

T*he changes in the culture core occasioned by the development of a subsistence based on plant and animal domestication was in some ways as dramatic as any of the biocultural transformations of the deeper past (see Chapters 4 and 6).* A full-blown agrarian society of millions of people is in some ways a big or bigger step in terms of social organization as the step from a weakly cooperative primate troop of 60 animals to the cooperative hunting band of the same size[1]. The food production revolution greatly impressed earlier scholars because it was the economic basis of "civilization"—literacy, mathematics, state political organization, and the like. There is no doubt that this complex of traits deriving indirectly from agriculture represent impressive changes from hunting and gathering. In industrial societies today we are still dealing with the ramifications of the food production revolution that began 10,000 years ago.

---

[1] Although recall that the hunting band is really part of a larger society of some hundreds to thousands of individuals of the same linguistic/cultural group, a unit with no real parallel in the animal case.

The evolution of food production has been intensively studied since the early 1950s and thus the development of societies dependent on food production is also much better known than any earlier transformation of human ecological patterns. The sites for studying this development are numerous because they are relatively recent and the food foragers who gave rise to them were populous. Several major archeological teams, beginning in the 1950s, conducted a number of quite sophisticated studies designed explicitly to test earlier hypotheses about agricultural origins. Archeologists of an earlier generation working in the regions of the first civilizations—V. Gordon Childe is the best known name—had made interesting speculations about this subject.

The most important early projects were led by Robert and Linda Braidwood (in the Near East) and Richard MacNeish (in Mesoamerica and the Andes). These investigators led multidisciplinary teams of archeologists, botanists, zoologists, radiocarbon daters, ecologists, and geomorphologists to study in areas carefully selected to be in the likeliest areas for the transformation from hunting and gathering to agricultural subsistence. They deliberately looked for evidence of plant and animal domesticates and other aspects of the ecological relations of the succession of societies across the transition. The result of these and similar investigations gives a fairly clear picture of the events of the revolution, although the processes involved are less clear. A large literature interpreting the events in terms of processes has grown up in the period since these investigations began. Prominent names associated with process hypotheses to explain agricultural origins include Kent Flannery and Lewis Binford. A number of botanists were also attracted to work on the evolution of plant domesticates from their wild ancestors. The work of Paul Manglesdorf and George Beadle on maize is especially noteworthy. The climate record over the relevant interval is recent enough to be comparatively easy to study, and is consequently fairly well understood.

II. The Evidence

A. The "Agricultural" or "Neolithic" Revolution

There are three non-controversial "centers" of crop domestication for which the archeological data are good and which are known to represent independent developments. These are listed below:

1. *Near East*—beginning about 9,500 bp.
2. *Meso-America*—beginning about 7,200 bp.
3. *Peruvian highlands*—beginning about 6,500 bp.

Evidence for the cultivation of rice in the Far East (Thailand), beginning about 8,500 BPis more controversial, as is the evidence for tropical root crop agriculture in West Africa. Figure 25-1 shows the centers of plant and animal domestication. The main crop plants to be first domesticated were large-seeded grasses and other annuals, maize, wheat, rice, beans, and many others. Highland Peru and the lowland tropics differed in the kinds of plants used--there the emphasis was on root crops (MacNeish, 1977).

A little after 10,000 years bp, agriculture "broke out all over the world, like measles." The several centers of domestication are almost contemporaneous and developments are very rapid (relative to a geological time scale or the time scale of human evolution at any earlier time). Indeed, although the agricultural "revolution" took an average of about 4,000 years to go from food foraging to complete dependence on domesticated products, on an evolutionary time scale this was a sudden, rapid event. *This* was a punctuational event if ever there was such, though it was still well within the scope of ordinary microevolutionary processes to accomplish.

Figure 26-1. Centers of plant and animal domestication. Copied from *The Times Concise Atlas of World History* (1982:7).

There were similar stages in each regional case. Table 25-1 illustrates with the Meso-American example.

Table 25-1. Outline of the basic archeological data recovered by Richard MacNeish in the Techuacan Valley, Southern Mexican Highlands. This is one of the classical examples of origin-of-agriculture excavation studies (adapted from MacNeish, 1964).

Phase	**Dates bp**	**Estimated Population (in 2,400km^2 valley)**	**Culture Core**	**% Animals in Diet**	**% Deomesticated Plants in Diet**
Ajuereado	>9,200	10-20	*Big game hunting*, including now extinct horses, antelopes and mammoths, but small game more important. *No special tools to process plant food.* Small bands, highly mobile.	>50(?)	0
El Riego	9,200-7,200	50-70	Broader spectrum of plant foods used *including protocultivars* of squash, chili, & avocado. *Seed-grinding tools. Macroband* camps in wet season. Shamans, ceremonial burials.	54	0-5
Coxcatlan	7,200-5,400	150-180	Still more specialized plant collectors with *a bit of plant cultivation.* Acquired gourds, beans, used wild corn. Larger wet season camps, but *still microbands in dry season*. Incipient agriculturalists.	34	14
Abejas & Purron	5,400-3,500	350-700	More sedentary, less use of microband camps. *Used domesticated corn. Pottery* developed in Purron.	30	20-30
Axxxxxn & Santa Maria	3,500-2,200	1,000-4,000	Almost completely sedentary, with *mud houses. Mainly domesticated plants*. Fancy pottery, ceremonial centers (temples). Possible start of irrigation.	30	40-45
Palo Blanco	2,200-1,300	18,000-26,000	Full-time agriculture, *irrigation heavily used.* New domesticates include tomatoes & turkeys. Large ceremonial centers, pyramids, etc. *Kings & bureaucrats.*	18	65
Venta	1,300-450	80,000-90,000	Commerce becomes important. *Large* residential towns *as well as ceremonial centers.*	17	75
Salada Spanish Conquest	~450		Domesticated animals and metallurgy introduced.		

Pleistocene big game hunters give way to specialized food foragers a few thousand years as a consequence of the "broad spectrum revolution". The classic big game hunting people of the Pleistocene showed little signs of using much plant matter, or even small animals and fish. However, over time these specialized food foragers built up larger populations per unit of land area and were forced to begin exploiting lower quality resources. They developed seed grinding equipment, digging tools, etc., preadapted to plant production. This event is known by the archeologists' term "**the broad spectrum revolution**". In addition to greater use of plants, it includes a tendency toward settled villages in favored areas, use of fish, shellfish, and small animals in much greater numbers than in the Pleistocene. For example, in the Highland Andes, deer bones declined sharply in middens[2], and guinea pig bones became very common, as a part of the broad spectrum revolution. Another good example is the shift in California from Folsom type peoples with a toolkit adapted for hunting big game to the acorn grinding, salmon drying people of the contact period. Some of these societies began to use the wild progenitors of what eventually became crop plants. In general, these post-broad spectrum systems were more locally specialized than big game/rich plant collecting subsistence systems were during the Pleistocene. Then the same basic animals and plants were exploited with the same basic technology over wide areas.

As these specialized food foragers began using species which ultimately become domesticates, incipient agriculture grew imperceptibly and slowly from specialized foraging (on a generation to generation time scale). At first, people may have merely protected and weeded naturally occurring stands of desirable plants and engaged in other management strategies short of actual cultivation. Later, seed might have been gathered, and the genetic changes leading to domestic races of crops initiated. Archeologists recognize domesticated crops mostly by key anatomical changes for which humans (perhaps inadvertently) select as they come to dominate the species' demography. In wild grasses, for example, seed heads break apart ("shatter") at maturity in order to scatter the seed. Domesticated varieties are non-shattering; this enables efficient harvesting. In legumes, the pods split explosively at maturity in order to scatter seed. Domesticated bean and pea pods remain closed until we shuck out the seeds. Zohary and Hopf (1988) provide a good discussion of the history and biology of all the important Old World crops. At first the proportionate dependence on domesticates was low, and a near complete loss of hunting and gathering strategies took considerable time.

---

[2] refuse heaps which are great sources of information for archaeologists

B. The Relative Nature of Time Scales

Notice that, on a conventional time scale[3]*, this "revolution" actually occurred slowly and gradually*. It took roughly 3,000 years for the transition from the barest beginnings of plant domestication to almost full dependence on domesticated foodstuffs in the Near East[4]. Compared to the Industrial Revolution, with which we are more familiar, the agricultural revolution was slow! It took a similar length of time for horticulture to spread from the Near East to far-Western Europe. From a macro-evolutionary perspective, however, the rates of cultural evolution achieved during the agricultural revolution occurred in the blink of an eyelid. Nevertheless let us think of it from the point of view of an individual living 8,000 bp. Agricultural change would have probably been imperceptible, with the acquisition of a new innovation only every few generations or so. It is doubtful that individuals ever felt part of a progressive, developing trajectory the way we do. At each point in time, lifeways probably seem like static traditions. Making allowance for large differences in time scales in different kinds of evolutionary and ecological processes and events requires some careful thinking. Our intuitions, developed in a world of incredibly rapid progress (well, change at any rate), are not necessarily very trustworthy.

C. Differences and Similarities between Centers

There were some striking environmental similarities between the main centers of plant domestication. Meso-America and the Fertile Crescent (the hilly uplands in the headwaters of the Tigris and Euphrates rivers, and adjacent regions) are particular similar. They are hilly, diverse, subtropical regions. Both regions were host to large-seeded grasses and a large flora of annual vegetation. Even today, most of our key plant domesticates were developed from natives of these two regions: The list includes maize, wheat, barley, various legumes, etc. Highland Peru differs somewhat in being tropical, although the extreme elevation and aridity give it more of a resemblance to Mexico and the Fertile Crescent than one might at first suppose. Also, the classically important domesticate of Peru is the white potato which is a root crop, not a grass seed domesticate.

There were also some interesting differences between Centers, for example the Americas were late and slow. Meso-American societies began the development of horticulture perhaps 2,000 years later than in the Near East. The pace of developments was also somewhat slower in the New World after the initial moves toward cultivation. Thus, the early city-states and initial empires that developed in Mesopotamia ca 5,000BP resembled the political structure of the most advanced American societies at contact ~500BP. Amer-

---

[3] i.e. the way we modern humans like to think about things.

[4] Note that 3,000 years is roughly 120 human generations.

ica, especially Meso-America, lacked the variety of domesticated animals found in Eurasia. Probably because the Pleistocene mega-faunal extinctions were more severe in the new world, there was a lack of pre-adapted animals that could be domesticated to provide the level of transport and traction needed for agrarian subsistence modes. Perhaps the role of horses and other domestic livestock in promoting labor efficiency and extending the reach of tradesmen and soldiers accounts for the quicker rate of evolution in the Old World.

There were also probably major evolutionary differences between the seed-agriculture of subtropical and temperate regions and the vegeculture of the tropics, the latter of which was late and diffuse. Tropical cultivators tend to use more vegetatively propagated[5] plants like sweet potatoes, taro, and bananas. Temperate and subtropical cultivators tend to use more seed crops like maize, wheat and rice. The archeological record in the tropics is very poor, but there is an indication that the development of tropical vegeculture was slow er, later, and less concentrated in "centers" (the restricted regions of innovation from which seed agriculture appears to have diffused).

D. The Importance of Climate Change[6]

The beginning of the broad-spectrum revolution and of the later shift to food production is roughly correlated with the end of the Pleistocene. The world became warmer and perhaps generally wetter beginning about 14,000bp. By about 10,000bp, climates were essentially modern. Notice in the many records shown in Appendix 24-A how high-frequency climatic variations suddenly became much less important across the Pleistocene-Holocene transition[7]. While the Pleistocene had strong climate fluctuations on time scales of 1,000 years or less, these fluctuations have been substantially muted in more recent times.

III. Hypotheses Attempting to Explain the Origin of Food Production

A. Inventor-Genius Hypotheses

According to Carter (1977), agriculture is an inherently better way to make a living—but it takes the rare genius to see it. Under this hypothesis there is extreme innovation limitation on the evolution of the culture core. We can categorize this as an extreme type internalist hypothesis of the "random trigger and breakthrough" type. It also has that strong flavor of "onward and upward" progressivism that we must beware of.

---

[5] Vegetative propagation involves planting a piece cut from a plant rather than seeds. For example, one propagates potatoes by planting pieces of potato with 'eyes' or root starts on them. One plants bananas by digging up a small offshoot from the base of a mature plant and planting it elsewhere in fertile soil.

[6] Refer to Appendix 24-A.

[7] approximately 10,000bp

B. “Settling In” Hypothesis

According to Braidwood (1967), food foragers gradually learn agriculture after they became more familiar with lower ranked resources during the “broad spectrum” revolution. This is very similar to Carter’s hypothesis, except that the inventor is not a “rare genius” but a careful observer of the habits of animals and plants. This hypothesis is also largely internalist and progressive.

C. Population Pressure Hypothesis

According to Mark Cohen (1977), agriculture was born of necessity when population density reached some critical threshold. Slow population increases in the late Pleistocene gradually caused people to adopt more and more “technology-intensive” means of production. Once this threshold favoring the adoption of agriculture was passed, cultural evolution took off at a great rate as population growth rates accelerated[8]. This is a punctuational hypothesis based upon environmental deterioration under which human competition for resources eventually causes the adoption of agriculture. In this sense it is also internalist.

This is a popular hypothesis but reflects a confusion about time scales. Population “pressure” builds very rapidly because of Malthus’ “law.” Over the course of 10s of thousands of years, there must have been many episodes of population “pressure,” even assuming that there were many density *independent* mortality episodes[9]. Even on the time scale of the development of food production, population pressure is liable to be more or less constant, not something that can explain a macroevolutionary event. That is, populations are not limited by resources can easily double in a century (or even a generation). As we saw in the case of pre-industrial population and technical improvement in England, population growth can easily keep up with fairly rapid technical improvement. On the several thousand year time scale of changes involved in the broad spectrum and agricultural revolutions, population increase could surely have kept up with technological improvement. Thus the driving variables must be related to controls of technical improvement (the rate of innovation), not to the rate of increase of population.

D. Ecological Hypothesis

Harris (1977) proposed a more sophisticated hypothesis based upon positive feedback and environmental deterioration that unlike Cohen’s identified the specific conditions

---

[8] This type of hypothesis is also typical of earlier social sciences human ecologists such as Amos Hawley (1986).

[9] For density independently regulated populations, consult Chapter 16. It is also reminiscent of Boserup (Chapter 16)

in which a hunter-gatherer population would benefit from adopting agriculture. This idea is best viewed as an explanation for why the adaptive topography might have a decided valley between hunting and gathering and agriculture, and how special circumstances might allow particular hunting and gathering societies to cross the valley. Although this hypothesis' focus is local in time and space, it is an important component of the best story we can currently tell about the origins of agriculture.

According to Harris, ordinary food foragers normally will not develop agriculture because there is stabilizing selection on the food foraging adaptation. As data on diets and effort expenditure show, many food foragers are not particularly stressed by a lack of food. There is therefore no obvious incentive for them to develop agriculture. Moreover, food production would conflict with the need of foragers to move frequently. This is important because of the importance of hunting as a status activity that requires participants to follow highly mobile game animals. Sedentary life therefore conflicts with food forager prestige systems. It also conflicts with immediate needs to move because local supplies of plant foods are rapidly exhausted. Two unusual factors must therefore converge before the shift to horticulture can emerge: a) a very rich environment, and b) the availability of food plants that are easy to domesticate.

According to this view, only rare combinations of circumstances will cause food foragers to adopt agriculture. Essentially, the argument is that a few particularly provident environments permit semi-sedentary life, such as those in which Native Americans in the Pacific Northwest coast and California Central Valley lived. However, some sort of social preadaptation appears to be necessary—it is hard to imagine that hunters would take naturally to planting crops because prestige norms are so involved with hunting prowess, and settled living conflicts with hunting. (As generations of missionaries and Indian agents discovered, it was very hard to turn Native American hunters into farmers.) The settled life that evolved in a few especially resource-rich areas under hunting conditions was perhaps a social precondition to agricultural developments.

Once life becomes relatively sedentary, the reliance on storable food products leads to using materialism (goods) for status competition. Such goods provide a motive for increasing work effort, leading to a sort of social feedback. Certain kinds of luxury goods, become "necessities" in status competitions, and old status "necessities" associated with hunting become less important. All of a sudden, hard work in the hot sun tilling a field can be turned into wealth and status. This work competes with roving long distances to acquire game. Even in the sedentary food foragers like the Northwest Coastal Indians, we saw status based on ownership of large quantities of heavy, non-portable goods. Materialism easily arises in settled folk, and will tend to turn them away from hunting and toward farming. Once there is enough farming to produce settled life, incipient agriculturalists are likely to get addicted to the easy life.

Sedentary farming communities can probably outcompete hunters and gatherers. Once farming becomes well established in any one locality, it will tend to spread. Farmers maintain dense populations relative to hunters, and were probably militarily dominant in habitats reasonably favorable for farming. Farmers also don't stop hunting. Rather dense agricultural populations probably reduce game to the point where hunters and gatherers cannot persist near their villages. Farming communities will expand, and hunting and gathering populations will normally have to give way. Many frontiers between hunting and gathering peoples and farmers are known ethnographically and archeologically, and the farmers usually expand at the expense of the hunters. There are exceptions. The Anasazi[10] culture spread into the Colorado River Basin country from Arizona and New Mexico, and then retreated, for example. Often, farming communities probably absorbed hunting and gathering societies. In Africa today, both Bushman and Pygmy societies tend to lose women especially to their horticultural and pastoral neighbors. The agricultural peoples are richer and life is a little easier on a farm or in a cattle camp. Horticultural and pastoral societies are often polygynous, and taking second and third wives from poorer folk is a normal thing. Thus people, especially women, flow into the farming communities, providing a demographic plus for farming and a negative for hunting and gathering.

A final ironical twist to the ecological hypothesis lies in Flannery's argument that some crops, such as corn, domesticated humans! A few kinds of plants will respond to human collecting with co-evolutionary adjustments that increase production. When certain crops are harvested, they may respond with genetic changes that improve yields. Humans then specialize on these plants, population densities rise, and a return to hunting becomes impossible. Competition between people favors improvements in cultivation techniques. Corn can be viewed as having "tricked" humans into growing it, spreading its seeds to new areas, fighting its competitors through weeding, etc. This hypothesis is based on biological positive feedback, plus environmental deterioration via population increase. People of California and the Northwestern American coast did not develop food production because oaks and salmon did not respond positively to exploitation.

E. Climatic Hypotheses

There are a suite of hypotheses which speculate that agriculture is an inherently su-

---

[10] The Anasazi were a group of Native American Indian cliff dwellers in what is now the Southwestern U.S. who were horticulturalists.

perior mode of subsistence, but that some sort of climate change trigger is required to get it going. V. Gordon Childe (1951) expressed the idea that desiccation caused people to invent agriculture in order to escape famine as they collected around a few desert oases in the Middle East. Binford(1968) proposed that population pressure increased when a climate-induced rising sea level forced coastal peoples inland. However, many researchers are skeptical of this claim. They argue that local population pressure must have been common throughout the Pleistocene climate changes. These changes would cause population regulation, but no evolution occurred during those incidents. This is similar to objections to Cohen; essentially, the time scale seems wrong. Populations grow up to exert pressure or collapse under the impact of adverse environments on a short time scale (one or two centuries) relative to the millennium-scale of most major cultural evolutionary events. Climate change, especially in the Pleistocene, must often have subjected people to demographic crunches, but only the last big change led to agriculture.

Charles Reed (1977) and H.E. Wright (1977) argue that climate change brought pre-adapted people and plants together in the Middle East ~10,000 bp. The problem with this hypothesis is that people around the world domesticated many crop plants in many different environments. Even if there are some commonalities in the “Center” environments, it is hard to imagine that there were not many combinations of people and plants—including the species that eventually became domesticated—during the Pleistocene. Thus again the specific factors responsible for the Neolithic revolution are not well identified by this hypothesis.

Climate hypotheses can be given a more externalist flavor. The Holocene[11] has been unusually quiet climatically, as you can see in the climate records (Flohn, 1979). Could it be that this was the first climatic regime for at least 75,000 years that is suitable for agriculture? Present droughts, floods, and longer-term climatic fluctuations like the “little ice age” from 1430-1850 AD cause substantial problems for agriculture (Lamb, 1977). There is reasonable evidence that climate changes in the Pleistocene completely rearranged biotic communities. Plant and animal communities did not shift intact north and south as the glaciers came and went. Instead communities were torn apart and reassembled as the climate changed. With fluctuations in climate it is difficult for farmers to cope.

The rapid fluctuations of the Pleistocene may have disrupted plant communities on a time scale so short that agricultural adaptations could never arise. It seems to take on the order of a 1000 years or more for a complex plant exploiting adaptation to arise, with its

---

[11] last 10,000 years

complex processing adaptations (e.g. acorn leaching and storage), and a careful balancing of the diet to avoid poisoning by secondary plant compounds and nutritional deficiencies[12]. Pleistocene climates appear to have been changing too rapidly for these kinds of adaptations to be reached. Rather the strongly fluctuating climate of the Pleistocene would have required a mobile hunting population to follow migrating herds of big game. Perhaps any form of sedentary or semi-sedentary life, much less agriculture, was impossible under such a climatic regime.

This is a fairly radically externalist hypothesis insofar as it lays much explanatory power in the hands of the changing climate. To some extent the data support it, although one should certainly keep in mind the present quality of both the archeological and climatic records. As we pointed out in Chapter 24 new climate data (and archaeological data) should help us refine these ideas. The archeological record suggests that Pleistocene hunters were doing very different things than recent hunters and gatherers of the broad spectrum sort, much less the agricultural societies that immediately followed the broad spectrum revolution in a few places (Price and Brown, 1985).

F. Most Plausible Current Hypotheses

The best hypotheses combine elements of an externalist hypotheses for the long time scale with internalist elements on the shorter time scale[13]. Let us combine the climate with the ecological hypothesis. This would allow us to predict just which people would first adopt food production, and how fast developments would proceed. Essentially, reduction in climatic variation made agriculture possible, and expanding populations of broad-spectrum foragers and incipient agriculturalists generated the *competition* that drove evolution “forward” to agriculture in the quiet Holocene environment. (Think of this as the externalist postulate.) The ecological feedback hypothesis accounts for *which* food foragers initiated food production. There was innovation limitation on the short- to intermediate-time-scale that caused that some societies to evolve domestication before others. The “genius” model has difficulty with the near-simultaneous, independent “invention” of food production in so many places. Braidwood’s “settling in” has similar problems; i.e., why wasn’t there very different timing in different places? It is also vague about exact mechanisms. The “quiet climate” part of our hypothesis solves this problem.

---

[12] Recall the maize/lysine/alkali story from the second Chapter .

[13] This is Peter Richerson’s present opinion, notice the change from the review he wrote for Agricultural History in 1979. Remember, we are on the frontier and things can change quite rapidly.

IV. Conclusion

The agricultural "revolution" is a good laboratory problem with which to investigate the connection between macro- and microevolutionary processes as they apply to cultural evolution. Different processes have different time scales, and each process plays a role according to its natural time scale. We have exposed you to an array of hypotheses (or tools) for thinking about the problem. The implications of the revolution for cultural evolution have been enormous. In a sense, all the increases of cultural sophistication since 10,000 years ago depend upon increasing the efficiency of resource utilization to support denser populations with more division of labor. On this view, we can say that an internalist hypothesis for the increased sophistication of culture is appropriate. A test of the externalist hypothesis regarding the role of climate is likely to come[14]. The Pleistocene has really not ended, and it is probable that a new glacial period will eventually occur, or that the more variable climates of the typical Pleistocene will recur. The climatologist Flohn (1979) thinks that the last 10,000 years have just been a lucky break, perhaps because volcanic activity has been unusually low. He worries about how we would cope with a renewed episode of strongly fluctuating climates. Is there a good chance we'd have to go back to being big game hunters. If we don't leave any big game to hunt, well….

Among other things, we hope to have conveyed the concept of time scales here. Thus, we've criticized a certain kind of population pressure hypothesis because it seems to imply that population growth has a natural time scale of hundreds of generations instead of tens of generations. Populations, as we saw in the demography chapter, tend to approach carrying capacities quite rapidly. Evolutionary time scales, even the comparatively rapid time scale of cultural evolution, are usually longer.

Only since the industrial revolution have these two time scales converged (thus, we have at least temporarily escaped Malthus' and Ricardo's dilemma). We've argued that when the time scale of climatic fluctuation coincides roughly with the cultural evolutionary time scale (as it did during the Pleistocene) we should expect a very different set of adaptations than when the time scale is longer. When the environment fluctuates rapidly, societies could not reach an adaptive equilibrium with the conditions of the moment; they were changing too rapidly. Rather, people would likely have had to have adapted to the variance itself with strategies that were more generalized and independent of local environmental details.

---

14. Indeed, it has! See H.E. Wright (1993). Environmental determinism in Near Eastern History. Current Anthropology 34:458-469.

V. Bibliographic Notes

References:

Ammerman, A.J. and L.L. Cavalli-Sforza. 1985. *The Neolithic Transition and the Genetics of Populations in Europe*. Princeton: Princeton Univ. Press. (Documents the diffusion of agriculture into Europe, and tries to deduce the genetic consequences of this event.)

Barraclough, Geoffrey, ed. 1982. *The Times Concise Atlas of World Histor*y. Maplewood, NJ: Hammond.

Beadle, G.W. 1977. The origins of *Zea mays*. Pp. 615-36 in Reed, C. A. *Origins of Agriculture.* The Hague: Mouton.

Binford, L.R. 1968. Post-Pleistocene adaptations. Pp. 131-41 in New Perspectives in *Archeology,* S.R and L.R. Binford (eds.). Chicago: Aldine.

Braidwood, R.J. 1967. *Prehistoric Men.* Glenview, IL: Scott, Forman.

Carter, G. F. 1977. A hypothesis suggesting a single origin of agriculture. Pp. 89-134 in Reed, C. A. *Origins of Agriculture.* The Hague: Mouton.

Childe, V. G. 1951. *Man Makes Himself.* New York: Mentor.

Cohen, M. N. 1977. *The Food Crisis in Prehistory. Overpopulation and the Origins of Agriculture*. New Haven: Yale Univ Press.

Coope, G. R. 1979. Late Cenozoic fossil coleoptera: evolution, biogeography, and ecology. *Ann. Rev. Ecol. Syst.* 10: 247-268. (The beetles tell all!)

Flannery, K. 1973. The Origins of Agriculture. *The Ann. Rev. of Anthropology* 2:271-310.

Flohn, H. 1979. On the time scales and causes of abrupt paleoclimatic events. *Quaternary Research* 12: 135-49.

Harland, J. R. 1971. Agricultural origins: centers and noncenters. *Science* 174:468-474

Harris, D. R. 1977. Alternative pathways toward agriculture. pp. 179-244 in Reed, C. A. *Origins of Agriculture.* The Hague: Mouton.

Hawley, Amos H. 1986. *Human Ecology: A Theoretical Essay*. Chicago: University of Chicago Press.

Lamb, H. H. 1977. *Climate: Present, Past and Future*. Vol. II. London: Methuen. (This is a classic, includes a lot of information on the effects of historical climate variation on human societies. Recently reprinted by in paper by Princeton.)

MacNeish, R.S. 1964. Ancient Mesoamerican civilization. *Science* 143: 531-7.

MacNeish, R.S. 1977. The beginning of agriculture in Central Peru. Pp. 753-802 in Reed, C. A. *Origins of Agriculture.* The Hague: Mouton.

Mangelsdorf, P. C., R.S. MacNeish, and W.C. Galinat. 1964. Domestication of corn. *Science* 143:538-544

McIntosh, S.K. and R.J. McIntosh. 1981. West African prehistory. *Amer. Scientist* 69: 602-13.

Meyer, J.T. 1971. The Origins of Agriculture: An Evaluation of Three Hypotheses. Pp. 101-121 in Streuver S., ed. 1971 *Prehistoric Agriculture.* Natural History Press, Garden City, N.Y.

Reed, C. A. (ed.). 1977. *Origins of Agriculture*. The Hague: Mouton. (This is an excellent collection. Reed’s own discussion and conclusions are an especially good synthesis.)

Streuver S., ed. 1971 *Prehistoric Agriculture.* Natural History Press, Garden City, N.Y. (This is a nice collection of classics)

Wright, H.E. Jr. 1977. Environmental change and the origin of agriculture in the Old and New Worlds. Pp. 281-320 in Reed, C. A. *Origins of Agriculture.* The Hague: Mouton.

Zohary, D. and M. Hopf. 1988. *Domestication of Plants in the Old World.* Oxford: Oxford University Press.

Chapter 26. THE ORIGIN OF STRATIFICATION AND STATES

> “Every state is a community of some kind, and every community is established with a view to some good: for mankind always act in order to obtain that which they think is good.” *(Politics,* Book. I, Ch. 1.)
>
> “For that some should rule, and others should be ruled is a thing not only necessary but expedient: from the hour of their birth, some are marked for subjection, others for rule.” (*Politics,* Book. I, Ch. 5.)
>
> Aristotle

I. Introduction

Complex societies are always stratified. The development of complex societies follows a few thousand years after the development of plant and animal cultivation. By “complex societies” anthropologists mean those with many full-time specialized roles. In hunting and gathering and simpler horticultural societies, recall that everyone engages in primary food gathering activities and related tasks. Typically the most significant division of labor was by sex, and almost all adults of the same sex had the same day-to-day tasks. In complex societies, the division of labor includes many full-time specialists, for example potters, weavers, traders, merchants, blacksmiths and so forth, in addition to farmers. This social complexity is universally accompanied by political specialization, such that formal leaders and their full time agents—soldiers, bureaucrats and (typically) priests—manage the collective affairs of the society. States are thus accompanied by a tremendous increase in the division of labor, by the suppression of small-scale violence, provision of public facilities such as roads, and by expanded redistributive functions to move products from the farm to the full-time specialists, and to move (some of) the products of the specialists to the farmers.

Complex societies are an ethical dilemma. In complex societies, there is usually a system of formal, ascribed (assignment by birth) ranks, and sharply differing access to prestige and prestige goods. Even subsistence goods are typically maldistributed. Even in more open societies such as our own with lots of achieved roles, some roles are accompanied by far greater rewards than others. And birth still counts for a lot. Greater rewards are usually associated with roles in governance and high state officials are typically an elite, though there may be other elites as well.

There are no complex societies that are egalitarian or anarchic; a complex division of labor seems to require government, and government always seems to allow some to be

The Moral Dilemma of Complex Societies:

Cooperation and division of labor bring huge benefits, but some people benefit much more than others from the collective production of goods and services.

better off than others. Thus, complex societies are always more or less strongly stratified, just as simpler societies are egalitarian or based upon achieved roles. This is the great moral dilemma of complex societies. On the one hand, cooperation and division of labor bring huge benefits, but on the other some people benefit much more than others from the collective production of complex systems.

As we saw in an earlier chapter, the basic agrarian state was characterized by a narrow hereditary elite with substantial privileges resting on the labor of a moderately large artisan and commercial class, and a very large peasant class. ***This is the problem we want to understand:*** *How could stratification and the state arise in the first instance from more egalitarian societies, and subsequently grow to such great extremes?*

Explanations for the state are of two types, coercive and integrative. Coercive theories suppose that states arose by conquest or the indigenous evolution of a coercive elite class. States are maintained by elites by force for the purpose of exploiting the mass of peasants and artisans. *Integrative* explanations are also termed “voluntaristic” or “functional.” Integrative theorist suppose that states arise to meet the needs of society as a whole for protection from violence, redistribution in time of need, etc. In the terms we have used in this course, the key question is whether or not stratification and state institutions are group-functional and at what level. Further, if state institutions are functional, are they functional for certain classes, or for society at large? Did formal leadership, and stratification arise because it made possible complex societies with a productive division of labor? Or is the state a tool for the diversion of the fruits of peasant and artisan labor to parasitical bands who monopolize the means of control of violence (more or less thinly disguised behind some mystical claptrap)? Or is some mixture of both explanations necessary?

As the epigraph from Aristotle shows, this twin character of states has preoccupied political theorists since there has been political theory. The advantages of large-scale political organization seem clear, but elite or another has almost always found the means to take disproportionate advantage of the common production of complex societies. An elaborate rationale for so doing has always come ready to hand. Some are always “marked for subjection” one way or another. How states can arise and persist despite this yin-yang property is perhaps the most interesting question of all.

It will not surprise you to learn that scholarship is badly contaminated by mythologizing in this field. Note the strong parallel between the moral dilemma posed by states and the two kinds of theories used to explain them. Marx was a pioneering conflict theorist, and American political ideology is strongly informed by the voluntarism of the Mayflower Compact and Constitutional Convention stories from our past. To assume a disinterested stance towards the state and stratification takes a serious effort of scholarly will-power! The history and anthropology of states are often used to try to make ethical/political points. Almost every undergraduate who has ever argued politics with his/her roommates has engaged in this sort of thing. If our aim is really to explain how states arose and how archaic states worked, we have to be careful not to get carried away in this regard. Today, let us not wring our hands over the inequities of states nor bemoan the life under Hobbesian anarchy. Let us try merely to understand L. F. Richardson’s advice (see epigraph to Chapter 18).

II. Macro-Evolutionary Data

A. The Basic Historical Pattern[1]

By about 5500 years ago the first conspicuous city-states arose in Mesopotamia, such as Sumer, from which they spread over large parts of the Old World. In the Americas, the Far East, and Africa, as we have come to expect, these developments were later. The Shang Dynasty was the first well developed state in China (3500BP), Chavin, in Peru, was the first in South America (ca. 3,000BP), Meso-America had states by ca. 2,000BP, and Sub-Sahara Africa by ca 1,000BP.

The development of states in antiquity was long the most fascinating problem for historians and archaeologists. They were interested in the development of writing, literature, the arts, and the like, and saw the emergence of humans from savagery and barbarism to civilization as our great evolutionary triumph. Modern scholars, with a wealth of information about simpler societies and about the deeper human past have not given the development of civilization quite so central a place; now we know of *other* revolutions in human societies that are quite as startling as the development of states.

Still, the development of states is quite an important evolutionary/ecological problem. Even quite archaic states left much more massive remains than any earlier types of societies. There was a revolution in the human ability to organize large scale collective projects, usually including religious and governmental architecture and fortifications. Most

---

[1] Much general information in this chapter is from Service (1975).

of you will have visited or at least seen pictures of these. The administrative complexity of states usually gave rise to writing, arithmetic, and calendars. Religion, art, politics, and eventually philosophy, science, and history became much more sophisticated that in simpler societies. Population densities often rose as redistribution and trade increased economic efficiency, and domestic peace reduced violence. However, developments in subsistence technology were rather modest; most of it was developed by the village-scale farmers who developed agricultural and horticultural techniques before the emergence of states.

Conspicuous, formal stratification developed first in tribal scale societies that preceded states. The classic chiefdom occupies an intermediate position between simple and complex societies, as we have observed before. A chiefdom has some degree of division of labor by ascriptive category, but the idiom of kinship is still strong; in theory at least, a chief is just the eldest male in the most senior lineage. His duties may be as much ritual as governance, and in the simpler cases he will still work his own fields. But from the principle of hereditary access to political, economic and ritual power that is the basis of chiefdom, states with a complex division of labor and elaborate stratification later arose. As states developed, the clan of the chieftain reduced emphasis on kinship linkages to the society at large and set itself up as a noble lineage qualitatively distinct from some commoner class. Then this class typically hired specialists such as scribes, priests, and soldiers to help in governing. A *chief* has to draw upon a network of kin obligations to enforce his authority. A *king* can issue orders to paid staff who carry them out. Western Europe crossed this frontier in the transition from the Dark Ages to the Medieval Period.

Note that political power and the ritual/religious function grew up together. The religious dimension of the most noble lineages was often emphasized as the kinship element declined. Temples were usually the first massive examples of large-scale coordinated effort, and the first rulers were often priest-kings derived directly from tribal chieftains whose roles often mixed sacred and economic/political leadership. Early kings usually claimed to rule to rule by sacred right, and often to be gods themselves. Monumental religious architecture develops to impressive heights as advanced chiefdoms evolve into states. Generally, the most impressive constructions are from the early state period. The Egyptian Pyramids are an example of this, as are the late Medieval cathedrals of Europe.

The first states are not clearly distinguishable from advanced chiefdoms; any sharp criterion would be arbitrary. In the course of the trajectory sketched above, the population under the control of the chief/king/high priest would rise to the order of 100,000 people or so. Protostates of this size often show signs of conspicuous urbanization, although the proportion of the population actually living in cities varies substantially. In the Mayan area, cities were temple complexes, and the great bulk of the population was dispersed. On the other hand Teotihuacan in the Valley of Mexico was a walled fortress city that could probably house the entire society in an emergency. All such early urban centers served ritual functions, and massive temple architecture is the rule.

Subsequent increases in size took place through amalgamation of city-state sized units into empires. Military conquest of one city-state by another was almost always involved, and there seems commonly to have been a long period of cyclical conquests and revolts before large imperial agrarian states became firmly established rule.

B. Political Evolution in Polynesia[2]

Polynesia is an excellent example of the earliest steps of state formation. Polynesian society evolved its basic features in the region of Tonga ca 3,000BP, after which Polynesian peoples dispersed at various times to a large number of Pacific Islands, mostly in the triangle marked by New Zealand, Easter Island, and Hawaii. (See figure 26-1.) Ecologically, these islands differ substantially in size, isolation, and climate (See table 26-1.) At the same time, other Pacific island areas were settled by other ethnic groups, mostly related Austronesian language[3] speakers. The Pacific formed a vast laboratory for replicated natural experiments in cultural evolution, an advantage anthropologists like Kirch mean to take advantage of for theoretical purposes. For our interest here, Polynesia is particularly important because it represents the most recent case of the formation of “pristine” states—those whose evolution was uninfluenced by the ideas from and political pressure exerted by other states. We suppose that events in Mesopotamia 5,500BP or Mesoamerica 2,000BP were similar. Indeed, the archaeology and history indicate considerable commonality in the way states evolved, although, as usual, variation is quite demonstrable.

Ethnographically, the Pacific is fairly well known. Many islands had minimal contact with continental outsiders until quite late. Much classic work was done in Polynesia and Melanesia by Bronislaw Malinowski, Raymond Firth, Marshal Sahlins, Margaret Mead, and a host of others. Archeologically, the region is becoming much better known, through the work of Kirch among others. The macroevolutionary patterns in Polynesia can now be investigated by two classic methods, ethnographic comparisons of living people at (presumably) different stages of a common evolutionary sequence, and by direct tracing of patterns in the archaeological record. According to Kirch, these two methods tell a

---

[2] Taken from Kirch, 1984.

[3] a family of agglutinative languages spoken in the area extending from Madagascar eastward through the Malay peninsula and archipelago to Hawaii and Easter Island and including practically all the native languages of the Pacific Islands with the exception of the Australian, Papuan, and Negrito languages

Figure 26-1. **a)** The Polynesian Triangle, Outliers, and the major islands and archipelagos of Oceania. **b)** Polynesian dispersal patterns as indicated by current archeological and linguistic evidence. (From Kirch 1984:18 & 78.)

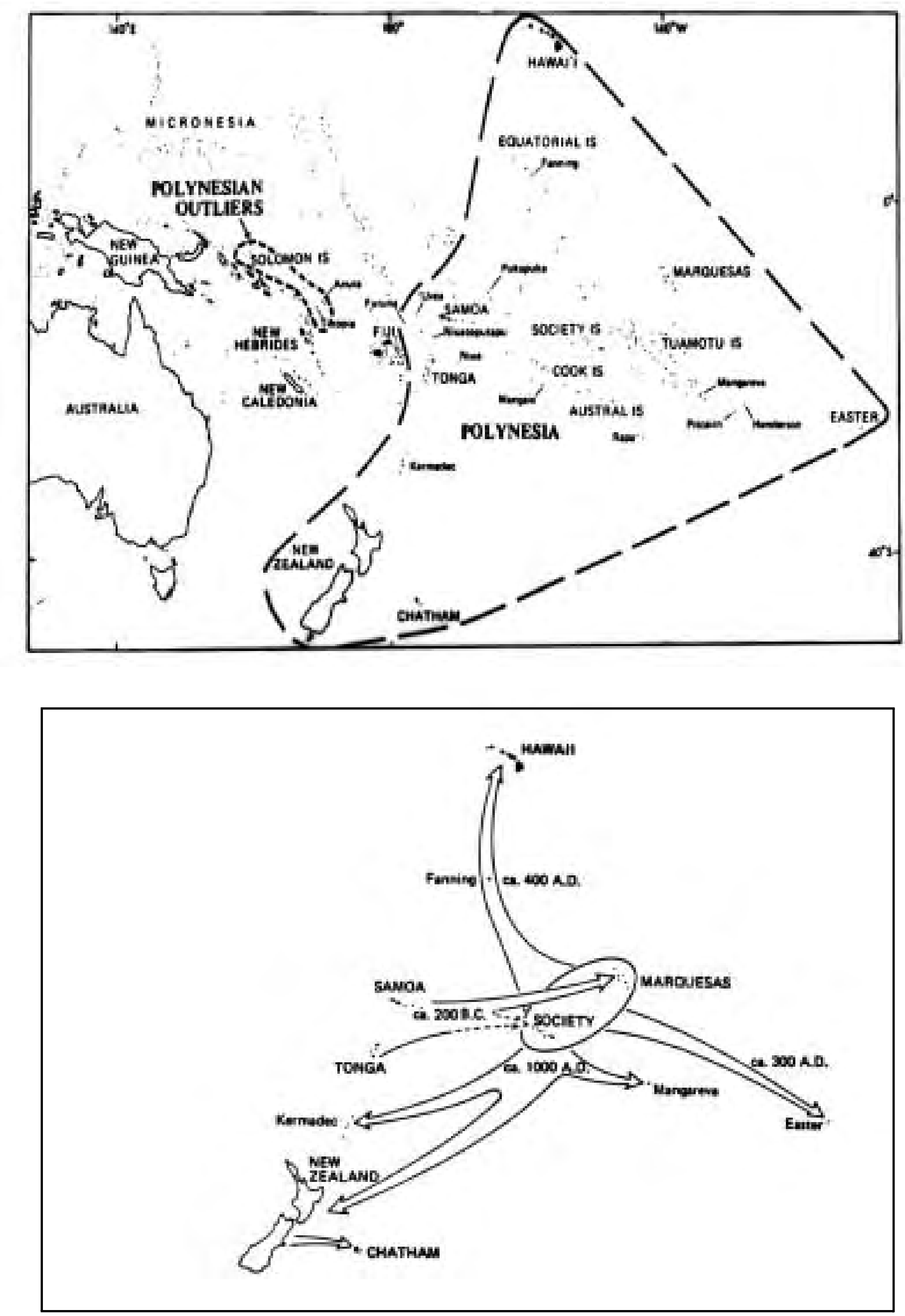
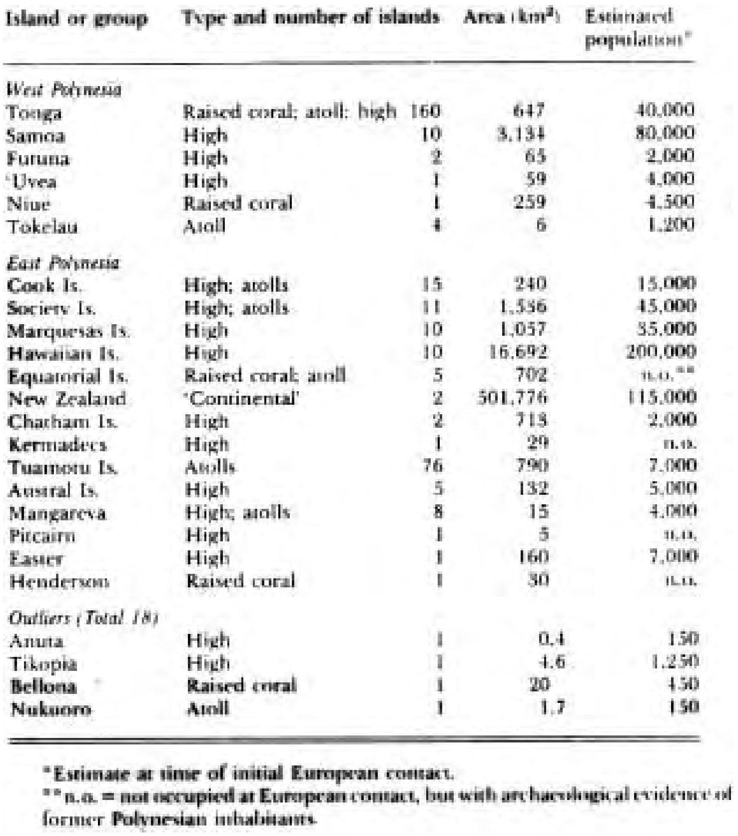


Table 26-1. Principal islands and archipelagos of Polynesia. (From Kirch 1984:19.)



Island or group	Type and number of islands		Area (km^2)	Estimated population*
West Polynesia				
Tonga	Raised coral; atoll; high	160	647	40,000
Samoa	High	10	3,134	80,000
Futuna	High	2	65	2,000
'Uvea	High	1	59	4,000
Niue	Raised coral	1	259	4,500
Tokelau	Atoll	4	6	1,200
East Polynesia				
Cook Is.	High; atolls	15	240	15,000
Society Is.	High; atolls	11	1,536	45,000
Marquesas Is.	High	10	1,057	35,000
Hawaiian Is.	High	10	16,692	200,000
Equatorial Is.	Raised coral; atoll	5	702	n.o.**
New Zealand	'Continental'	2	501,776	115,000
Chatham Is.	High	2	713	2,000
Kermadecs	High	1	29	n.o.
Tuamotu Is.	Atolls	76	790	7,000
Austral Is.	High	5	132	5,000
Mangareva	High; atolls	8	15	4,000
Pitcairn	High	1	5	n.o.
Easter	High	1	160	7,000
Henderson	Raised coral	1	30	n.o.
Outliers (Total 18)				
Anuta	High	1	0.4	150
Tikopia	High	1	4.6	1,250
Bellona	Raised coral	1	20	450
Nukuoro	Atoll	1	1.7	150

*Estimate at time of initial European contact.
**n.o. = not occupied at European contact, but with archaeological evidence of former Polynesian inhabitants.

substantially similar tale, and we can feel reasonably confident of the main outlines of Polynesian political evolution.

The first significant development was the evolution of a ranked lineage system in Ancestral Polynesia. Other Pacific island societies lack this innovation, but it was almost certainly present in the root Polynesian society in the Tonga area before dispersal to the other islands because: (a) it is present in one form or another in all Polynesian Societies, and (b) the words that refer to chiefs (*ariki*), and their powers (*tabu*, *mana*) are all cognates[4]. Thus, unlike most other Pacific Islanders, Polynesians evolved a chiefly principle of the inheritance of ritual and political status by the senior male of the senior lineage. This is the ranked lineage system that is often associated with societies organized at the tribal level. Recall that the males of the "senior" lineage (descended through eldest sons from the society's founder) are ascribed the leadership roles. In some circumstances, Polynesians developed

---

[4] related by derivation, borrowing, or descent from the same ancestral language

very elaborate chiefdoms/simple states, using the ranked lineage system as a foundation. It is interesting that only this Pacific group embarked on this trajectory, despite many ecological commonalities between Polynesia, Micronesia, and Melanesia. We have previously mentioned Marshall Sahlins (1963) famous argument about the historical differences between Melanesia and Polynesia. In the smallest scale societies where we assume chiefship evolved, it is just functionally equivalent alternative to the commoner Pacific bigman system.

The degree of elaboration of the chiefly organizational principle in the direction of a state depended upon two important variables, the time since settlement (and its close correlate population density), and island size. A third variable, ecological suitability of Polynesian technology, was important in the special case of dry (Easter) and temperate (New Zealand) islands. The islands were settled by small groups of Polynesian navigators who set themselves up as the senior founding lineage of the new island. Most islands or island groups were rather distant from the ancestral homeland, and there is no evidence that regular contact was maintained. For some generations, junior lineages budded off to pioneer new lands. At some point the island or archipelago became densely enough populated to initiate a series of economic intensification measures. On smaller islands, this stage was reached more quickly than on larger ones.

On all islands, the chiefs played an important ritual and political role. For example, they typically managed food storage and redistribution. These were economically important activities because of the frequency of natural disasters (droughts, typhoons) which frequently struck the islands. However, the explicit rationale for food gifts to the chief had a religious basis. The chief represented the ancestral gods on earth, and through him supernatural power (*mana*) flowed from them. His ability to *tabu*[5] certain activities (e.g., the exploitation of a particular section of reef) allowed him to use his supernatural powers for secular ends, and hence to rule in theory as an agent of the gods. On smallish islands and atoll complexes, there was typically a paramount chief, perhaps with largely ritual functions, and a series of smaller chiefdoms of a few hundred people each. In some cases, for example Easter Island, there is evidence of intense conflict between small chiefdoms for scarce resources in rich environments and perhaps even in those that were degrading. However, even on tiny Easter Island (160 km^2), the amount of collective effort that could be organized by Polynesian chiefs was impressive, as evidenced by the hundreds of giant stone statues.

---

[5] 5. forbidden to profane use or contact because of supposedly dangerous supernatural powers

A recurrent theme of Polynesian folklore is the flight of lineages that lose conflicts from their home island. Perhaps long-distance voyages of settlement were a result of such conflicts, and there was a tradition of using exile to settle such disputes between lineages[6]. On smaller islands, the equilibrium political level was a simple tribal system based on the classical ranked lineage principle. Polynesia was perhaps a paradise, but it was not an entirely peaceful and egalitarian place, even on the small islands with relatively little development of stratification.

On larger islands, the initial developments did not differ from those on small ones, except that it took longer for higher population densities to be reached. However, the larger islands had much greater potential for the development of larger political units. All of the really large ones, with the exception of New Zealand, developed substantially in the direction of advanced chiefdoms-protostates. Tonga, Samoa, and Hawaii particularly had large, highly organized chiefdoms of a few tens of thousands of people encompassing whole islands or island complexes.

Hawaii is an example of the scale of political elaboration that could take place given the institution of chieftainship.[7] Hawaii was settled ca 1,500BP, and the period until about 300BP was a pioneering phase. On the evidence of temple architecture, most political power resided in the hands of local chiefs, who supervised the construction of modest local temple complexes. By 300BP, population densities had risen to near the level found at contact 150 years later (200,000 people), and the intensification of agricultural production had begun. The intensification of production included the development of irrigation, terracing, and other permanent field agricultural systems, and advances in animal husbandry and aquaculture. Large-scale temple construction was initiated, indicating a considerable increase in the scale of maximal political organization.

Just after contact, King Kamehameha conquered the whole archipelago and became the whole archipelagoes paramount chief/king. At contact, there was a rich oral history covering the last couple of hundred years of political developments in some detail. Of course ethnographic observations also became possible about that time. The typical chiefdom before Kamehameha's conquest comprised ca 30,000 people. The chiefly lineages had cut themselves off from junior lineages to become a separate ruling class. Commoners lost their corporate kinship system and the land ownership that went with it. This is the only

---

[6] In Micronesia one of the traditional means for dealing with extreme social conflict, such as can arise on an island due to homicide, is to put the offender on a canoe and banish them.

[7] Kirch also treats Tonga and Easter Island in detail, and these cases have interesting similarities to and differences from Hawaii.

case in Polynesia where a class system evolved that replaced the traditional ranked lineage system. The chiefs ruled through a system of special retainers and subchiefs of the elite class which retained the ranked lineage structure. There were religious specialists, soldiers, agricultural overseers, and specialized craftsmen at their command. The hierarchy was five distinct steps deep: Chief, chief's court advisors, subchiefs (typically warrior commanders), stewards (drawn from the most junior lineages of the chiefly caste), and commoners.

Interestingly enough, there was a tendency for the chief himself to specialize in ritual affairs, and delegate secular authority to his in-laws. This tendency to separate religious and secular authority went even further on Tonga. The importance of religious ideology in advanced chiefdoms and early states cannot be underestimated. Indeed, state religion stays with us right into the modern period (did you ever learn what antidisestablishmentarianism *meant*?). One wonders why this separation occurs, and why the *formal, ascribed* paramount chief takes the ceremonial role. This is not unlike constitutional monarchy systems in Britain and Japan. Perhaps the ascribed leaders are often not the most able, and trade their symbolic value to the highest bidder (to put it a bit crassly)? That is, chiefly families that had a great deal of prestige—but lacked much talent—might ally themselves through marriage with the elite lineage that was strongest in terms of talent, wealth, and influence. This would enable them to preserve their prestige at the expense of losing much power.

Much of the direct motivation for chiefly aggrandizement of power was apparently competitive. Chiefly status vis a vis other chiefs depended upon costly and elaborate displays and conspicuous consumption. For this reason, chiefs were keenly interested in the intensification of production within their domains to build their wealth. Another form the same competition took was military conflict between chiefdoms. The object was conquest, and the enlargement of one's dominions and status. However, political developments were apparently not sufficient, at least until Kamehameha, to allow a permanent consolidation of power much beyond the level of 30,000 people. The result was several centuries of cyclical conquests and revolts, as the scale of political consolidation fluctuated.

Despite the severance of a genealogical connection between commoners and chiefs, the ideology of chieftainship enjoined a sort of benevolent paternalism toward the commoners. For example, the chief was still supposed to be responsible for managing resource redistribution so as to provide some relief in times of natural disasters. Chiefs were faced with a difficult political dilemma that gave teeth to this ideal. A chief's junior male relatives and other individuals high in the noble hierarchy could only look forward to a gradual decline in the status of their descendants as they became distanced from the chief's senior offspring each generation. However, if the chief were to require replacement, a usurper could not only take power himself, but ensure a higher status for his descendants. Thus, unpopular chiefs ran a real risk that their junior relatives would lead a revolt, and the support of commoners was apparently decisive in determining the success of such revolts. Revolts were quite common. Thus a chief was on the horns of a dilemma. Competition with other chiefs led him to drive his commoners ruthlessly to support his ritual and military ambitions; concurrently, fear of revolt caused him to be quite sensitive to being unpopular. The lack of a clear solution to the dilemma made politics very turbulent, but also left room for rapid evolution. Innovations that reduced the dilemma, such as technical innovations in production or political innovations that reduced the risk of revolt, would no doubt have spread quickly.

After contact, access to ships and guns acquired from Europeans allowed Kamehameha to quickly conquer the local chiefdoms/petty states and erect an unambiguous conquest state covering the whole archipelago with himself as King.

The Polynesian case seems to have many parallels with the evolutionary trajectory of early states in Mesopotamia, Egypt, Mexico, China, and Peru. The reemergence of states in North-Western, Central, and Eastern Europe toward the end of the Dark Ages also seems to have followed a similar trajectory as rough, egalitarian war-bands first settled down to become farmers and then divided into a hereditary elite deriving from the most prestigious lineages and a mass of commoners descended from conquered folk and the lesser lineages of the conquerors. The surviving Roman traditions (especially as preserved in the South and East and by the Church) provided a structure for state formation much as did the sacred chieftainship of the Polynesians. The ancient germanic Goths, who caused the Romans so much trouble, apparently independently developed the institution of strong kingship, and temporarily became the strongest pastoral power on the Western Steppe. Conversion of Northern and Western Europeans to Christianity in the Medieval period was accomplished by missionaries who concentrated on elites, particularly petty kings. It is tempting to think that kings converted because of the role of Christian ideology in propping up the state. With the usual caveat that there will be ecological and non-adaptive differences between examples of similar evolutionary trajectories, Polynesia is probably a very useful case to use to supplement archaeology in thinking about ancient state origins.

III. Hypotheses

A. Food Plant Production a Prerequisite

No scholar doubts that the development of agriculture was a precondition for states. Presumably, population densities and per capita production must rise to a certain level before a state elite, or even a tribal chieftain, can be freed from primary production to the degree required for them to have a specialist role. Note how the scale of political organization was closely related to population size and density in Polynesia. Advanced chiefdoms arose only on large islands, and on these only when densities became high. It takes a fairly large, dense population to support a real chief, much less a king. And other occupational specialties are required in order to give them much to organize. As tribal chieftains acquire enough full time specialized retainers to assist them in government, at some point they can style themselves kings and a state is born. As we saw earlier, states are supported by either plow agriculture or advanced horticulture, and the former led more often and sooner to states.

The development of stratification and states is far from perfectly correlated with subsistence technology. On the other hand, this cannot be the whole story. For example, North-Western Europe was agricultural for perhaps 5,000 years, but remained at a tribal level of political organization until quite late; real states began to arise in the medieval period from petty kingdoms/glorified chiefdoms (areas of Roman conquest aside). In Africa, politically unorganized societies coexisted for long periods with chiefdoms and small states. In India, the state was historically a fairly marginal institution, perhaps because caste regulates the division of labor, elsewhere an important state function.

Furthermore, the scale of political organization has fluctuated substantially over time in the same place. Small states have collapsed (e.g., in the Mayan area), and great empires have grown and vanished, such as Rome, leaving petty states and even tribal societies in their wake. Large-scale political organization is clearly somewhat fragile. Renfrew (cited in Chapter 6) has made quite a point of the instability of states among societies in the lower ranges of agricultural productivity. Yoffee and Cowgill (1988) give examples of collapses of ancient states and discussions of some of the reasons for them. The potential for excessive demands of chiefs to lead to revolt, as illustrated in the case of Hawaii, could clearly limit the scale of integration, and explain how cycles of consolidation and collapse could occur. The long-run trend to consolidation of large states in some areas but not others is likely to depend upon a number of factors, including ecology, technical changes in transport, statecraft, and military organization and hardware. The integrative and coercive hypotheses (see Service, 1978, for a convenient summary) give us some clues as to how these factors might work. We will return to these ideas in the next section.

It is worth noting that tribal (and similar) institutions generally remain important in states, rather than disappearing. Ancient states attempted to enforce monolithic ideologies on the entire populace, and modern nationalism is in this tradition. People should have their main political loyalty to the state. However, this ideal is seldom achieved in practice; states must reach accommodation tribal institutions of one kind or another. In agrarian states, tribal institutions lived in a partly symbiotic, partly competitive relationship with the state. For example, the Ottoman Empire, which disappeared at the end of World War I, had Orthodox Greeks, Orthodox Slavs, Orthodox Armenians, Moslem Arabs, and Moslem Kurds among its citizens, all dominated by Moslem Turks. The tribes were responsible for much of the on-the-ground maintenance of order and provision of services to the population. Agrarian states had rather small bureaucracies by modern standards and left much to the tribes out of necessity. The tribes were themselves very complex, with many variations at the local level, linked mainly by segmentary principles of loyalty, though in some cases at least a religious hierarchy maintained a degree of formal organization at the tribal level. Groups like the Kurds have ancient roots, and have been members of many empires, but have never had a state of their own nor any other form of formal organization at the whole-tribe level. The spread of nationalism in the late 19th and early 20th Centuries tore apart the Ottoman and Austro-Hungarian multi-ethnic Empires, even as the Soviets were successful in maintaining the Russian Empire.

At this moment the Russian Empire is apparently dissolving. It is striking how strong tribal loyalties remained after 70 years of relentless propaganda and repression by the Soviets, and how rapidly tribal organizations could arise to seek independence. The Caucasus region is an especially interesting laboratory, because historically many small tribal groups of agrarian mountaineers asserted their independence against all comers, until the Russian conquest in the 19th Century. As the Soviet Empire has weakened they've seized the chance to aggressively declare their independence. States are always the result of a dynamic equilibrium between larger and smaller scale institutions, and the organizations based on the larger can collapse quite suddenly if the smaller scale ones win out in the ongoing competition.

B. A Role for Non-adaptive Variation

The Pacific case suggests that non-adaptive variation, specifically the evolution of the hereditary chief ideology, may be important. Sahlins (1963) wrote a classic paper contrasting the Polynesians and the Melanesians. Despite many ecological and subsistence similarities, Polynesians developed elaborate chiefdoms and states on large islands, as we have seen, whereas the Melanesians classically lack ranked lineage systems and chiefs, even on the largest islands they inhabit, such as New Guinea and the Bismarcks. Sahlins attributed the difference to the traditional hereditary lineage-ascribed status ideology of the Polynesians. Even on small islands like Tikopia, and on large islands during the colonization phase while population was small, the ranked lineage/*mana*/*tabu* system was maintained. Thus the germ of a social framework for state formation in appropriate circumstances was always present in Polynesian but not Melanesian societies. There does not seem to be anything special about the environment of ancestral Western Polynesia that stimulated the development of ranked lineages. Thus, historical happenstance may well play a big role in this and other cases of state formation.

There seem to be no externalist hypotheses to explain state formation beyond the requirement for a reasonably productive farming system. Everyone invokes internal hypotheses. States are one of the ultimate consequence of cultivation, even though they took varying periods of time to arise.

C. Integrative (Functional, Voluntaristic) Theories

The basic argument for the origin of states because of its functions to society as a whole is: (1) there are gains to be made from organized human cooperation and coordination; (2) advanced societies are organized to exploit these opportunities; and (3) these opportunities are the reason why states evolved.

Thomas Hobbes advanced an early, hardheaded, argument of this sort. For him a state, the Leviathan, was necessary to ensure public peace, otherwise there would exist a state of "war of all against all". People would voluntarily give over their freedoms even to the most dictatorial government because anarchy was worse. (Hobbes was politically active during the period of the English Revolution (1640s) and knew his anarchy first hand.) This is not too farfetched. As we have seen, some simple societies approximate this state. It is said that many New Guinea highlanders welcomed the White Australians, because they brought police who suppressed warfare. Much as Hobbes and the deterrence theory would lead us to expect, people often have to fight when they would rather not, and states can "secure domestic tranquility;"as the United States Constitution says.

Advanced chiefdoms and states do suppress internal violence, although formal legal codes tend to arise fairly late. Chiefs seem reluctant to risk their authority by taking too much responsibility for administering justice. Rather, they seem to offer a sort of mediation service, with self-help violence remaining the ultimate recourse in disputes.[8] States typically have some sort of court system, but often it is far short of a comprehensive legal/penal system as we know it. Chiefdoms and states do regularly provide for defense against foreign enemies and major internal revolt. Chiefs and kings obviously are interested in these activities, but the interest of governor and governed perhaps largely coincide here. At least,

---

[8] This contrasts with contemporary Western legal systems where those behaviors that are most deleterious to society are identified as *crimes*. When a criminal act is committed, it is by law a crime against the state rather than against an individual victim. In this fashion, the state interposes itself between disputants so as to nip cycles of vendetta in the bud.

population densities seem to rise as states suppress small-scale violence and prevent constant predatory raiding. Recall the tendency of the population of China to fall in times of political trouble; this seems to be a common pattern. The same territory can support a considerably higher population, perhaps twice or more as high, if states suppress local violence.

Of course, states themselves are responsible for much large-scale violence. International anarchy still prevails, and states have fought wars between themselves with a fair frequency. There is undoubtedly an arms race built into the evolution of states that can run as fast as technical and institutional innovations permitting the increase in scale of political organization can occur. Presumably, the last 5,000 years have been spent on this escalatory spiral. Perhaps the best times in this regard were the periods of unchallenged hegemony by large empires, such as the Chinese, Roman, and British. In such cases, international and domestic peace prevailed over large areas for significant periods of time. Unfortunately, statesmen have not discovered how to make such structures popular, stable, and competent in the long run. The former Yugoslavia's recent troubles are dramatic but not so exceptional, as we saw in Chapter 18.

Clearly, everyone can be better off if large-scale public works like irrigation facilities can be organized, and if specialization and trade among specialists are possible under the protection of a political authority (recall the protection rents argument from Chapter 21). Other integrative suggestions are Karl Wittfogel's hydraulic hypothesis that the earliest states were based upon the organization of irrigation schemes, and Elman Service's idea that political authority arose to supervise trade and redistribution. Given the strong religious ideology in states, even temples can be interpreted as a kind of public works for collective benefit. Both chiefs and commoners apparently believe that intercession with the gods is absolutely necessary for society to function. As we saw in the Hawaiian case, chiefs were interested in public works and the management of redistribution. A strong chiefdom was a rich and happy one, so one might argue that chiefs were motivated to keep at least one eye on the common welfare.

D. Coercive Theories

The governing elite of a state society often arises by conquest. Carniero (1970) developed a classic argument that coercion is basic to state formation, and gives an account of its long history. Military victory of one society over another is common. If the winner of a military conflict can permanently control the defeated, they can set themselves up as an hereditary, exploitative elite. Carneiro imagines that no independent community would willingly place itself under an overlord, especially one that claimed an right to rule by superiority of birth. Even when defeated in war, people will ordinarily seek to escape their conquerors by movement to new lands. Indeed history is full of population movements motivated by an effort to escape more powerful groups. Most of the present European ethnic groups were once refugees from the pastoral warfare of Central Eurasia, for example. Carneiro thinks that these efforts will fail when agricultural or horticultural populations are "circumscribed", when they cannot escape conquest for one reason or another. His examples include irrigation farmers, who, once densities were more than moderate, face starvation if they tried to escape into the desert after loss of a war. The farmers of a Peruvian Coastal Valley, for example, cannot realistically hope to flee into the rainless waste to escape conquest. However, forest horticulturalists in Amazonia could easily flee to new, similar, relatively empty territory if defeated. Similarly, the buildup of population density can hem people in with other people. In the circumscribed cases, the vanquished have to submit to whatever their conquerors desire to impose. What the conquerors desire is to live as kings and lords at the expense of the defeated.

History and archaeology give ample evidence that this process has been important. For example, the early Mesopotamian city-states based apparently on a religious elite rather soon gave way to ones dominated by military aristocrats, although, of course, the religious center of power remained, as it does to this day. Cities became fortified, and strong cities began to attempt multi-city empires. Very commonly, barbarian warlords either created states of their own or inserted themselves as the elite of existing ones, especially after the rise of pastoral societies. Saddam Hussein draws on a deep, if rather dark, tradition of statecraft, whose development began in his own Mesopotamia, modern Iraq.

Another coercive theory of Marxist inspiration imagines that states grow up to protect class interests. Essentially, the idea is that some people tend to become more prosperous than others because of economics, ecology, or chance. The lucky ones then develop state institutions, including a mystifying state religion in order to protect and enlarge the economic or prestige advantages of their class. The rise of the *nomenklatura* (members of the Communist Party recruited as government bureaucrats) in the former USSR to the status of aristocrats during this century might be considered an example of this—although probably not the example most marxists would prefer to use!

E. Hypotheses Not Mutually Exclusive

The Polynesian case illustrates phenomena explicable by both variants of conflict hypotheses. Chiefdoms certainly did not enlarge until population grew to the point that some groups could not escape conquest by migration. Moreover, chiefly conquests were an important means of increasing the scale of political organization. Further, the exaltation of chiefly lineages, and the subdivision of Hawaiian society into two class-like strata does have a marxist flavor. Those lineages endowed with higher status by the ancestral Polynesian ideology certainly did manage to greatly exalt that status in the course of political evolution on the larger islands. On the integrative side, chiefs did organize great collective enterprises, use their resources to help everyone in times of disaster, and suppress local feud and murder. The coercive and integrative hypotheses are usually debated as if we must choose one or the other. It would seem, however, that we can mix or match them.

IV. Experimental Tests

A. Introduction to the Experiments of Insko et al. (1980, 1983)

Social psychologists have developed a nice experimental system for testing such hypotheses using artificial societies in the laboratory. The hypotheses discussed in the foregoing section have been developed from the historical, archaeological and ethnographic record. At first glance, an *experimental* test of these ideas seems absurd. Not so. These experiments are very interesting despite their artificiality. Remember, any experimental system is highly artificial. But what we sacrifice in artificiality we get back to some extent in terms of an ability to control variables, and at least understand the experimental system in some detail. Experiments thus often give us insights obtainable in no other way. The first of these experiments was done by Donald Campbell (Jacobs and Campbell, 1961), whose ideas on cultural evolution we have met before.

Insko et al. set out to test the coercive theory of Carneiro and the voluntaristic theory developed by Service. Service (1975) figured that stratification would have emerged first in the context of trade or redistribution. For example, in a collection of agricultural villages, some village would have a central location or a geographic advantage that would naturally make it richer as trade developed. Other societies would then come to recognize them as the natural social leaders. Stratification of the tribe type would emerge first from this natural trade-derived leadership. State type stratification would emerge later. After testing Service’s voluntaristic theory, Insko et al. went on to compare this sort of explanation of the origin of stratification with one derived from conquest.

B. Design of the Experiments

Insko et al. set up artificial societies in the lab that lasted for nine “generations”. Each society was composed of four people (undergrad Psychology 1 students as usual) of the same sex. Each generation after the first three, the oldest member of the group “died”, was debriefed, given tests, and replaced by a naive subject.

Two basic types of societies were set up to mimic three societies living in a common *circumscribed valley*. Society B was the central society with the richest resources and was central in the trade network. Societies A & C were peripheral and had less resources. To mimic resource distributions, each society folded origami, paper hats and boats and such. Society B could make two different products, while societies A & C could make only one, but different ones. To mimic the idea that specialization and trade can lead to higher payoffs for everyone, the experimenters bought sets of products from the societies for quarters. The most valuable sets were ones composed of all four types of products. The least valuable were sets composed entirely of the products of groups A and C; the two products of group B were of intermediate value. The payoff ratio was 4 units for A or C products alone, 10 units for B products alone, and 16 units for trading sets. Thus, there was a real advantage to exchange, especially for the A & C groups. However, groups A & C could not control the terms of trade.

To mimic the voluntaristic hypothesis, the groups could trade a total of four times per generation, after a work period in which they folded origami and selected a representative. However, both the A & C groups could only trade with group B's representative, not with each other. Other than that, A & C groups were free to negotiate the best deal they could.

To mimic the coercive hypothesis, the subjects were given an anagram test. The test was a sham, subjects slated at random to be in group B were given an easy test, those in groups A & C a hard one. The experimenters used the test "results" to encourage subjects in Group B to think themselves naturally superior to individuals in groups A & C, and to encourage A & C individuals to believe that they were inferior. To mimic coercion instead of trading, group B representatives collected the production of groups A & C and returned to them whatever group B members thought appropriate. Also, at the end of a trading period, they got all of group A & C's leftover products (those that could not be made into sets).

C. Results

The experimenters tested a number of effects in this series of experiments. We will focus on a few, production and money earned[9], amount of conflict between groups, and perceived leadership within and between groups.

> *Production and money earned: see Tables 1 & 2 from Insko et al. overleaf.* There are some quite interesting effects here. Both measures show that coercion reduces total production and income, relative to free trade. Conditions tend to improve over time for all groups, as cultural evolution improves trading and production skills. Group B worked less hard in Carneiro treatment, and so did their exploited A & C groups. However, the B groups tended to earn about the same income in both treatments, although the Carneiro treatment A & C

---

[9] These were different because of the differential payoff schedule favoring members of group B.

> groups did rather poorly. Notice the strong sex effect, A & C females did well in the Service group but quite poorly in the Carneiro treatment.
>
> *The amount of conflict between groups*. See table 4 from Insko et al. overleaf. Conflict was substantially higher in the Carneiro than in the Service condition, especially for males. Men in Carneiro societies A & C actually did attempt to sabotage, strike, and otherwise influence society B to treat them better—eventually with some success. Women tended to be more acquiescent to exploitation of society B.
>
> *Leadership results.* Within groups, there was a strong tendency for a seniority rule to evolve over time. Most subjects perceived that group B were the leaders. Most group B members naturally accepted this state of affairs (mean of 6.5 on a 7 point scale). Acceptance by A & C members was lower, especially in the Carneiro condition (Service acceptance was 4.02, under Carneiro it was 3.10).
>
> *Informal differences in the results.* The experimenters also report strong informal differences between the two treatments. The Service condition subjects had fun, the Carneiro ones did not. Society B, Carneiro treatment, subjects were often quite callous toward society A & C members. As time passed these society B members tended less and less to perceive themselves as being unfair; the ideology of innate superiority encouraged by the experimenters seemed to occur.

This experiment hardly solves all of the problems associated with the origin of states, but it does give us some useful insights. The first is that laboratory microsocieties can be set up, and made to perform in sensible ways. Since actual human behaviors are evolving here, the technique seems to furnish useful experimental models for a number of problems. Second, as far as it goes, the experiment suggests that both trade and warfare could be important in the creation of complex, stratified societies. Especially in the integrative case, this kind of society might make everyone better off, although some relatively better off than others. The coercive state is not so successful here. However, the dominant class is just about as well off as in the volutaristic case, so they have no special motivation to change. On the other hand, there is considerably more social friction in the coercive case, and such societies ought to be less stable. The Carneiro and Service style states might represent coordination or coevolutionarily stable alternative states. The more functional Service state might replace the Carneiro one by group selection.

As judged against the historical record, the most unrealistic prediction one might make from these experiments is that integrative principles should tend to dominate coercive principles. Since the experimental integrative (i.e., Service) groups were wealthier, had more acceptance of B's leadership, and were less plagued by overt conflict, they ought to win the competitions among states in the long run. Historically, coercive states seem to

(tables from C. A. Insko et al., 1983)

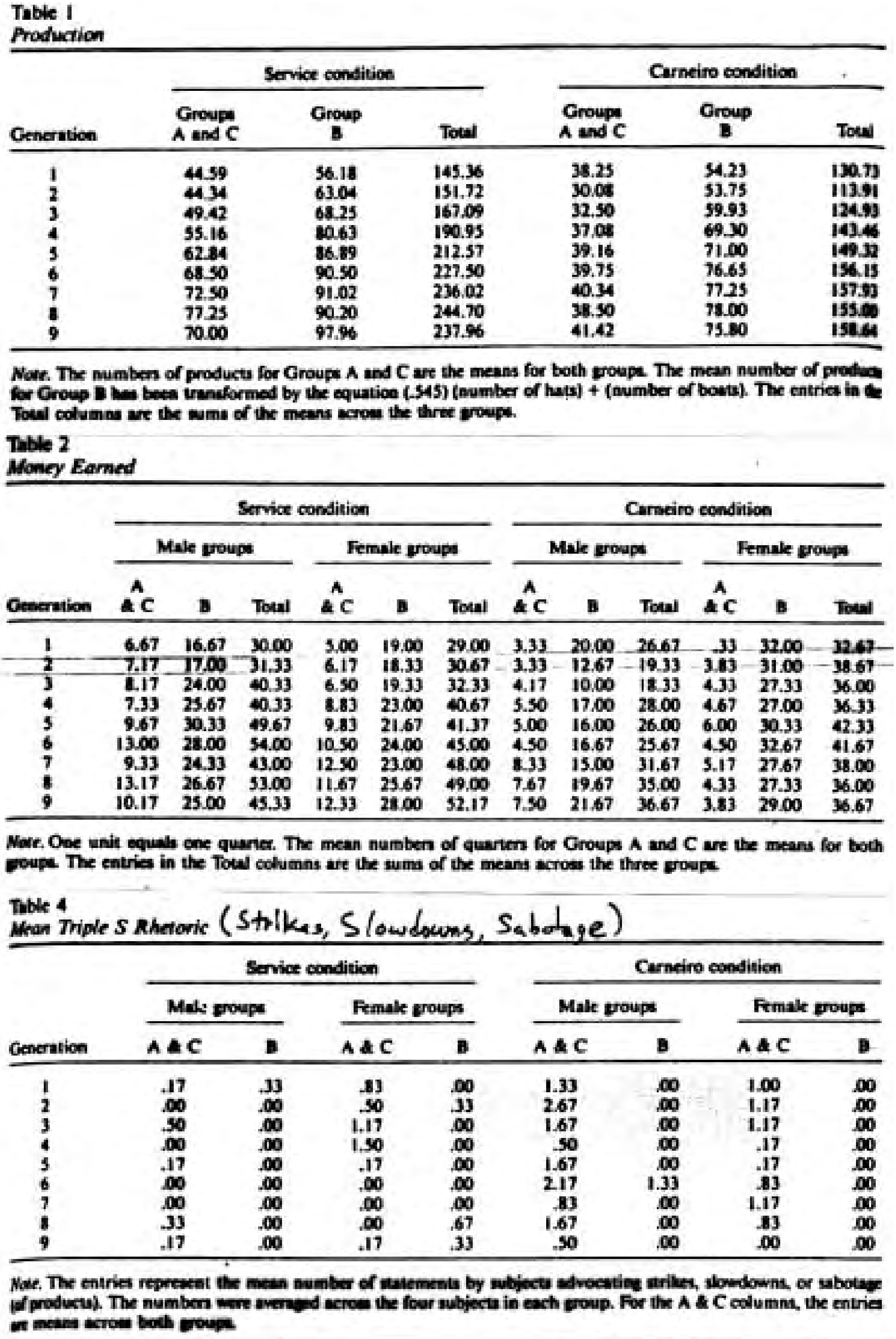


Table 1
Production

Generation	Service condition: Groups A and C	Service condition: Group B	Service condition: Total	Carneiro condition: Groups A and C	Carneiro condition: Group B	Carneiro condition: Total
1	44.59	56.18	145.36	38.25	54.23	130.73
2	44.34	63.04	151.72	30.08	53.75	113.91
3	49.42	68.25	167.09	32.50	59.93	124.93
4	55.16	80.63	190.95	37.08	69.30	143.46
5	62.84	86.89	212.57	39.16	71.00	149.32
6	68.50	90.50	227.50	39.75	76.65	156.15
7	72.50	91.02	236.02	40.34	77.25	157.93
8	77.25	90.20	244.70	38.50	78.00	155.00
9	70.00	97.96	237.96	41.42	75.80	158.64

Note. The numbers of products for Groups A and C are the means for both groups. The mean number of products for Group B has been transformed by the equation (.545) (number of hats) + (number of boats). The entries in the Total columns are the sums of the means across the three groups.

Table 2
Money Earned

	Service condition						Carneiro condition					
	Male groups			Female groups			Male groups			Female groups		
Generation	A & C	B	Total	A & C	B	Total	A & C	B	Total	A & C	B	Total
1	6.67	16.67	30.00	5.00	19.00	29.00	3.33	20.00	26.67	.33	32.00	32.67
2	7.17	17.00	31.33	6.17	18.33	30.67	3.33	12.67	19.33	3.83	31.00	38.67
3	8.17	24.00	40.33	6.50	19.33	32.33	4.17	10.00	18.33	4.33	27.33	36.00
4	7.33	25.67	40.33	8.83	23.00	40.67	5.50	17.00	28.00	4.67	27.00	36.33
5	9.67	30.33	49.67	9.83	21.67	41.37	5.00	16.00	26.00	6.00	30.33	42.33
6	13.00	28.00	54.00	10.50	24.00	45.00	4.50	16.67	25.67	4.50	32.67	41.67
7	9.33	24.33	43.00	12.50	23.00	48.00	8.33	15.00	31.67	5.17	27.67	38.00
8	13.17	26.67	53.00	11.67	25.67	49.00	7.67	19.67	35.00	4.33	27.33	36.00
9	10.17	25.00	45.33	12.33	28.00	52.17	7.50	21.67	36.67	3.83	29.00	36.67

Note. One unit equals one quarter. The mean numbers of quarters for Groups A and C are the means for both groups. The entries in the Total columns are the sums of the means across the three groups.

Table 4
Mean Triple S Rhetoric (Strikes, Slowdowns, Sabotage)

	Service condition				Carneiro condition			
	Male groups		Female groups		Male groups		Female groups	
Generation	A & C	B	A & C	B	A & C	B	A & C	B
1	.17	.33	.83	.00	1.33	.00	1.00	.00
2	.00	.00	.50	.33	2.67	.00	1.17	.00
3	.50	.00	1.17	.00	1.67	.00	1.17	.00
4	.00	.00	1.50	.00	.50	.00	.17	.00
5	.17	.00	.17	.00	1.67	.00	.17	.00
6	.00	.00	.00	.00	2.17	1.33	.83	.00
7	.00	.00	.00	.00	.83	.00	1.17	.00
8	.33	.00	.00	.67	1.67	.00	.83	.00
9	.17	.00	.17	.33	.50	.00	.00	.00

Note. The entries represent the mean number of statements by subjects advocating strikes, slowdowns, or sabotage (of products). The numbers were averaged across the four subjects in each group. For the A & C columns, the entries are means across both groups.

have been at least as common as voluntaristic ones. One possibility is that coercive states may actually tend to become more like integrative ones over time, as we'll see in the conclusions.

There is also another possibility. *Perhaps voluntarism is easier to achieve in small political units, and is more common at the tribal level.* Often, tribesmen were the conquerors of states, so perhaps their organizational superiority expressed itself in conquest. Mancur Olson (1982) suggests that small political units can organize themselves more rapidly and easily for their own self interest. By contrast, large political units, particularly those that are not coercively organized, may often not be able to organize themselves as readily. People interested in the collapse of states have often argued that ancient states tended to become ossified over time. Perhaps the increasingly intricate organization of selfish interest groups within the ruling elites, combined with the disaffection of the peasants and artisans regularly led these states to a regression to the tribal level of political organization. Recall the arguments from the early part of the course on the difficulty of evolving (and maintaining) the altruism necessary to ensure cooperation and produce public goods in large groups.

V. Conclusions

It seems likely that, as the Insko experiments suggest, both coercive and integrative processes can lead to stratification, and that in most cases the two are intertwined in the origin and subsequent evolution of states. At least this would account for the dual nature of stratified societies. Well organized trade and redistribution of goods, public peace, and public works do tend to make most people better off than they otherwise would be (most citizens have some voluntary loyalty to existing political arrangements in most states). However, elites generally find ways to secure more than their "fair" share of the advantages of the state's existence. Most citizens' loyalty is provisional, and this can promote revolution or sedition if the elites are too harsh, if they see any alternative. W. McNeill (1982) suggests that this is the case (see Chapter 21). Conquering warlords often seem to gradually implement administrative reforms that reduce their impact on the peasants.

For example, the Turkish expansion at the expense of the Byzantines around 1,500 was apparently welcomed by Anatolian and Balkan peasants, because the Byzantine elites had grown rather corrupt and exploitative. Even when the coercive power is concentrated in the hands of an elite, "strikes, slowdowns, and sabotage" are a partially effective means of limiting the degree of exploitation. But no state on record has been entirely egalitarian. The Hawaiian case seems to rather strongly suggest this tangling of the coercive and integrative processes to me.

Much work remains to be done on the evolutionary theory of the state. Some sort of game theoretic analysis that yields a mixed strategy of exploitation *and* provision of public goods as the ESS seems required here, but to my knowledge one hasn't been done yet. The analysis would involve asymmetric games. The commoners have some power, but the elites have more. If commoners engage in strikes, slowdowns and sabotage, they can make life fairly miserable for elites, though elites can make like much more miserable for commoners. Thus, internal processes will tend to prevent the worst possible exploitation of the commoners. Also, too-harsh elites may tend to get replaced through a group selection mechanism. Any analysis will have to explain why the political processes in states are so turbulent and why this game does not seem to remain at some stable equilibrium for long. One suggestion, by Jack Goldstone (1986), is that population increases rapidly under benevolent governments, more rapidly than technology can respond. Thus, the prosperity engendered by wise policies evaporates, unrest rises, rebellion and invasion occur, the population falls as a result of war and disease, and the cycle can begin again.

We hope this chapter suggests to you that historical research, field research among contemporary groups, experimental studies, and theory all have contributions to make to understanding the complex problems in human ecology and evolution. It is hard to see how efficient progress can be made by any one in isolation of the others. In our opinion, too many scientists disparage the methodological approaches of others—theorists despise empiricists, psychologists anthropologists, economists psychologists, etc. Classically, the social science disciplines have specialized as much with respect to method as to subject matter. Thus psychologists do experiments, anthropologists do description by participant observation, economists do formal theory and analyze government statistics, and sociologists and political scientists do surveys. Each discipline has a stock defense of its own methods and a ritualistic denigration of those of sister disciplines. However, each discipline's methods only sees a partial and distorted view of the whole. We need each other!

VI. Summary

A. Concepts: states vs. chiefdoms

B. Discovery: covariation of states, stratification, complex society

C. Hypotheses: Coercive vs. voluntaristic role for non-adaptive variation

D. Model: Strategic interaction between elites and commoners (strike, sabotage, slow-downs)

VI. Bibliographic Notes

References:

Goldstone, J. 1986. The English revolution: a structural-demographic approach. In: J. Goldstone (ed.) *Revolutions*. San Diego: Harcourt, Brace, Jovanovich.

Insko, C.A., J.W. Thibaut, D. Moehle, M. Wilson, W.D. Diamond, R. Gilmore, M.R. Solomon, and A. Lipsitz. 1980. Social evolution and the emergence of leadership. *Journal of Personality and Social Psychology* 39: 431-48.

Insko, C.A., R. Gilmore, S. Drenan, A. Lipsitz, D. Moehle, and J. Thibaut. 1983. Trade versus expropriation in open groups: a comparison of two types of social power.*Journal of Personality and Social Psychology* 44: 977-99.

Jacobs, R.C., and D.T. Campbell. 1961. The perpetuation of an arbitrary tradition through several generations of laboratory microculture. *Journal of Abnormal Social Psychology* 62: 649-58.

Kirch, P.V. 1984. *The Evolution of Polynesian Chiefdoms*. Cambridge: Cambridge Univ. Press.

McNeill, W. 1963. *The Rise of the West*. Chicago: Chicago Univ. Press.

Olson, M. 1982. *The Rise and Decline of Nations.* New Haven: Yale University Press.

Richardson, L. F. 1960. *Statistics of Deadly Quarrels*. Pittsburgh: The Boxwood Press.

Sahlins, M. 1963. Rich man, poor man, big-man, chief: political types in Melanesia and Polynesia. *Comp. Stud. Soc. Hist.* 5: 285-303.

Service, E.R. 1975. *Origins of the State and Civilization.* New York: Norton.

Wittfogel, K.A. 1957. *Oriental Despotism: A Comparative Study of Total Power*. New Haven: Yale Univ. Press.

Yoffee, N. and G.L. Cowgill. 1988. *The Collapse of Ancient States and Civilizations.* Tuscon: Univ. of Arizona Press.

Chapter 27. THE DEVELOPMENT OF COMMERCIAL AND INDUSTRIAL SOCIETIES

I. Introduction

A. Evidence

We have more information about this revolution than any other because it was so recent and because printing was one of the earliest inventions of the period. However, as current political debates over the issues that divide first, second, and third world countries show, there is a great deal of dispute about how to interpret this information. We are in the midst of this revolution and any approximation to objectivity is hard to achieve—ethnocentrism and mythologizing abound.

B. Commercial and Industrial Societies (re)Defined

Commercial and industrial societies are those in which a majority of the population withdraw from the agricultural sector to participate in specialized occupations associated with trade and manufacturing. As we saw in the chapter on trade, virtually all human societies trade—certainly all of them have elaborate patterns of internal redistribution. However, with the exception of perhaps a few trading city-states of antiquity, the class of primary producers of most human societies was far larger than the commercial and craft/manufacturing classes. Trade and redistribution involved relatively few commodities, and was mostly organized by kinship networks (on the smaller scale) and by political authorities (on the larger scale). Trade through the market mechanism seems to have been of variable but modest proportions throughout most of human history. A great exaggeration of the division of labor and the importance of trade marks the commercial/industrial revolution.

A recap of data covered in Chapter 8. An exact date for the beginning of what McNeill (1980) calls “the commercial transmutation” is hard to fix with any precision. He traces its roots back to the Mediterranean trade of the Roman Empire, together with the establishment of a tenuous trade with the Orient in the same period. The trade diasporas that engaged in this and later long distance trade in the Old World laid the foundations, but were clearly within the pattern long established by agrarian states, except perhaps for a few small, specialized city-states in Greece and elsewhere that might have fit our definition. China was the commercially and industrially most dynamic society in the world during the period from about 1000 to 1500 AD. The collapse of the Roman Empire and the ravages of the plagues combined to make Europe a blighted backwater for several centuries. Beginning about 1000 AD, this part of the world began an initially slow recovery as a vigorous trade grew up, first centered on the Italian city states like Genoa, Florence and Venice.

Some of there small polities probably fit our definition of commercial-industrial societies. By 1500 AD, the centers of commerce were moving to the Atlantic, and the voyages of discovery, by opening a global marine trade network, solidified the position of the Atlantic powers. Of these, the British were the most vigorous, especially after the industrial revolution began there in the 18th century. By 1800 or so Britain came to fit our definition, no doubt the fiirst large society to qualify as commercial-industrial.

As we saw in Chapter 8, the commercial and industrial "transmutations" had tremendous repercussions: occupational diversification, the growth of modern states, substantial population expansion, the growth of rationalism, eventually rapidly rising incomes in the industrial nations, and European political hegemony on a world scale. Because it is our kind of societies we are talking about, perhaps we are broadly ethnocentric about "our" revolution and exaggerate its importance. Still, these do seem, objectively, pretty impressive accomplishments relative to agrarian societies. The spectacular risks of modern technology—nuclear war and climate changes driven by greenhouse gas emissions—are perhaps proof enough that this event in human history deserves to be listed among the four[1] we examine in this part of the course.

The question to answer is why did the most recent great revolution in the culture core occur among unimpressive European folk? Scholars from Marx and Weber to the present day have taken the "Rise of the West" as the capital fact of recent world history. Northwestern Europe had heretofore been one of the backwaters of the Old World, lightly civilized in a few places by the Romans, otherwise living under chieftains and petty kings and practicing a relatively primitive and unproductive agriculture. We have seen that even Mediterranean regions of Europe were comparatively backward from after the fall of Rome until 500 years ago. At 1400 AD smart money would probably have bet on some more impressive society, such as China, to lead the next half millennium. The European story has an rags-to-riches appeal, balanced by nouveau riche excesses.

II. Hypotheses

(Our discussion is based on Tuma, 1971, and McNeill's various books, especially his *Rise of the West* and *Pursuit of Power*).

A. Easily rejected ones

All serious scholars have taken the trouble to list a number of hypotheses that seem implausible.

---

[1] origin of the human adaptive pattern, origin of plant and animal domestication, origin of states and stratification, and development of commercial and industrial societies

> It does not seem that any kind of *external hypothesis* will account for the emergence of commercial and industrial societies. The climatic changes that were occurring during this period were not exceptional and probably did not affect Europe differentially. Commercial and industrial societies seem to have developed as part of the mostly slow and halting development of technology and other culture core elements that had been going on since the origin of food production some 9,000 years earlier. (Of course, on the geological time scale, the changes of the last 9,000 years have been exceedingly rapid.) Something must have been impeding earlier development that was removed or broken through in rather dramatic fashion about 1500. We need a progressivist theory to account for the collapse of some previous pattern of innovation limitation that prevented the emergence of commerce and industry.
>
> *It does not seem as if the discovery of the New World was decisive* to the fortunes of Europe. American precious metals did provide money and a commodity desired in the Orient, and so facilitated trade. But the fortunes of Europe were already on the rise by 1500, and much the same trajectory seems likely to have ensued in the absence of the New World discoveries. Spain and Portugal, the nations with the earliest and largest gains from the New World fared poorly in the end, relative to those such as Britain, Holland, Sweden, etc. that came late or never developed a significant presence there.
>
> *No one seems to have been able to defend the hypothesis that some key feature of the European physical environment was particularly important.* McNeill (1982) is at pains in his comparison of China and Europe to show that the Chinese had solved transportation problems on a considerable scale centuries earlier than the Europeans, and that in most essential respects the Roman period had most of the prerequisites that finally led to the commercial revolution 1500 years later. In China for example, the Sung Dynasty and the succeeding Mongol Emperors constructed a Grand Canal between the Yellow and Yangtse Rivers, used the cheap transport provided to develop a very impressive iron and steel industry in the coal and iron-ore rich area of Honan and Hopei, and developed a merchant fleet that made major voyages of discovery in the Indian Ocean (sailing as far as the east coast of Africa).
>
> *The common ethnocentric folk theory of innate superiority is not tenable.* As races (genotypically), Northern Europeans, were just a bunch of barbarians that had fled more powerful peoples at various times in the past. During most of the period of Chinese growth, Northern Europeans were one of Eurasia's regions of underdevelopment. Southern Europeans clung to the shattered, faded glory of fallen Rome. As late as the 13th Century, Marco Polo found China much more impressive than his native Northern Italy—which at that time was the most developed part of Europe. The self-respecting civilizations of the continent must have viewed Europeans as a backward group in an unpromising corner of the world.

In other words, it seems that any of the advanced agrarian societies could have evolved into commercial/industrial societies any time after 0 AD. It happened to take 1500 years for the right combination of circumstances to occur to start the process, but it might well have taken more or less depending upon chance events, and these events were more or less equally probable in any of the advanced culture areas of the Old World. First Rome, the China teetered at the edge of commercial and industrial development, but shrank back rather than forging ahead.

B. Conflict Hypotheses (Internal Constraints Models)

Our first problem is to identify what slowed down the development of commerce and industry. These are in some sense better than purely agrarian technologies if only because the resulting societies are richer and more powerful. Several conflict hypotheses have been advanced to try to account for the impediments on the path to commercial and industrial societies.

These hypotheses are all derived from, or closely related to those of Marx, though most scholars do not seem to take Marx's exact model for the origin of capitalism too seriously. Marx thought that any given means of production set up contending classes. The victory of a new class gave rise to revolutions that affected the whole structure of social arrangements. Many modern social scientists have borrowed the general idea that conflict between classes or interest groups within societies are important in explaining social change and cultural evolution. In general, the existing ruling class is likely to be hostile to developments implied by the evolution in technology if new technology implies social revolution, and uses its position of power to retard the progress of technical and social evolution.

McNeill's hypothesis is typical of type. The first thing to explain is why the commercial transmutation took so long. His starting point is the conventional notion of economics that competition is the spur to innovation. Open economic, political or military competition will reward successful innovations and encourage diffusion of useful innovations. The question, given the reality of substantial rivalrous competition and conflict in all human societies, is why innovation is usually quite slow compared to the pace set in modern commercial and industrial societies. The general idea is that elites will act to limit open competion in order to avoid technical and economic change that might undermine their dominant positions.

> *First, states can and do limit trade*: The political dynamics of agrarian states work against very much dependence on trade conducted through free markets. First, most states are coextensive with most of the area over which really large-volume trade is possible. The shipment of goods and soldiers follow the same routes, and states tend to be limited, like trade, by the costs of transportation and communication. Thus most trade is internal, and easily subject to the dictates of state policy.
>
> *Second, state limitation of trade will often be popular with traditional elites:* Market trade is liable to give rise to a class of wealthy merchants who are feared as political rivals by rulers. Political competition aside, ruling bureau-

> crats and aristocrats usually disdain merchants, artisans, and the calculation and manual labor that goes with their occupations. Physically and ideologically, the rulers of states, otherwise the most sophisticated and wealthiest class, tend to be distant from the gritty world of economic enterprise. This is perhaps a by-product of the association in states of the secular and religious elite. State leaders have to cultivate an ideology of unselfish interest in the welfare of society as a whole. Mercantile enterprise manifestly depends on selfish calculation or perhaps it is just that elite status is usually ascribed, while the tumult of trade favors the achievement principle. In any case, those who might be in the best economic position to be innovators tend to be disinterested or hostile to innovation.
>
> *Third, envy and hostility may characterize peasants and craftsmen as well:* The profits of traders excite the envy of peasants and craftsmen as well; they tend to feel that the traders' profits come from their efforts. Manufacturers are likely to harm the interests of traditional craftsmen through cheaper, less labor intensive production. Thus, elite regulation of merchants and markets is likely to be popular among the masses as well as among elites.
>
> Fourth, 'normal' vices of markets existed: Presumably all of the vices of markets we reviewed in Chapter 22 existed, and both the strongest and largest classes viewed the vices as outweighing the gains to unregulated entrepreneurship.
>
> *Finally, there is the temptation to confiscate "unfair" profits:* State authorities are always tempted to confiscate the accumulated wealth of merchants, and thus reduce incentives for engaging in trade.

According to McNeill, the result of all this generally tends to be an equilibrium in which the potentially dynamic market sector was kept small.

McNeill uses recently developed historical data on Sung Dynasty China to illustrate the potential for the commercial transformation under the existing technology, and the way in which the political interests of agrarian states tend to inhibit this potential. Beginning about 1000 AD China embarked on a long experiment with market rationality. This resulted in dramatic economic gains for China, as noted above, although one wonders the extent to which population growth cut into the per capita gains. But eventually the Chinese seem to have decided to cut this experiment short, around 1500. Once the decision was made by the central administration, it was relatively easy to implement, because of the strong Sung central administration. The commercial and industrial elites that suffered from the change in policy had no effective means to evade compliance. It is easy to imagine that another century of the market experiment in China would have led to their discovery of the New World and an era of Chinese, rather than European hegemony. As it was, many of the technical advances of the Chinese diffused back to Europe to feed the initially slower, but sustained, development of commerce there.

European political disunity favored the commercial and industrial revolutions. Most scholars seem to agree with McNeill that, by contrast with China, one important reason that commercial societies developed in such an unrestrained manner in Europe was its political disunity. The idea in our terms is that political disunity set up a situation in which a competitive arms race dynamic (which favored sustained general technical innovation) could flourish despite all the impediments to markets in advanced agrarian states.

No strong empire formed in Europe. In the late medieval period, the Church attempted to set up a unitary European state, the Holy Roman Empire, but without lasting success. Later, the Hapsburgs attempted to create a hegemony in Europe using the luck of their inheritance of large territories in Central Europe, Spain, and the Low Countries. The growing European regional monarchs' skill at balance-of-power politics and a little luck (e.g., the English victory over the Spanish Armada in 1588) prevented that and left the Hapsburg crown broke. Perhaps this was just an accidental failure of statecraft; the Chinese had recovered from periods of disunity, and the agrarian empire elsewhere remained the norm. Perhaps if fate had run with Hapsburg Philip II and his Admiral, the Duke of Medina Sidona, instead of with Elizabeth and her commanders like Francis Drake, during that fateful week 31 July-6 August 1588 when the Spanish Armada was defeated, Europe would have pulled back from the commercial/industrial revolution too. (Drake is a nice symbol for the ethical perils of an unrestrained commercial sector. He was a patriot/pirate, devout Protestant, sometime slave trader, and always the complete entrepreneur.)

In Europe, for reason of historical happenchance, the radius of political power came to be and remained much smaller than the radius of effective trade. A disproportionate share of trade was external rather that internal. This gave commercial entrepreneurs a substantial scope for independent action. When a local potentate's policy became hostile to commerce, one could always move to a new location. Market activity is a powerful stimulus to innovation, because any innovation that allows one firm to undersell the market and still make a profit can earn handsome profits. Political fragmentation tended to ensure that markets remained fairly free, since merchants and manufacturers had a hard time conspiring with governing elites to create a monopoly. Entrepreneurs in another jurisdiction could always organize a competitive enterprise. Recall from the chapter on trade the problems that Spain and Portugal had in enforcing trade monopolies in the face of English and other smugglers.

To whatever extent market organization was more efficient, competing states were forced to favor it or decline in political and military influence. Furthermore, the political competition between states favored a sound economic policy, if only to provide the wherewithal for weapons. The decline of Spain and Portugal is given as an example of the penalty for failure to stimulate market activity. We have previously seen how Spain tried to run trade with the New World as a state monopoly, rather than through market mechanisms. Her inefficient statist economic system improverished Spain relative to the more dynamic Northern Europeans, and weakened the Hapsburgs as a result. Weapons developments themselves tended to be favored by competition between states, and fragmented states' purchases of weapons stimulated technical development and commerce. Thus, businessmen became an important influential class in their own right; rulers took to courting them instead of confiscating their wealth and suppressing their activities to satisfy popular and aristocratic resentment. In not a few states, merchants became the dominant class, as in Venice and Holland. In the end, European political chaos forced the agrarian elite into an alliance with merchants, bankers, and manufacturers, and to an unusual reliance on unregulated market economic activity that greatly rewarded innovation. Weber's Calvinists fell like sparks in the dry tinder of inter-state rivalry (see section D below). Today, nations that have spent more than fifty years under various communist banners are sacrificing socialist principles to enlarge market sectors—largely because their highly-bureaucratized and centrally-planned economies have been a handicap in competition with the West.

C. Some Miscellaneous Impediments and Historical Factors

Barbarian invasions from the steppes destroyed Rome and badly and repeatedly disrupted the Chinese and Middle Eastern societies. This set back the most sophisticated societies evolutionarily exploring in the vicinity of the commercial and industrial adaptation.

Disease epidemics also dealt periodic setbacks to the societies most likely to undergo a commercial transformation. Others have argued that the 14th Century depopulation due to the Plague was a spur to the development of capitalism because it made labor scarce and expensive, hence motivating entrepreneurs to invest in labor-saving innovations.

Climatic deterioration during the late Middle Ages may have harmed the Middle East's prospects for leading social evolution again, as this region had from 9,000 to 4,000bp. In the Middle East, the various Moslem empires (e.g., Turkey at the beginning of the modern era) were politically very powerful, but most of the fundamental innovations that overturned the agrarian order came from China and later the West. The Middle East was ideally suited to acquire innovations from both and become the leading culture area but did not.

D. Non-Adaptive Trigger?

Some process generating variation non-adaptively is a likely candidate for furnishing the breakthrough that engendered the commercial and industrial revolution. The success of these commercial and industrial societies in war and exploitation in the event is convincing evidence of the superiority of this style of culture core, in the evolutionary sense of superior at any rate. Once developed, modern ideas have spread rapidly from centers of innovation like Venice and Britain. If some other society had made the breakthrough earlier, it ought to have achieved the dominance the Europeans enjoyed. Agrarian societies seem to have been primed for the commercial and industrial Revolution, awaiting only a spark to initiate the process. (Note that ethical superiority requires a separate argument; might doesn't necessarily make right. Just because Europeans have been the foremost military powers for the last 500 years does not by itself make them good guys.)

Max Weber formulated the most famous trigger hypothesis. Weber, an important turn-of-the-century figure in the development of the social sciences, formulated his theory in his essay *The Protestant Ethic and the Spirit of Capitalism*. He posed the problem in much the same way outlined above; why did Europe instead of the apparently more advanced Orient make the commercial and industrial breakthrough? There were four parts to his basic thesis:

> *Weber argued that a certain attachment to rationality as a mode of thought had a deep tradition in the West.* According to Weber, Oriental societies did not develop the rationalistic philosophy of the Greeks, such as the ideas of deductive mathematical proofs, critical, objective, historical studies, elaborately rationalized theology, or rational legal codes. Weber did not seem to view rationality as especially useful in the classical context, just a formalistic preoccupation of the leisured classes[2]. Formal rationality might have originally arisen via runaway indirect bias perhaps, as a prestige form. But it was a pregnant preadaptation, because put to practical use it was to be the engine of the breakthrough.

> *The second step of Weber's argument was connecting the idea of rationality to commerce and technical development.* Weber argued that men of commerce in the West turned rationality to some account in the Italian Cities, but that further developments were inhibited by the tendency of the prosperous to dissipate their profits in high living, the purchase of titles, gifts to the Church, and the like. Sensible people who make money spend it. The prevailing Catholic religious doctrine and aristocratic prestige norms were hostile to business and banking; trader's profits were viewed as the fruits of shady practices, interest on loans was forbidden by biblical injunction, etc. Accumulation and reinvestment was not encouraged. Successful businessmen sought to legitimate their ill-gotten gains by acquiring more legitimate, prestigious occupations. Venicians tended to marry into the old landholding elite and retire from commerce. Business was merely a means to an end, not an end in itself.

> *The breakthrough came during the Reformation among the Calvinist sects that*

---

[2] We are all familiar with the characterization of rationality in the hands the Medieval scholastics: "How many angels can dance on the head of a pin?"

> *combined a strong emphasis on rational means with ascetic personal habits.* The key idea in Calvinism was predestination. The elect were chosen by God, and his chosen were supposed to experience a “calling.” The called elect did not retreat into monasteries as is more typically the case in ascetic movements. Rather, they were supposed to live exemplary personal lives of honest hard work and thrift, a sort of worldly asceticism. The rational practice of one’s profession or business was encouraged, but conspicuous consumption was not. The entrepreneur’s conscience was protected from conventional anti-business norms by his sense that he was doing the work of the elect, and his exploited workers might feel the same way (especially if they were also Calvinists). This led rapidly to the accumulation of wealth that could only be reinvested in new enterprises because it couldn’t be spent on personal indulgence. The first capitalists were born as an accidental by-product of an obscure Genevan religious ideology, although one that tapped deep Western traditions.
>
> *Once the virtues of saving and investment were clear by this demonstration effect, the movement rapidly secularized.* Benjamin Franklin, with his homespun advice on how to get ahead, epitomized for Weber the Calvinist doctrine shorn of its religious ideology. Even the Catholic Church backed away from earlier structures against sound business practice, and religious prohibitions were no impediment in the Protestant countries, where commercial and industrial development became more dynamic. This hypothesis fits the pattern of shift of commercial activity from the Catholic Mediterranean countries to the Atlantic Protestant ones after l500.

Weber’s thesis has been debated for the best part of a century now, without a consensus emerging. His hypothesis might be part of the answer at least. We’re attracted by it as at least a hypothetical example of the runaway indirect bias effect (a good source of non-adaptive cultural variation) might play a large role in this episode of cultural evolution. Weber’s scenario can be recast in terms of cultural evolutionary mechanisms that would account for how an evolutionary valley might be crossed by chance (the development of the Protestant ethic by the runaway or handicap process), followed by an arms race up the newfound adaptive slope (this is the competitive industrialization of the modern world in which we are all active participants). Figure 27-1 illustrates this idea using the topographical metaphor introduced in Chapter 23.

E. Consequences

The commercial revolution challenged and upset all sorts of existing social arrangements, for example by leading to strong monarchal states in most areas of Europe. The rise of absolutist monarchs at the expense of the nobility was in part the result of the rising importance of trade and manufactures, and an alliance between kings and the newly emerging bourgeoisie at the expense of the old landed aristocracy. The impact on non-Europeans was also substantial. In the mercantilist era between about 1550 and 1750, the more advanced European states like Britain competed strenuously with each other for overseas markets, while trying to protect internal markets. Chartered monopoly companies carried on much

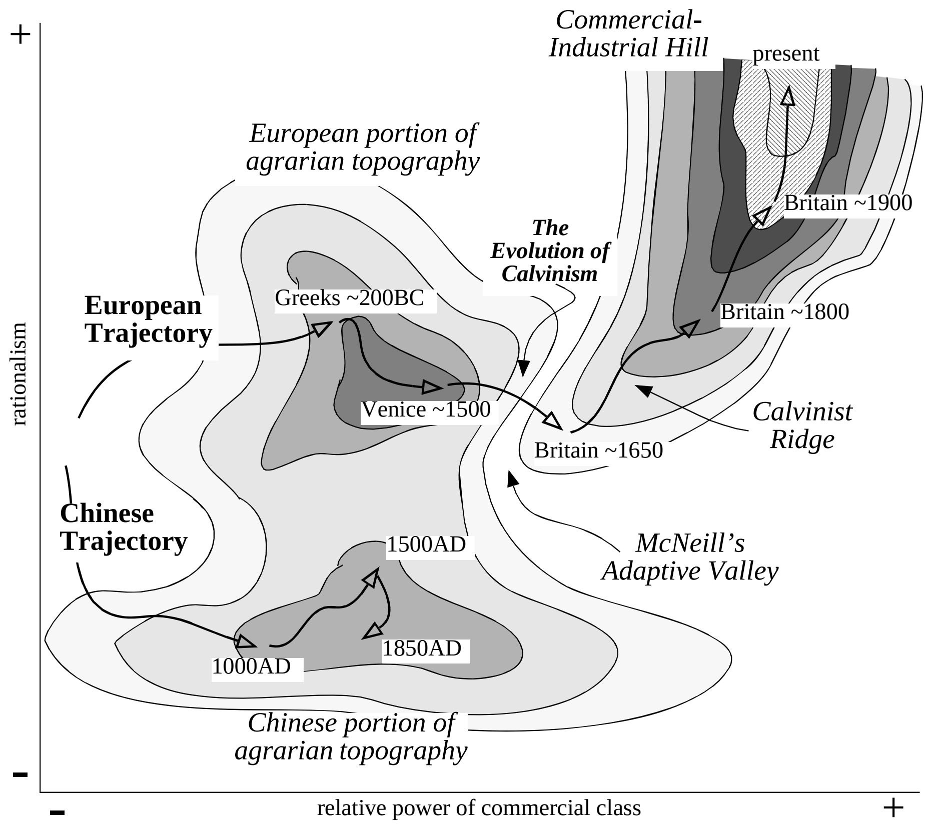


Figure 27-1. An illustration of Weber’s hypothesis that Calvinism was a preadaptation that enabled Northern Europeans to take advantage of technological innovations associated with the industrial revolution. Compare the European and Chinese cases.

of the trade, although there were always enough companies operating to keep competition keen, even ruthless. (See Chapter 17).

III. The Industrial Revolution

A. Why Britain First?

The next problem to explain is the industrial revolution. This began in Britain around the middle of the 18th century. Now the problem of the commercial revolution occurs again on a smaller scale.

Why Britain and not some other European nation? According to the historian E.J. Hobsbawm, many Western European states had by this time well-developed commercial sectors engaged in both domestic and overseas trade, all poised for the industrial revolution. He believes that British government policy was more steadfastly pro-business than any other, especially pro-foreign trade. The purchase of armaments especially naval guns and the like, to support this commerce stimulated industry, as did the overseas markets that the naval guns "protected".

Another answer is that merchants and the landed aristocracy were on closer terms in Britain. The main resistance to industrialization in Britain tended to come from craft guilds, whose traditional occupations were badly upset by machine industry. Since the landowning and commercial classes had a larger common political interest in Britain than elsewhere, and because part of the landowners' interest came from evicting farmers to raise wool for the export trade, a combination of competition for wage labor and political power reduced the effectiveness of guilds in Britain. Thus entrepreneurs were led to invest in manufacturing equipment instead of just commerce.

The augmentation in military power from Britain's industrialization forced other nations like France, to follow rush to industrialize, whether they wanted to or not.

B. Institutionalizing Economic Growth

Recall the argument from Chapter 22 that economic growth has "addictive" qualities powered by a compulsive attempt to satisfy ultimately unsatisfiable comparative wants. Perhaps an important reason for the explosive rate of technical change after the industrial revolution really got rolling is that rates of economic growth outran population increase, as we saw in Chapter 16. This did two things, at least. It kept up a sustained flow of profits for reinvestment in new innovations; we escaped Ricardo's stagnation scenario. It also gave the mass of the population a stake in economic development. People came to "enjoy" rising wealth and popular political pressure turned substantially from suspicion to relative enthusiasm, if not for market activity itself, at least for the benefit of rising incomes that to this day markets and private entrepreneurship seem most effective at creating. Socialist governments of Western Europe, such as that of Mitterand in France, reluctantly turn to the market to satisfy this desire, and the Communist nations have collapsed under pressures for lifestyle improvements that their economies couldn't meet. How different this is compared to the classical situation where ruling elites found it popular with peasant masses and with their aristocratic supporters to curtail the market! Nevertheless, if the Easterlin-Frank hypothesis is correct, economic growth is built on a foundation of sand because in the end there is no satisfying comparative wants.

IV. Conclusion

McNeill speculates that rapid economic growth that has characterized the last few centuries is coming to an end. Plan rationality[3] (centralized planning) is gaining influence at the expense of the market. He guesses that the rapid technical evolution of the commercial and industrial periods will turn out to be a temporary lapse from conditions where innovation-inhibiting processes are much stronger.

Clearly, the flaws of markets attract a lot of attention, and just as clearly a return to the 19th century level of reliance on markets is unlikely. Also, the European style of small states protecting their sovereignty with balance-of-power techniques is a good deal more dangerous, given modern military technology, than it has ever been before. Still, arms races and comparative wants are powerful processes, the social analogs of individual addictions. No matter how unpleasant, even life-threatening, they are difficult to escape. It's a wild era to live in, but exciting as hell while it lasts. For the thrill seeker, the modern era is the ultimate roller coaster ride. For the conservative, it is a "stop the world, I want off" affair. It is difficult to guess what form the next temporary(?) equilibrium will look like or when we'll get there.

It is not difficult to reach the conclusion that the several factors McNeill mentions plus Weber's hypothesis are all required to explain the exact timing and locales of the commercial and industrial transmutations. It perhaps took a series of historical accidents to bridge the gap between classical agrarian and commercial and industrial societies.

We're not at all sure how much agreement the compound hypothesis presented here would attract from scholars. The pieces *are* constructed from very well-regarded, if controversial, sources. The worth of the specific hypothesis aside, We hope the chapter illustrates how historical hypotheses with major elements of non-adaptive chance events might work. Note that the elementary mechanisms we've invoked in these hypotheses are not unscientific. We met indirect bias as a quite ordinary evolutionary mechanism in Chapter 14.

Perhaps the only reason that some processes seem to be unique and properly historical is that we simply cannot average over enough individual cases do statistics. Chance events that are large enough take away the tool scientists use to finesse probability—replication. In some cases there is only "one world, no control". A process that would be scientifically understandable if we had knowledge of some other worlds becomes historical when we are restricted to one. Is *this* the difference that produces a valid distinction between science and history?

---

[3] See Chapter 23, section IV.

V. Summary

Key Hypotheses:

Political unity—fragmentation as a regulator of technical progress

Weber’s Protestant Ethic

The power of coparative wants

IV. Bibliographic Notes

References:

McNeill, W.H. 1982. *The Pursuit Of Power: Technology, Armed Force, and Society Since AD 1000*. Chicago: University of Chicago Press.

McNeill, W.H. 1980. *The Human Condition: An Ecological and Historical View*. Princeton: Princeton University Press.

Tuma, E. 1971. *European Economic History*. New York: Harper and Row.

Weber, Max. 1958. *The Protestant Ethic and the Spirit of Capitalism*. New York: Scribners.

Chapter 28. SUMMARY AND REVIEW

> Many of the views which have been advanced are highly speculative, and some will no doubt prove erroneous; but in every case I have given the reasons which led me to one view rather than to another. It seemed worthwhile to try how far the principle of evolution would throw light on some of the more complex problems in the natural history of man.
>
> Charles Darwin, 1874
>
> *The Descent Of Man* (Summary and Conclusion)

I. Broadest Issues of the Book

A. The Claim for an Ecological/Evolutionary Approach

As you perhaps recall from the first chapter, we said that the overarching question of the book was how adequate the ecological/evolutionary approach was for understanding human behavior. *Does theory and method borrowed from biology—but extensively remodeled to fit the peculiarities of the human case—provide a proper foundation for a science of this particular animal?* The special claim of human ecology is not to replace the conventional social sciences (or sciences of human biology) but rather to provide a framework for synthesizing the many disciplines that contribute to understanding *Homo sapiens*.

This is a controversial thesis in some quarters. *This book can be read as an extended essay arguing in favor of it.* Each of the book's substantive chapters is intended to review a bit of theoretical reasoning or a body of data that can be fitted into a synthetic ecological/evolutionary science of human behavior. Some of this material was directly inspired by ecological ideas, but much of it was drawn from classical social science concepts, models, and hypotheses that human ecology claims to be able to integrate. Thus, you will have learned a lot of social science and related material in this book, whether or not you think the main thesis justified!

No single social science discipline has the breadth of ambition of human ecology. Ordinarily, a thesis like this should be argued comparatively. "Human ecology is a better approach than its alternatives, _______________, and ______________." However, there really are no alternatives to the ecological/evolutionary approach. Typical approaches to the the explanation of human behavior are limited to particular levels of organization (psychology, sociology), to the question of origins but not contemporary behavior (paleoanthropology), or to contemporary behavior but not its origins (economics). To be sure, there are many cases in which there are objections to particular planks in the ecological platform. There are also those that deny that scientific methods are really applicable in the case of humans. But we do not think there is any other scholarly tradition in the social sciences with quite the same synthetic intentions as human ecology, which aims for an account of human origins and behavior drawn from all the relevant disciplines including biology, the geophysical sciences, the social and behavioral sciences, and history.

B. Alternatives to Anthropocentrism, Ethnocentrism, and Mythology

Another important subtheme in the book is the idea that social scientific ideas are a substitute for anthropocentrism, ethnocentrism, and mythologizing about human behavior. For example, we think it important to understand that arms races may not be due in any important part to the evil intentions of our enemies (or the military, or the CIA, etc.) but rather to the game logic inherent in particular situations. Avoiding arms races may mainly be a matter of evading this logic. In fact, if this is so, searching for bad guys is a waste of time. Focusing our attention on mythical enemies could well be a dangerous diversion! Myths provide a sense of comfort in an uncertain world, but it is most important these days that we deal with the *real* problems. Only a scientific approach holds much promise for separating myths and reality. Badly intentioned people are a problem, but for our part we fear even ‘innocent’ myths more.

II. Relationships Between Major Blocks of the Book

There were four major blocks of chapters in the book. It will help you to put the whole field in perspective if you think about the basic nature of each block and their relationships to one another.

A. Human Natural History

In this series of chapters, we surveyed the diversity of human societies using the technology-culture core idea of Steward as an organizing principle. It was essentially a review of what has been discovered about human behavior using the ecological/evolutionary approach. This knowledge lies short of the intellectual frontier; but we have to traverse it in order to get to the exciting, confusing questions that actually do lie on the frontier. The essential discovery discussed in this section is that there is a strong correlation between the technology employed by a society and social and political institutions, most especially when environmental variables are taken into account to explain variation within subsistence types. There is even a relationship to psychological variables (recall the cognitive style and child-rearing practice relationship.) Steward and his followers succeeded in making adaptation to environment via technology a powerful idea, but that they did not satisfactorily solve the four problems of Chapter 2. For example, their progressivist account of evolution, and hence of the concept of adaptation, is very weak.

B. Theory of Human Evolution

To remedy the ecology/evolution weakness of Stewards approach, the second part of the book introduced models of evolutionary processes derived using the methods used by Darwinians to understand organic evolution. The key to this approach is to focus on populations of variable individuals, and to study what happens to heritable variation as populations move through time. We used relatively simple models of human life cycles to break the evolutionary process down into a series of structural variations and evolutionary forces that allow us to account for what happens to individuals as they acquire their heritable variants and try to use them to make a living. Things already get pretty messy, as genes and culture interact with one another, and each is affected by several evolutionary processes at the same time.

However, some of these complexities of culture and gene-culture coevolution are attractive because they give us reasonable preliminary answers to some of the most puzzling features of human behavior. For example, the sociobiological forces of guided variation and direct bias account for why culture frequently seems to produce adaptations very much like those of ordinary organisms, while frequency dependent bias and indirect bias might account for why humans are so cooperative and so prone to generate seemingly maladaptive or nonadaptive symbolic variation.

These ideas are all controversial and uncertain of ultimate success; here we are operating on the frontier. We believe that the understanding of human evolution that is ultimately incorporated into more secure knowledge will look a lot like what you have studied here, but then we're partisan reporters. An obvious defect of these models is that they treat the environment in rather stylized and abstract terms as selective forces, information acquired by experience, and the like. They lack much of the gritty feel of real populations interacting with real environments.

C. Systemic Interactions

It is to a more realistic account of such complex environment/population interactions that we turned in third block of chapters. We looked at population regulation, environmental impacts, collective decision-making, disease, trade, warfare, and the diffusion of innovations. Our focus was on the society or population as the unit of analysis, but we argued that many of the same interactions, suitably modified as to detail, also obtain between smaller units, down to individuals, within societies.

We hope you see the close relationship between the abstract evolutionary processes of the previous section with the processes we examined in this one. It is the ecological processes in this section that actually drive the more abstractly presented evolutionary processes of the previous one.

For example, it is the ecologically determined advantages of trustful cooperation within groups that, combined with the peculiarities of cultural transmission that perhaps account for why organized warfare is the typical mode of human conflict, and why international trade was for so long organized by ethnic trade diasporas. For another example, the studies of diffusion of innovations we examined suggest how the costs of information and decision-making that were such a large part of the theory of cultural evolution actually work out in practice. We also examined how population growth processes generate the selective and decision-making pressures that are central to models of evolutionary processes. Of book, the evolution of technology and norms has a potent effect on demographic processes; ecology and evolution are opposite sides of the same coin. Even more basic perhaps, the myopic, step by step nature of evolutionary processes helps us account for the environmental deterioration dynamics that often occur.

Recall the skeletal explanatory formulas that were introduced in the first chapter:

Ecological equation:

Phenotype = *f*(genes, culture, environment)

Evolutionary equation:

Genotypes = *f*(past environments, evolutionary forces)

By the end of this block of chapters, there was some flesh on all these bare bones.

D. Evolutionary Transformations of Human Ecological Patterns

To test how far we could get with tools at hand, we examined the main revolutions in human subsistence.

The first problem was to stretch the microevolutionary time scale considered in the chapters in block B to the macroevolutionary one. Recall that this is a problem of accounting for limitations to the rate of evolution due either to internal processes within the evolving populations or external to it in the environment. For example, long stable environments may find most populations on adaptive peaks, so that further evolutionary change depends on environments changing.

However, a sudden environmental change may set in motion a complex, slow, and halting series of evolutionary changes as populations climb a rough fitness hill with many local optima where they get stuck for more or less long periods of time, depending on a great many ecological details. The time scale for cultural evolution can be at least 10,000 years, if the idea is correct that the change in variation in climate 10,000 years ago set off the train of human evolutionary responses of which we are still part. We reviewed several hypotheses to explain major human ecological revolutions using various *internalist* arguments.

On longer time scales, the externalist idea that macroevolutionary patterns are mainly due to the geophysical evolution of the Earth, the simplest macroevolutionary extrapolation from our microevolutionary theory, might well be correct, as the relative stability of upper paleolithic peoples from 40,000 to 10,000bp suggests.

III. Review of the Four Problems of Human Ecology

An alternative approach to reviewing where we have come in this book (highly redundant with the one above) is to ask: how far have we gone toward solving the main problems humans pose for ecological analysis? We introduced these four questions in the second chapter of the book, where we suspect they seemed a touch abstract to most of you. However, because they summarize the main underlying themes that tie all parts of the book together, they now are worth raising again for you to think about as you review the book.

A. The Relationship Between Genes and Culture

How are we to understand culture as a means of adaptation to environments?

If culture is a system of inheritance, we can use Darwinian methods, population thinking—remember, the implication here is that we ought to make a close study of heritable variation; if we can understand the small-scale dynamics of how cultural variation is acquired and transmitted, we can solve this and the other four problems, at least in principle. Recall that “in principle” means in part that we keep environments simple.

Sociobiological hypothesis:If the decision-making forces are very strong, and selection operates on the determinants of these forces, culture is adaptive in a straight-forward way. The argument from natural origins guarantees that this must be true in some sense, or to some extent.

Costly information hypothesis: If culture is a means of evading information costs, decision-making forces will be weak, selection and other forces acting on cultural variation can favor traits that are maladaptive from the genes’ point of view

Evidence: We have reviewed much evidence that can be accounted for by the sociobiological hypothesis (e.g., the importance of kinship in social organization). We have also reviewed evidence such as the demographic transition that is difficult to reconcile with sociobiological thinking. Some of the evidence we looked at (e.g., patterns of the diffusion of innovations) make it seem as if people treat decisions as costly to make.

B. Relationship Between Ecological and Evolutionary Processes

How do humans relate to their environments and what are the long-run consequences of this interaction?

> *Technology and the culture core concept*: Steward's idea shows how technology-environment interactions can powerfully influence the culture core, and the core potentially includes much of the cultural repertoire. But Steward's evolutionary account is separate from his ecological ideas, and this is unsatisfactory.

> *The forces of cultural evolution*:We saw how selective and decision-making effects acting on culture interact with the environment and with the processes of organic evolution; we can see how ecological processes can generate long-run patterns of change in the cultural as well as the biological case.

> *Coevolutionary complexity*: Environment-population interactions can generate very complex and often counter-intuitive processes. This is particularly so when the environment itself is part of the evolving system, as in the case of environmental impacts, interactions with other species (e.g. disease organisms, or other human tribes, classes, or nations). Evolutionary "games" often exhibit behavior that is unexpected within the framework of a fixed environment. For example, positive feedback loops can get set up that cause a long train of evolutionary consequences, after the fashion of an arms race. We saw hypotheses advanced that the most disease-ridden populations have an advantage in inter-societal conflict; that morally dubious market mechanisms can create enough technical progress to make whole nations prosperous, that an irrational willingness to fight may be rational, and so on.

These complexities make it very difficult to understand the tempo and mode of human evolution (or organic evolution for that matter) in simple terms. For example, in our examination of the main evolutionary events in human history, we often had trouble accounting for them with a simple externalist hypothesis; progressive internalists ones often seemed necessary. In no case could we even hypothesize that there was a simple univariate explanation for the tempo and mode of human evolution.

C. Group Size and Levels of Cooperation

Why are humans, compared to most other animals, able to organize themselves on such a large scale?

> *The public goods problem:* Cooperation is hard to achieve in large groups. The reciprocal altruism solution of sociobiologists is at least debatable in the human case.

> *Group selection on cultural variation:* Group selection may be more frequent in the cultural than in the genetic case via conformist transmission (frequency dependent bias) and runaway effects, and the low costs of these transmission rules may generally prevent individual-level selective processes from undoing them.

> *Large-scale cooperation very important*: We met examples of large-scale cooperation, including warfare, and organization based on ethnic and class sentiments (e.g., the importance of interest groups within societies that organize themselves to collectively favor or oppose policies).
>
> *Note well* that the existence of cooperation at one level has a tendency to cause problems of intensified conflict at others. War is the most extreme example, but the problems of solving large-scale public goods problems in societies with interest groups can also be a problem, as we saw in the case of voting paradoxes. At the same time, forcing individuals to interact only through markets has its problems as well.

D. Symbolic Behavior

Why do modern humans engage in such elaborate rituals, pursue such seemingly irrational prestige norms, and believe so strongly in objectively ridiculous ideologies?

> *The hypothesis of the symbolic anthropologists*: Recall that the strongest objections to any sort of ecological/evolutionary theory come from the idea that the use of symbols frees us from ordinary adaptive constraints on our behavior. It has been claimed that this means that the whole approach we have taken in this book is misguided.

> *Indirect bias and the runaway process*: In order to answer this criticism, we proposed a systematic explanation of how cultural evolutionary processes could produce maladaptations. At the same time indirect bias and symbols have many individual and group fitness enhancing functions. The argument here is that the methodological objection of the symbolic anthropologists can be met, but they might be more or less correct on the substantive issue; perhaps some human behavior is just plain maladaptive.

> *Evidence*: We saw the importance of indirect bias in the opinion leadership phenomenon of innovation diffusion. Extensive symbolic capacities appear to be a late development in human evolution, and one might imagine that the spurt of human evolution during the last 100,000 years has something to do with this. We saw some potentially important uses of symbols, as in the ritualization of conflict. Weber’s Protestant Ethic hypothesis suggests that the runaway process might sometimes have very important consequences.

IV. Conclusion

We said at the beginning of the book that human ecology is an area of science where the frontier problems of the discipline can be presented in a way that makes minimal demands on previous knowledge. In this book we’ve tried to expose you to this frontier. Now you can see what that means more clearly. We have more interesting hypotheses than firm answers, and no little amount of plain confusion. By no means are all of the problems of understanding human behavior well posed, let alone solved. We’ve thrown some more light on these problems since Darwin’s day, but they remain complex ones. For a scientist, this is home, a veritable Bre’r Rabbit’s briar patch of interesting, unsolved problems. (In the epigraph quote, Darwin meant to signal this fact to his readers, at least as much as he wanted to be apologetic.)

We hope you have enjoyed this aspect of the book; it is the most fun for scientists themselves. The frontier is where a practicing scientist finds real problems to solve. However, we sometimes worry that science is a poor spectator sport. Studying the known facts is rewarding and useful, and speculating loosely about the unknown is fun. Actually working on the scientific frontier to reduce chaos, error, and confusion to orderly knowledge is apt to be confusing, boring, and just plain *hard work*—like life on a real frontier. Some of the ideas may even be downright scary. Scientists suffer all this for the occasional thrill that comes from discovering an important bit of new knowledge for oneself.

Even if you did not enjoy it, we hope you have gotten some insight into the somewhat perverse motivations of scientists. We find unsolved problems exciting, but only if we think we can solve them. And we find solid answers, once they really are solid, boring. This is more or less the opposite of what sensible people prefer. Solid answers are useful, and unsolvable ones are fun to argue about. Scientists get their kicks working very hard to turn fun things to think about into boring, usually complicated, occasionally useful, facts!

On another level, however, the lack of good, well-verified answers to the big questions in human ecology, and in the social sciences more generally, is a bit scary. Our high level of ignorance about the causes of human behavior is not reassuring. The idea that arms races and the dangerous game of war are a virtually natural phenomenon—and thus extremely difficult to control—is a positively chilling thought. Arrow’s idea that there is no guarantee that human collectivities can act according to simple norms of rationality, or Boyd and Richerson’s hypothesis that absurd cultural norms can arise through runaway indirect bias, are no help for sleepless nights. The Easterlin-Frank idea that modern growth economies are bad or not good strikes at one of the few ideas for which there is a degree of consensus in the modern world. We share the planet with a large, dangerous, unpredictable animal, each other.

We, for one at least, find it uncomfortable to live on the same planet with a bunch of big, dangerous animals that we do not understand very well. Writing some chapters in this book feels a bit like writing the script for a horror movie, except that it really happens! Perhaps the most important practical message of this book is that we do not yet know enough about humans to reliably control our more dangerous and destructive behaviors. Until we do, the human adventure is often liable to be a little more exciting than one would like.