Introduction to Living Organisms

Form and Function

Guiding Questions

- Why do we study living organisms?
- What is life?
- What are the properties of life?
- What functions maintain life?
- What functions maintain populations or species of living organisms?

Why do we study life?

- No one answer really... there are many reasons.
  - Reasons may include
- Simple Reasons- curiosity, aesthetics, wonder, awe, reflection
- More Complicated reasons- to better understand how we fit in this world and how our actions may effect the world around us.
- Practical Reasons- to make our life easier, more comfortable, safer etc

What is life?

- Life itself defies any one simple definition
- Instead we describe life but its properties and its functions.

What are the properties and functions of a living organism?

- Order.
- Growth and Development
- Sense and Respond
- Process Energy
- Regulate

- Order

Growth and Development

- Sense and Respond

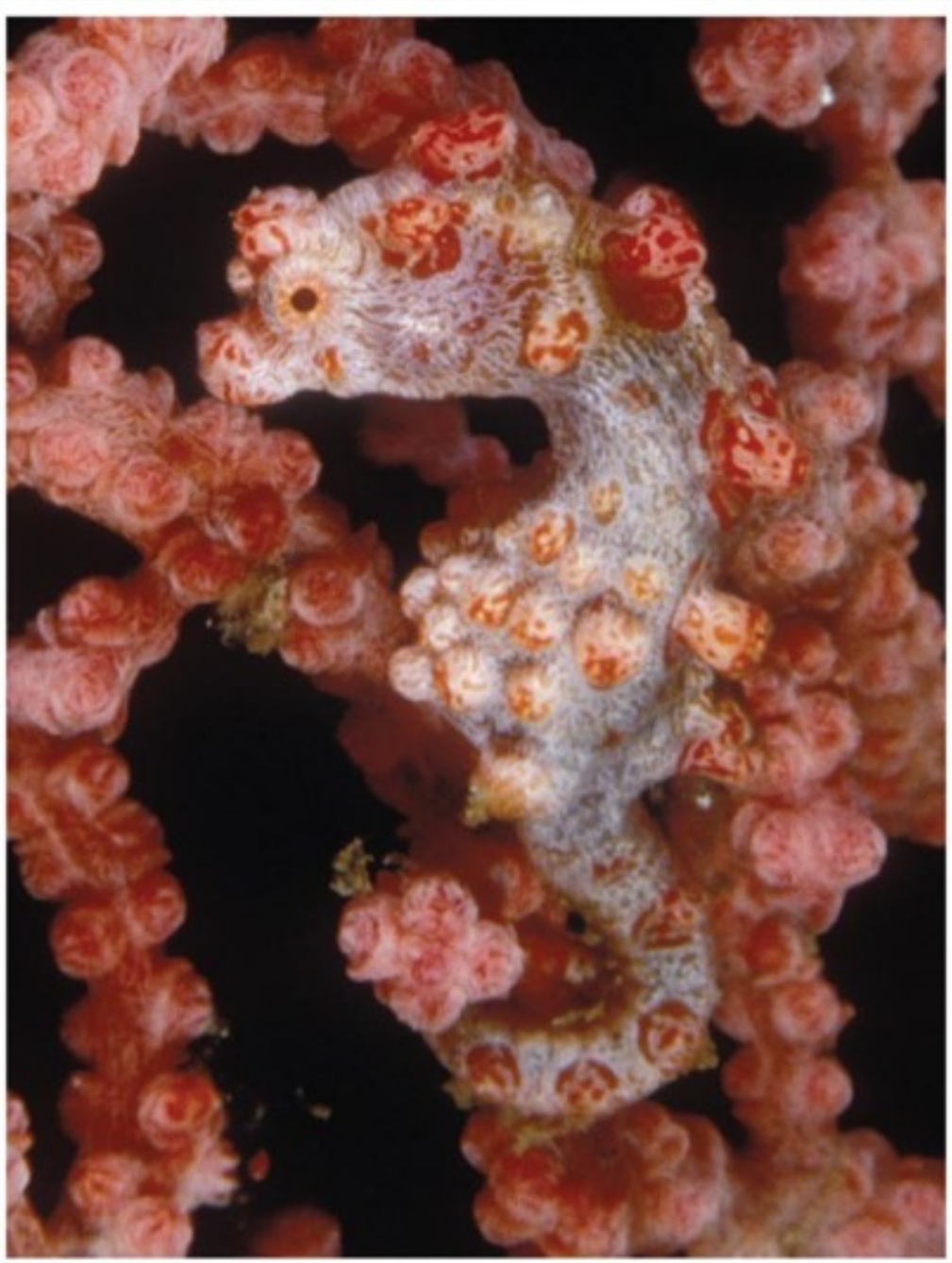
- Process Energy

- Regulate

What are the properties and functions that maintain life over time?

- Adaptation
- Reproduction

- Adaptation



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Additional Points

- The study of life is challenging prospect for the following reasons.
- Life has been around a very long time?
- There is great diversity in living and extinct organisms?
- Life operates as many different levels?
- Life occupies many diverse habitats?

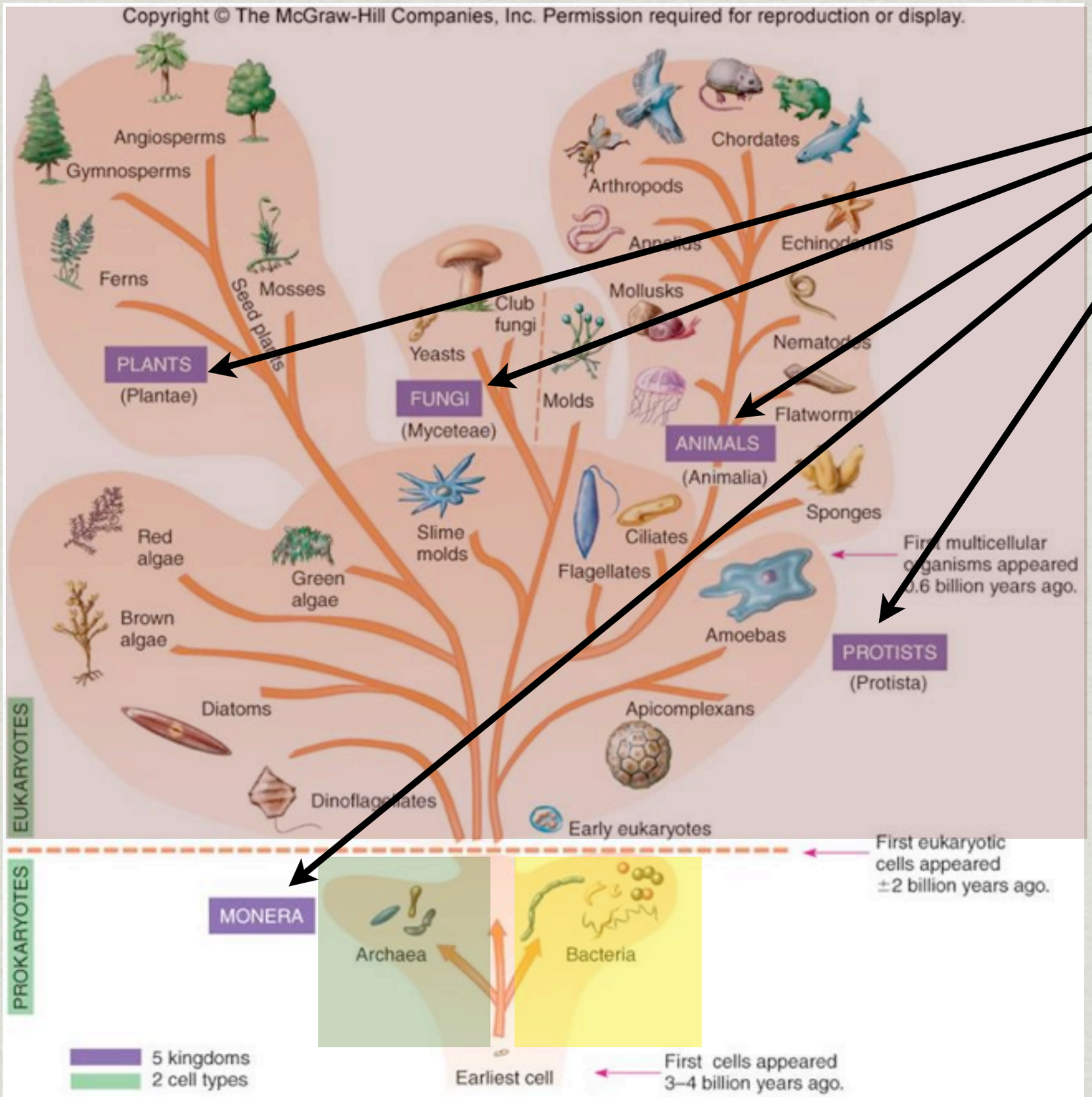
Living organisms have been around a long time...

- Life began nearly 4 Billion years ago

Table 26.1 The Geologic Record

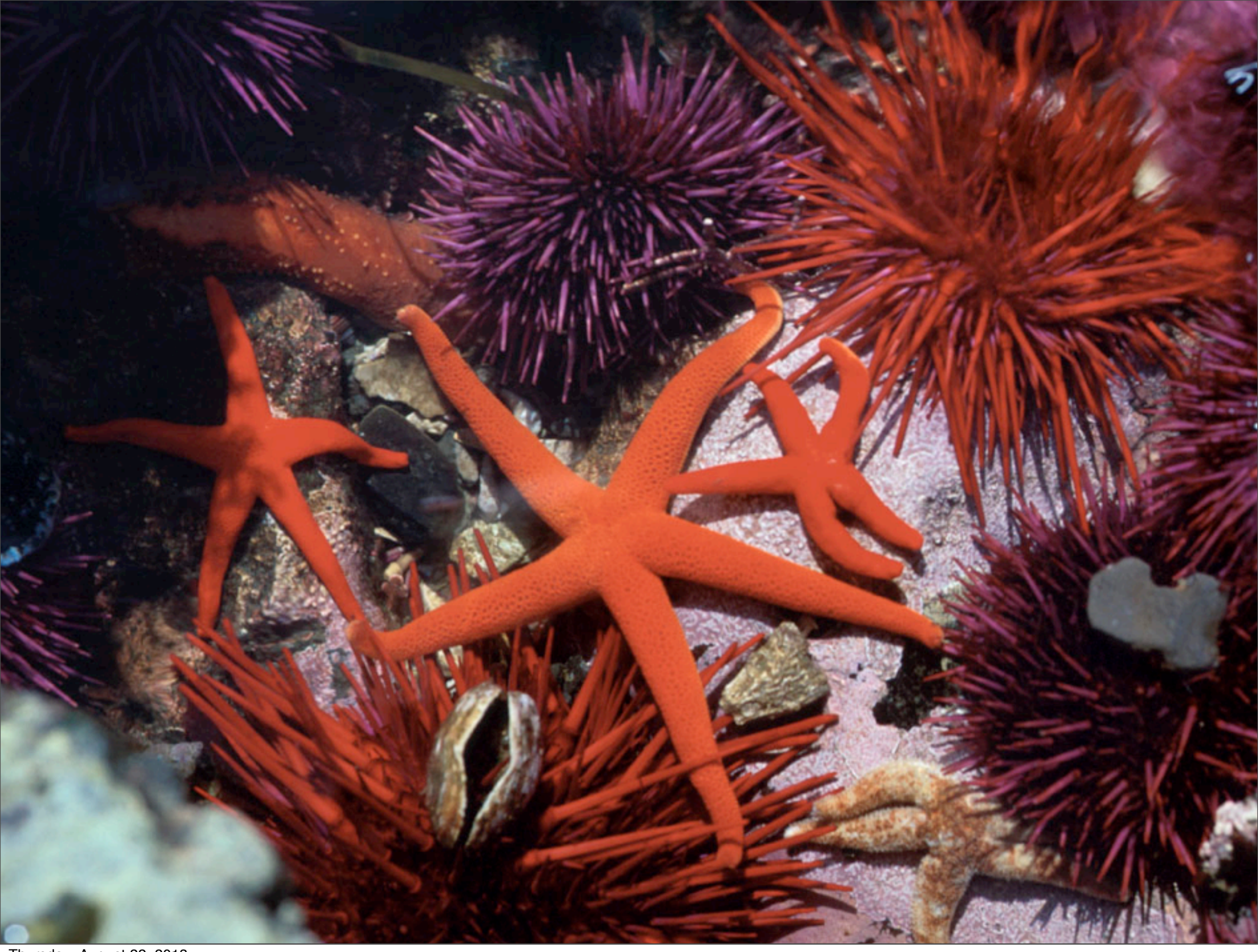
Relative Duration of Eons	Era	Period	Epoch	Age (Millions of Years Ago)	Some Important Events in the History of Life
Phanerozoic	Cenozoic	Neogene	Holocene	0.01	Historical time
			Pleistocene	1.8	Ice ages; humans appear
			Pliocene	5.3	Origin of genus *Homo*
			Miocene	23	Continued radiation of mammals and angiosperms; apelike ancestors of humans appear
		Paleogene	Oligocene	33.9	Origins of many primate groups, including apes
			Eocene	55.8	Angiosperm dominance increases; continued radiation of most modern mammalian orders
			Paleocene	65.5	Major radiation of mammals, birds, and pollinating insects
Proterozoic	Mesozoic	Cretaceous		145.5	Flowering plants (angiosperms) appear; many groups of organisms, including dinosaurs, become extinct at end of period (Cretaceous extinctions)
		Jurassic		199.6	Gymnosperms continue as dominant plants; dinosaurs abundant and diverse
		Triassic		251	Cone-bearing plants (gymnosperms) dominate landscape; radiation of dinosaurs; origin of mammal-like reptiles
	Paleozoic	Permian		299	Radiation of reptiles; origin of most present-day orders of insects; extinction of many marine and terrestrial organisms at end of period
		Carboniferous		359.2	Extensive forests of vascular plants; first seed plants; origin of reptiles; amphibians dominant
		Devonian		416	Diversification of bony fishes; first tetrapods and insects
		Silurian		443.7	Diversification of early vascular plants
		Ordovician		488.3	Marine algae abundant; colonization of land by plants and arthropods
		Cambrian		542	Sudden increase in diversity of many animal phyla (Cambrian explosion)
Archaean				600	Diverse algae and soft-bodied invertebrate animals
				2,200	Oldest fossils of eukaryotic cells
				2,500	
				2,700	Concentration of atmospheric oxygen begins to increase
				3,500	Oldest fossils of cells (prokaryotes)
				3,800	Oldest known rocks on Earth's surface
				Approx. 4,600	Origin of Earth

There is great diversity among life



5 KINGDOMS

3 DOMAINS



Strangely enough we do not know how many species currently inhabit the earth.

- Current estimates range in the order of millions
  - This of course does include extinct species

Life operates at many different levels.

- Life interacts with nonliving world
- Different species interact with one another
- Members of the same species interact
- Organ systems work together to form organisms
- Tissues work together to form organs
- Cells can work together to form tissues

Life occupies many diverse habitats.

- Life has been found 6 miles below the surface of the earth and as far as 6 miles above the surface of the earth
  - From the North Pole to the South Pole
    - In the ocean, lakes, rivers, deserts, forests, mountains, grasslands, wetlands, tundra, near extremely hot thermal vents and even in ice.

Life occupies many diverse habitats.

Despite the Diversity of life...

- Even though there are millions of different species
- Even with species occupying virtually every habitat
- And even though life varies in size from a single tiny cell to a mighty multicellular whale

- ALL LIFE FACES THE SIMILAR COMMON CHALLENGES!

COMMON CHALLENGES

- Involve the following variables

- **Water**
- **Food**
- **Oxygen**
- **Temperature**
- **Wastes**
- **Defense**
- **Moving**
- **Reproducing**

Let's take a closer look!

- Before we look at these common challenges, lets take a closer look at the properties and functions of life.
- Recall the Properties:
  - Order, Grow & Develop, Sense & Respond, Process Energy, Regulate, Adapt, Reproduce

- Order

Cells are the smallest collection of matter that are alive.

- Subatomic particles
- ↓
- Atoms
- ↓
- Molecules
- ↓
- Organelles
- ↓
- CELLS

} NOT ALIVE

} LIVING

LIFE ITSELF IS AN EMERGENT PROPERTY, WHERE THE SUM IS GREATER THAN ITS PARTS

- Organs
  ↓
- Organ Systems
  ↓
- Organisms
  ↓
- Populations
  ↓
- Communities
  ↓
- Ecosystems
  ↓
- Biosphere }

APPROX. A 12 MILE "BUBBLE" AROUND EARTH WHERE LIFE CAN BE FOUND

Growth and Development

Unicellular Growth & Development

- Growth & Development- most of the time when we speak of growth and development we are referring to multicellular organisms...however
- Growth- Strictly speaking individual cells can grow larger.
- Development- Cells can turn on and turn off certain genes throughout there life as a response to its environment, but again we do not usually think of cells as developing

Multicellular Growth & Development

- Growth- refers to the act of becoming physically larger
  - Growth- occurs through cell division, we are larger as adults not because a cell or a few cells became significantly larger but rather because we are comprised of many more cells

- Development- refers to changes in the organisms or patterns of growth that organisms under go over time or at different times throughout its life

- Sense and Respond

SENSING THE ENVIRONMENT

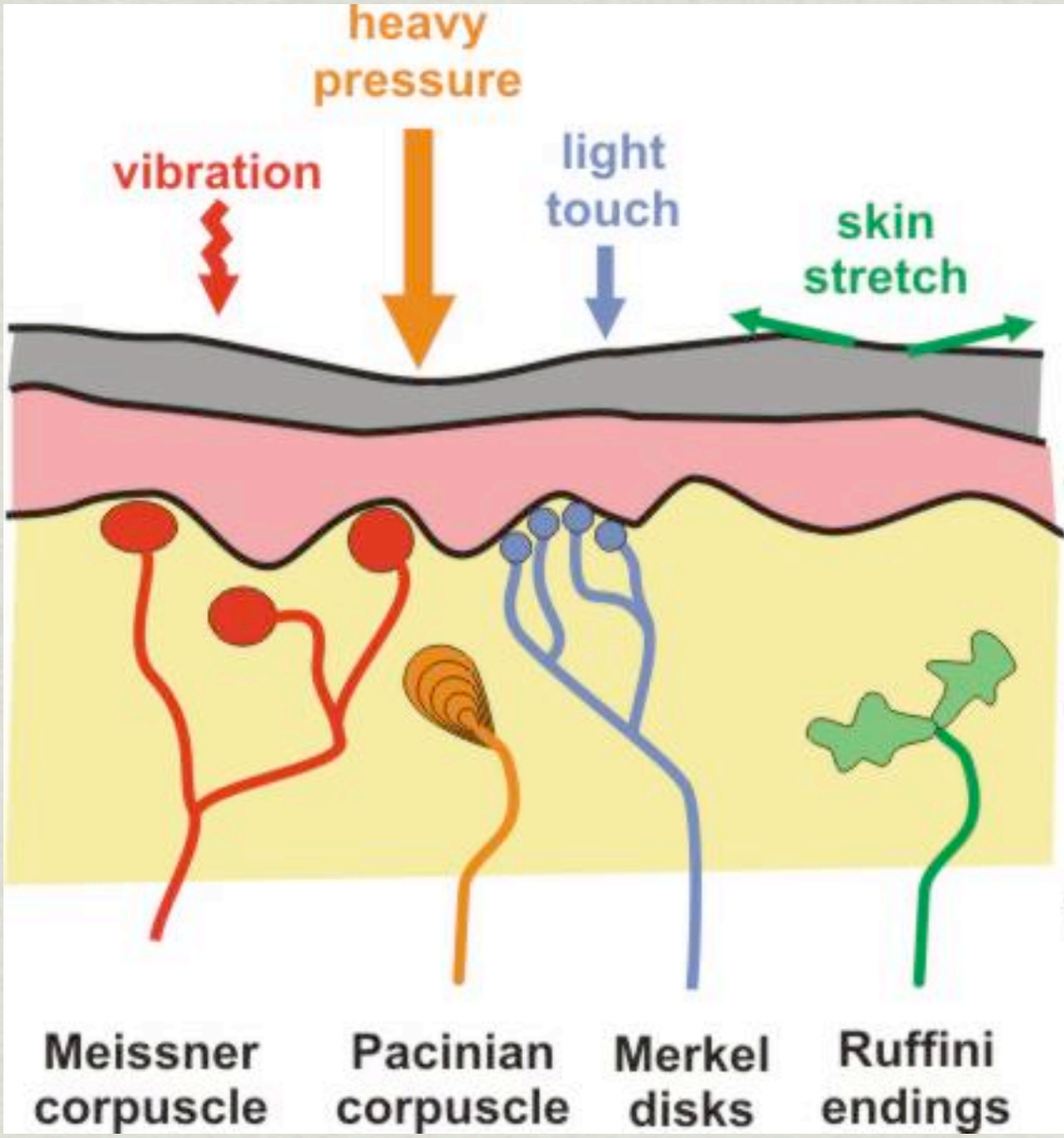
- The first step in interacting with the environment is detecting stimuli.
  - All stimuli represent forms of energy
- Sensory pathways have in common four basic functions: sensory reception, transduction, transmission, and perception.
  - Although sensory pathways vary from unicellular organisms to complex animals the four basic functions loosely hold true

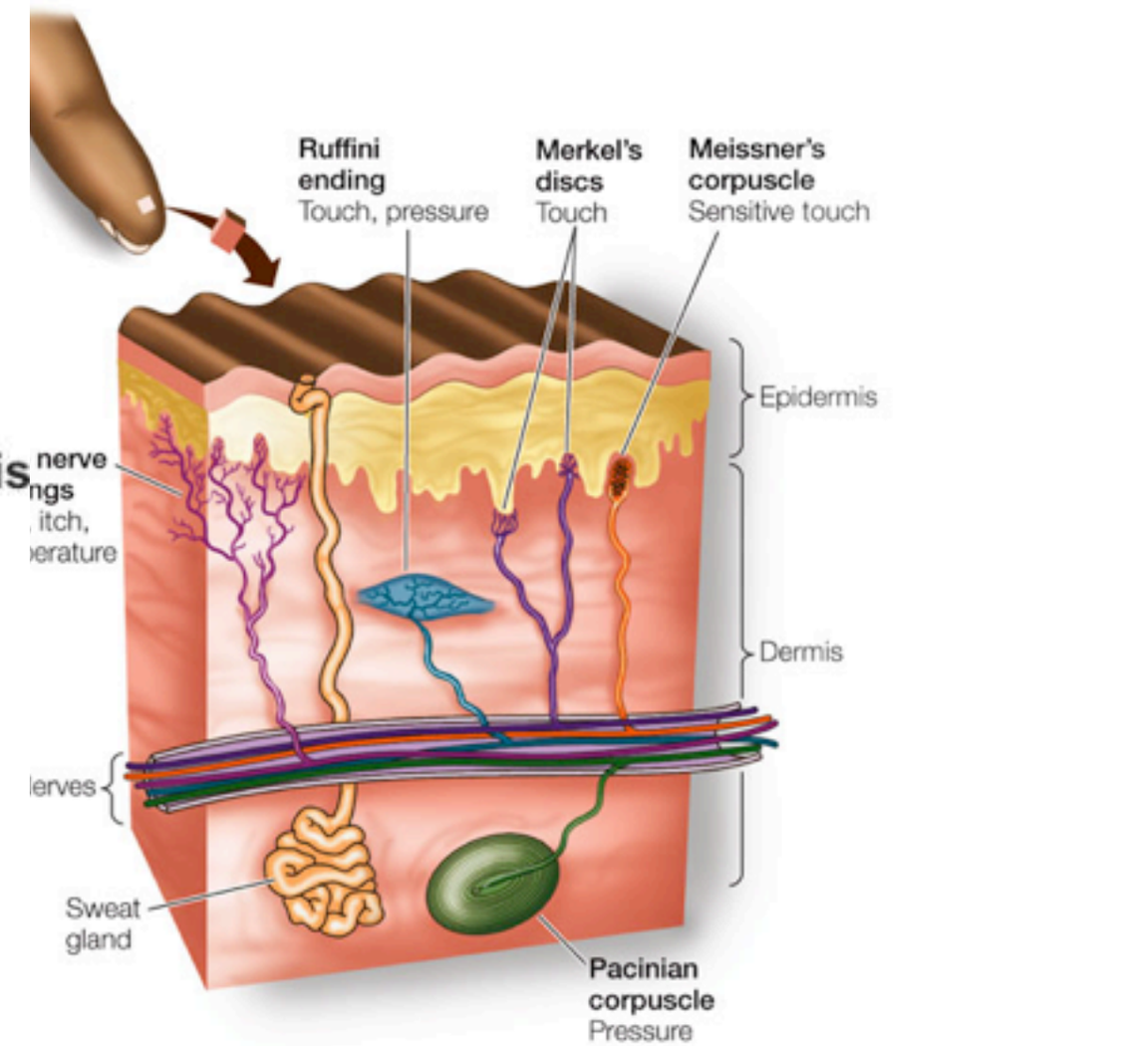
SENSORY RECEPTION

- Begins with the detection of stimulus by sensory cells (multicellular organism)
- These sensory cells have sensory receptors that detect the stimuli directly. (unicellular and multicellular organisms)
- The type of stimuli regularly detected include: electromagnetic radiation, pressure, temperature, chemicals

Mechanoreceptors

- Sense physical deformation caused by forms of mechanical energy such as pressure, touch, stretch, motion and sound





Chemoreceptors

- Transmit information about specific molecules or total solute concentration.
  - Osmoreceptors in brain detect concentration of blood and generate perception of thirst if blood in concentrated
  - Many organisms have receptors for specific molecules such as oxygen, carbon dioxide, glucose and amino acids.

MALE SILKWORM

The antennae have many hairs each loaded with chemo-receptors

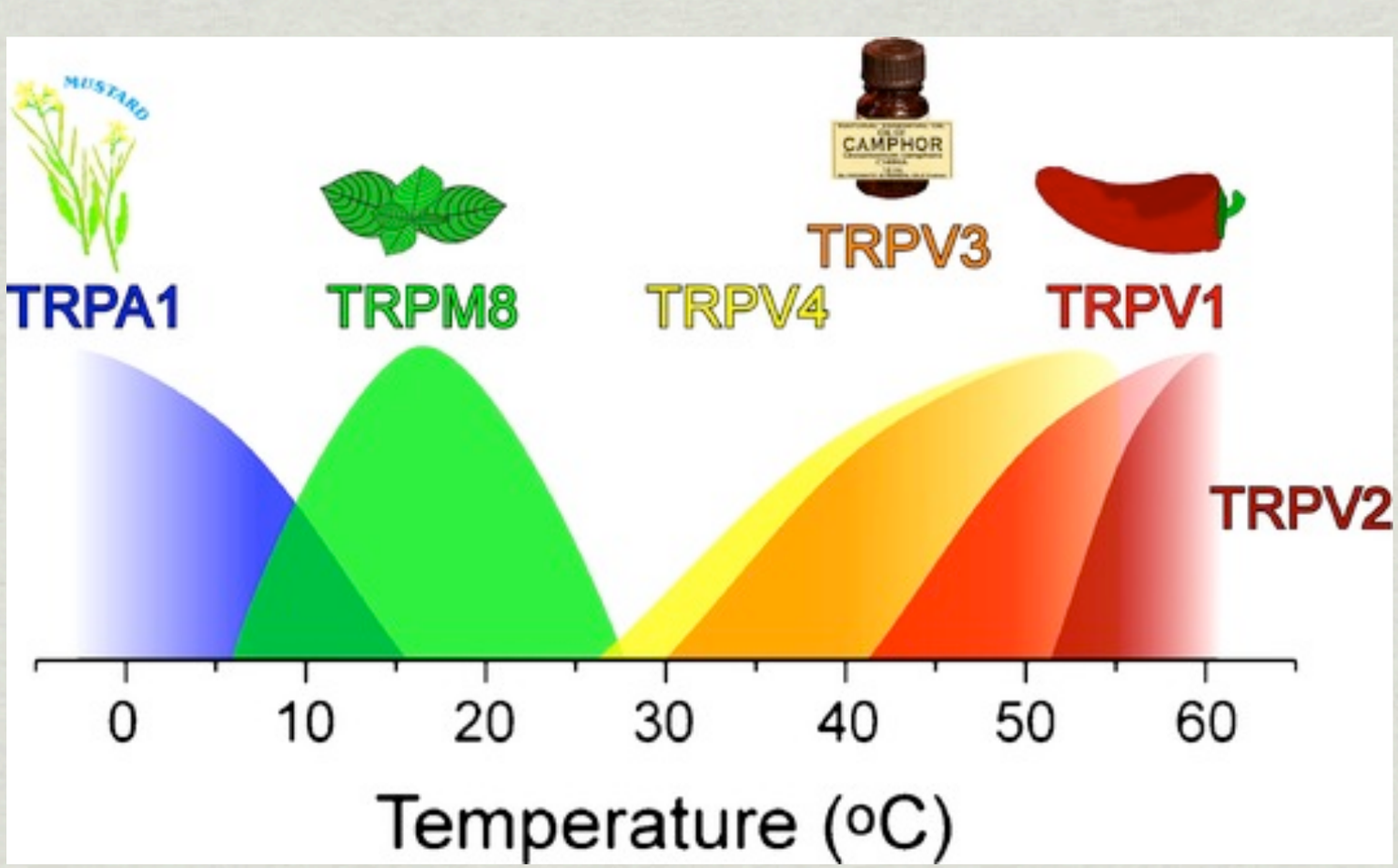
Electromagnetic Receptors

- Detect various forms of electromagnetic energy such as light, infrared, UV, electricity and magnetism.
  - Snakes detect infrared radiation.
  - Pigeons detect magnetic fields.
  - Platypus detects electric fields.

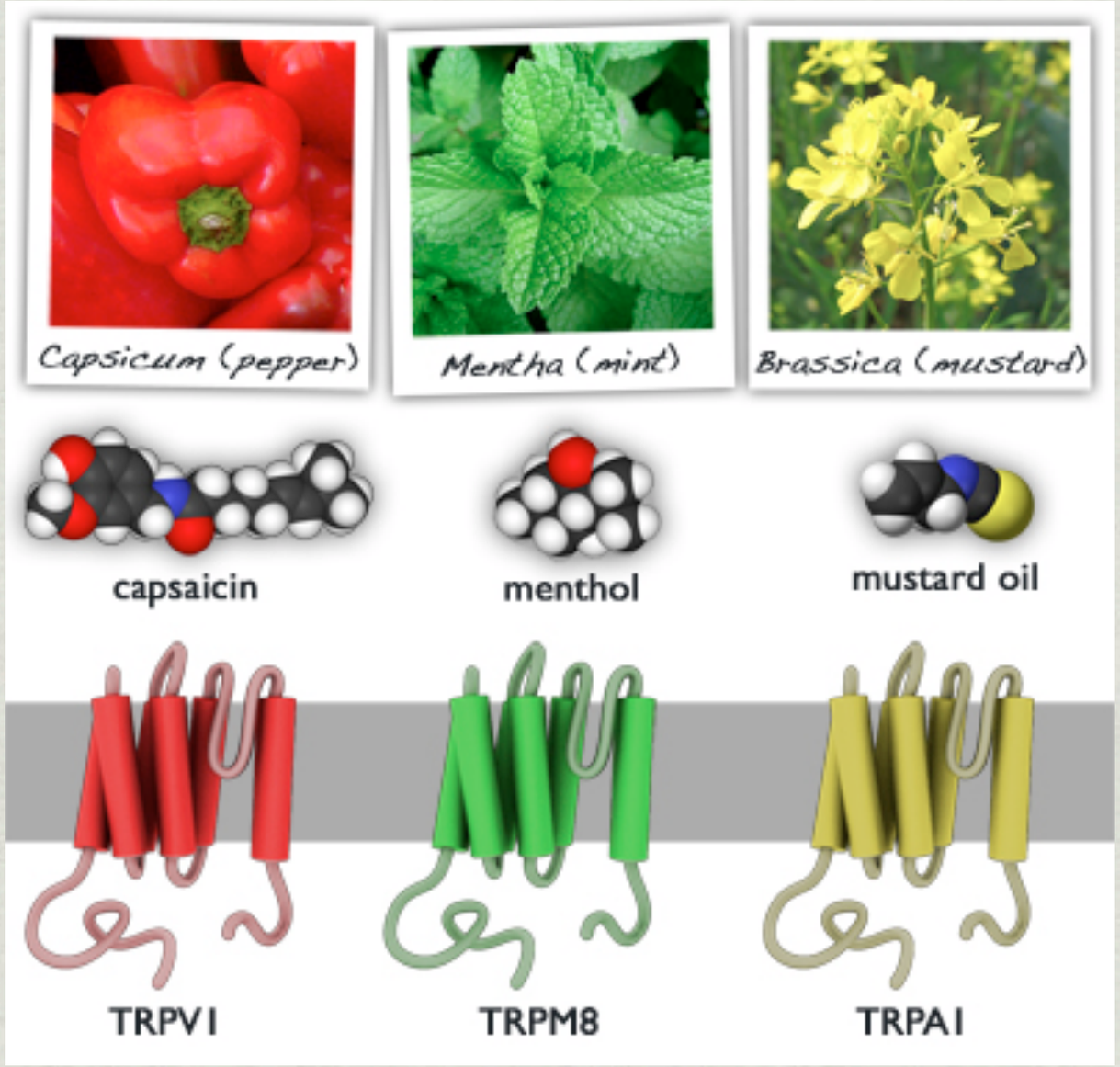
Thursday, August 22, 2013

Thermoreceptors

- Detect heat and cold.
  - Mammals have different kinds of thermoreceptors that belong to a family of receptors called “TRP’s”
  - Each TRP receptor detects a different temperature range.



- Each TRP receptor detects a different temperature range.
  - *Capsaicin (chemical found in hot peppers) binds to the same receptor that detects heat. Thus peppers taste "hot".*
  - *Menthol (chemical found in plants) binds to the same receptor that detects cold. Thus menthol taste or feels "cold".*



Nociceptors (Pain Receptors)

- Detect extremes: temperature, pressure, heat or chemicals.
  - Many of the other receptors can act as a pain receptors in cases of extreme stimuli.
- Pain is an important defensive trigger as it cause the organism to withdraw from danger

Receptors Outside of Higher Organisms

- All cells and all multicellular organisms have receptors able to detect mechanical, chemical, electromagnetic and heat stimuli.
  - Bacteria can detect light stimuli using *bacteriorhodopsin* or *bacteriophytochrome* receptors, they also can detect chemicals
  - Plants can detect light stimuli using *phytochrome* receptors, they also can detect touch, gravity, chemicals

Receptors Outside of Higher Organisms

- The main difference lies in perception,complex animals create perceptions .
- Perceptions are interpreted. Interpretations lead to a variety of behaviors and responses
- Simple organisms do not create perception but rather exhibit *taxis* and *tropisms*.

RESPONDING TO THE ENVIRONMENT

- Responses at the organismal level involves taxes and tropisms.
  - Mobile organisms move towards or away from stimuli.
  - Stationary organisms change their pattern of growth or development in response to stimuli
- Responses by animals are characterized as regulation or conformation.

Responses at the organismal level involve taxes and tropisms

- **Taxis:** is an innate behavioral response by an organism with motility towards or away from a stimulus, positive taxes move toward stimulus while negative taxes are away from the stimulus..

- **Tropisms:** growth of an organism (usually a plant) in response to a stimulus, positive tropisms show growth toward stimulus while negative tropisms are away from the stimulus.

RESPONDING TO GRAVITY

GRAVITROPISM

PHOTOTROPISM

RESPONDING TO LIGHT

CHEMOTAXIS BY A WHITE BLOOD CELL

- Process Energy

Chemical Energy

- The activities of cells, tissues, organs or even whole organisms depend on chemical energy
- This chemical energy is used to produce ATP ("cellular gasoline")
- THE ULTIMATE SOURCE OF ENERGY USED BY CELLS TO PRODUCE ATP AND THE MECHANISM OF ATP PRODUCTION DOES VARY SOMEWHAT BETWEEN LIFE FORMS

Processing Energy

- THE ULTIMATE SOURCE OF ENERGY (FOR MOST) LIVING ORGANISMS COMES FROM THE SUN!

- THE MAJORITY OF ENERGY PROCESSING OCCURS THROUGH PHOTOSYNTHESIS AND CELLULAR RESPIRATION

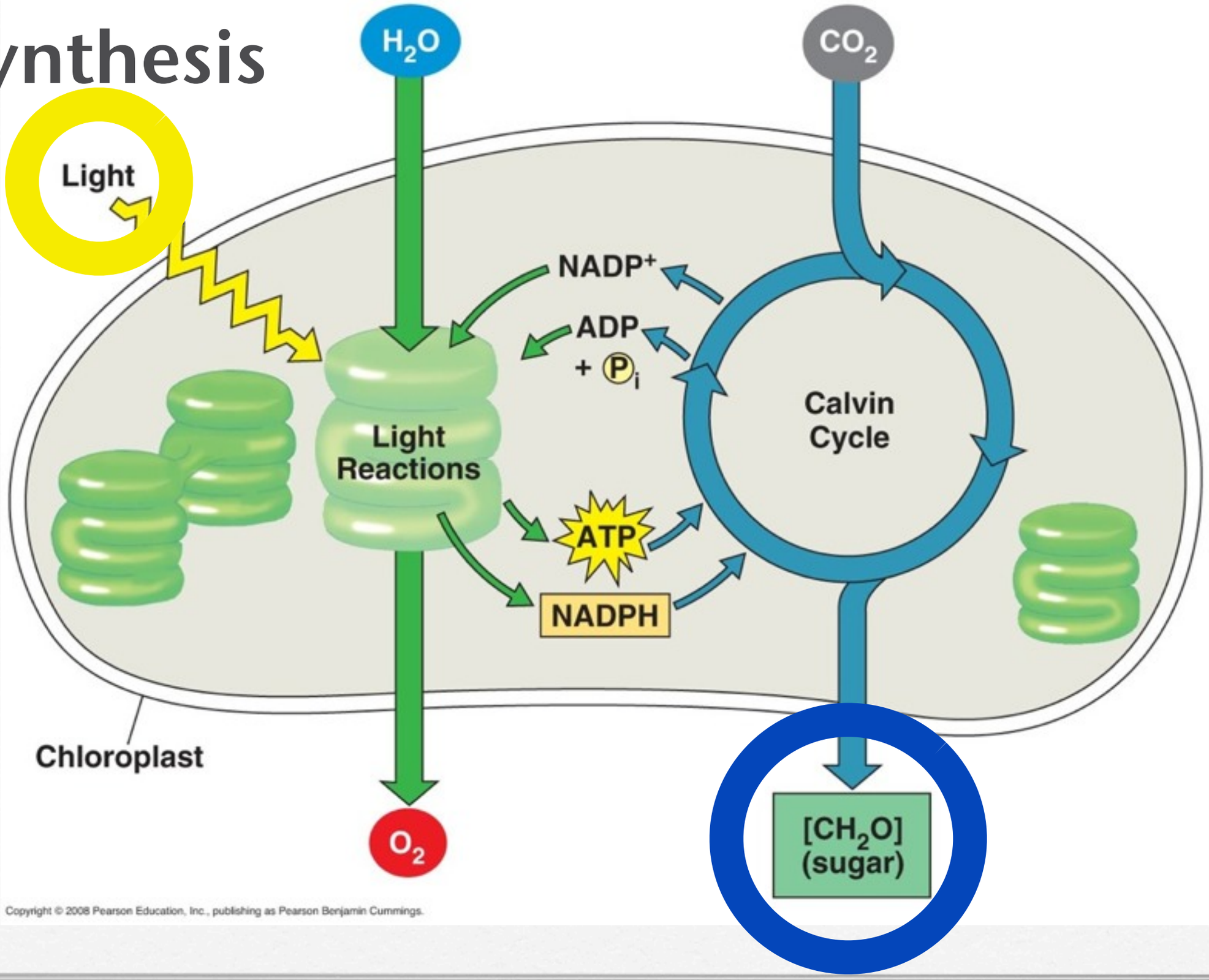
- Phototrophs: obtain energy from light

- Chemotrophs: obtain energy from chemicals

Processing Energy

- Phototrophs: obtain energy from light
  - The process of photosynthesis converts light energy into chemical energy.
  - Light energy takes carbon dioxide and water and converts them into sugars. These sugar molecules store energy in their chemical bonds

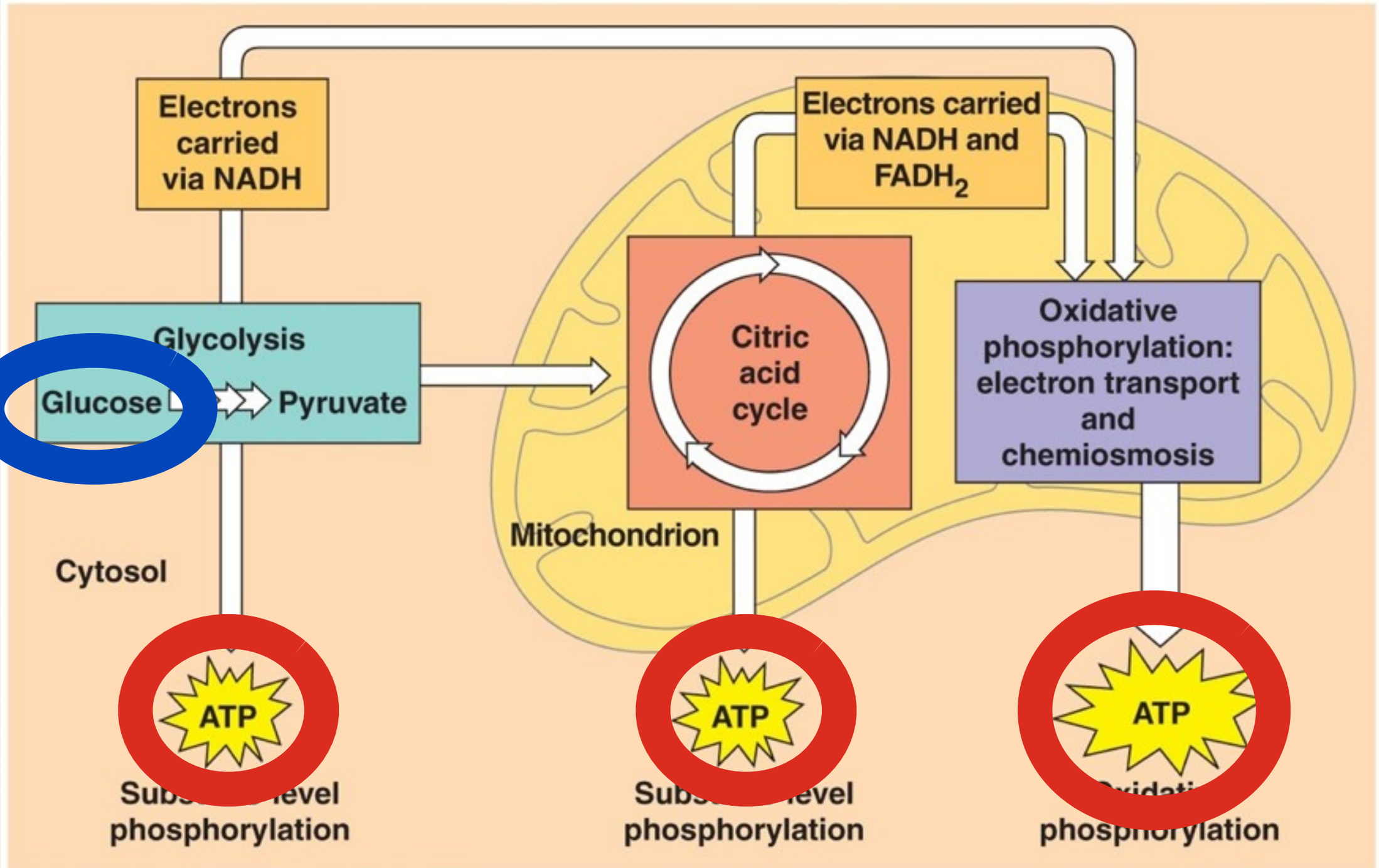
Photosynthesis



Processing Energy

- Chemotrophs: obtain energy from chemicals
  - All cells use harness the energy in chemical bonds to produce a molecule called ATP.
  - The process that produces ATP from sugars (most of time)is called cellular respiration.
  - In general all cells do cellular respiration, they use sugar to make ATP, the big distinction lies in whether the organism makes its own sugars or has to consume its sugars

Cellular Respiration

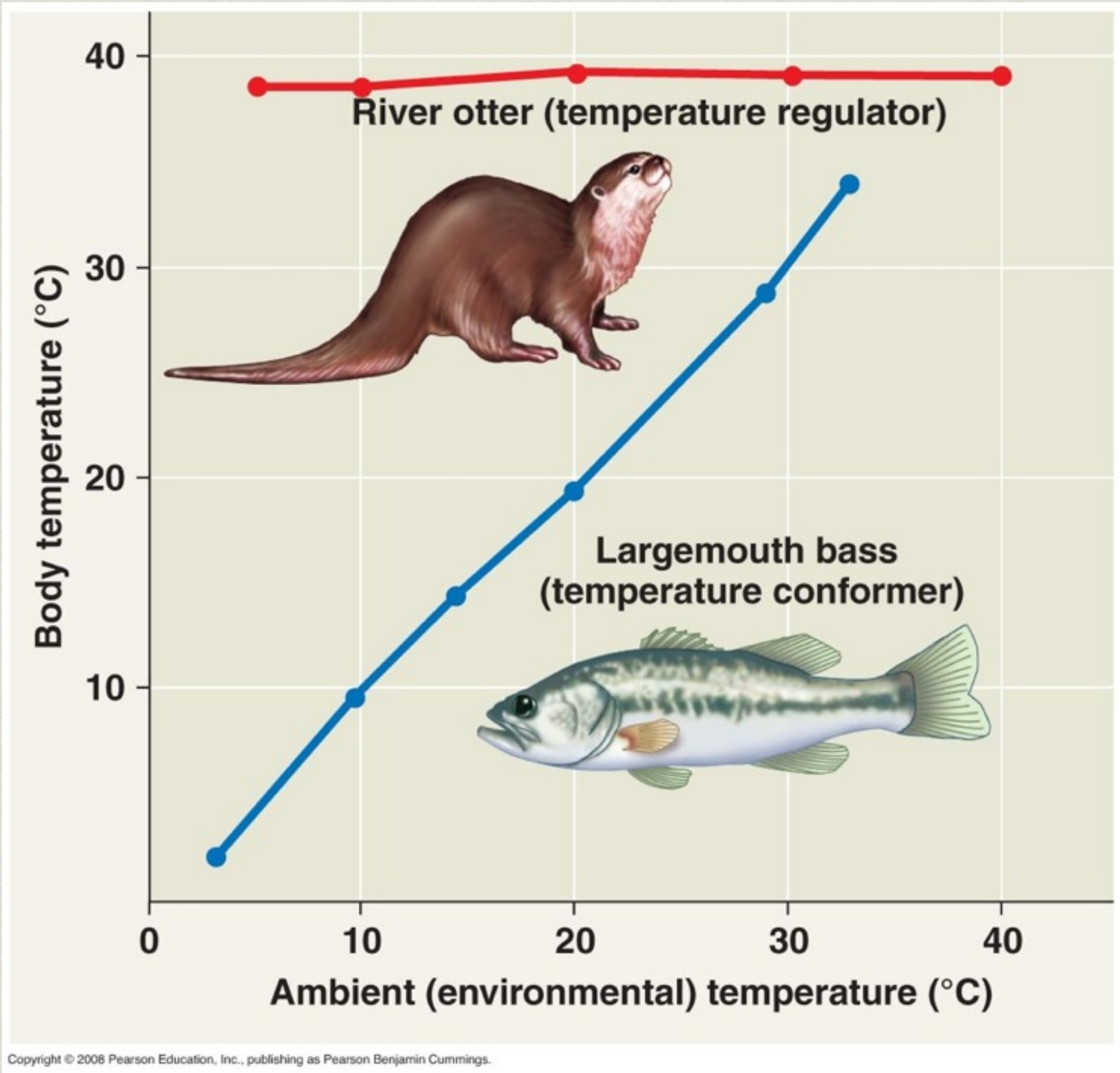


- Regulate

Responses by animals are characterized as regulation or conformation.

- **Regulator:** an animal that uses internal mechanisms to control internal change in face of external environmental fluctuations.

- **Conformer:** an animal that allows its internal condition to change in accordance with external changes in the variable.

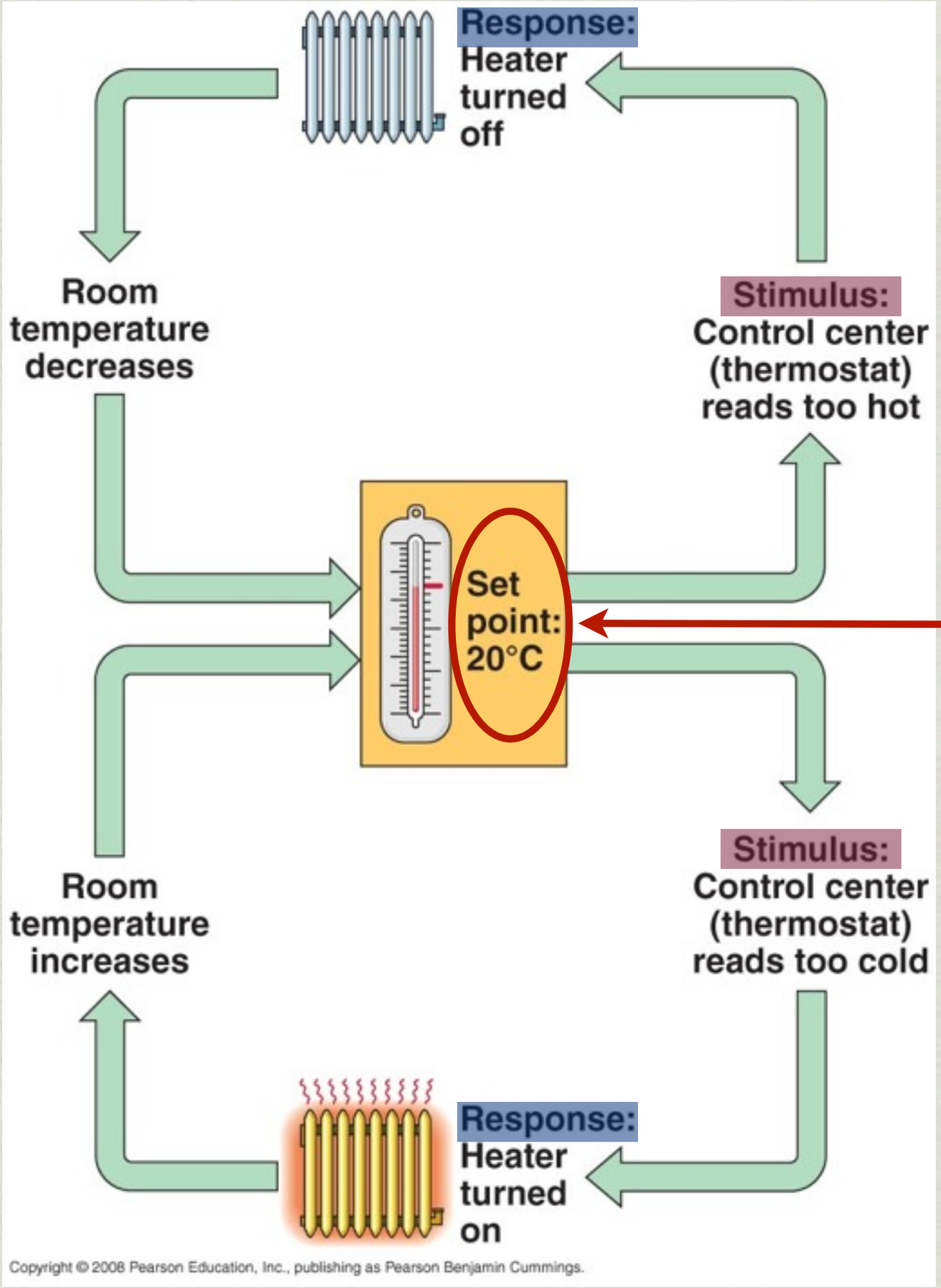


When it comes to solute concentration in its blood the bass regulates its internal environment

Homeostasis

- **Homeostasis:** “steady state” refers to the maintenance of an internal environment.
- It means that an internal environment stays relatively constant in spite of external environmental fluctuations some of which may be extreme.
- Human examples
  - Blood pH 7.4 (+/- .1)
  - Temperature 98.6° F
  - Blood Glucose Concentration 70-110mg/100ml

MECHANISM OF HOMEOSTASIS



NONBIOLOGICAL EXAMPLE

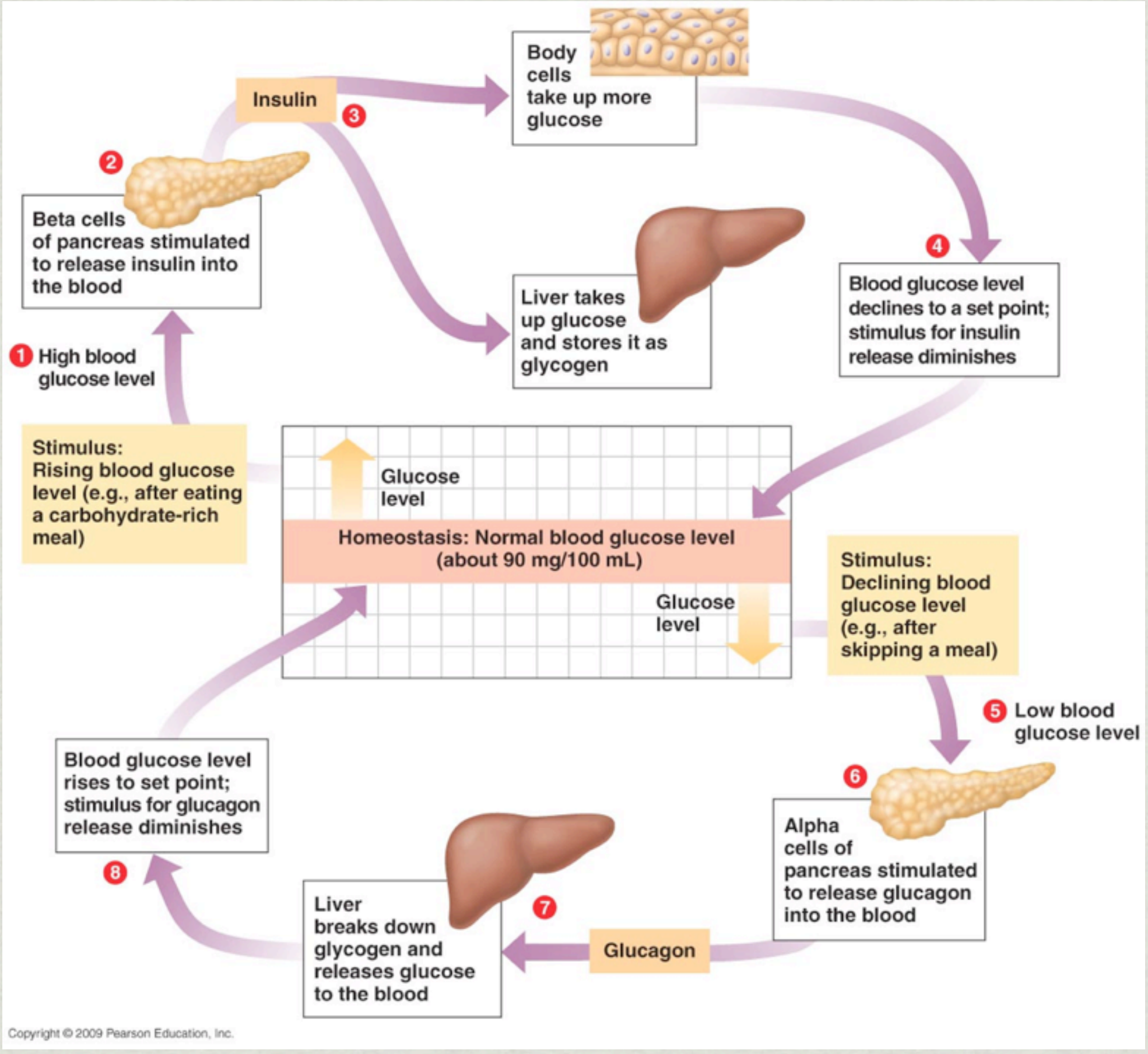
CAN ALSO BE A "RANGE "

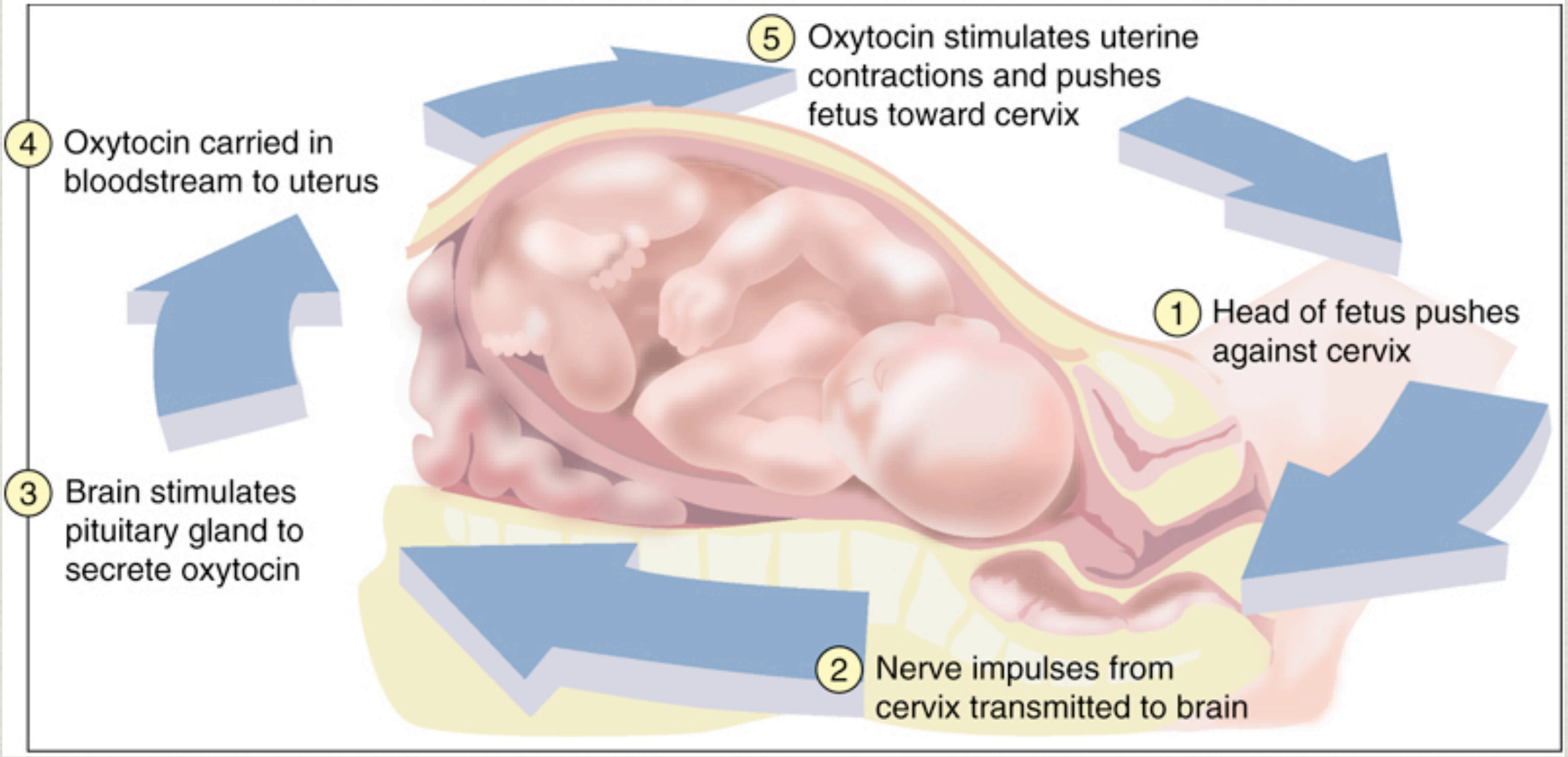
Feedback Control in Homeostasis

- **Negative Feedback:** control mechanism that reduces or counteracts the stimulus
- ***Positive Feedback:** control mechanism that amplifies the stimulus.
  - *Does not play a major role in homeostasis but instead helps drive processes to completion.*

CONTROL OF BLOOD SUGAR

NEGATIVE FEEDBACK



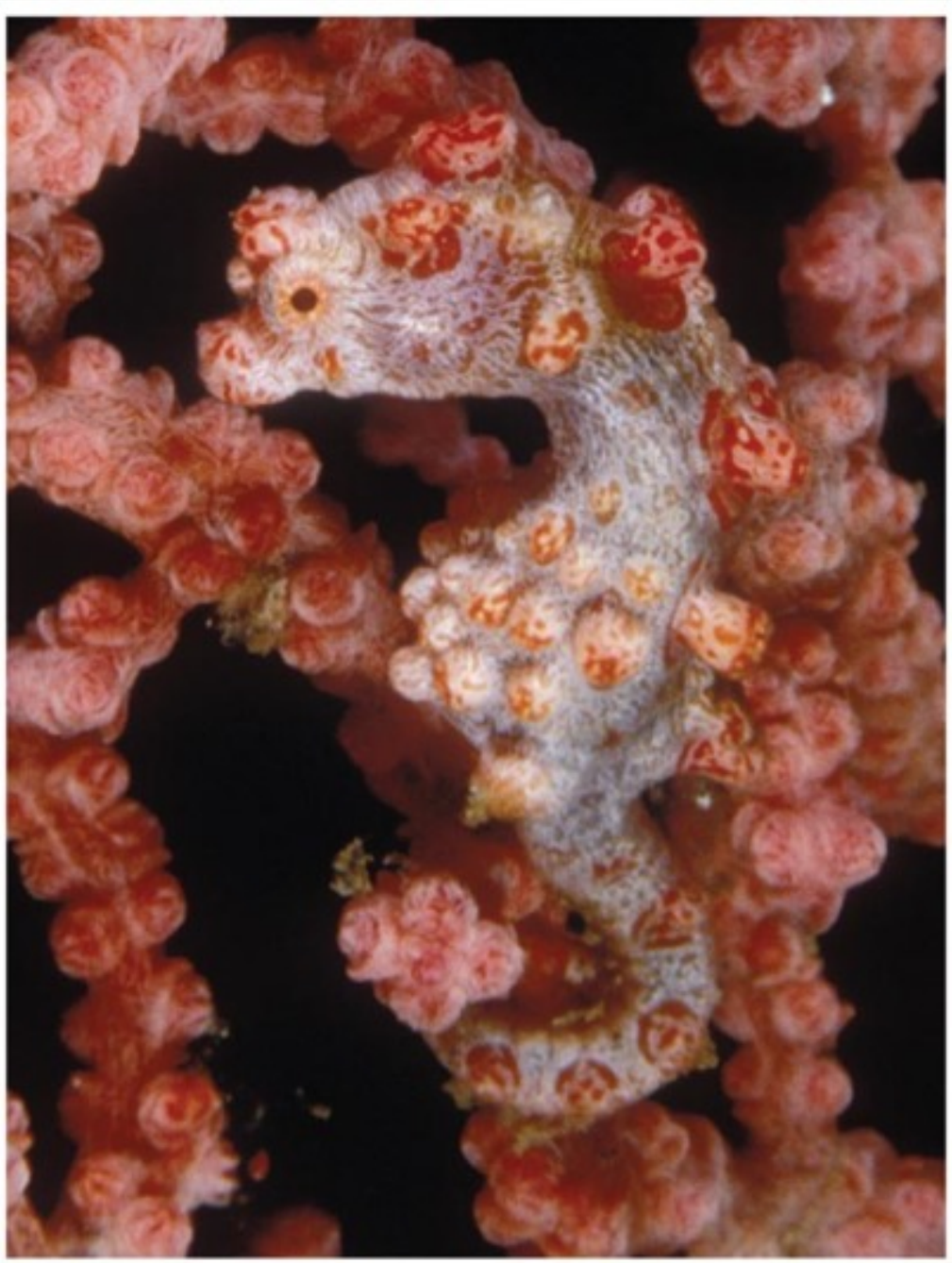


PARTURITION → POSITIVE FEEDBACK

Final Points on Homeostasis

- Physiological responses to stimuli are not instantaneous, they take time!
- Homeostasis moderates but can not eliminate changes in the internal environment.
- The variable fluctuates whether the organism has a “set point” or a “range”
- Homeostasis is enhanced by adaptations that reduce fluctuations in the first place.
- It is dynamic!

- Adaptation

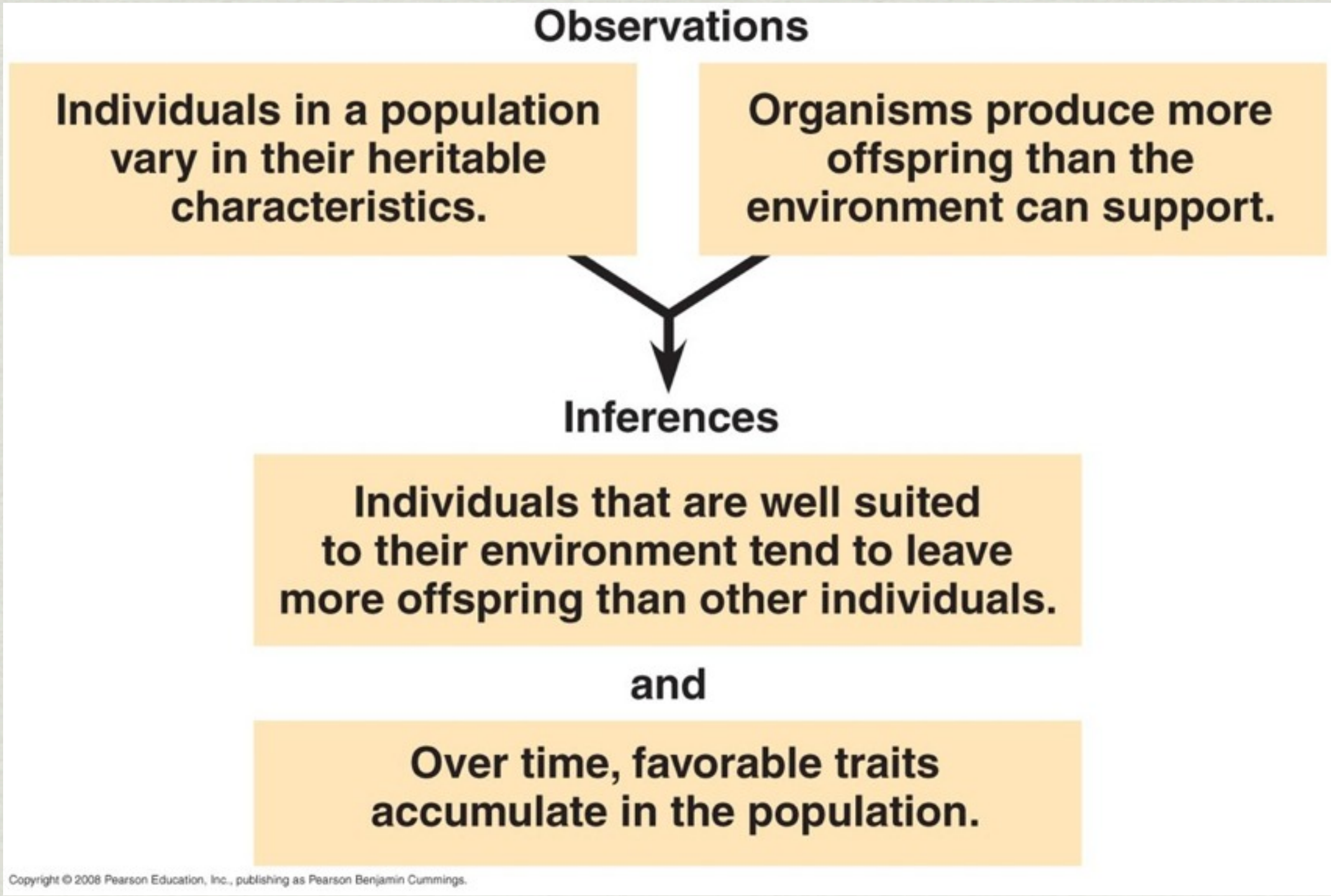


Adaptation

- It is the biological imperative to reproduce!
- It is an absolute requirement for a species if they are to remain extant.
- Before an organism can attempt or successfully reproduce they must first survive.
- Certain traits increase the chance of survival of an individual, as these traits become more frequent in a population the species adapts to its surroundings and consequently has a better chance of remaining extant.

Adaptation- Natural Selection

- **The mechanism behind adaptation is natural selection.**



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The Purpose of Life!?*#?

- **It could be said that the purpose of life from a biological perspective it pass your genes (or closely related genes) to the future generations.**

- 1. Reproduction is unique, in that, it is not an imperative for individuals to be alive or remain alive.

  - It is however imperative for the continuation of the species.

- 2. Many biologists feel that Reproduction is in fact "THE" biological imperative and that ultimately Reproduction drives all actions and adaptations of living organisms.

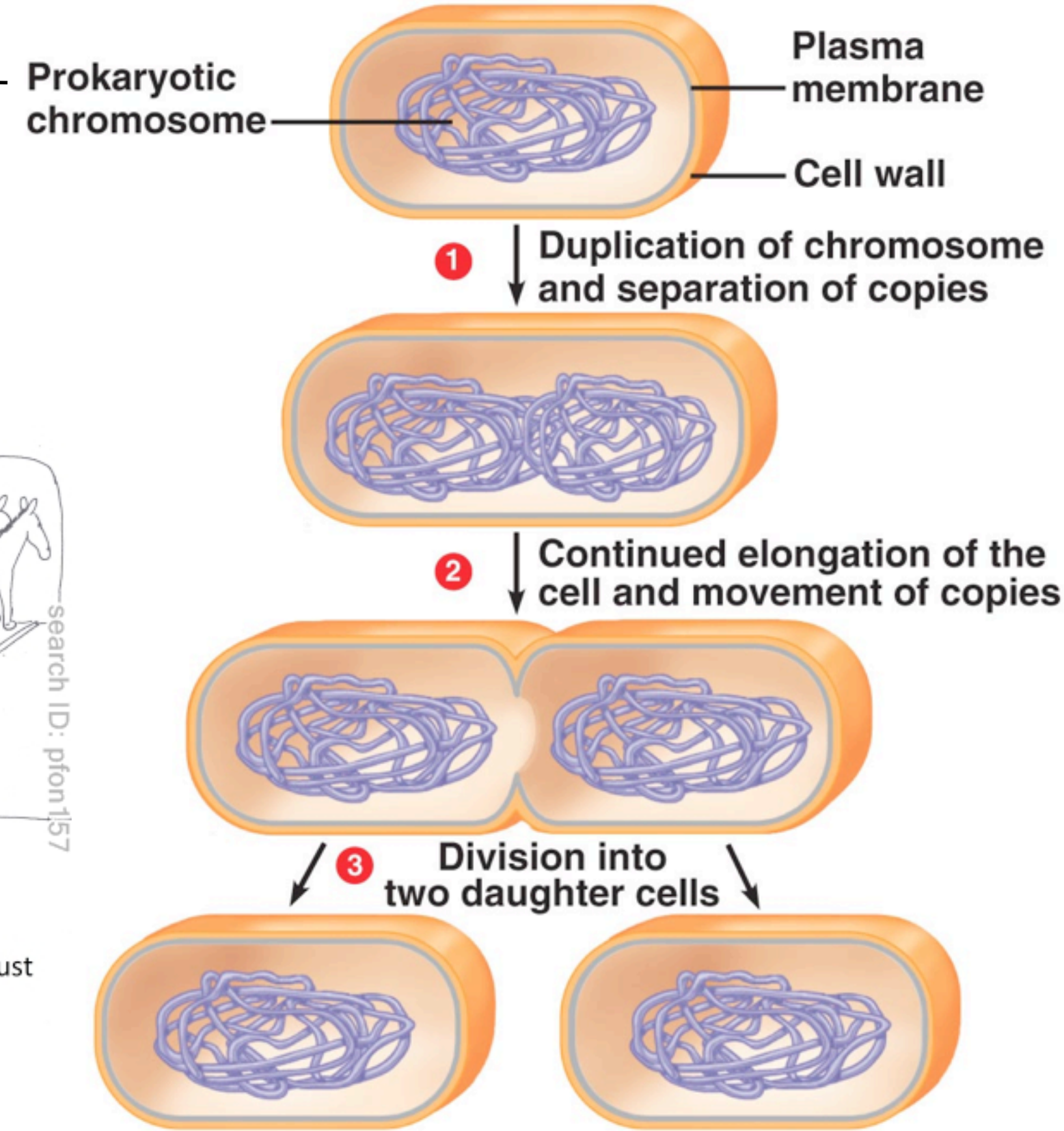
General Points Regarding

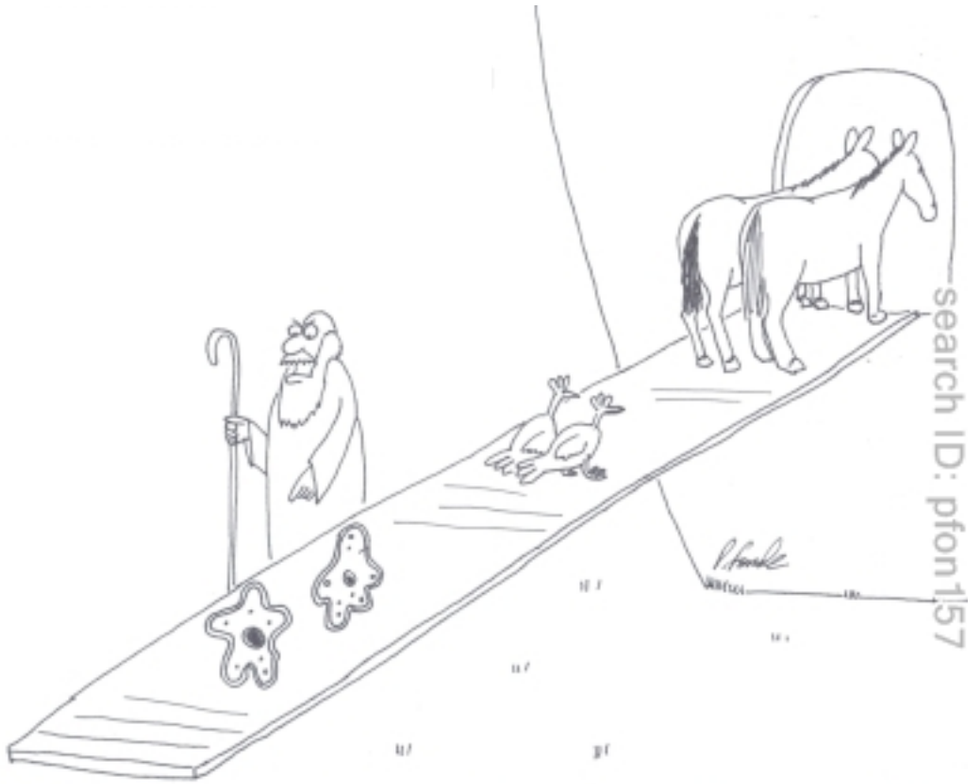
- "Life begets life"... more or less organisms reproduce their own kind.
  - Oak trees give rise to Oak trees, euglenas produce euglenas, humans produce humans, etc
  - some offspring are identical to their parent(s) while others are very similar to their parent(s)

- All cells arise from preexisting cells.
- Cell division underlies All reproduction.
  - It is necessary for unicellular reproduction and multicellular reproduction, for asexual reproduction and sexual reproduction.

Cellular Division-Prokaryotes (Binary Fission)

A single Circular chromosome that contains genetic instructions

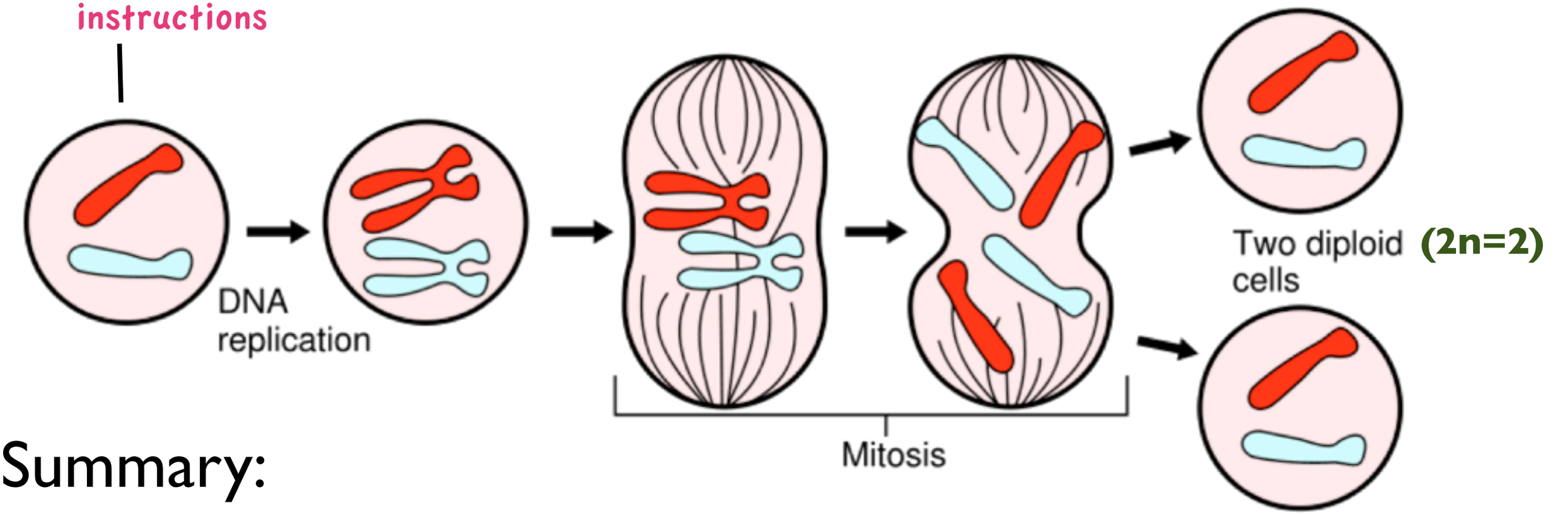




"Nice try! We only need *one* of you. You can just turn around and be on your way, buddy."

Cellular Division- Eukaryotes (Mitosis)

Two or more linear chromosomes that contain genetic instructions



Summary:

-2 diploid cells produced

-identical to parent & each other

-same # of chromosomes as parent cell

-used in growth, repair and development of a multicellular organism

There are Two Types of Reproduction

- ASEXUAL REPRODUCTION.
  - the parent/cell passes exact copies of its genetic instructions to its offspring/daughter cells
  - the offspring or daughter cells are called *clones*
    - any difference that does happen to show up in the offspring is a result of a genetic mistake (mutation)
- SEXUAL REPRODUCTION.
  - two parents give rise to offspring that have unique combinations of genetic instructions inherited from the two parents
  - in contrast sexually produced offspring are vary from parents and siblings, they are not exact replicas

Reproductive Strategies have

- ASEXUAL REPRODUCTION.
  - (+)Energetically Inexpensive
  - (+)Faster and more offspring produced
  - (-)Generates *No Variation
- SEXUAL REPRODUCTION.
  - (-)Energetically Expensive
  - (-)Slower and less offspring produced
  - (+)Generates Much Variation