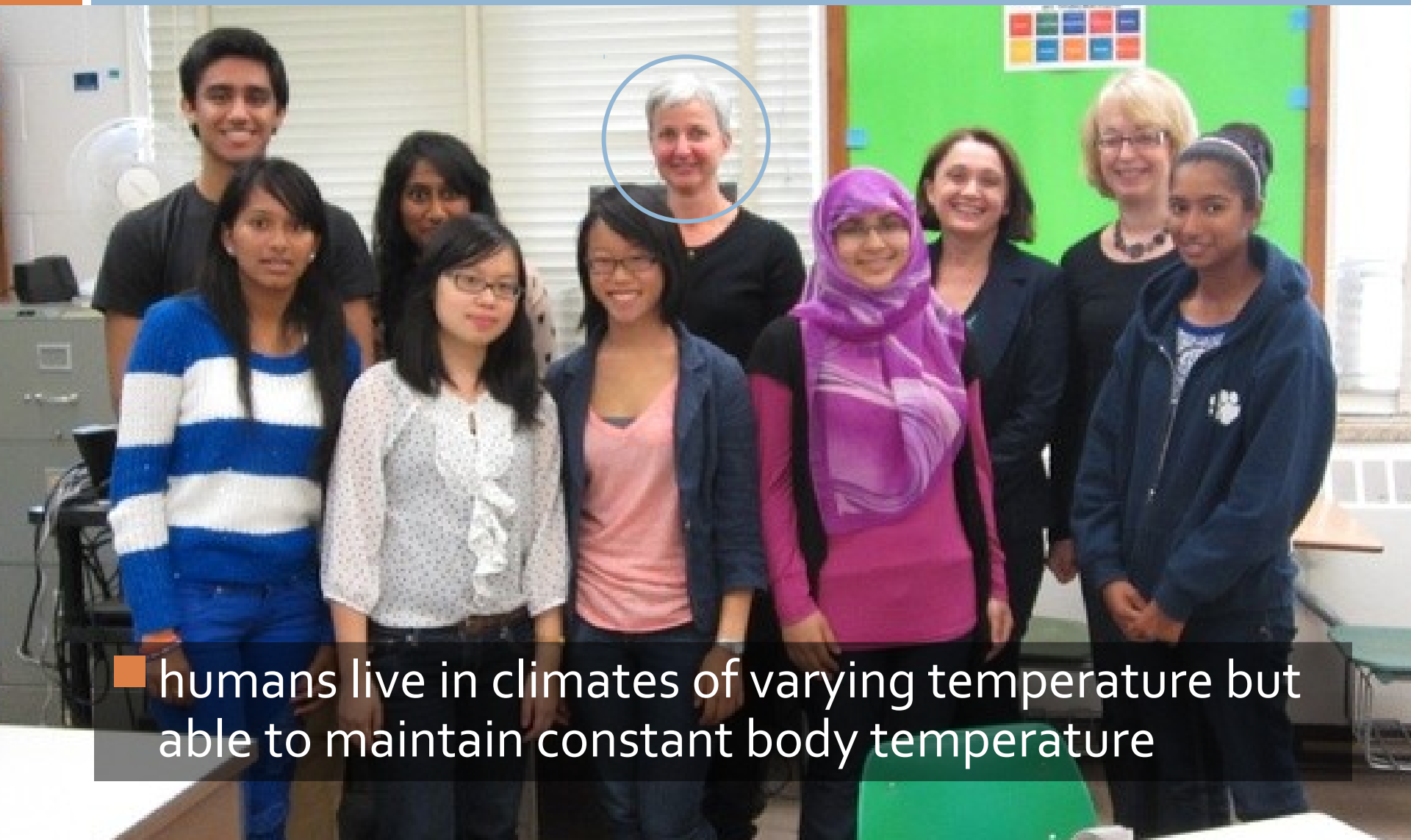
Thermoregulation

Thermogulator Adaptations

Thermoregulation

- Regulation of internal body temperature
- Maintenance of body temperature within an acceptable range

Example of Thermoregulator



- humans live in climates of varying temperature but able to maintain constant body temperature

Cold & Warm blooded

- Why are the terms for classifying organisms into cold-blooded and warm-blooded inaccurate?
- What are the correct terms?
- What is the advantage of being able to regulate body temperature?
- What is the disadvantage of regulating body temperature?

Thermoregulation

	Ectotherm	Endotherm
Metabolic rate	Low	High
Heat generation	Too little to warm body	Enough to keep body warm
Internal body temperature	Determined by environment	Stable, regardless of external fluctuations
Example organisms	fish, reptiles, amphibians	mammals, birds

Advantage of Thermoregulation

1. High levels of aerobic metabolism
   - Perform vigorous activity for longer periods
   - E.g. flight
2. Enable terrestrial living
   - Extreme temperature fluctuation on land (opposed to aquatic)

Disadvantage of Thermoregulation

1. Energetically expensive
   - Example: at rest, body temperature 20^{0}C
   - humans: 1300-1800 kcal/day
   - alligator: 60kcal/day
1. Need to consume more food

Methods of Thermoregulation

- Adaptations:
  - Physical adaptations
  - Behavioral adapations
  - Circulatory adaptation
- Physiological changes:
  - Rate of heat exchange
  - Evaporative heat loss (cooling)
  - Rate of heat production
  - Rate of metabolic heat production

Physical Adaptations

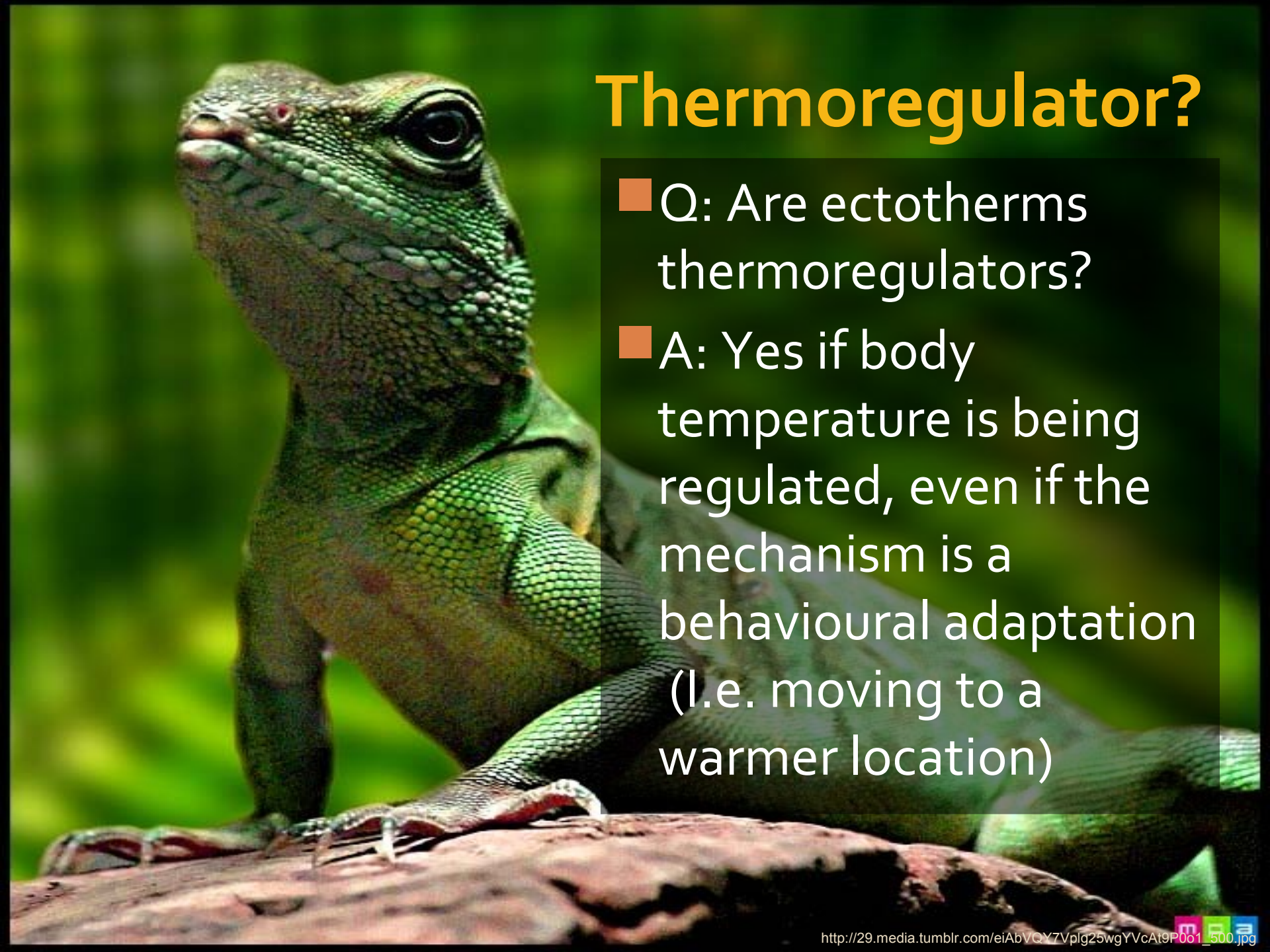
- Insulation
  - hair, fur, feathers
  - fat located just beneath th

Behavioral Adaptations

- Gross Movement
- Huddling:
  - decrease surface area & heat loss
- Re-locating:
  - Finding shaded areas
  - Basking in sun
  - Migration

Marine Iguana (*Amblyrhynchus cristatus*). Basking in the sun.

http://life-sea.blogspot.ca/2011/08/life-of-marine-iguana.html



Thermoregulator?

- Q: Are ectotherms thermoregulators?
- A: Yes if body temperature is being regulated, even if the mechanism is a behavioural adaptation (I.e. moving to a warmer location)

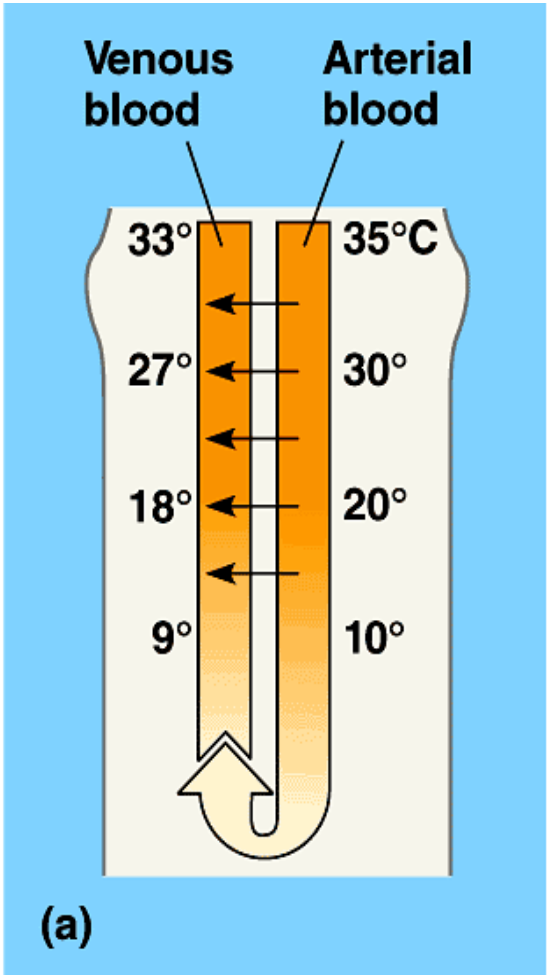
http://29.media.tumblr.com/eiAbVQY7Vplg25wgYVcAt9P0o1_500.jpg

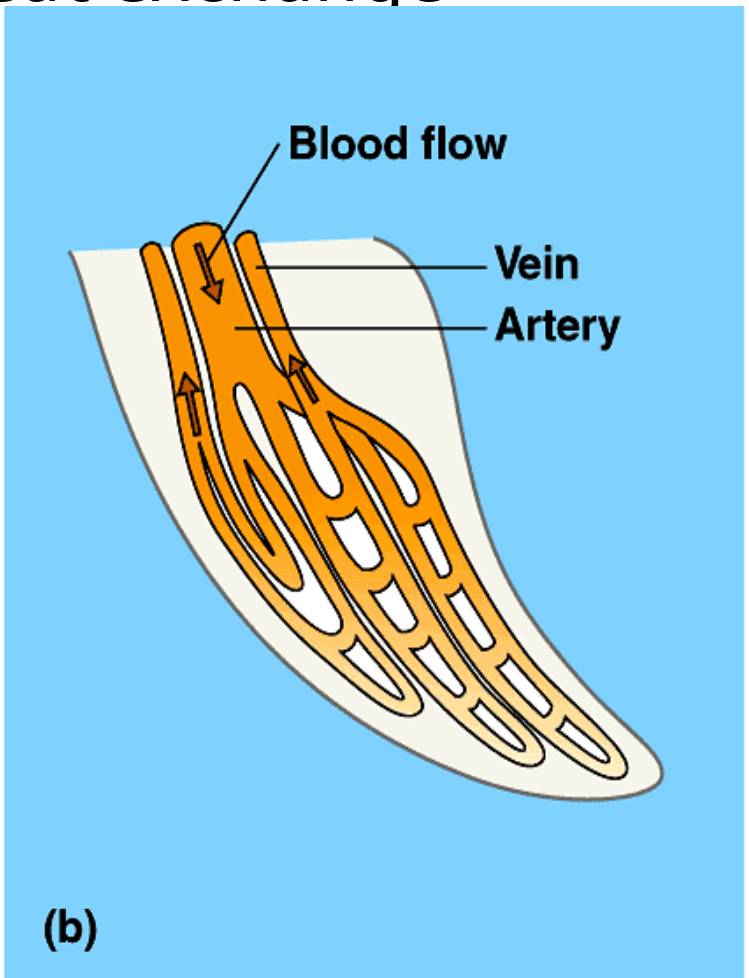
Behavioural Adaptations

- Torpor: state of low metabolic activity
  - Applied during environmental extremes
  - Conserves energy
- Hibernation: long-term torpor
  - Survive long periods of cold temperatures on limited supplies of energy
  - Body temperature declines
- Estivation: summer torpor
  - Survive long periods of high temperatures or when water is scarce
  - Example: Lung Fish (http://www.youtube.com/watch?v=ZUsARF-CBcI)

Circulatory Adaptation

- Counter current heat exchange





(Fig. 44.5)

Countercurrent Heat Exchange

- Arteries carrying warm blood in limbs (and wings) are in close contact with veins conveying cool blood back toward the trunk
- Venus blood approaching torso will be almost as warm as the body core

Methods of Thermoregulation

- Adaptations:
  - Physical adaptations
  - Behavioral adaptations
  - Circulatory adaptations
- Physiological changes:
  - Rate of heat exchange
  - Evaporative heat loss (cooling)
  - Rate of heat production
  - Rate of metabolic heat production

Rate of Heat Exchange

- Regulated by blood vessel size
  - Vasoconstriction
  - Vasodilation

Rate of Heat Exchange

- Vasoconstriction
  - Decrease superficial blood vessel diameter
  - Decrease blood flow to surface, cooling skin
  - Reduce heat loss from body
- Vasodilation
  - Increase in diameter of blood vessels near body surface
  - Increase blood flow to surface, warming skin
  - Transfers body heat to environment

Extreme Cold

- Why does your body allow you to get frost bite?
- What happens to body temperature with hypothermia? Why is hypothermia such a concern but frost bites aren't?

Cryopreservation

- Suspending life due to freezing
  - frozen cytosol can expand to break the cell membrane
  - Need to dehydrate cells before freezing
- Only certain cell types can be cryopreserved
  - Semen
  - Blood (special cells for transfusion, or stem cells)
  - Tissue samples like tumors and histological cross sections
  - Human eggs
  - Human embryos that are 2, 4 or 8 cells

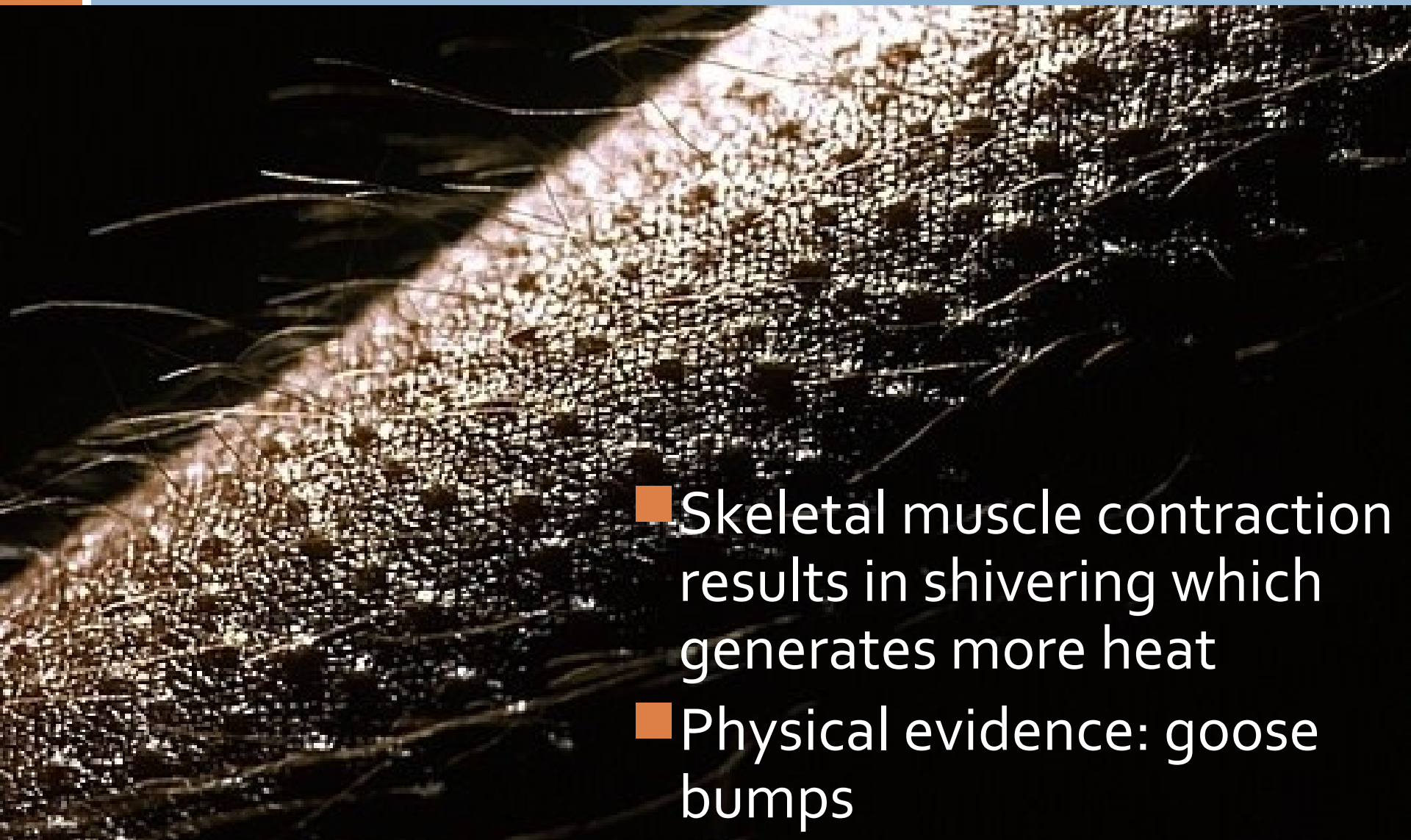
Frozen Wood Frogs

- Kenneth B. Storey – Carleton University
- Video: http://www.youtube.com/watch?v=UvCdOXG2rPo (1:56)

Evaporative Heat Loss (cooling)

- Water absorbs heat when it evaporate
- Sweating evaporates water across skin thus removing heat from body

Rate of Heat Production



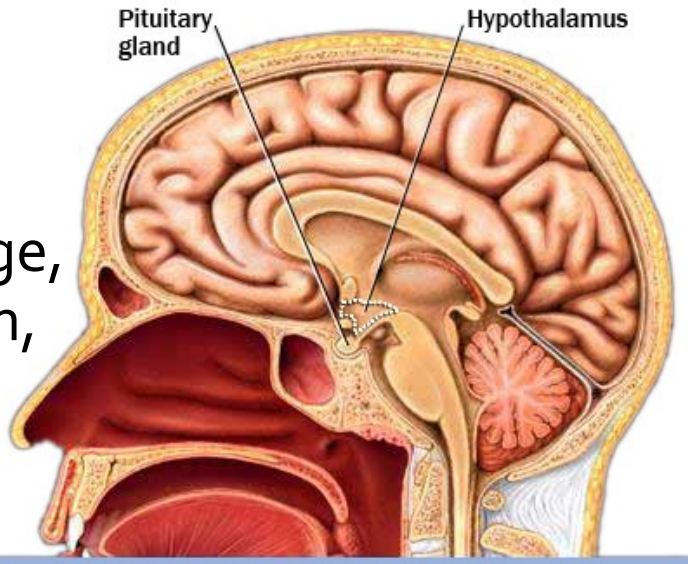
- Skeletal muscle contraction results in shivering which generates more heat
- Physical evidence: goose bumps

Rate of Metabolic Heat Production

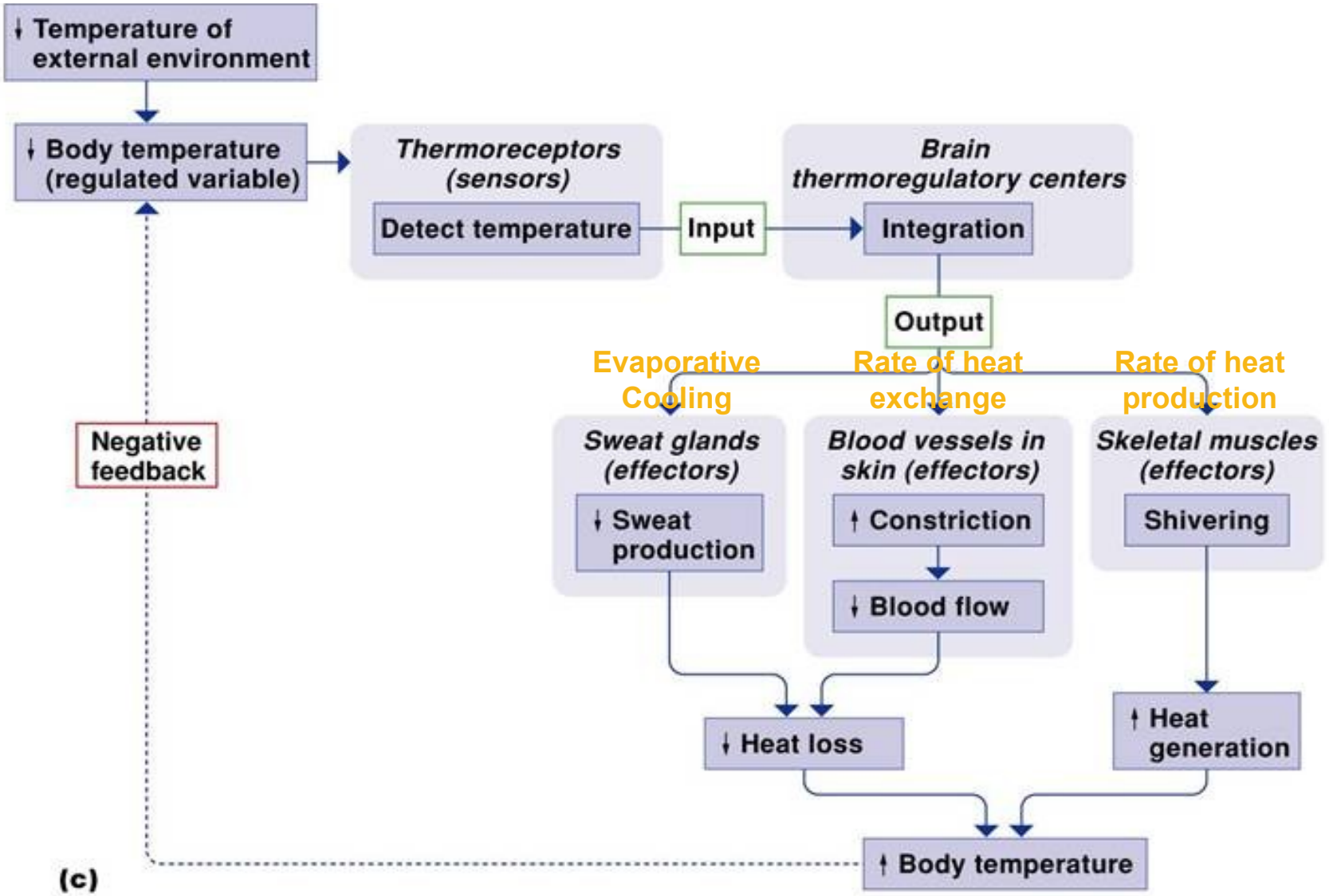
- Hormones can cause mitochondria to increase metabolic activity to produce heat instead of ATP
- Brown adipose (fat) tissue metabolism
  - Fat cells have high concentration of mitochondria to generate heat
  - newborns have many of these cells; don't shiver
- Applies only to endotherms

Brain: The body's thermostat

- Sensory receptor (input):
  - Thermoreceptors on skin sense temperature
- Integration: hypothalamus
  - Contains neurons that respond to changes in body temperature above and below the normal range
- Effector (output):
  - Behavioural changes
  - Physiological changes (heat exchange, evaporative cooling, heat production, metabolic rate)



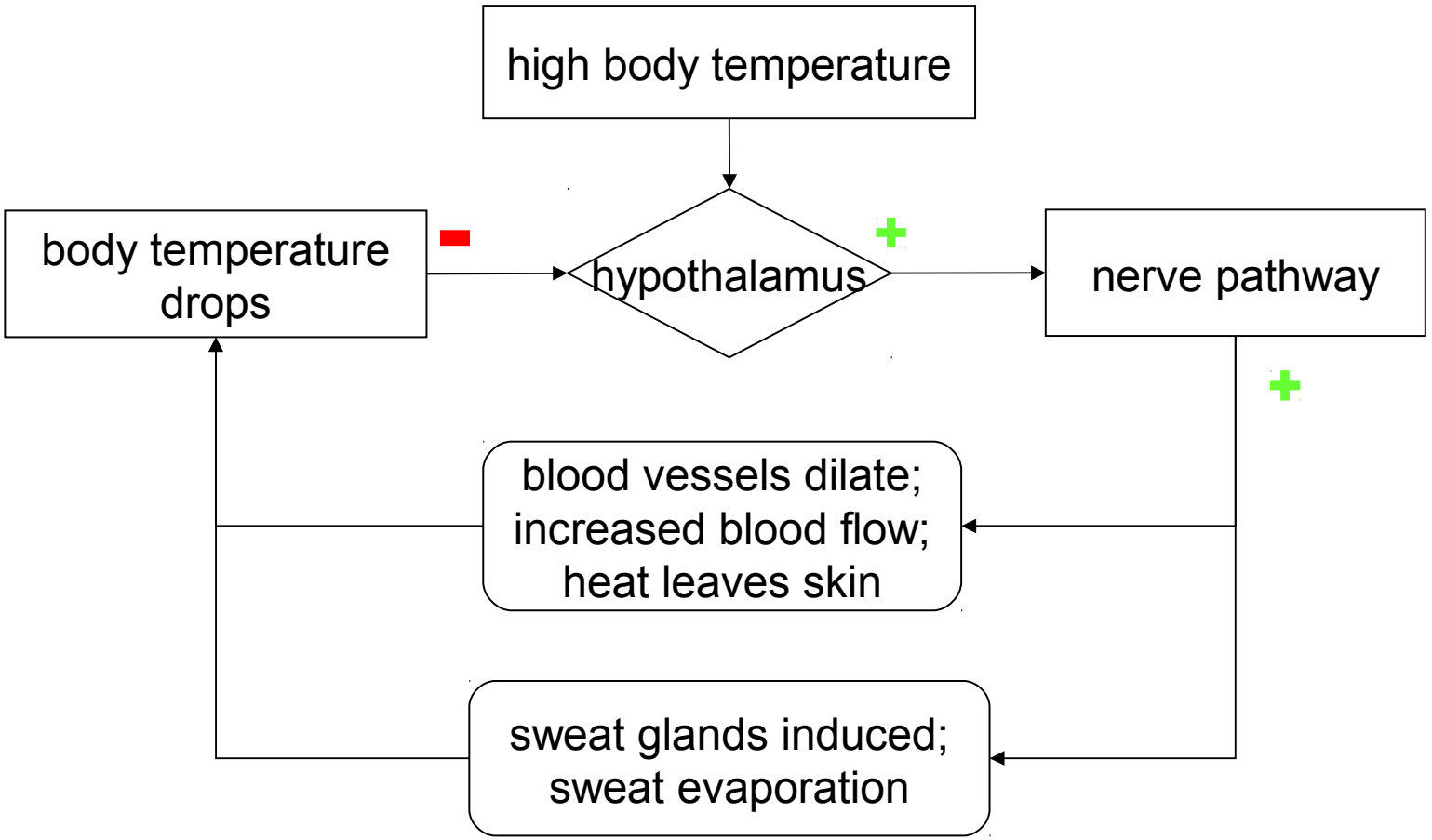
Cold Response: Physiological Changes



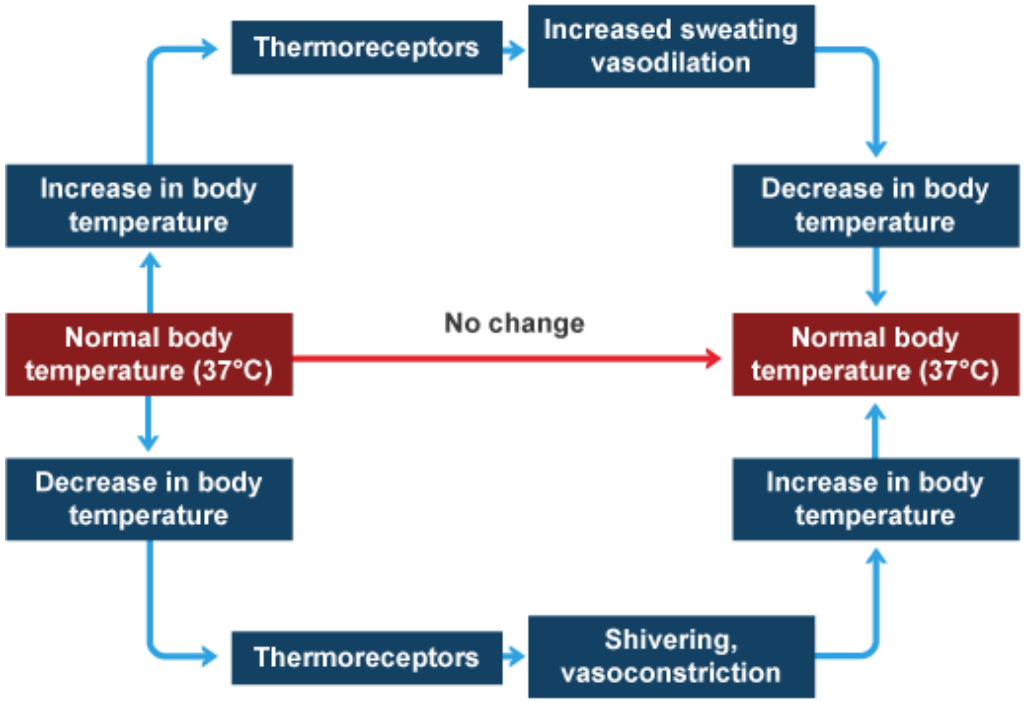
Cold Response: Physiological Changes

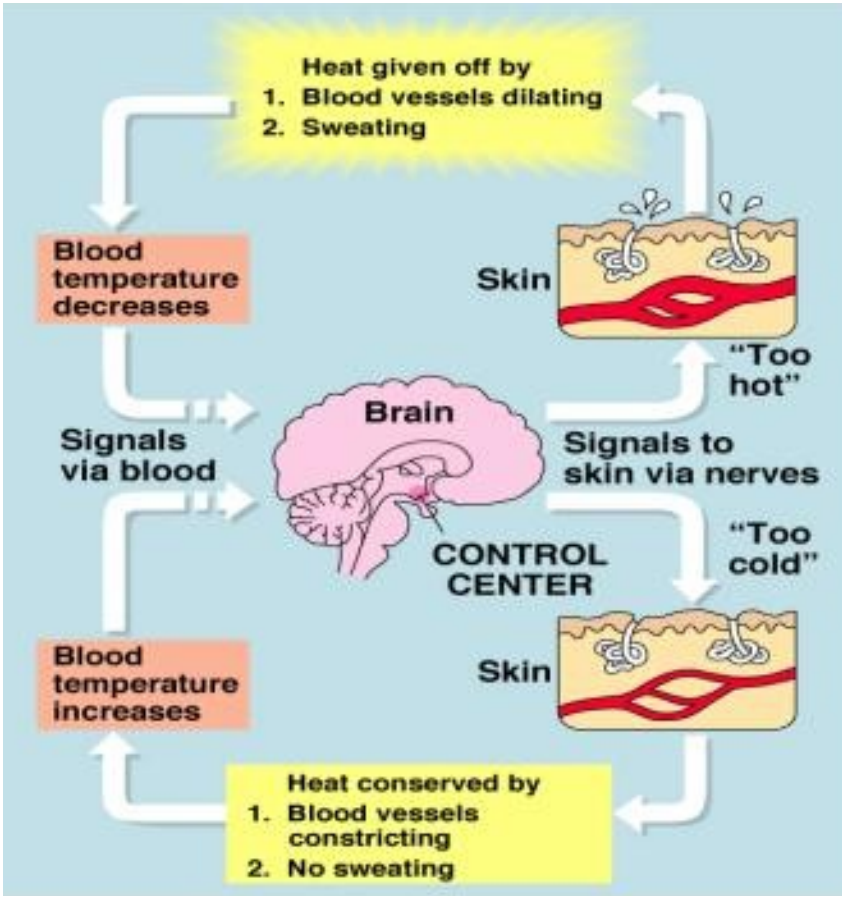
- Rate of heat exchange decreases:
  - Vasoconstriction of blood vessels near skin
  - less blood to skin = less heat loss
  - Blood redirected to torso (organs)
- Rate of heat production increases:
  - muscles contract
  - shivering generates heat
- Rate of metabolic heat production increases:
  - brown adipose (fat) tissue metabolism

Heat Stress Response: Physiological Changes



Physiological Thermoregulatory Response





http://www.bbc.co.uk/bitesize/intermediate2/biology/images/200/113_bitesize_intermediate2_biology_subunit5_metabolic_rate.png

http://bioserv.fiu.edu/~walterm/B/homeostasis/lectur33.jpg

Physiological Thermoregulatory Response Summary

Stimulus	Decrease temperature	Increase temperature
Blood vessels		
Skeletal muscles		
Sweat glands		

Physiological Thermoregulatory Response Summary

Stimulus	Decrease temperature	Increase temperature
Blood vessels	Vasoconstriction: decrease blood flow	Vasodilation: increase blood flow
Skeletal muscles	Shivering	
Sweat glands	Decrease production of sweat	Evaporative cooling: increase sweat

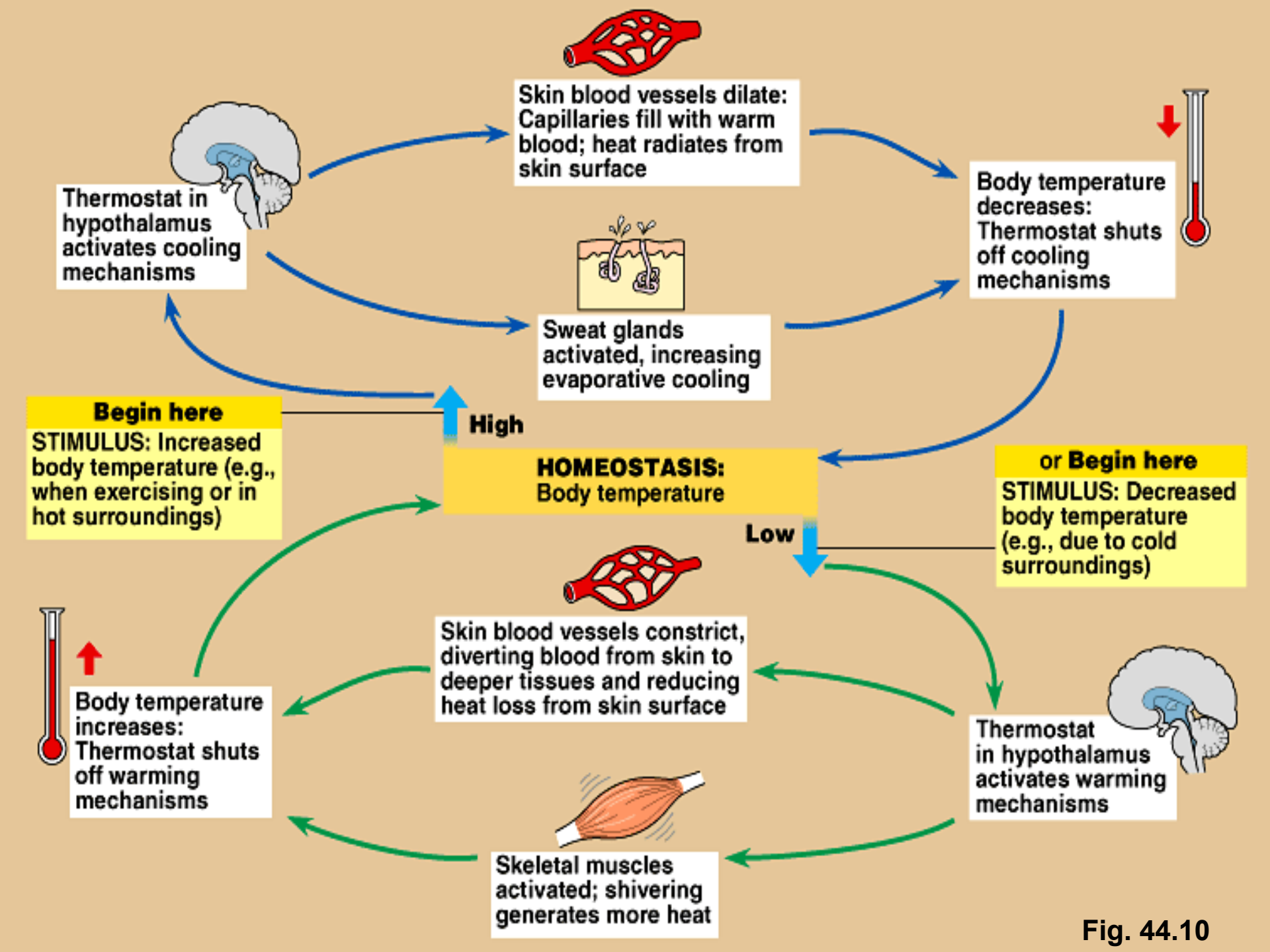

Skin blood vessels dilate: Capillaries fill with warm blood; heat radiates from skin surface
Thermostat in hypothalamus activates cooling mechanisms
Body temperature decreases: Thermostat shuts off cooling mechanisms
Sweat glands activated, increasing evaporative cooling
Begin here
STIMULUS: Increased body temperature (e.g., when exercising or in hot surroundings)
High
HOMEOSTASIS: Body temperature
or Begin here
STIMULUS: Decreased body temperature (e.g., due to cold surroundings)
Low
Skin blood vessels constrict, diverting blood from skin to deeper tissues and reducing heat loss from skin surface
Body temperature increases: Thermostat shuts off warming mechanisms
Thermostat in hypothalamus activates warming mechanisms
Skeletal muscles activated; shivering generates more heat

Fig. 44.10