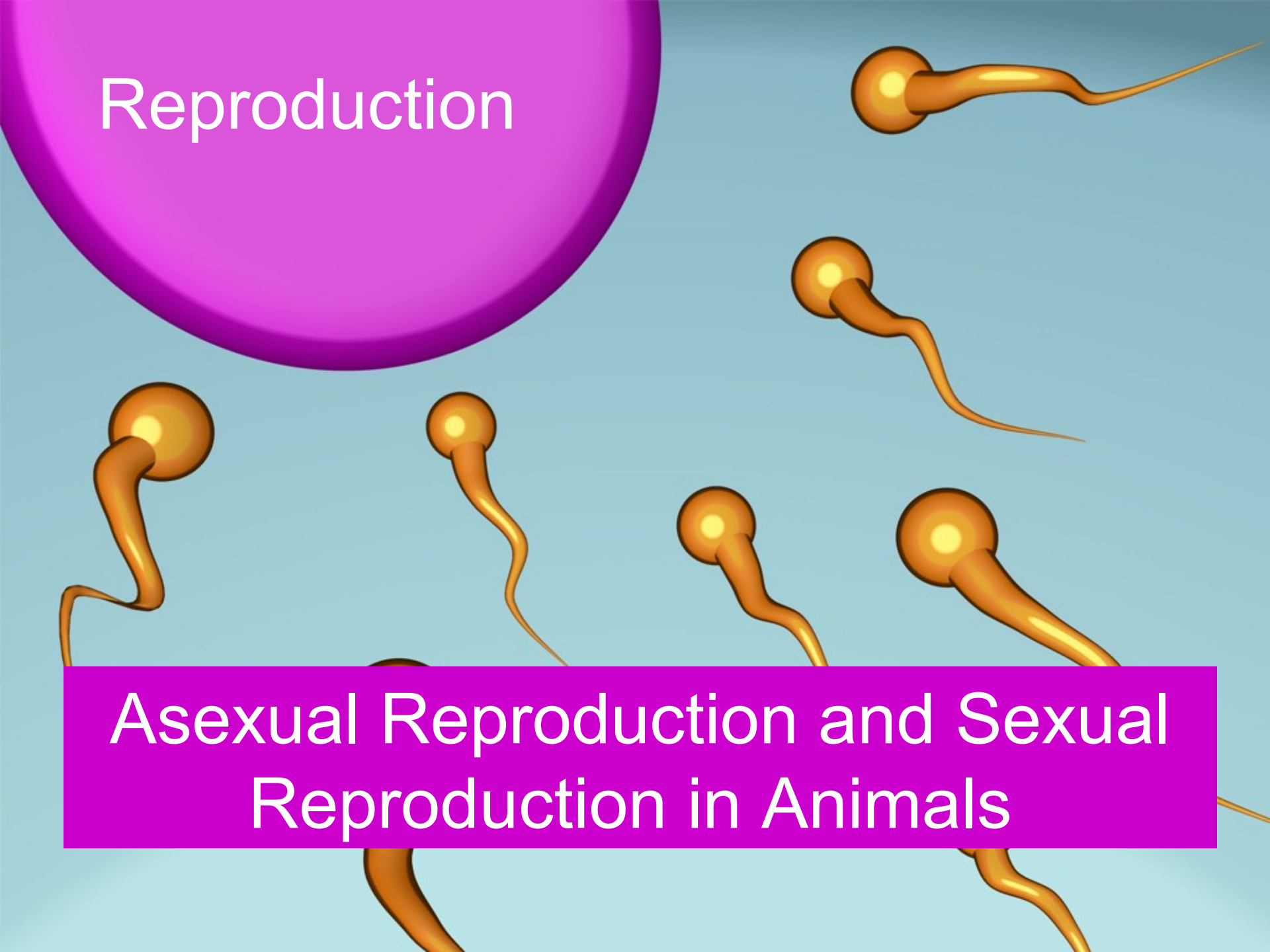
# Reproduction



## Asexual Reproduction and Sexual Reproduction in Animals

# Learning Goals

- Distinguish between asexual and sexual reproduction and the list advantages/benefits and disadvantages/costs of each
- Describe reproduction in unicellular organisms
- Summarise reproduction and development in mammals and describe the three steps of fertilization
- Summarise the function of the male and female reproductive systems including the menstrual cycle in females

# Reproduction

- Individual organisms do not live forever.
- Therefore the continuity of a species relies on individuals **reproducing**.
- There are two types of reproduction: **asexual reproduction** and **sexual reproduction**.



# Asexual Reproduction

- Unicellular organisms such as bacteria and protists as well as some plants, fungi and a few animals reproduce **asexually**.
- That is, they reproduce by mitotic divisions producing offspring that are identical to their parent- **clones**.
- In multicellular organisms the new individual will arise from a cellular division of an ordinary body cell (a **somatic** cell).
- Many organisms that reproduce asexually have the ability to reproduce sexually also but the occurrence of this may be rare.
- Organisms that reproduce asexually are found in stable environments to which they are very well suited.

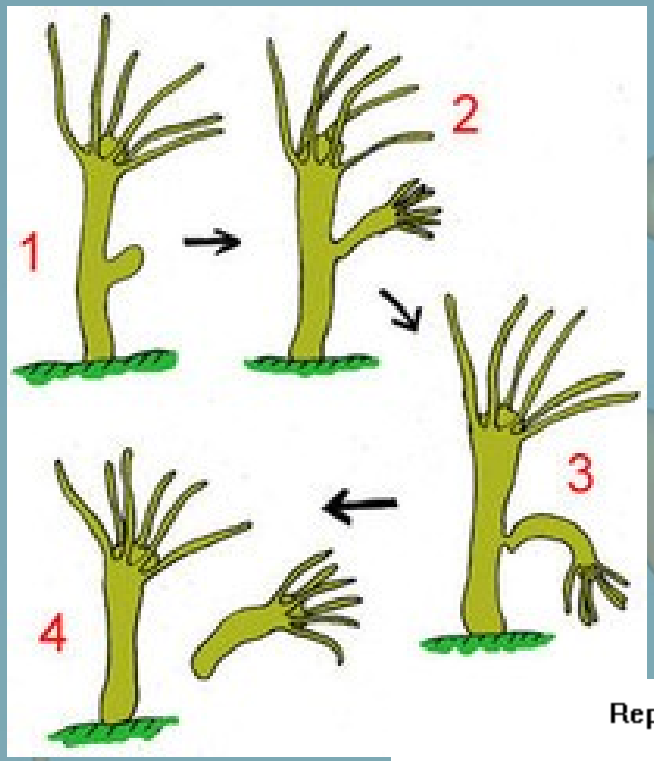
# Ways of Reproducing Asexually

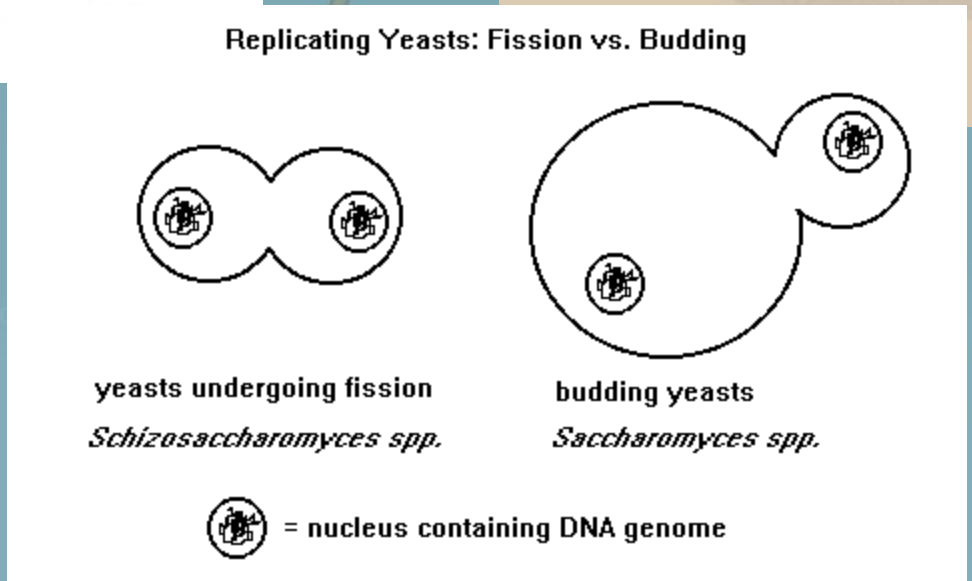
- There are several ways an organism may reproduce asexually:
  - Fission and Budding
  - Fragmentation
  - Spore Formation
  - Vegetative Reproduction
  - Parthenogenesis

# Fission and Budding

- **Fission** is common among unicellular organisms such as bacteria.
- Fission occurs after the mitotic division of the nucleus when the parent cell splits into two equally sized daughter cells forming a new organism.
- **Budding** is similar to fission except that the division of the cytoplasm is unequal. The new individual arises from an outgrowth, or bud, from the parent.
- Budding can also be seen in small multicellular animals.

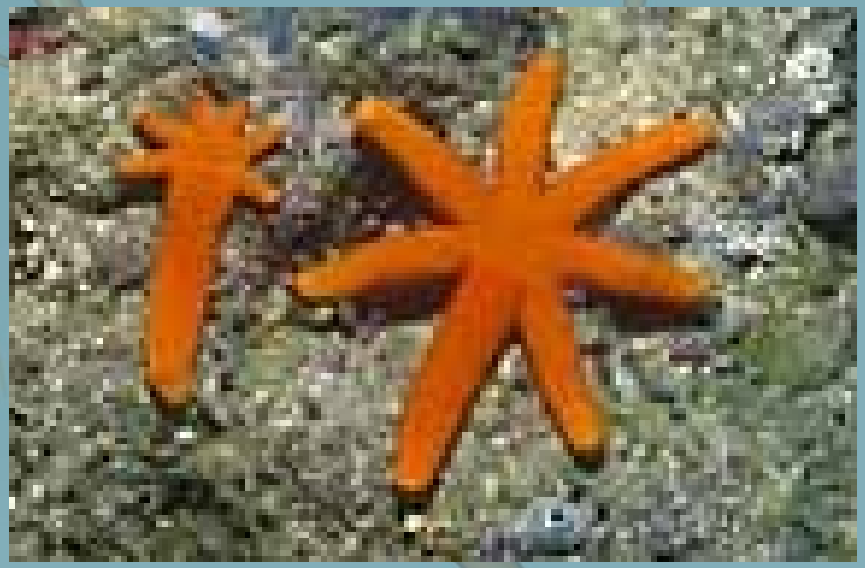
# Fission and Budding

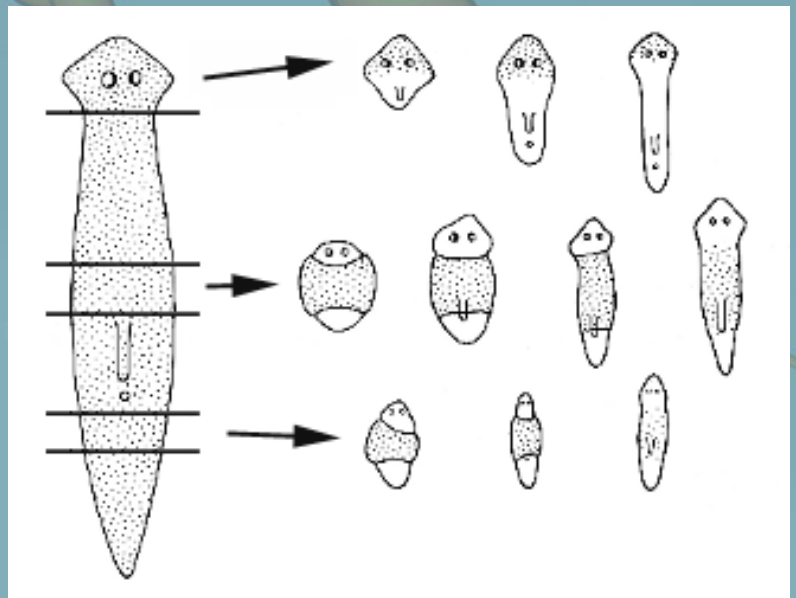


# Fragmentation

- **Fragmentation** occurs in multicellular organisms when the body of the organism breaks into two or more parts each of which will form a new organism.
- This form of reproduction is common in flatworms, marine worms, and echinoderms (starfish).
- With worms and new individual may form when the worm gets so long that it simply falls apart forming new organisms.



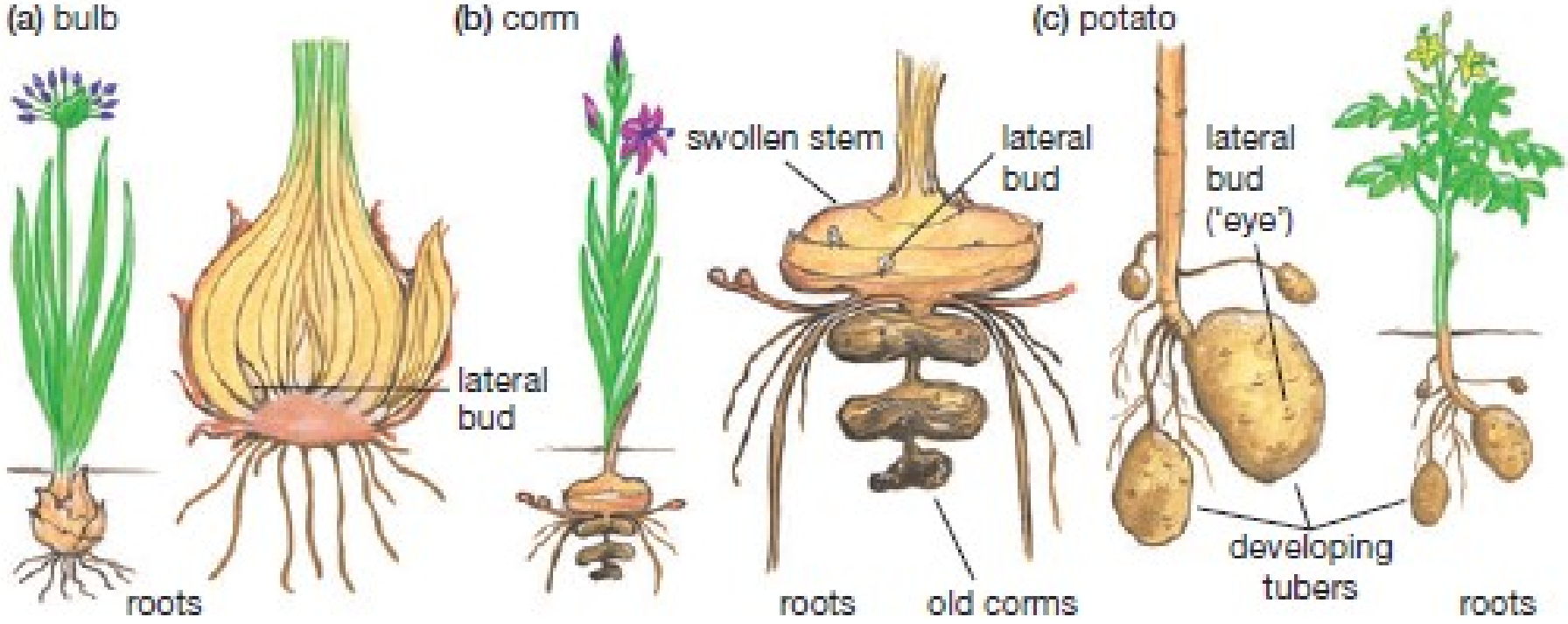


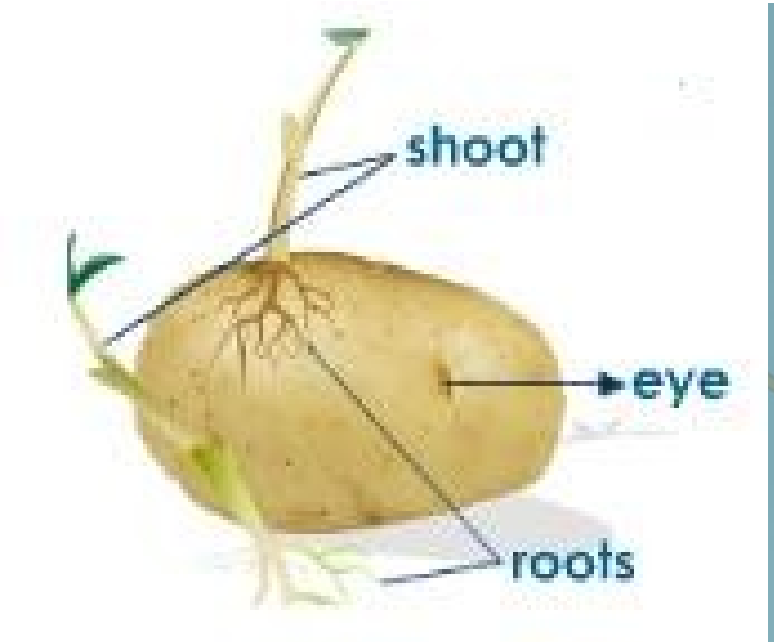
# Spore Formation

- **Spores** are formed by fungi and are often contained within a structure known as a **sporangium** which will disintegrate releasing the spores into the environment.
- When a spore lands in a suitable environment it will germinate forming a new fungus.
- Spores are formed by budding.


# Vegetative Reproduction

- Many plants are capable of vegetative reproduction which is the separation of one plant to form a new, independent plant.
- Vegetative reproduction may arise form many parts of a plant including the leaves and underground stems.
- **Rhizomes** are underground stems that branch and give rise to new shoots and roots
- Note that these plants can also reproduce sexually. Asexual reproduction is however faster and may allow the plant to out-compete neighboring species of plant wanting the same resources and space.


(a) bulb
(b) corm
(c) potato
lateral bud
swollen stem
lateral bud
lateral bud ('eye')
roots
roots
old corms
developing tubers
roots


shoot
eye
roots

# Parthenogenesis

- **Parthenogenesis** is the development of an unfertilised egg into a new individual that is a clone of the parent.
- In order to obtain the needed **diploid** set of chromosomes the egg will often duplicate by mitosis and then fuse to give the egg two sets of chromosomes.
- Animals that are parthenogenetic include bees, wasps, ants, and some species of birds and lizards.

Figure 11.7
In a few groups of lizards, such as the gecko *Heteronotia binoei*, reproduction occurs parthenogenetically. Only females are present in the population.

# Parthenogenesis

- The fertilised eggs of bees, wasps and ants will develop into females.
- An unfertilised egg however will duplicate by mitosis and fuse to form a diploid cell. These cells then develop by further mitotic divisions into males.
- Unfertilised eggs of some species of lizards and our very own stick insects will develop into females. A population of these organisms in some regions may be composed entirely of female organisms.

# Advantages and Benefits of Asexual Reproduction

- No need to spend time and energy finding a mate
- No need to use energy resources producing eggs and sperm that potentially would never be used

# Disadvantages and Costs of Asexual Reproduction

- Lack of variation within the population means the species is less likely to survive after environmental change

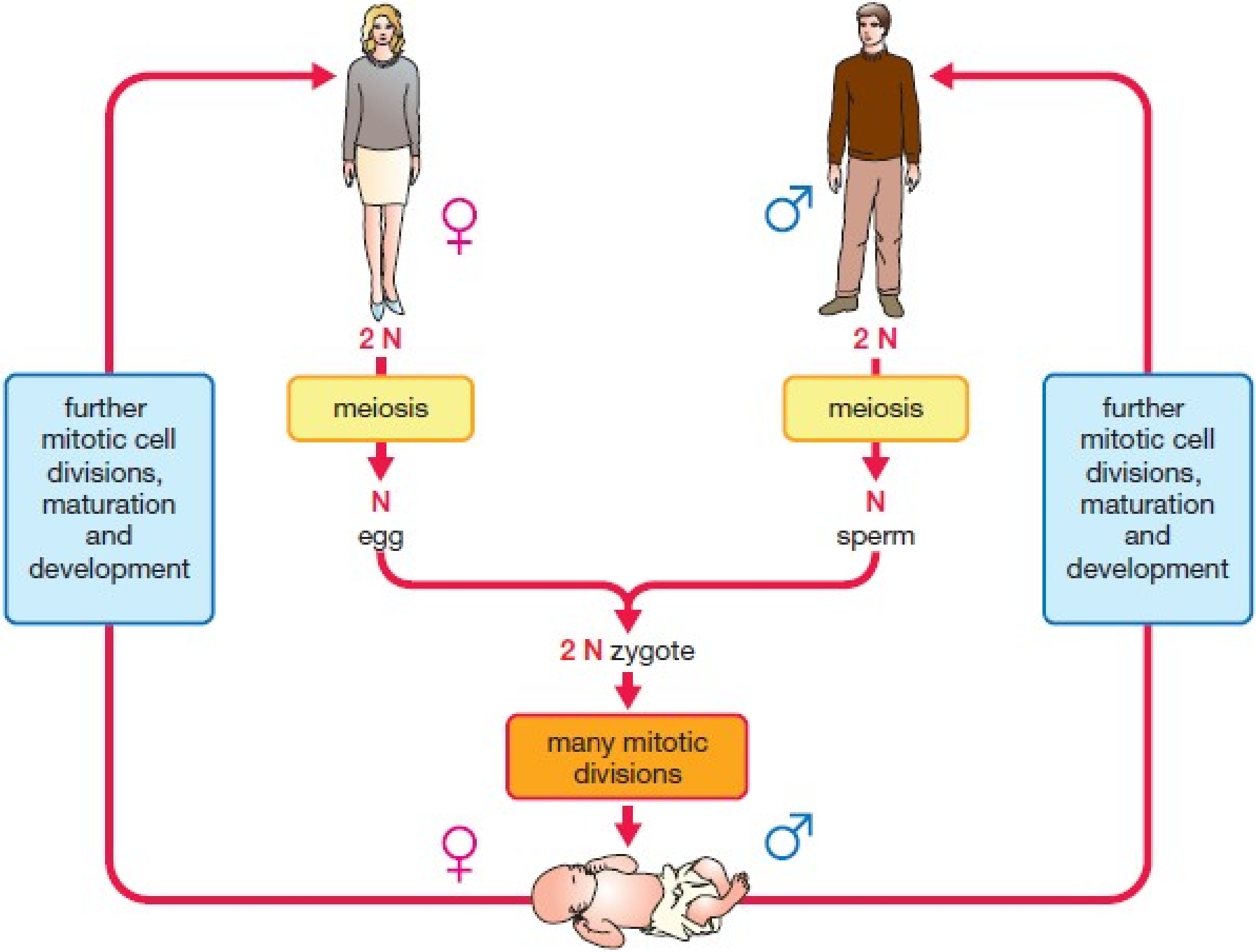
# Sexual Reproduction

- Most multicellular organisms reproduce **sexually**.
- Sexual reproduction involves male and female **gametes** (sperm and eggs) uniting to form a **zygote**. This zygote is a unique new individual introducing variation into a population.

- The cells of multicellular organisms can be divided into two broad categories:
  - **Germ cells** which give rise to the gametes. **Gametes** are the cells that combine in sexual reproduction to form a new organism.
  - **Somatic cells** are all cells of the body with the exception of the germ cells.

# Sexual Reproduction

- Sexual reproduction involves the following processes:
  - Meiotic divisions of the germ cells produce **haploid** gametes (one set of chromosomes) usually **ova** (eggs) and **sperm**.
  - The ova and sperm fuse to form a **diploid** (two sets of chromosomes) **zygote** (single cell).
  - This zygote then divides by mitotic divisions to produce a large number of cells that differentiate to form the various different types of tissues that make up the new individual.


2 N
meiosis
N
egg
2 N
meiosis
N
sperm
further mitotic cell divisions, maturation and development
further mitotic cell divisions, maturation and development
2 N zygote
many mitotic divisions

# Sexual Reproduction

- Sexual reproduction usually involve two parents but there may be only one.
- Some worms such as tapeworms are **hermaphrodites** meaning they have both male and female reproductive organs.
- Hermaphrodites do not self fertilise as a first option but when they do they produce genetically different offspring.

# Advantages and Benefits of Sexual Reproduction

- The genetic diversity introduced by sexual reproduction can allow a species to survive changing environmental conditions. This is a major benefit to the survival of the species.

# Disadvantages and Costs of Sexual Reproduction

- The organism must use energy to produce germ cells
- The organism may have to change its usual pattern of activity to ensure these gametes are brought together at the right time of the year.
- Some reproductive behaviours may attract predators not only a reproductive mate.
- Reproduction in some species leads to deadly competition between males.
- The costs of sexual reproduction however clearly outweigh the costs as reflected by the fact that nearly all eukaryotic organisms reproduce sexually.

# Sexual Reproduction in Animals

- The reproductive system is composed of **primary** and **secondary** sex organs.
- In animals the primary sex organs which produce the gametes are the **ovaries** in females and the **testes** in males.
- Secondary sex organs include the various glands that produce nutrition and lubrication, the ducts and chambers that provide areas for storage and development of the gametes and the organs for mating and protection of the developing embryo.

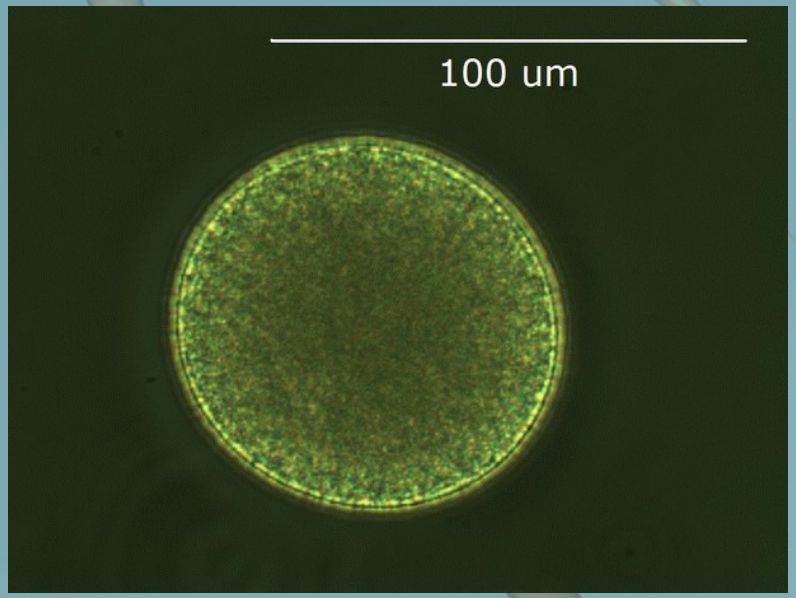
# Stages in Mammalian Reproduction

- The stages of mammalian reproduction include:
  - Gamete formation
  - Fertilisation
  - Development of the embryo and fetus

- Note that I will be focusing on Human Reproduction. There are slight differences in the structure of the reproductive systems of other mammals but their physiology is based on the same principles.

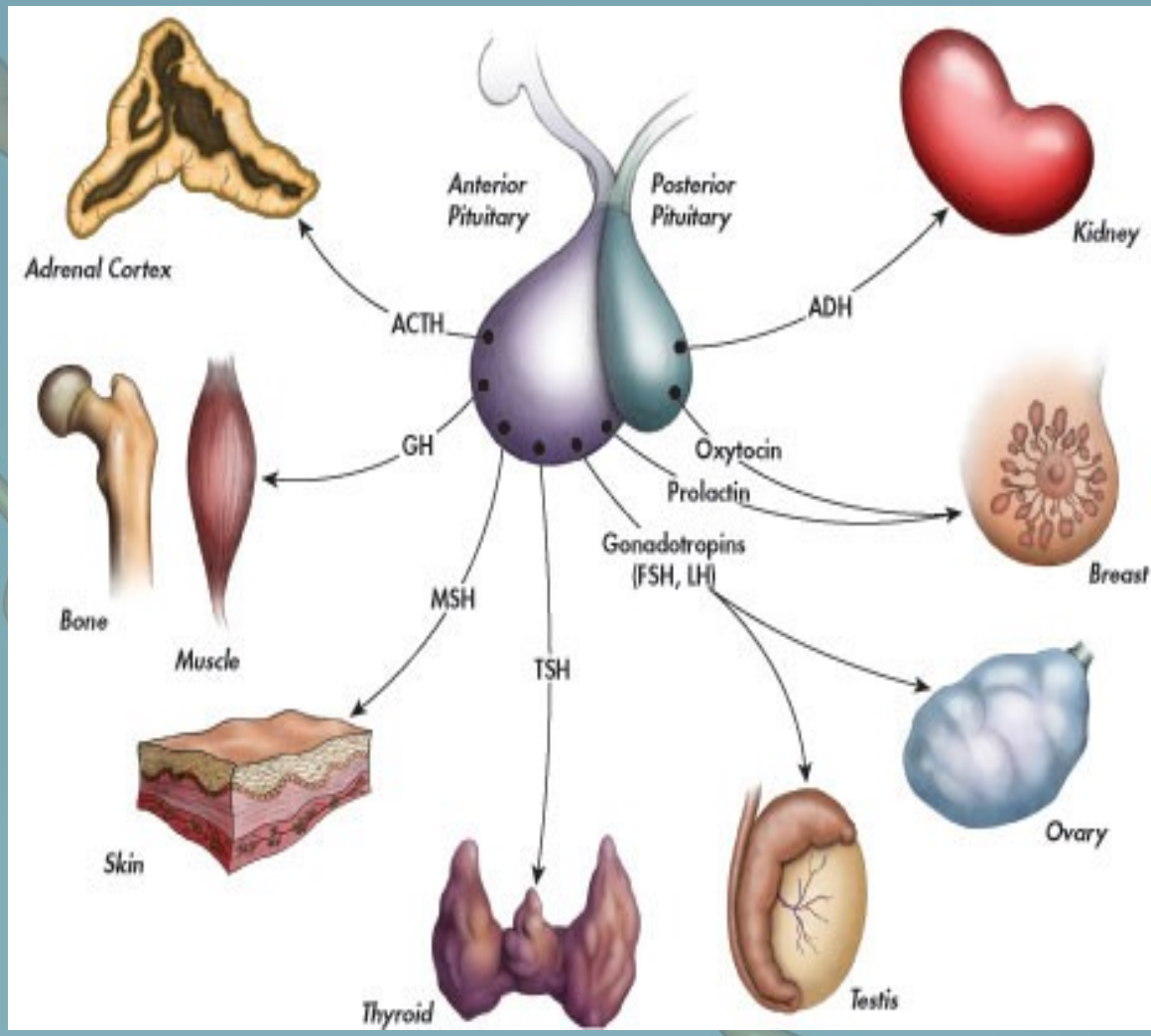
# Gamete Formation

- Gamete formation involves the formation of the **eggs** (ova) and **sperm**.
- Eggs are large cells that are not mobile and contain the food stores needed for the development of the embryo.
- Spermatozoa (sperm) are mobile cells usually with a tail that contain a limited food source.



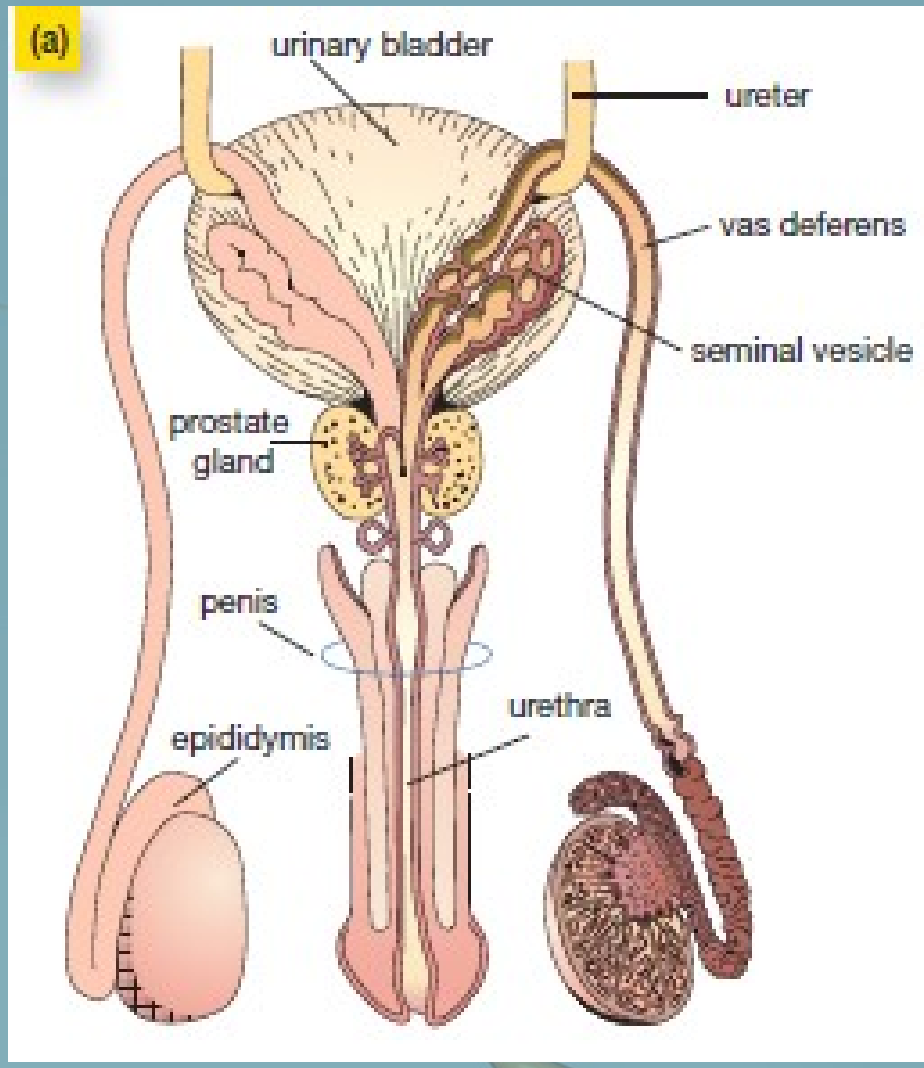

# Gamete Formation

- The production of the gametes is under the control of hormones released from the anterior pituitary gland in the brain.
- The two hormones involved in gamete formation include follicle stimulating hormone (FSH) and luteinising hormone (LH).



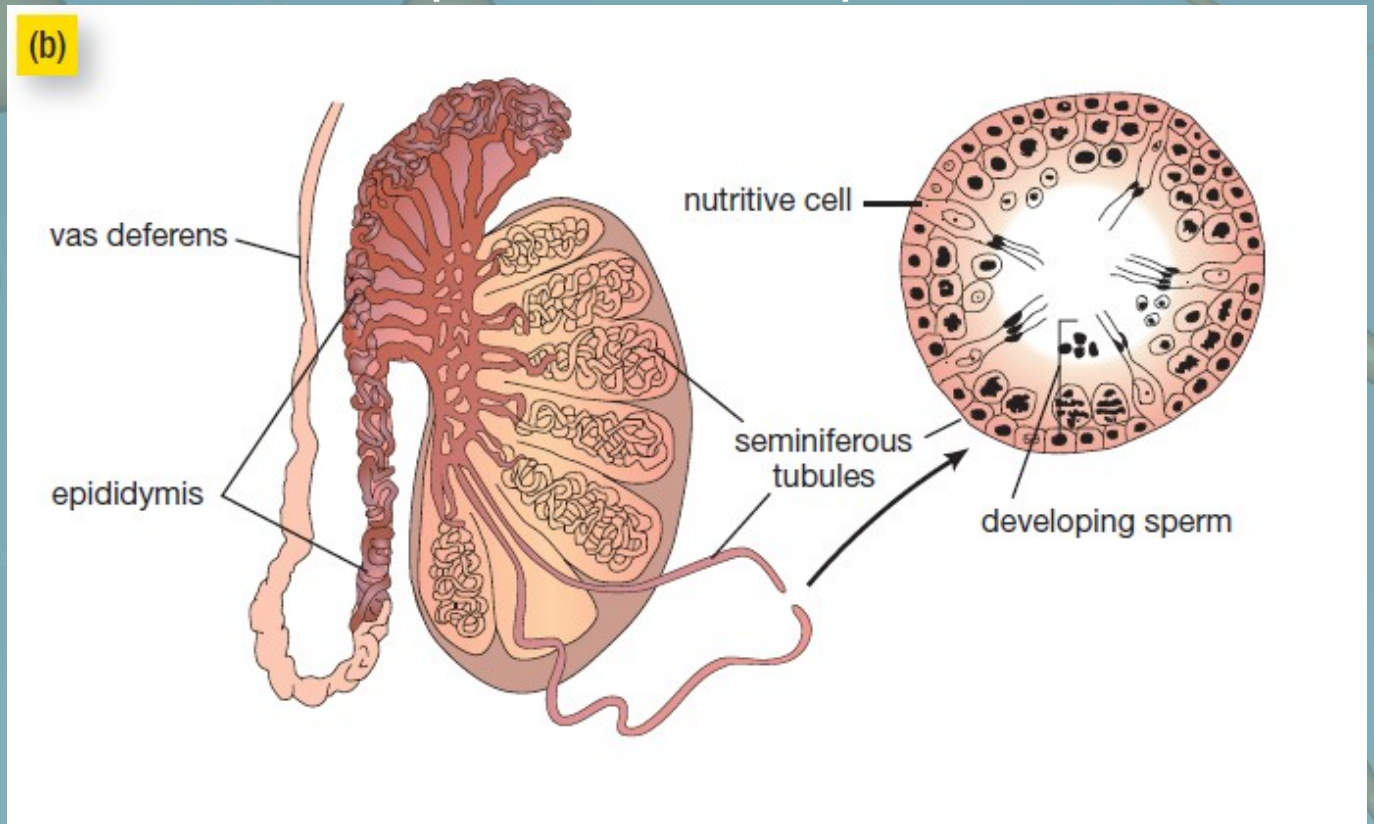
# The Male Reproductive System

- Consists of paired testes which continuously produce sperm (in many organisms); paired accessory glands which produce secretions that make up 95% of the volume of the semen; and a system of ducts leading to the urethra.
- LH simulates the release of testosterone by the testes.
- FSH acts on the testes to stimulate sperm production (spermatogenesis).



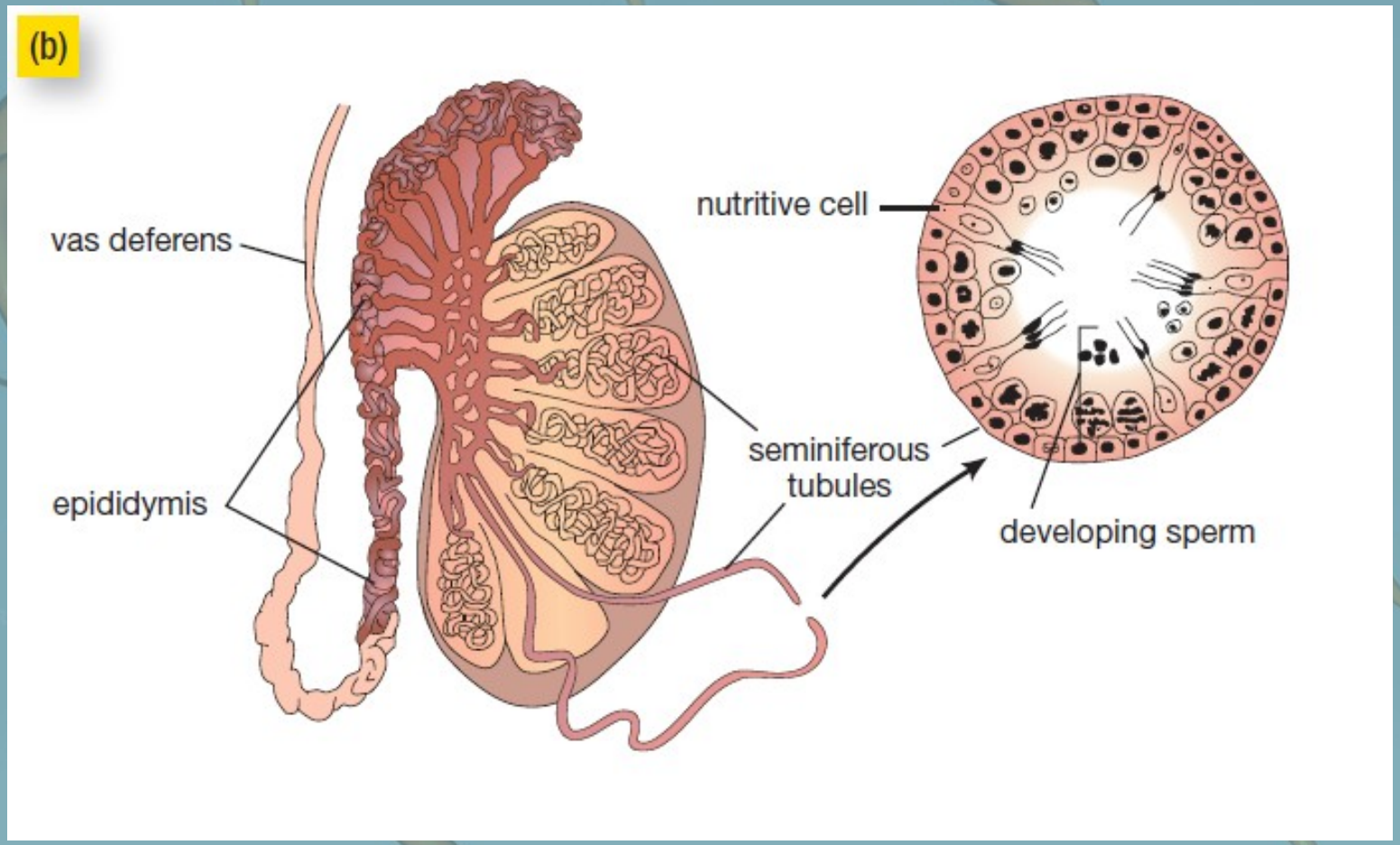
# The Testes

- The testes are composed of many tubules.
- Lining the outer region of these tubules are sperm **precursor cells**.
- Mitotic divisions of these cells produce **spermatocytes** each of which divides to produce four sperm cells.



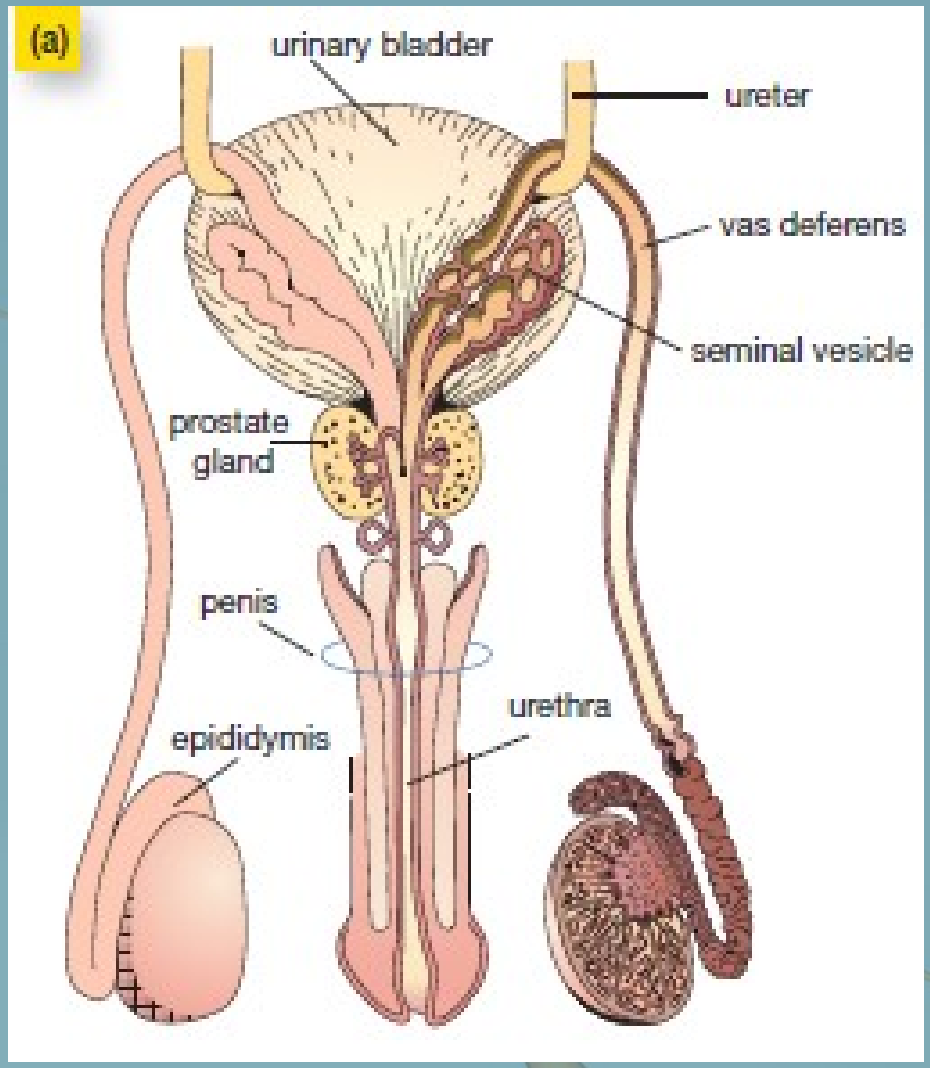
# The Male Reproductive System

- From the testes the sperm pass into the epididymis. Here the sperm complete maturation and are stored for up to 6 weeks.



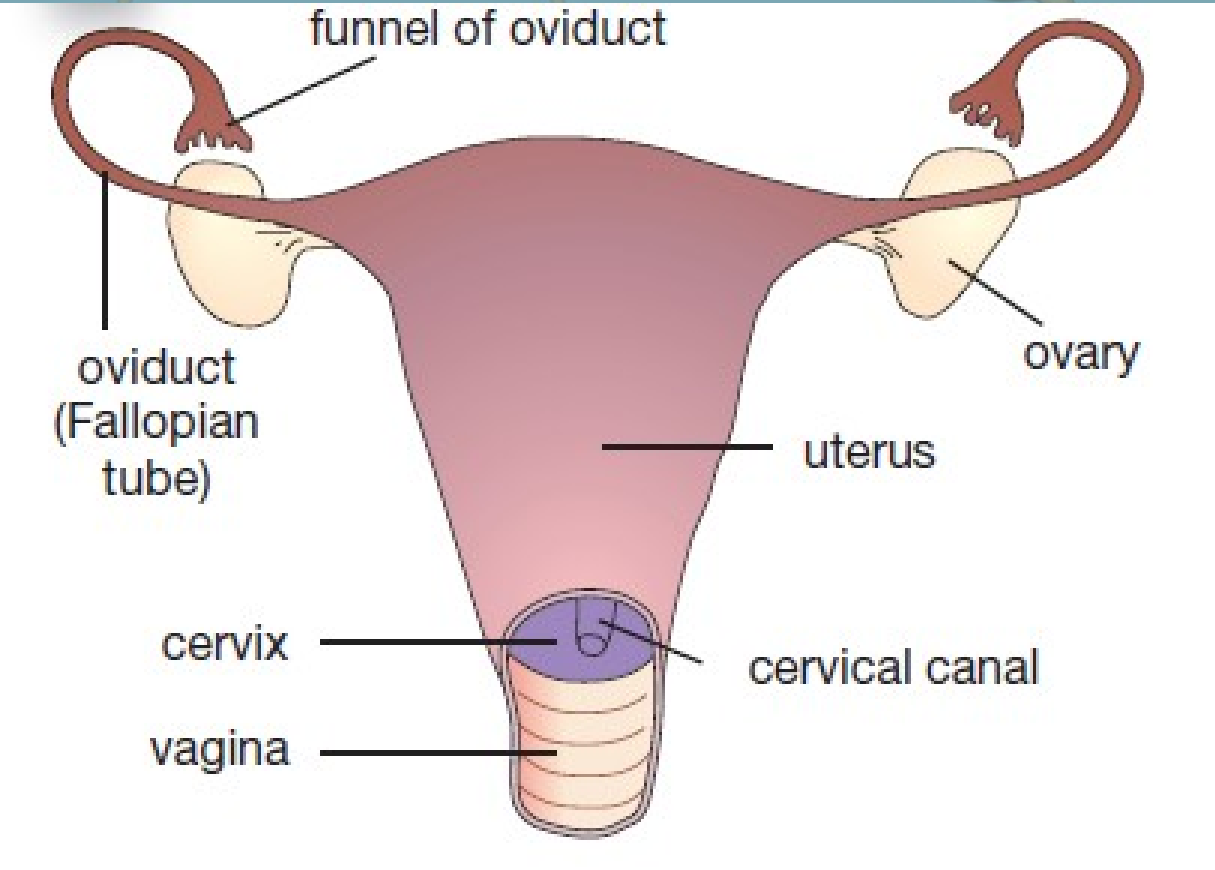
# The Male Reproductive System

- During mating contractions of the vas deferens move sperm towards the urethra.
- On the journey secretions of the accessory glands are added forming seminal fluid.
- This fluid causes the sperm to become motile and provides them with nutrition.



# The Female Reproductive System

- The female reproductive system consists of the ovaries which give rise to egg cells, the fallopian tubes, the uterus, the cervix and the vagina.

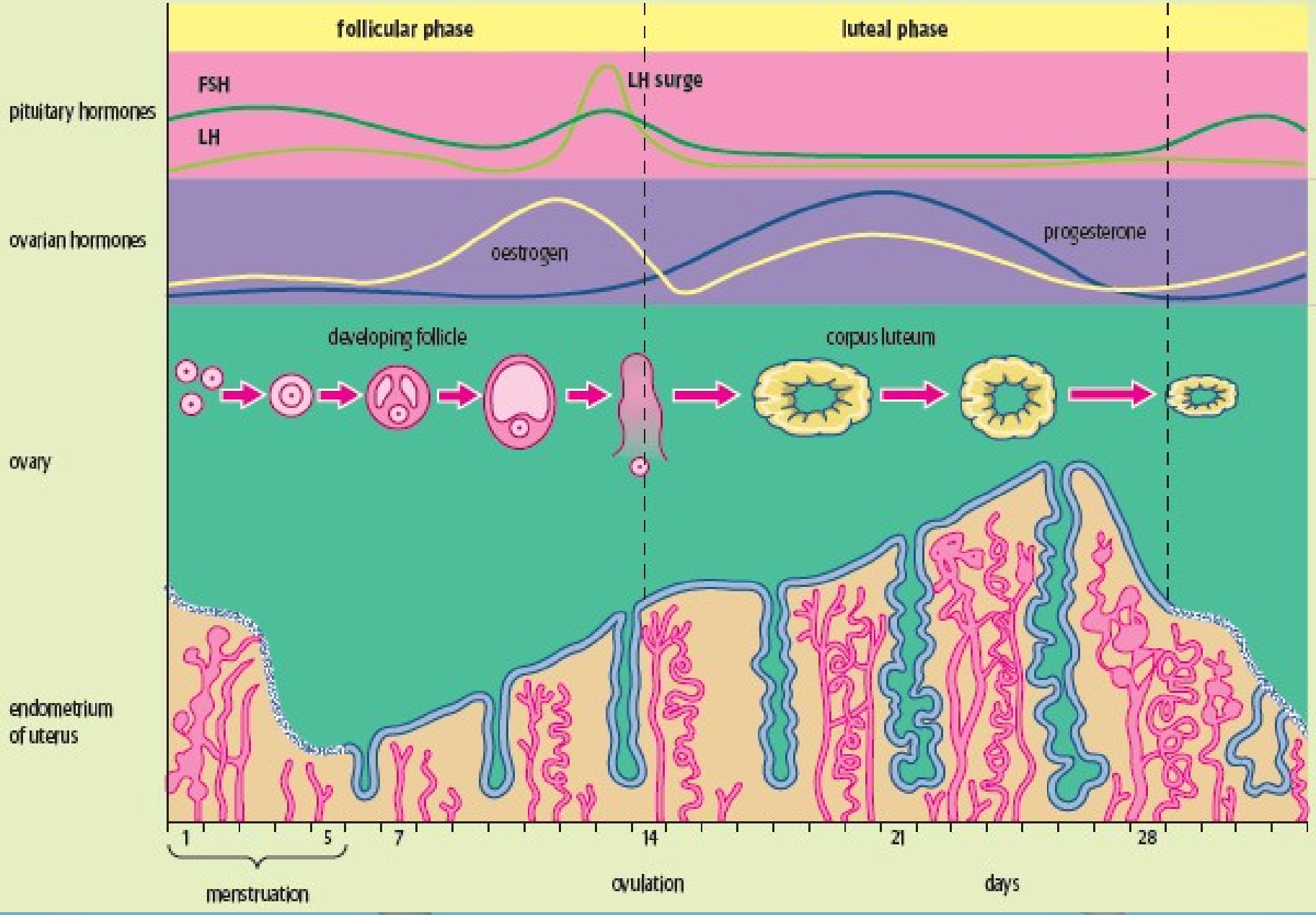


# The Female Reproductive System

- Before birth meiosis of the oocytes (the germ cells of the ovaries) begins. This division is stopped. However a female is born with her ovaries already possessing all of her potential eggs cells.
- Once maturity is reached the ovarian cycle commences and further development of the eggs begins.
- FSH will influence one of the oocytes to resume meiotic division.
- This will occur within a group of cells called a follicle. Only one of the cells within the follicle will form an egg cell.

# The Female Reproductive System

- A developing follicle will release **oestrogen** which causes the lining of the uterus (the endometrium) to become thicker, softer and develop a rich supply of blood vessels ready to receive a fertilised egg.
- LH triggers **ovulation** which is the release of the egg from the follicle. The egg is transported by fluid currents to the fallopian tube (oviducts) which further contract to move the egg to the uterus. In primates usually only one egg is released. In most other mammals a number of eggs are released with each ovulation.
- The follicle left behind after fertilisation is known as the **corpus luteum**. Stimulated by the presence of LH the corpus luteum secretes large amounts of oestrogen and progesterone. These hormones further thicken the lining of the uterus.


follicular phase
luteal phase
pituitary hormones
FSH
LH
LH surge
ovarian hormones
oestrogen
progesterone
developing follicle
corpus luteum
ovary
endometrium of uterus
1
5
7
14
21
28
menstruation
ovulation
days

# The Female Reproductive System

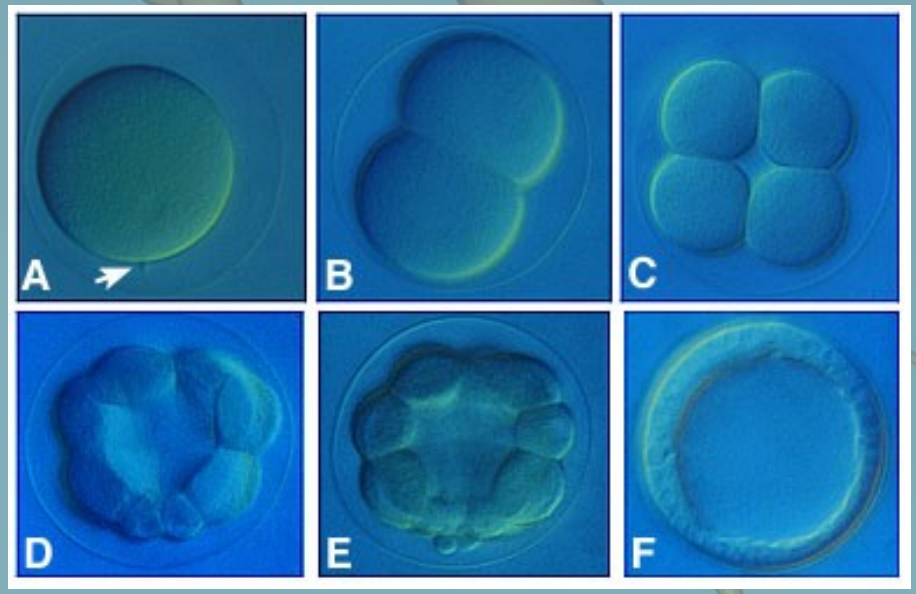
- An unfertilised egg will simply pass through the reproductive system. The corpus luteum breaks down and stops releasing hormones causing the disintegration of the lining of the uterus.
- The lining of the uterus is released during menstruation (period) and marks the being of a new ovarian cycle.

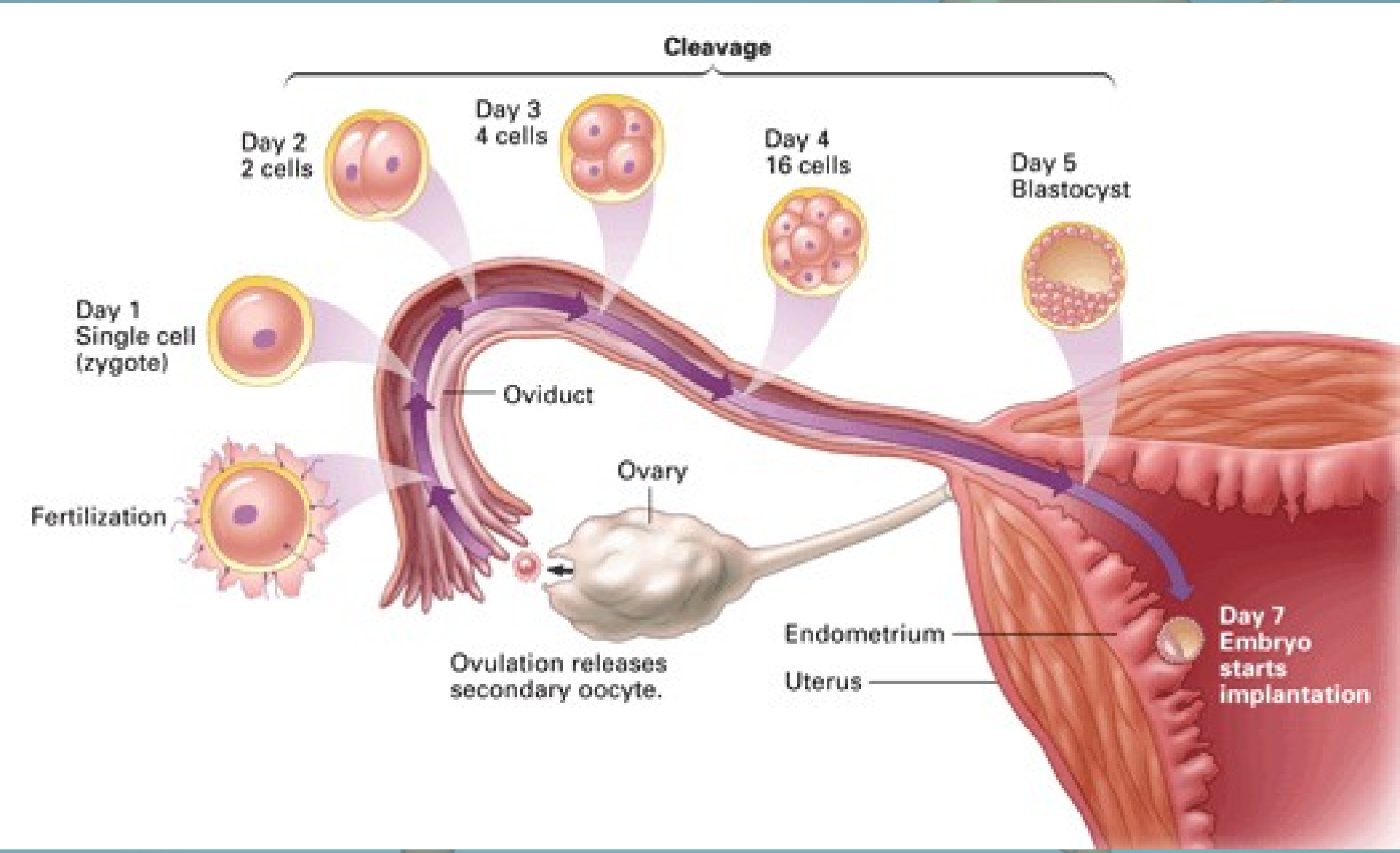
# Fertilisation

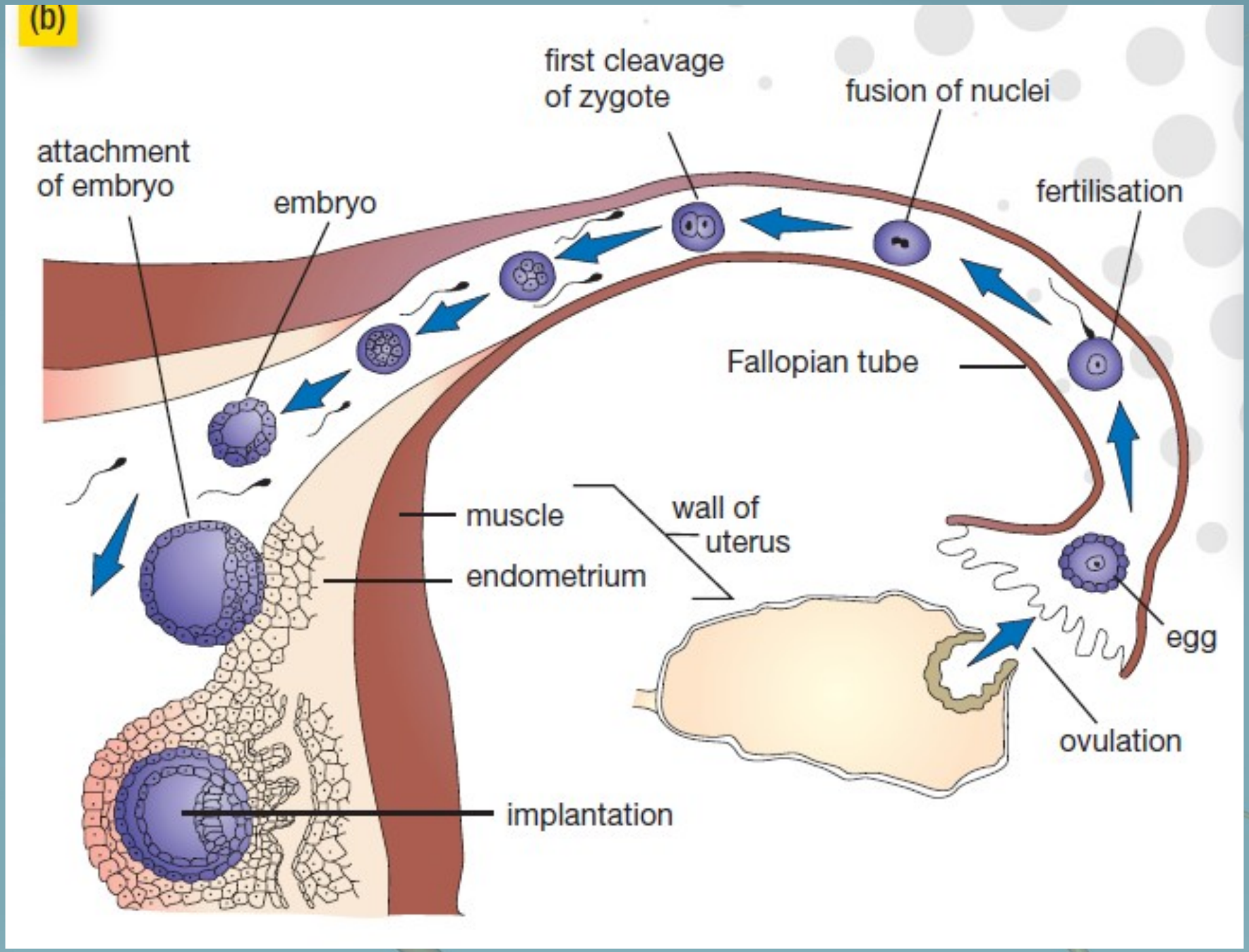
- **Fertilisation** is the fusion of two gametes to form a zygote.
- In mammals it occurs internally in the **oviduct** (in humans, the **fallopian tube**).
- Involves three events:
  1. Recognition and penetration of the egg by the sperm
  2. Activation of the egg cell which initiates development
  3. Fusion of the egg and sperm nuclei

# Fertilisation

- The result of these three processes is a **zygote-** the beginning of a new individual.
- A zygote is the size of the egg cell which is a very large cell. The first step after fertilisation is **cleavage**.
- **Cleavage** is a period of cell division in which the egg cell is divided into many hundreds of smaller cells. This occurs as the embryo passes down the fallopian tube into the uterus.

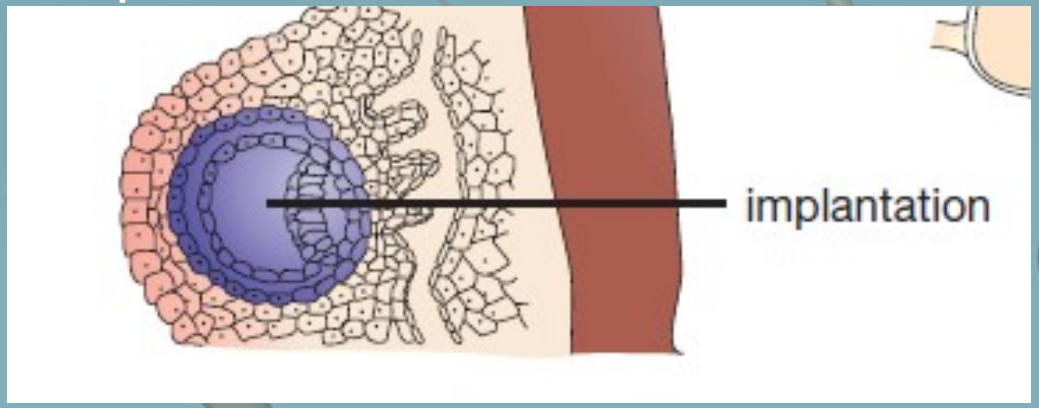




Cleavage
Day 2
2 cells
Day 3
4 cells
Day 4
16 cells
Day 5
Blastocyst
Day 1
Single cell
(zygote)
Oviduct
Ovary
Fertilization
Ovulation releases
secondary oocyte.
Endometrium
Uterus
Day 7
Embryo
starts
implantation


(b)
first cleavage of zygote
fusion of nuclei
attachment of embryo
embryo
fertilisation
Fallopian tube
muscle
wall of uterus
endometrium
egg
ovulation
implantation

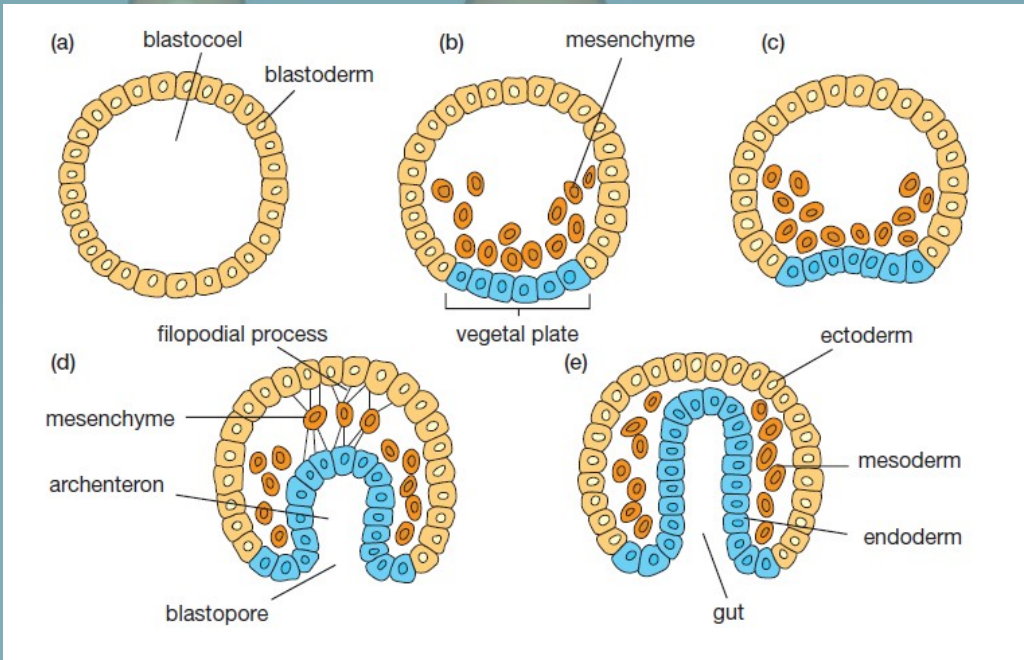
# Implantation

- When the embryo reaches the uterus it is known as a **blastocyst**.
- The blastocyst adheres to the lining of the uterus and **implantation** follows.
- The **placenta** forms when finger-like projections of the embryonic cells become embedded into the uterus.
- The placenta has various functions including to exchange nutrients and wastes between maternal and embryonic blood and to produce hormones.



# Development of the Embryo and Fetus

- The genetic information within each cell plays a vital role in the development of an individual from the blastocyst.
- Under instruction from the DNA the nuclei begin to produce new proteins. The embryo forms a hollow structure with three layers: the ectoderm (outer), the mesoderm (middle) and the endoderm (inner).



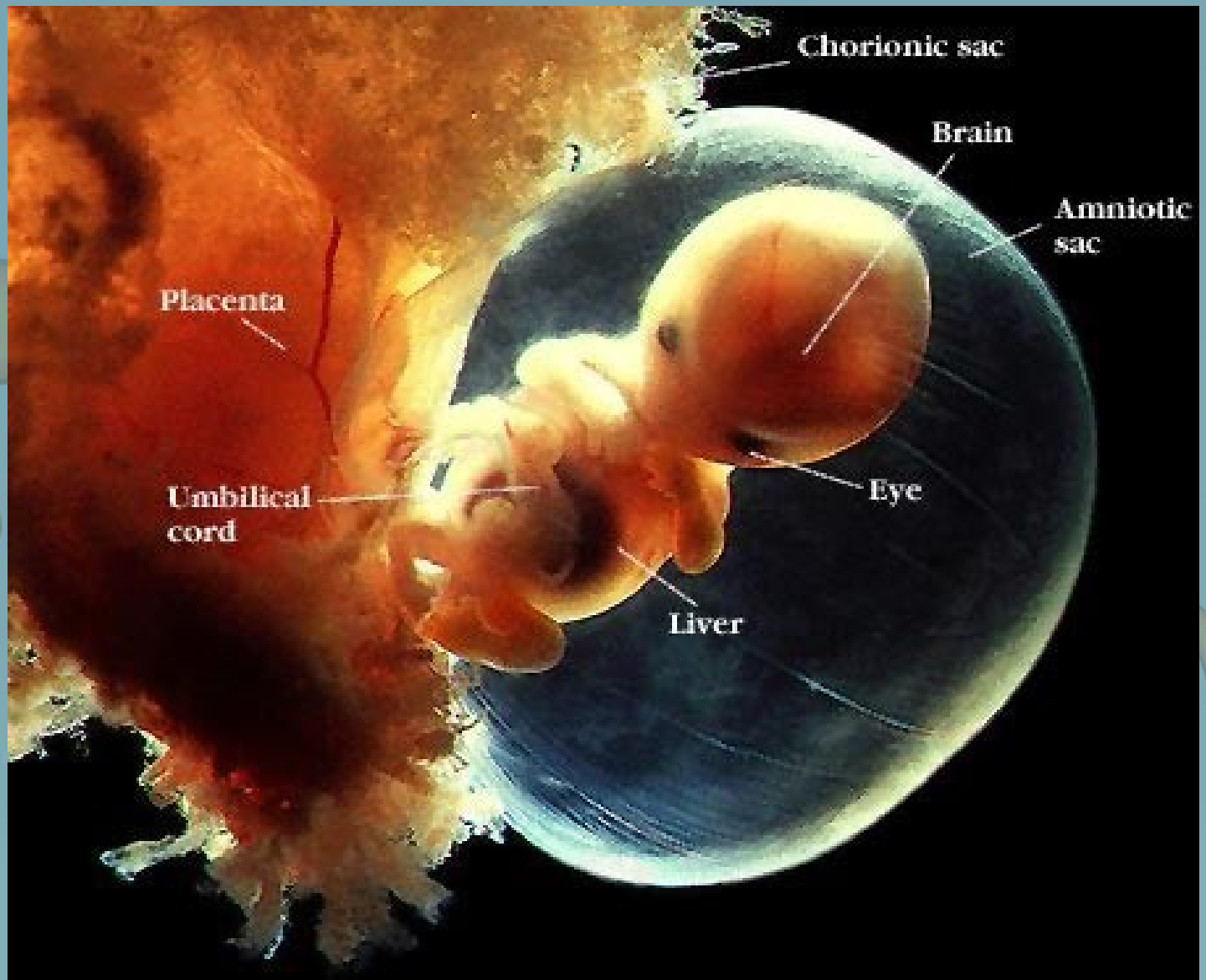
# Development of the Embryo and Fetus

- The **ectoderm** will form the skin cells and cells of the nervous system
- The **endoderm** will form gut tissue
- The **mesoderm** will produce bone and muscle tissue as well as the circulatory, excretory and reproductive systems.
- As development of these cells continues tiny organs appear. The brain will develop first followed by the circulatory system, the limbs, skin, bone and muscle tissue. Cells further differentiate and grow in size.

# Development of the Embryo and Fetus

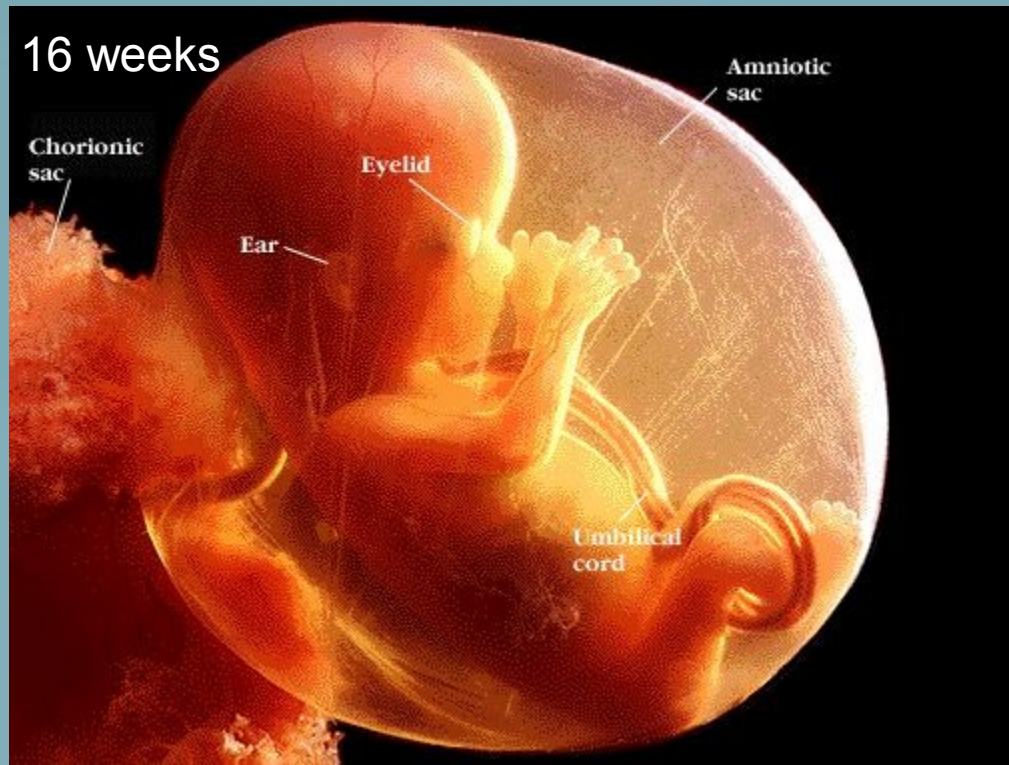
- The embryonic stages ends eight weeks after fertilisation. The organism is known as a fetus and is distinctly human.
- For the rest of gestation the organs continue to develop and tissue becomes more specialised. Muscle cells will be able to contract, red blood cells carry oxygen through the circulatory system, connective tissue forms bone.

# 8 Weeks Old


Chorionic sac
Brain
Amniotic sac
Placenta
Umbilical cord
Eye
Liver

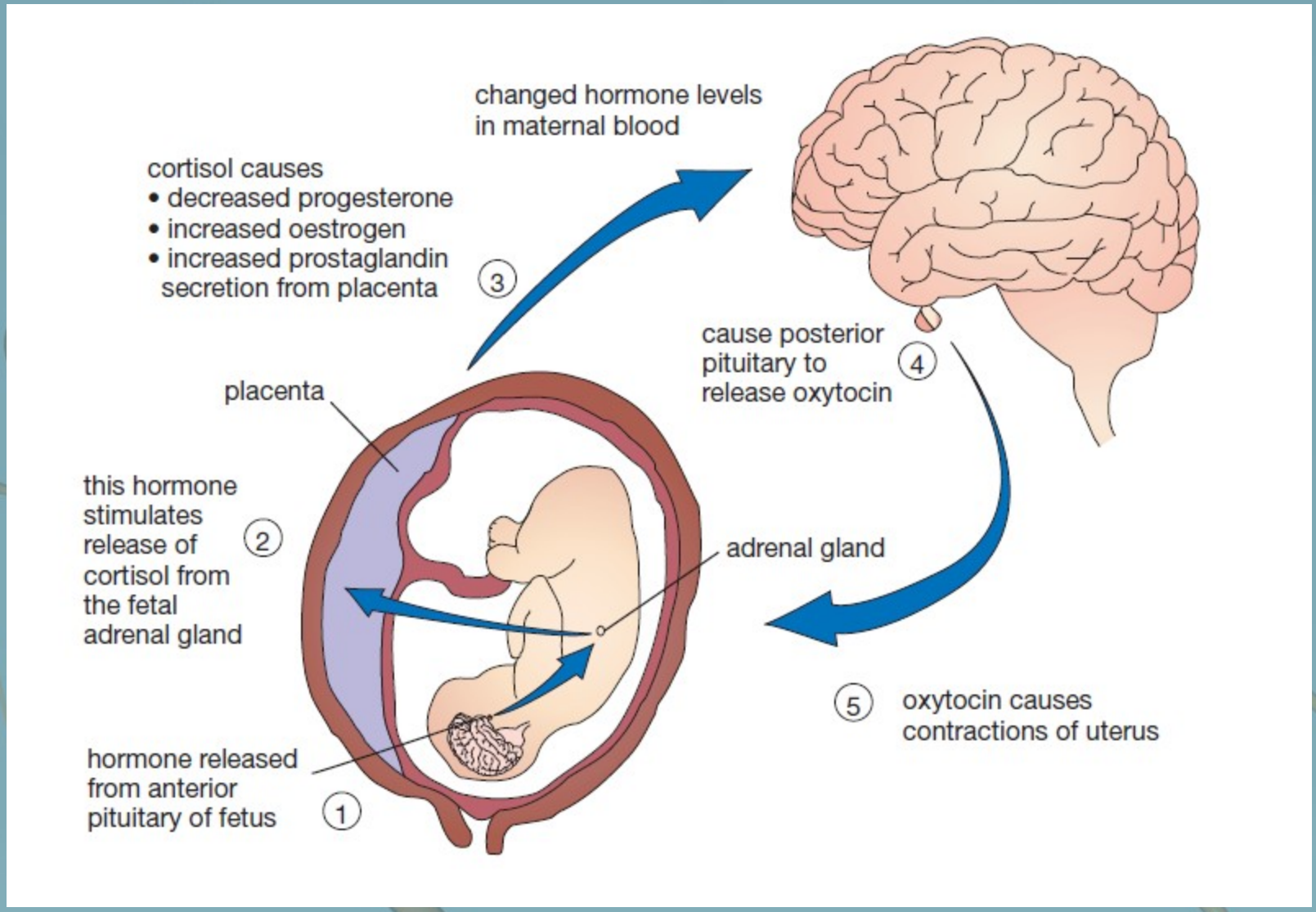
# Development of the Embryo and Fetus

- The developing fetus is surrounded by a fluid. This fluid is known as amniotic fluid and serves to protect the fetus and allow the fetus to move around.
- The fetus is nourished by exchange of materials across the placenta.



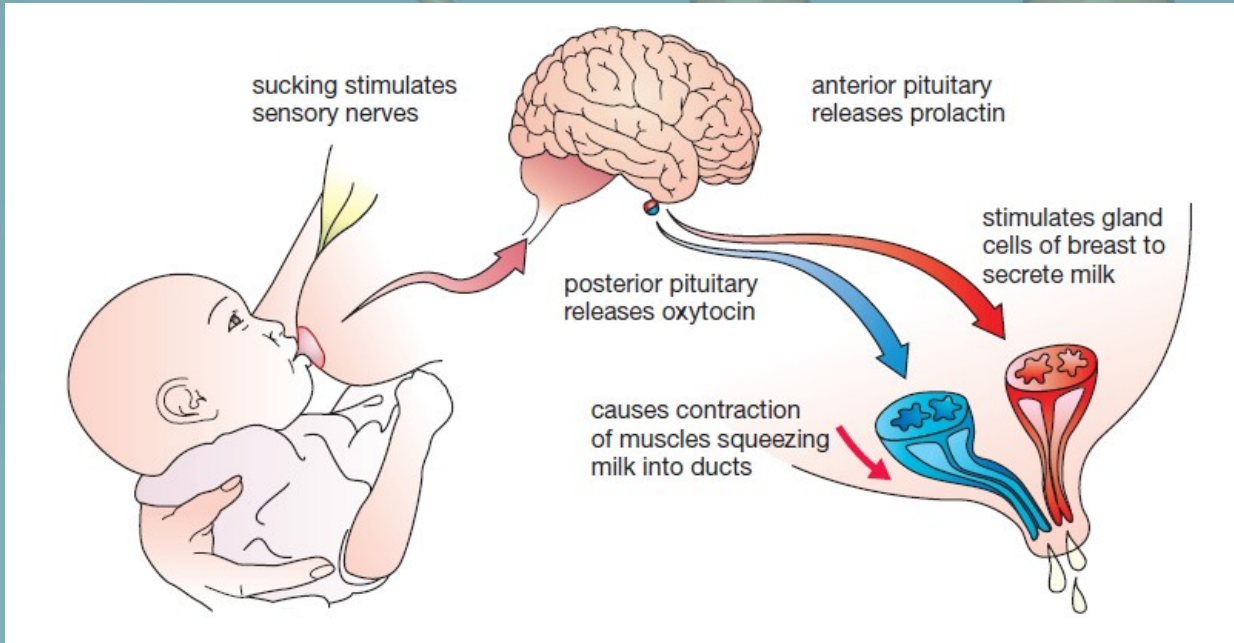
# Birth

- **Birth**, or **parturition**, is under the control of hormones.



# Lactation

- During pregnancy the breasts enlarge and develop in preparation for lactation.
- At birth the hormone prolactin is released from the anterior pituitary gland stimulating the production of milk.
- Suckling of the baby causes the release of oxytocin from the posterior pituitary gland which simulates contraction of breast muscle releasing this milk.



# Growth

- A new born human, a neonate, is born completely dependent on adults. Most of their movements are reflexes.
- Many systems continue to develop after birth although at a much slower rate.