October 03, 2024

Master Degree in Bionics Engineering

Course of Principles of Bionics and Biorobotics Engineering

Lesson title:

General Characteristics of Biological Kingdoms as Models - Locomotion and Movement (preview)

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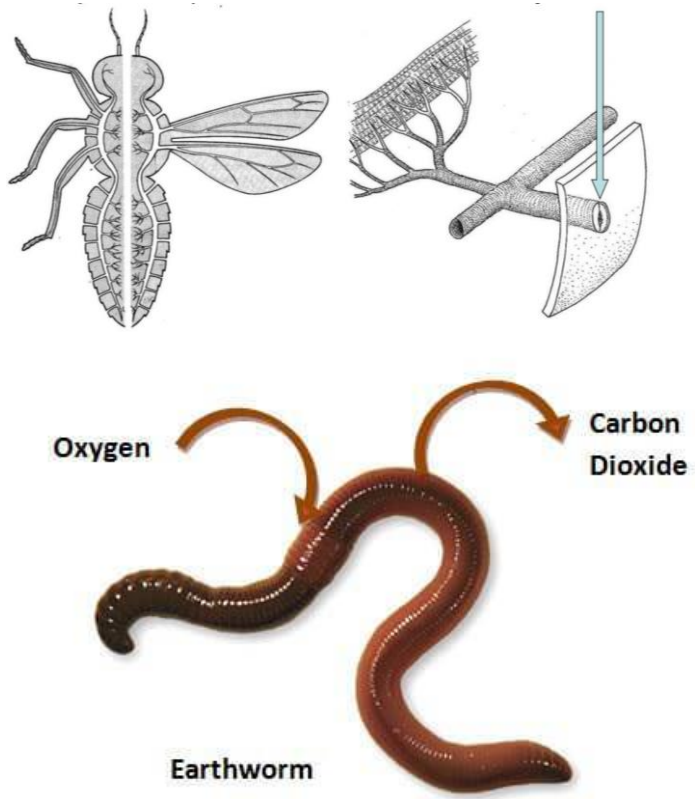
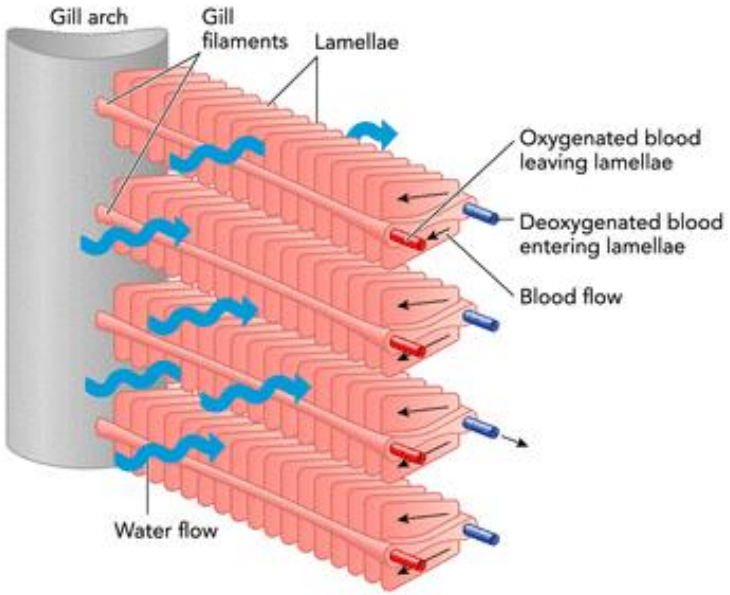
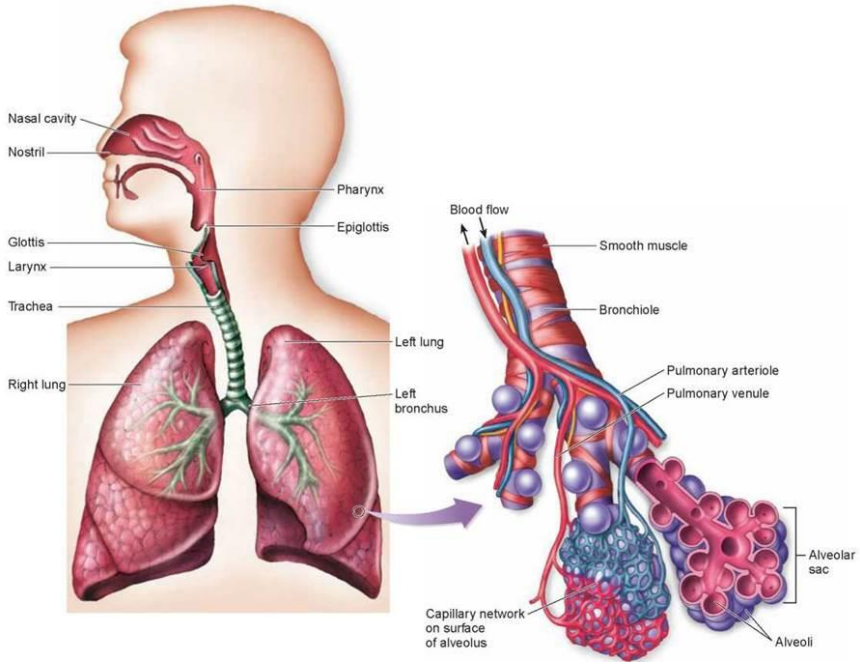
General Characteristics of Animals

Eukaryotic multicellular organisms that comprise the biological kingdom of Animalia

Animals respire **aerobically**, taking in oxygen (inspiration) and then releasing carbon dioxide (expiration). Oxygen is important to cell respiration as it serves as the final electron acceptor in redox reactions during the synthesis of metabolic energy. The different animal structures involved in the exchange of respiratory gases: (1) skin of tapeworms, earthworms, and leeches, (2) trachea of insects, (3) gills of fish, and (4) lungs of mammals, reptiles, and birds. Amphibians use different respiratory organs at different stages, i.e. gills at the tadpole stage and then skin and lungs at the adult stage.







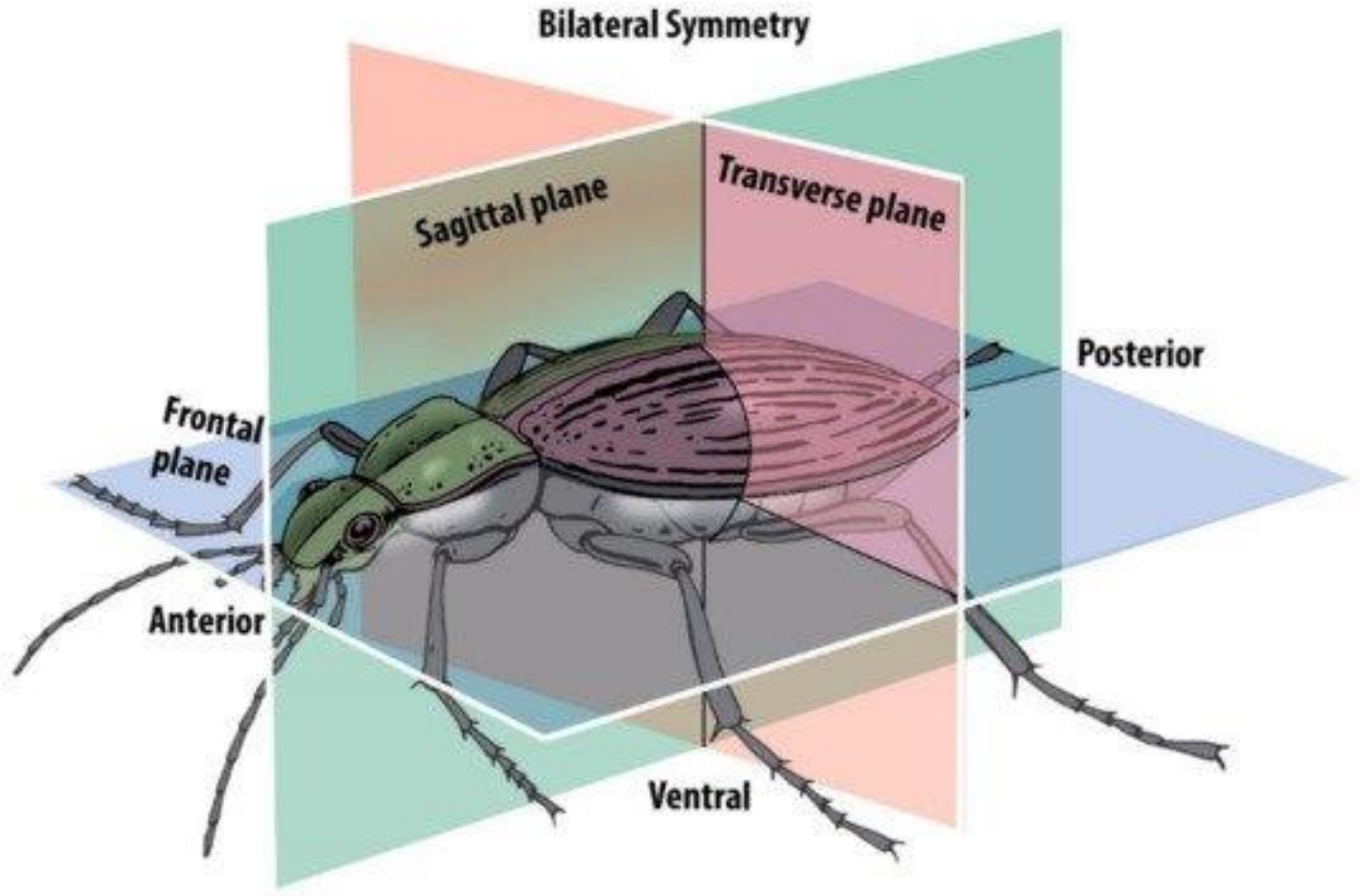
General Characteristics of Animals

Eukaryotic multicellular organisms that comprise the biological kingdom of Animalia

In general, animals possess the following biological systems: integumentary system, lymphatic system, muscular system, nervous system, reproductive system, respiratory system, skeletal system, and urinary system.

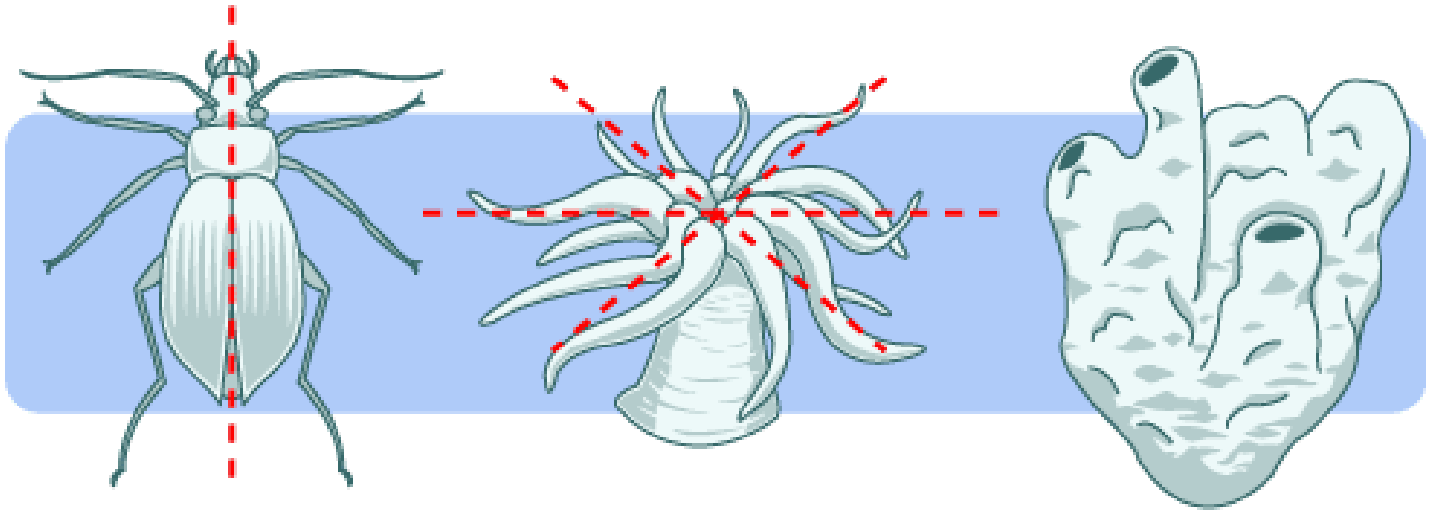
Animal Symmetry

If dividing the body of most animal species by a sagittal plane, the result is having two sides with roughly mirror images, at least morphologically (**bilaterally symmetry**). The appearance of bilateral symmetry in animal evolution was a major advancement, because bilateral animals are much better fitted for directional (forward) movement than are radially symmetrical animals. Bilateral animals form a monophyletic group of phyla called the **Bilateria**. Bilateral symmetry is strongly associated with **cephalization**.



Animal Symmetry

Radial symmetry applies to forms that can be divided into similar halves by more than two planes passing through the longitudinal axis. These are tubular, vase, or bowl shapes found in some sponges and in hydras, jellyfish, sea urchins, and related groups, in which one end of the longitudinal axis is usually the mouth.



Spherical symmetry means that any plane passing through the center divides the body into equivalent, or mirrored, halves. This type of symmetry is found chiefly among some unicellular forms and is rare in animals. Spherical forms are best suited for floating and rolling.

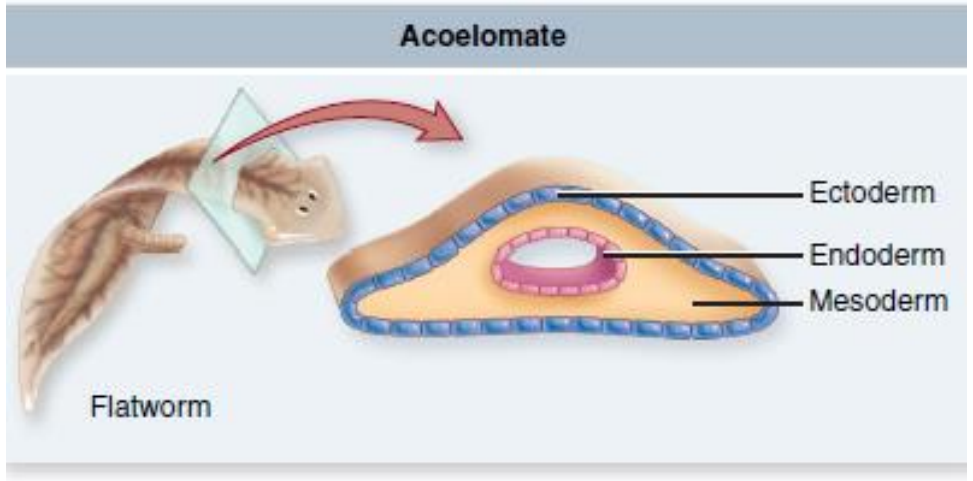
Triploblasty

Many animals produce three embryonic tissue layers as they develop.
Flatworms, ribbon worms, humans, etc. have all three tissue layers, and are triploblastic.

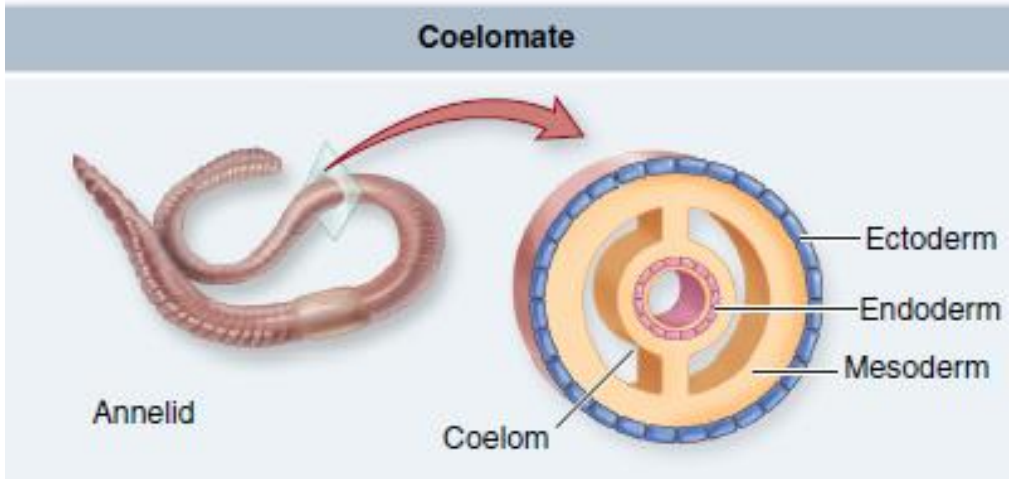
Animal embryonic tissue layers

Endoderm	Digestion and respiration structures
Mesoderm	Muscles, bones, blood, skin, and reproductive organs
Ectoderm	Skin, brain, and nervous system

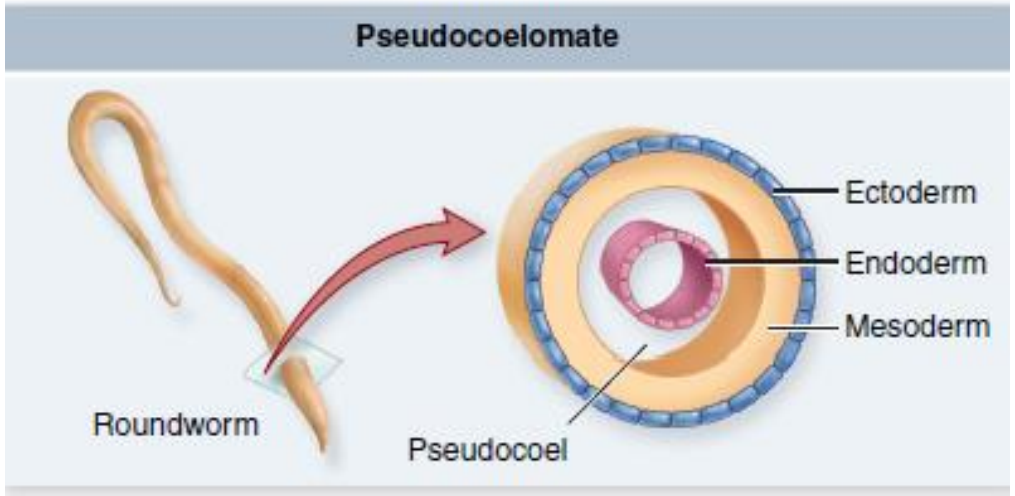
Body Cavities



No body cavity surrounding the gut. The region between the ectoderm and the endoderm digestive tract is filled with mesoderm called **parenchyma.**



Presence of a true coelom lined with mesodermal peritoneum.



Presence of a cavity surrounding the gut, but it is not lined with mesodermal peritoneum.

Metamerism

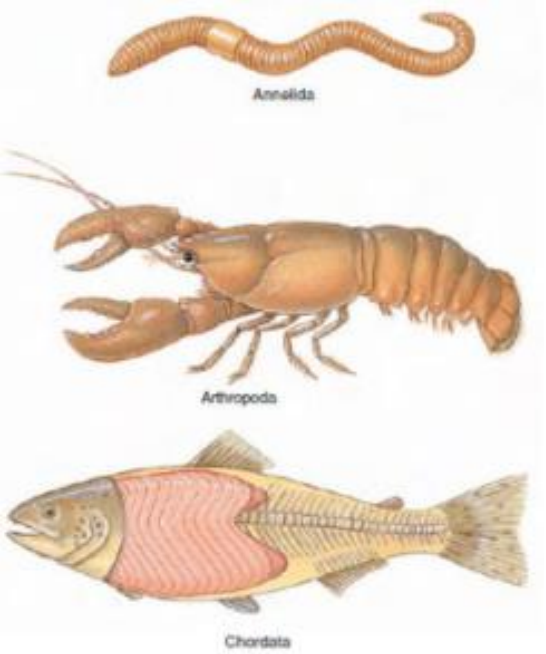
- Repetition of similar body segments along the longitudinal axis of the body.

- Each segment is called a **metamere**, or somite.

- The segmental arrangement includes both external and internal structures of several systems. There is repetition of muscles, blood vessels, nerves, and setae of locomotion.

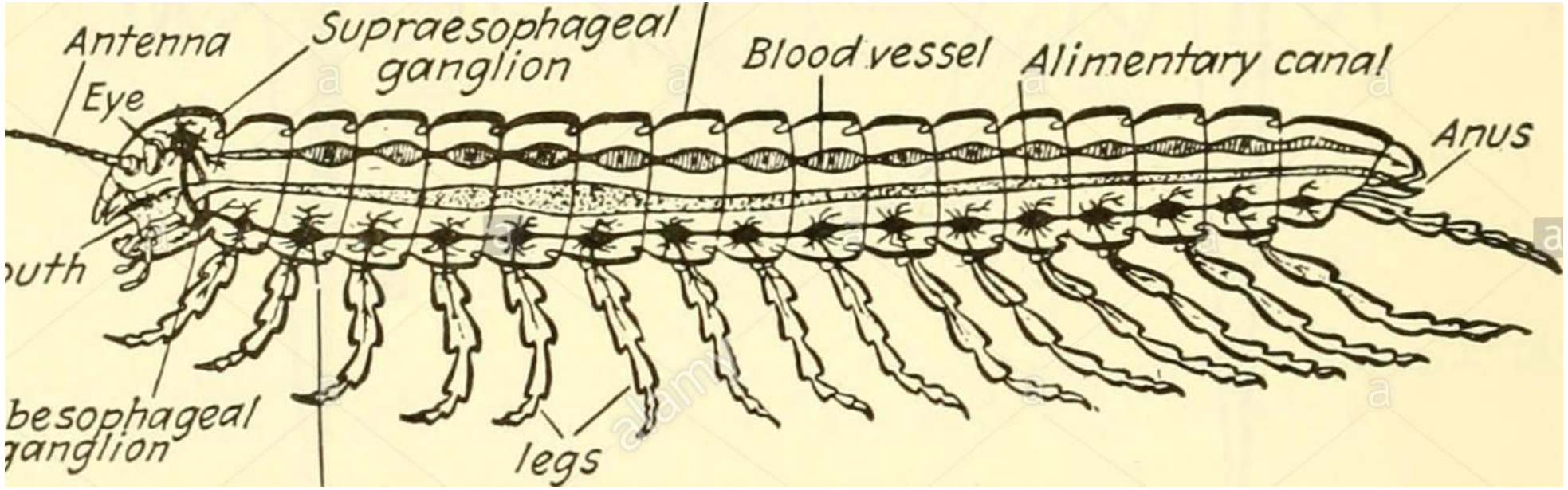
- Evolutionary changes have obscured much of the segmentation in many animals, including humans.

- True metamerism is found in only three phyla: Annelida, Arthropoda, and Chordata

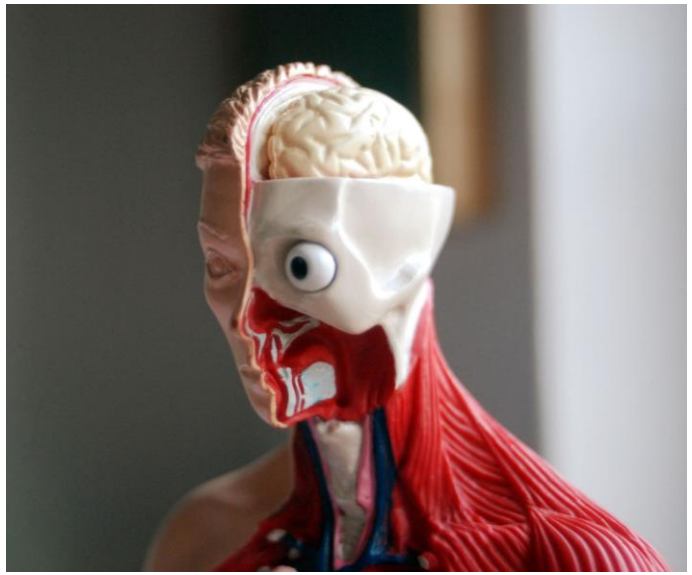


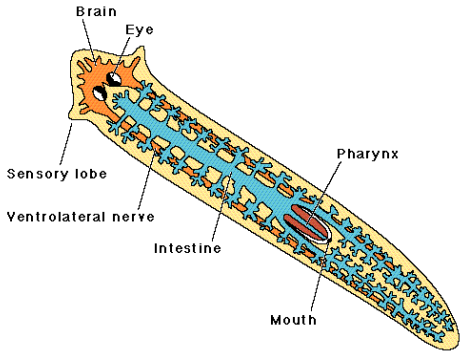
Metamerism

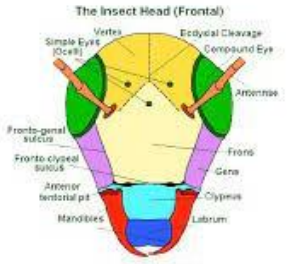
	True Metamerism	Pseudo-Metamerism
Definition	In true metamerism, the parts of the bodywork collectively work for the entire organism.	In pseudo-metamerism, the repeated part of the body may perform the independent task from each other.
Coordination	In true metamerism, the segmented body parts are well coordinated.	In pseudo-metamerism, there is zero coordination between the fragments.
Examples	Earthworms (annelids)	Tapeworms (Cestoda)

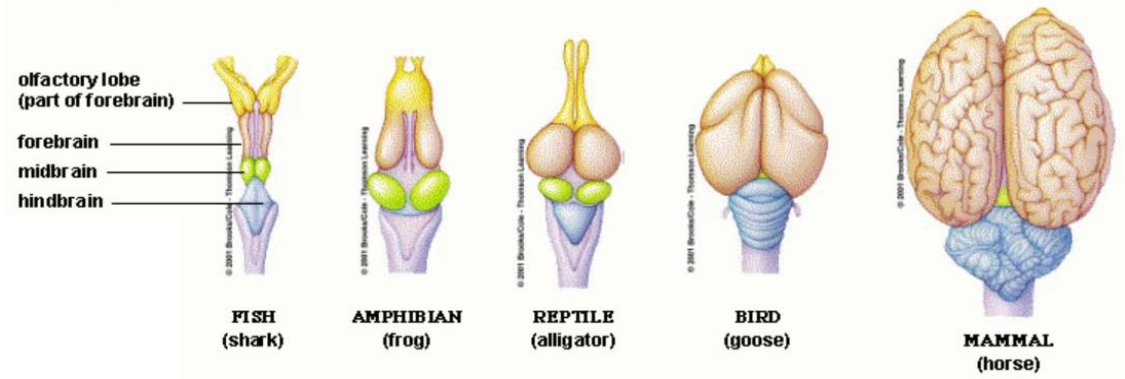


Cephalization









Differentiation of a head is called cephalization and is found chiefly in bilaterally symmetrical animals. The concentration of nervous tissue and sense organs in the head allows obvious advantages to animals moving through its environment. This is the most efficient positioning of organs for sensing the environment and responding to it. Usually, the **mouth** of the animal is **located on the head** as well, since so much of an animal's activity is concerned with procuring food. Cephalization is always accompanied by differentiation along an **anteroposterior axis** (**polarity**). Polarity usually involves gradients of activities between anterior and posterior ends.

https://biocyclopedia.com/index/general_zoology/the_hierarchical_organization_of_animal_complexity.php

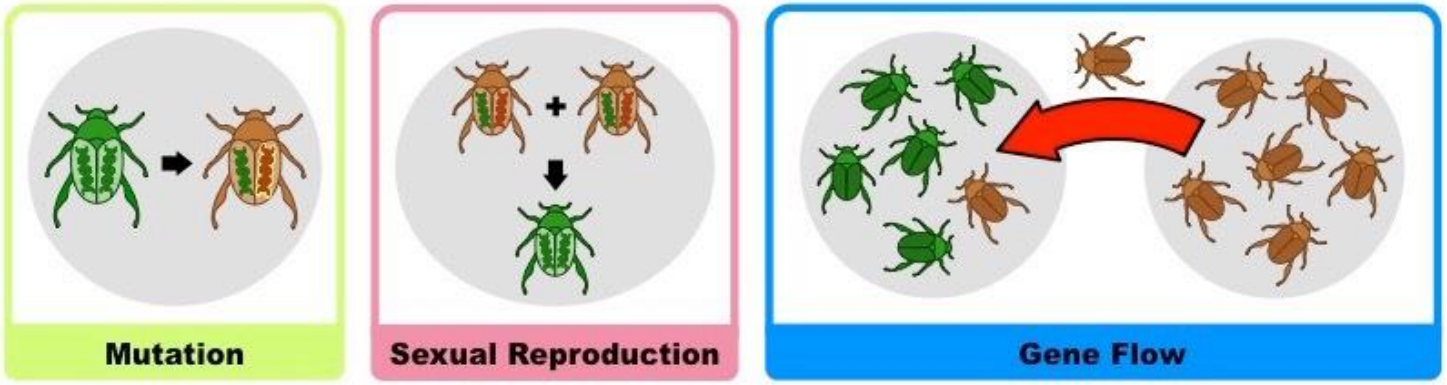
https://biocyclopedia.com/index/general_zoology/types_of_tissues.php

Evolution

Evolution is change in the heritable characteristics of biological populations over successive generations. These characteristics are the expressions of **genes** that are passed on from parent to offspring during reproduction. Different characteristics tend to exist within any given population as a result of **mutation**, **genetic recombination** and other sources of **genetic variation**.

Evolution occurs when evolutionary processes such as **natural selection** and **genetic drift** act on this variation, resulting in certain characteristics becoming more common or rare within a population. The circumstances that determine whether a characteristic should be common or rare within a population constantly change, resulting in the change in heritable characteristics arising over successive generations. It is this process of evolution that has given rise to biodiversity at every level of biological organization, including the levels of species, individual organisms and molecules.

Mechanisms of Variation:



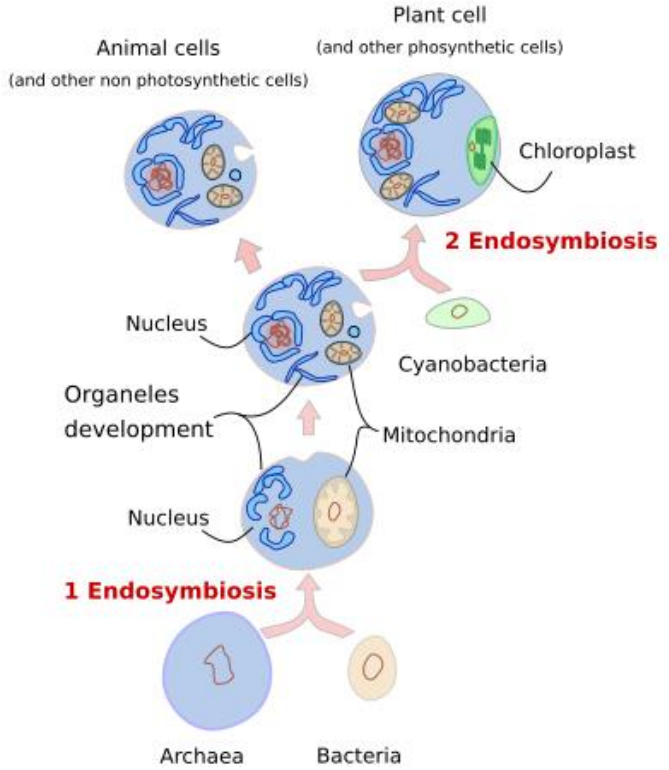
Mechanisms of Change:

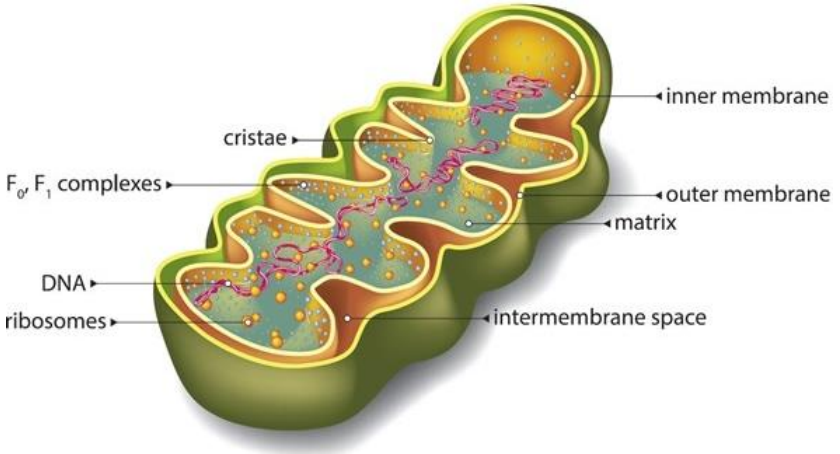
Year	% dark	% light	
1848	5	95	←clean air, light-colored bark
1895	98	2	←pollution, dark-colored bark
1995	19	81	←Clean Air Act, light-colored bark

industrial melanism

Evolution

Animals (and Plants) owe their origins to **endosymbiosis**, a process where one cell ingests another, but for some reason then fails to digest it. The evidence for this lies in the way their cells function. Both plant and animal rely on structures called **mitochondria** to release energy in their cells, using aerobic respiration to produce the energy-carrying molecule ATP. There is considerable evidence that mitochondria evolved from free-living aerobic bacteria: they are the size of bacterial cells; they **divide independently** of the cell by binary fission; they have their **own genome** in the form of a single circular DNA molecule; their **ribosomes** are more similar to those of bacteria than to the ribosomes found in the eukaryote cell's cytoplasm; and like chloroplasts they are enclosed by a **double membrane** as would be expected if they derived from bacterial cells engulfed by another cell.

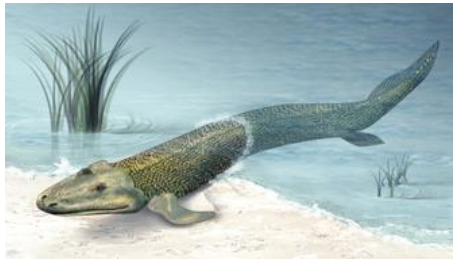


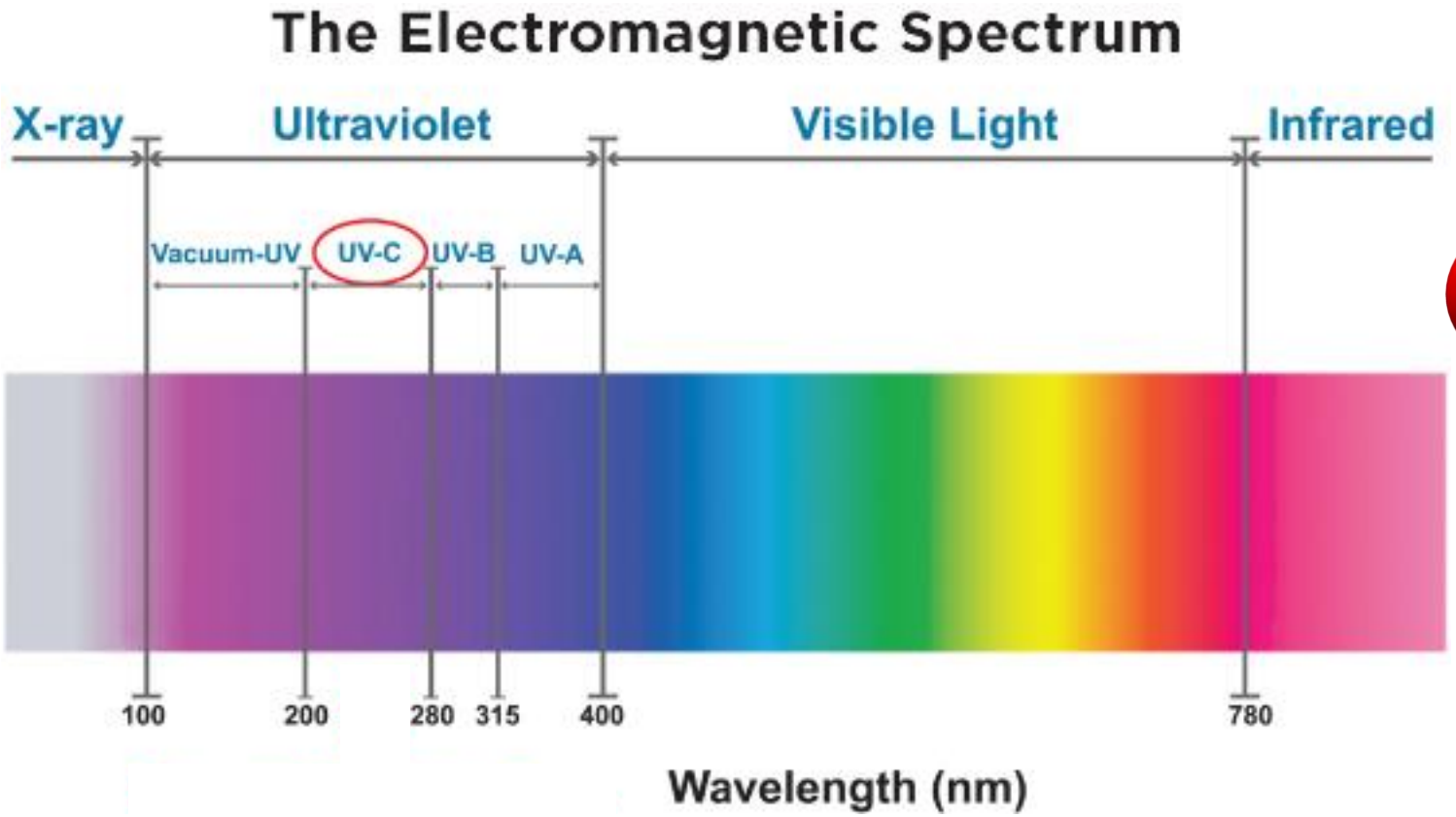


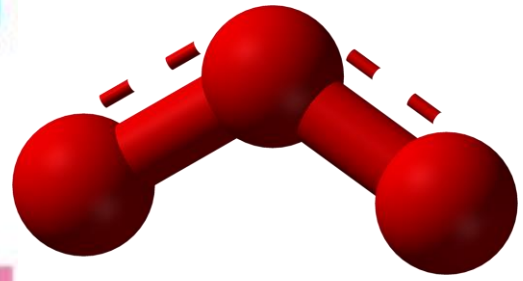
Pea aphids are commonly infested by parasitic wasps. Their secondary endosymbionts attack the infesting parasitoid wasp larvae promoting the survival of both the aphid host and its endosymbionts.

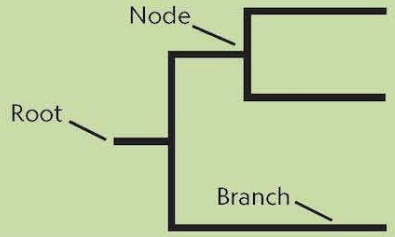
Evolution

Like the plants, animals evolved in the sea. And that is where they remained for at least 600 million years. This is because, in the absence of a protective ozone layer, the land was bathed in lethal levels of UV radiation. Once photosynthesis had raised atmospheric oxygen levels high enough, the ozone layer formed, meaning that it was then possible for living things to venture onto the land.









THE TREE OF LIFE

A phylogenetic tree shows the evolutionary relationships among different organisms. The branches of the tree show where genetic or physical similarities and differences between organisms begin or end.

A phylogenetic tree is like a family tree. The root of the tree represents a distant ancestor of the species that appear at the ends of the branches. The branches separate at nodes, or points where ancestral lines split into new lines of evolution.

Deuterostomia

Protostomia

Chordata
(vertebrates, mammals, humans)
~60,000 species

Echinodermata
(starfishes, sea urchins)
~7,000 species

Arthropoda
(insects, crustaceans, spiders, ticks)
~1,500,000 species

Nematoda
(roundworms)
~20,000 species

Tardigrada
(water bears)
~1,200 species

Mollusca
(clams, snails, squids)
~8,500 species

Annelida
(earthworms, leeches)
~12,000 species

Brachiopoda
(lamp shells)
~300 species

Platyhelmintha
(flatworms)
~13,000 species

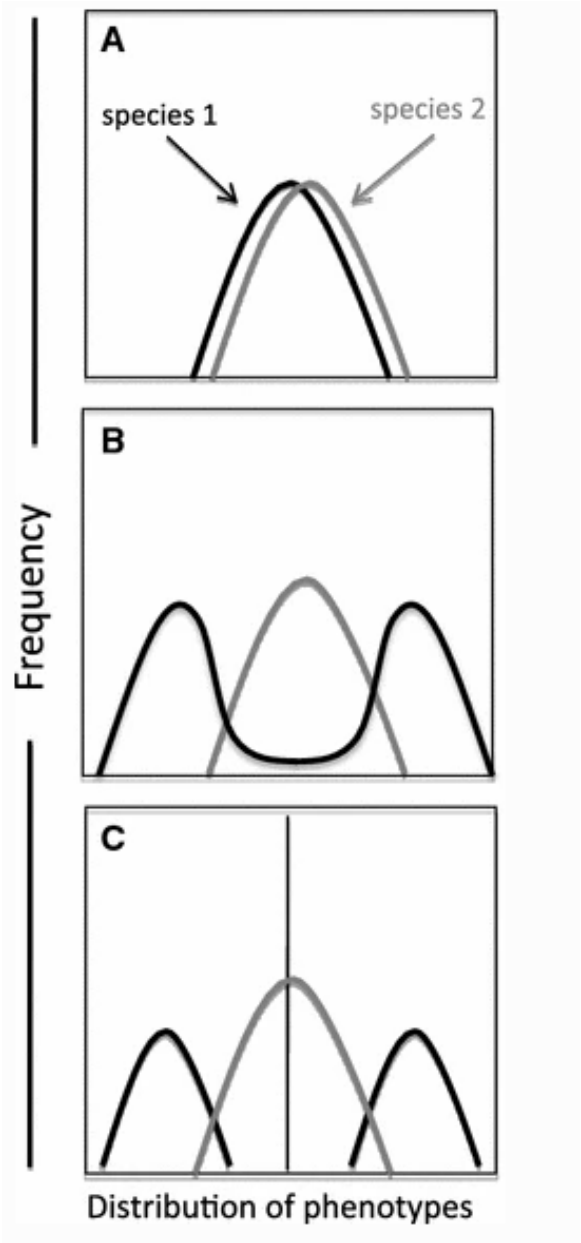
~700 million years ago

Porifera
(sponges)
~5,000 species

Cnidaria
(sea anemones, corals, hydra, jellyfishes)
~9,000 species

This tree of life shows the relationships among common groups of animals. The main branch in this tree, which separates the animals into two distinct groups, *Deuterostomia* and *Protostomia*, split about seven hundred million years ago. This tree shows how today's animal species have diverged over time from common ancestors.

NATIONAL GEOGRAPHIC



Model in which interspecific competition fosters ecological divergence and speciation in a single habitat

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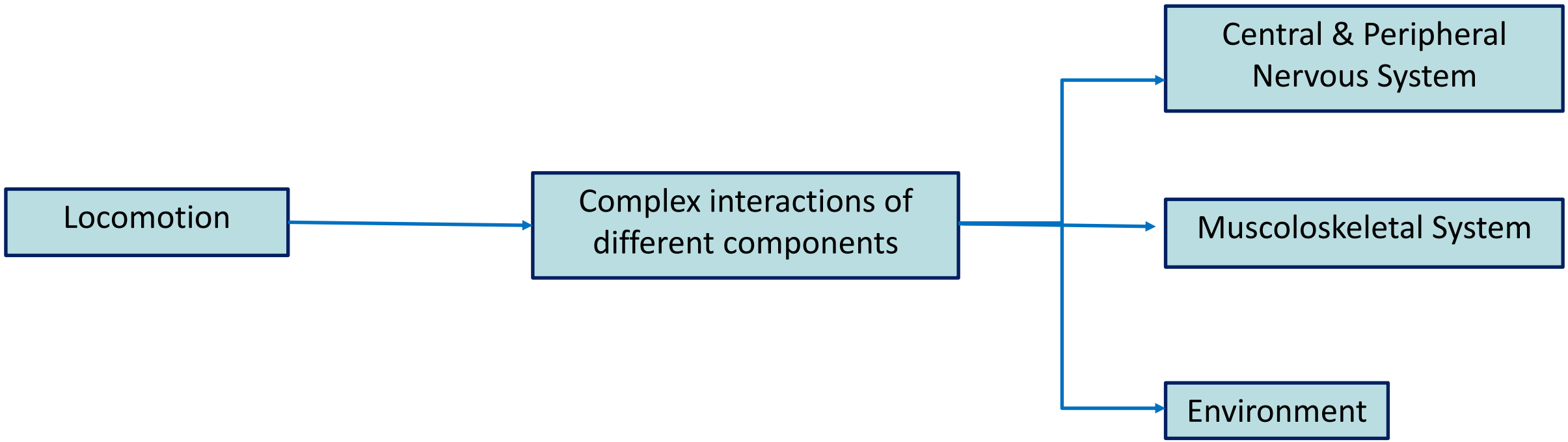
Biological Locomotion and Bioinspired Systems

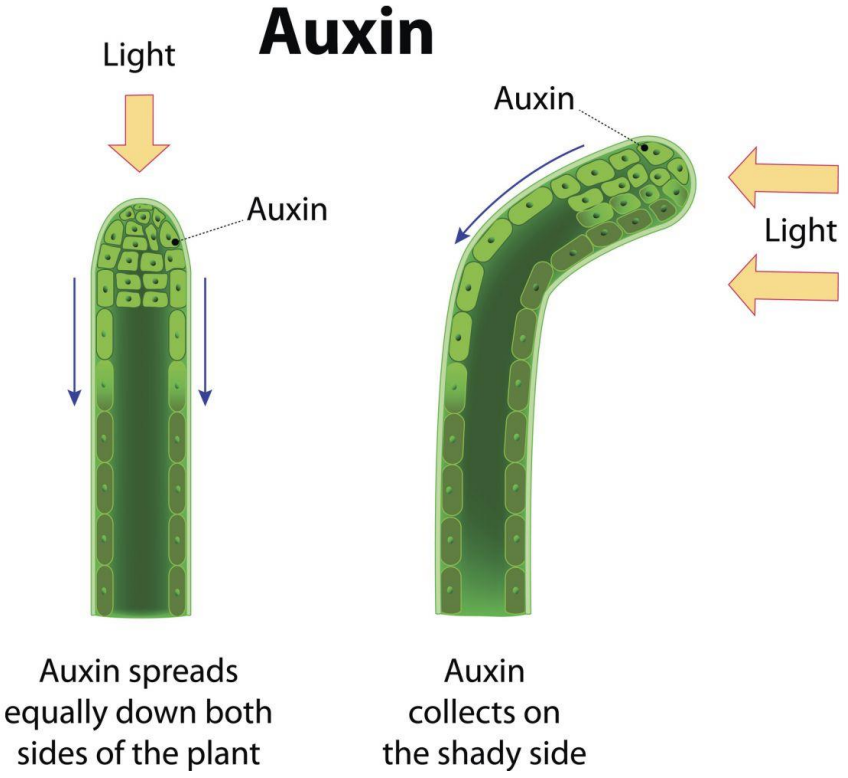


Movement or locomotion?

Movement: displacement of a body part or parts of an organism that does not produce a change in the position of the organisms.

Locomotion: the movement of a part of the body produce a change in the position and location of the organism.

Plant phototropism



Plant gravitropism