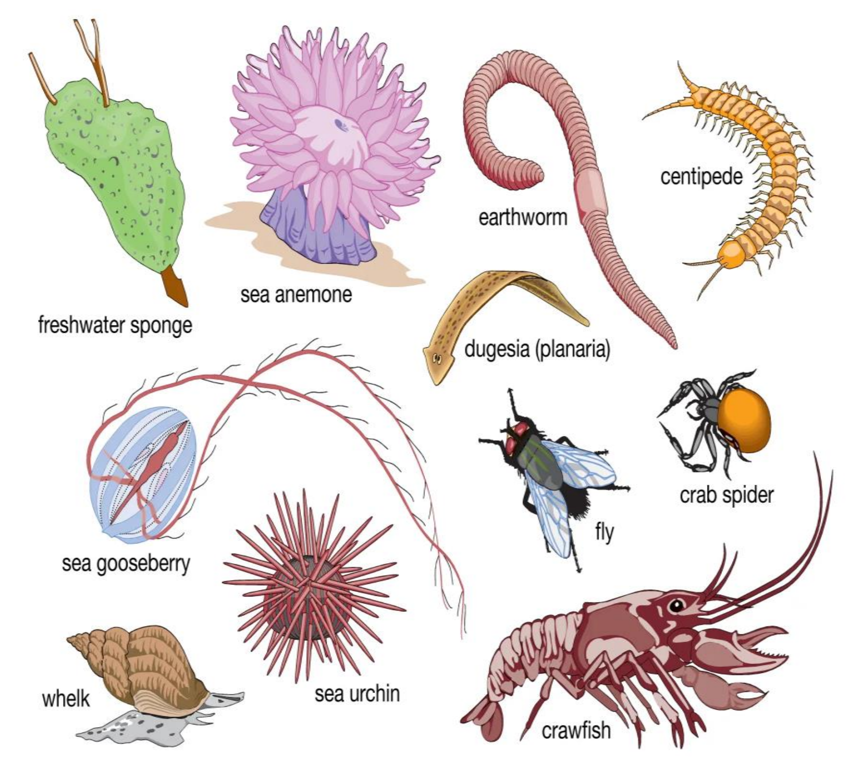
STRUCTURE AND FUNCTIONS OF INVERTEBRATES

SEMESTER: I
UNIT: I



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UNIT-I

DIVERSITY OF ANIMAL KINGDOM

Diversity of Animal kingdom: Linnaeus and the origin of classification, taxonomic characters and reconstruction of phylogeny, Levels of organization-Unicellularity-multicellularity, Colonization and organization of germ layers-Division of labour and organization of tissues-ectoderm, mesoderm and endoderm-Development of Acoelomate organization-symmetry-symmetry-segmentation and cephalization

ANIMAL DIVERSITY

Animal diversity represents the fundamental structural differences between groups of organisms; adaptive diversity represents the smaller differences between species as a result of habitat specialization

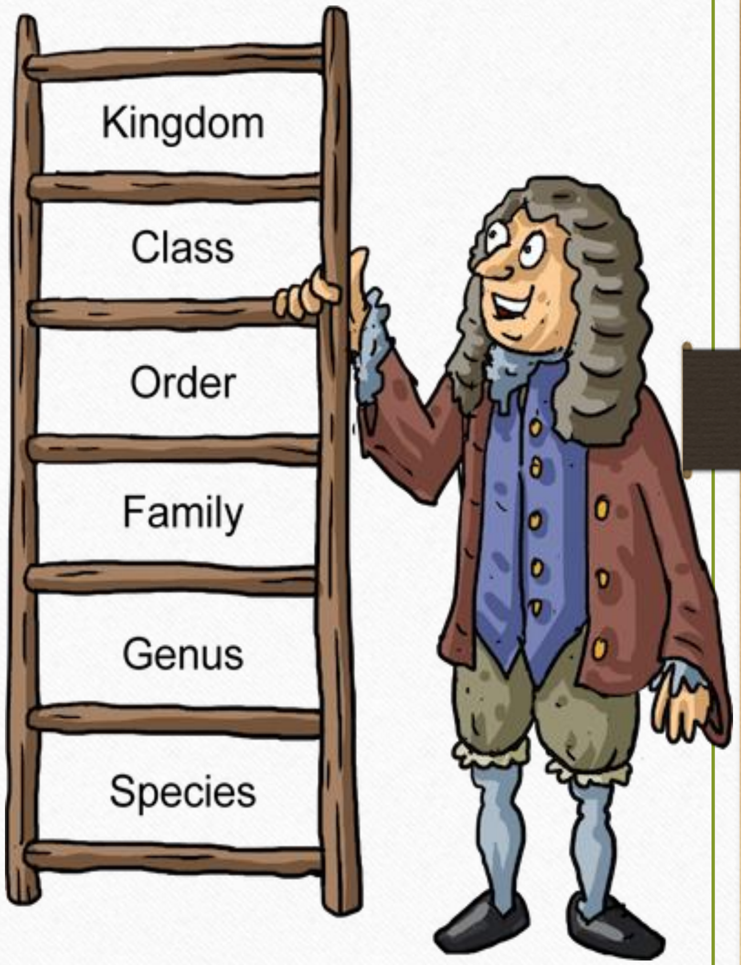
Classification of Living Things

Scientists estimate that there are between **3 million** and **100 million** species of organisms on Earth.

Taxonomists--biologists who specialize in identifying and classifying life on our planet--have named approximately **1.7 million** species so far.

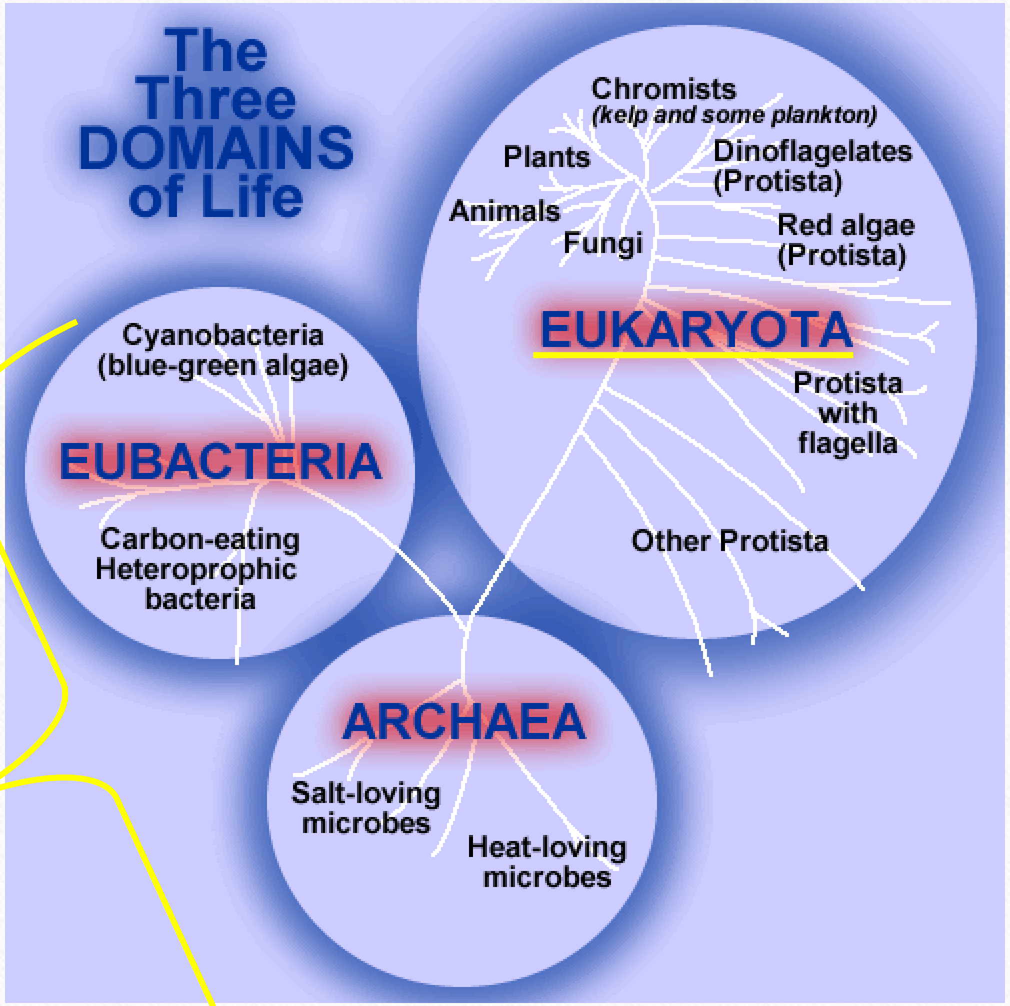
Each year, about **13,000** **new species** are added to the list of known organisms.

So, how do scientists **classify** (organize) all these millions of species?



2 Types of Cells

3 Domains and 4 Kingdoms

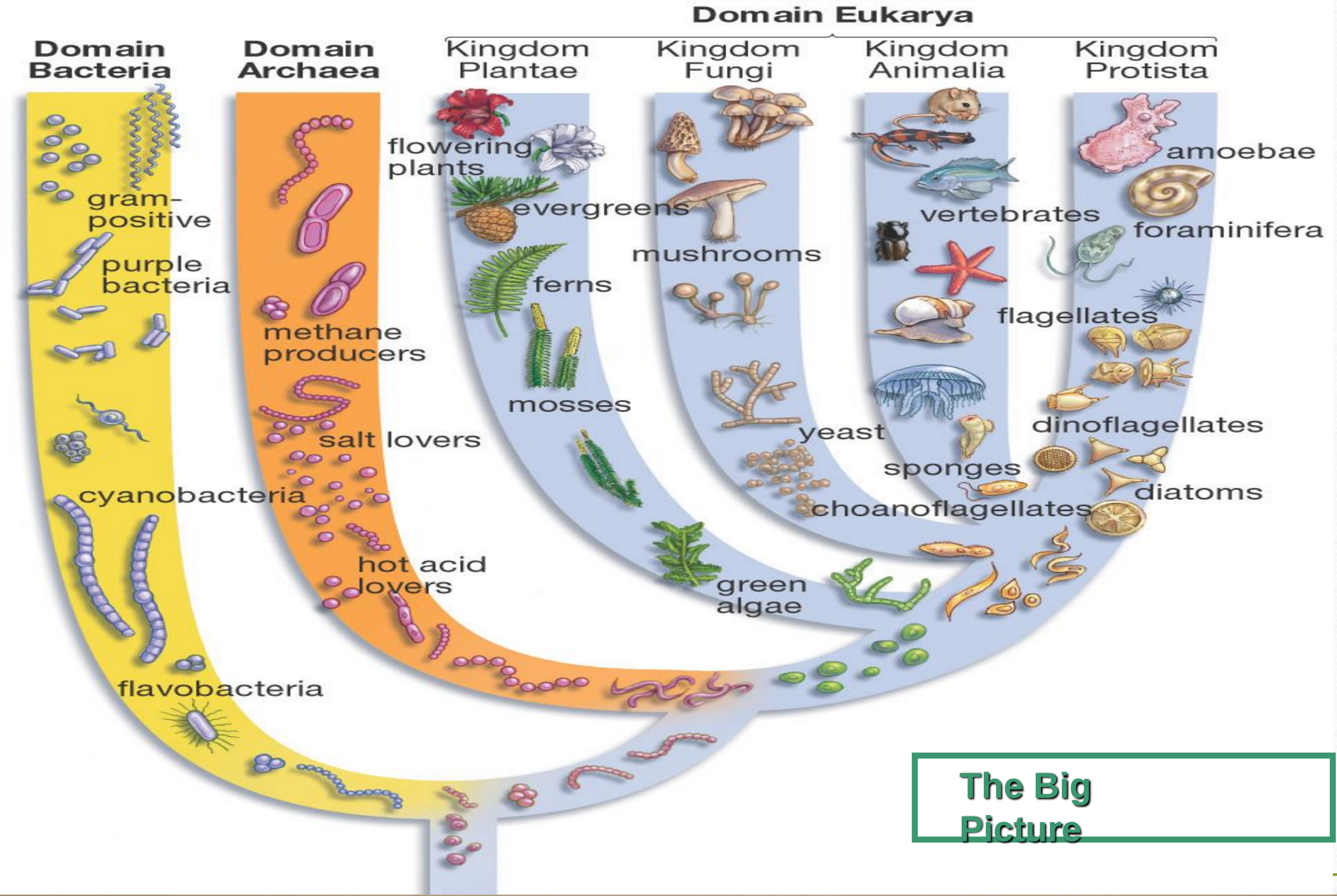


EUKARYOTES

organisms **with** a nuclear membrane

PROKARYOTES

organisms with **no** nuclear membrane



The Big Picture

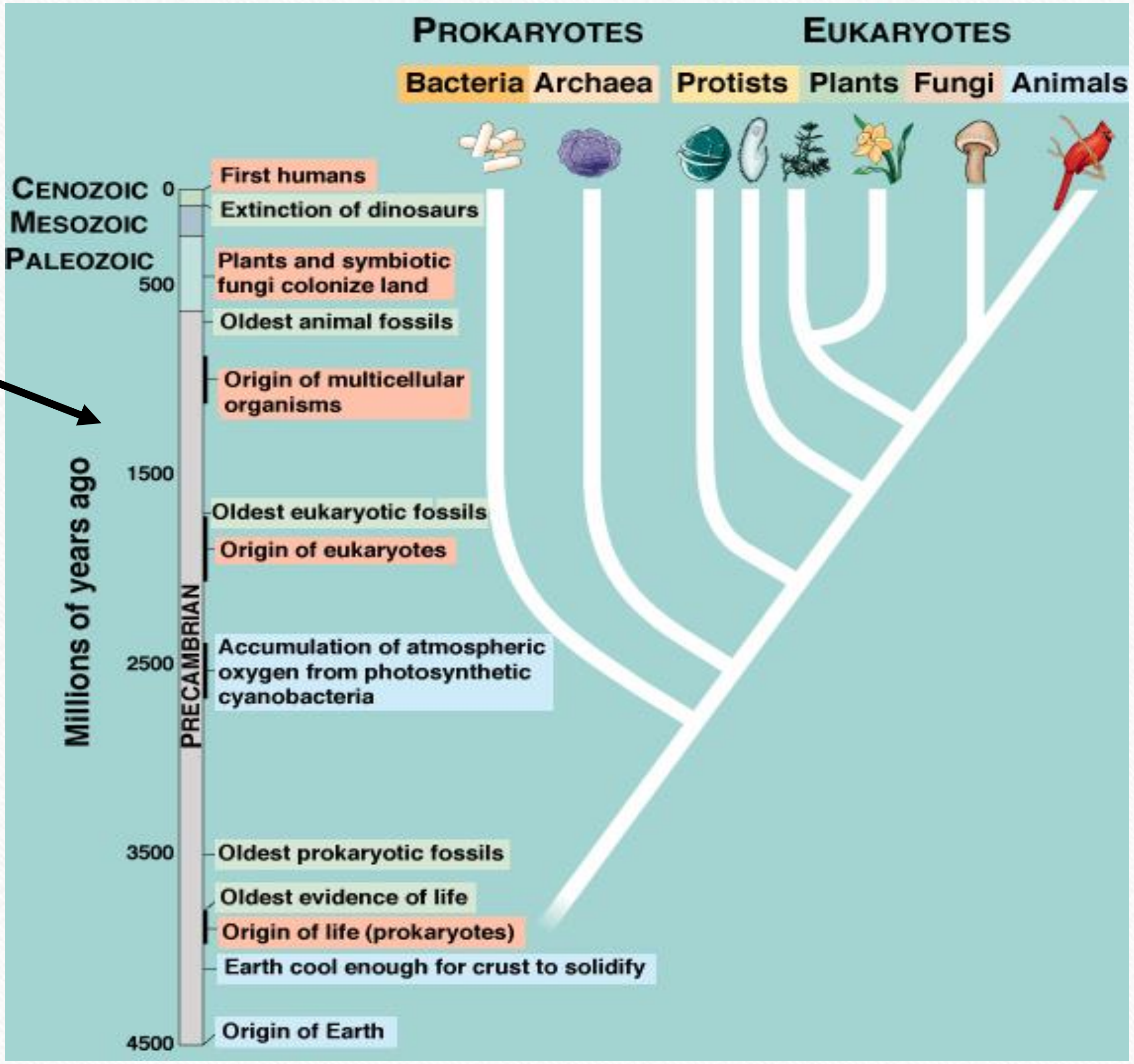
The History of Life on Earth

Multicellular eukaryotes (<u>with</u> nuclear membrane) evolved about 1 billion years ago.

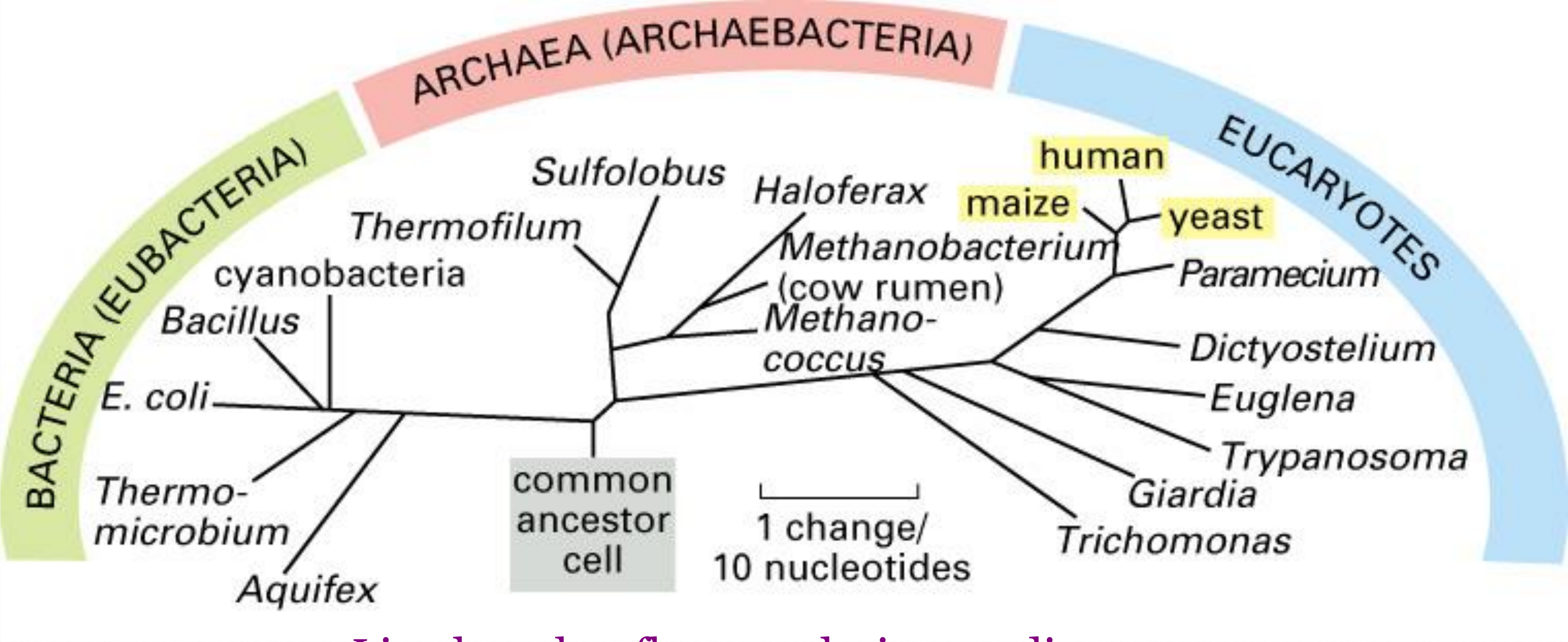
For 2.6 billion years, life was **unicellular.**

Life began on Earth 3.6 billion years ago as a **prokaryotic cell** (single-celled organism with **no nuclear membrane).**

The Earth formed 4.5 billion years ago.



Life's History and Diversity



Line length reflects evolutionary distance.

Note the close spacing of the groups **plants** **(maize)**, **fungi** **(yeast)** and **animals** **(humans).**

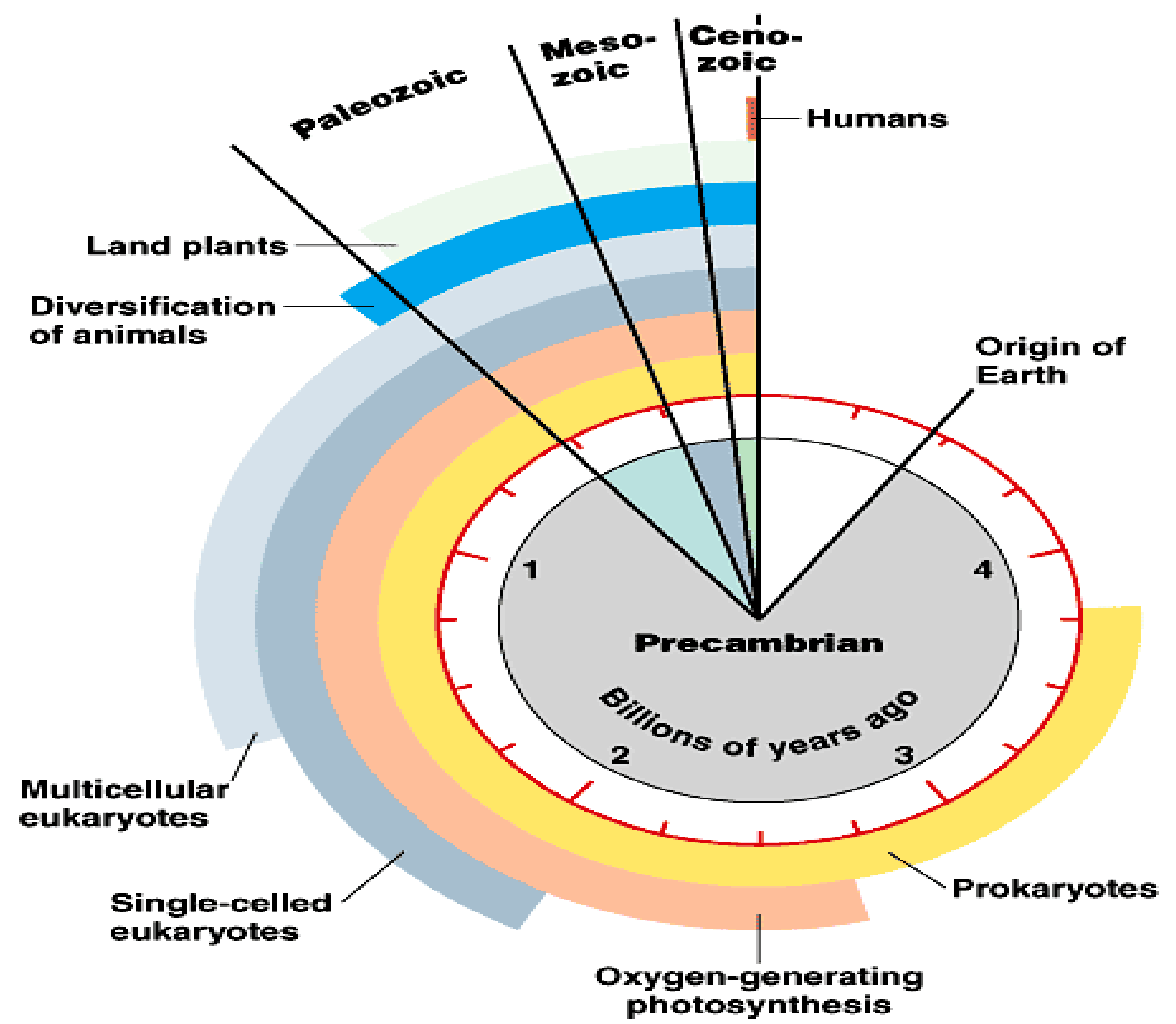
We've got a lot more in common with bacteria and plants than we think!

Life's History

Animals diversified in the ocean about 600 million years ago.

Plants colonized land about 440 million years ago and were followed shortly by animals.

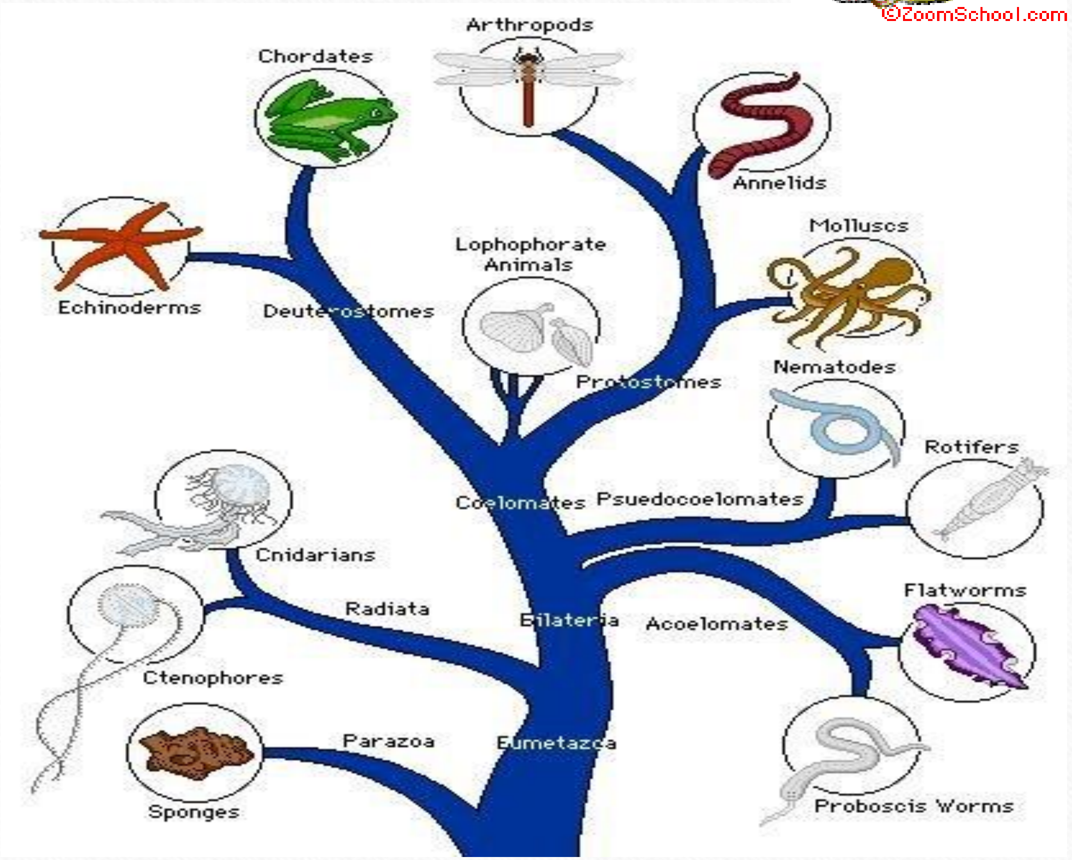
Humans of any sort are a very recent evolutionary development (~ 7 million years ago).

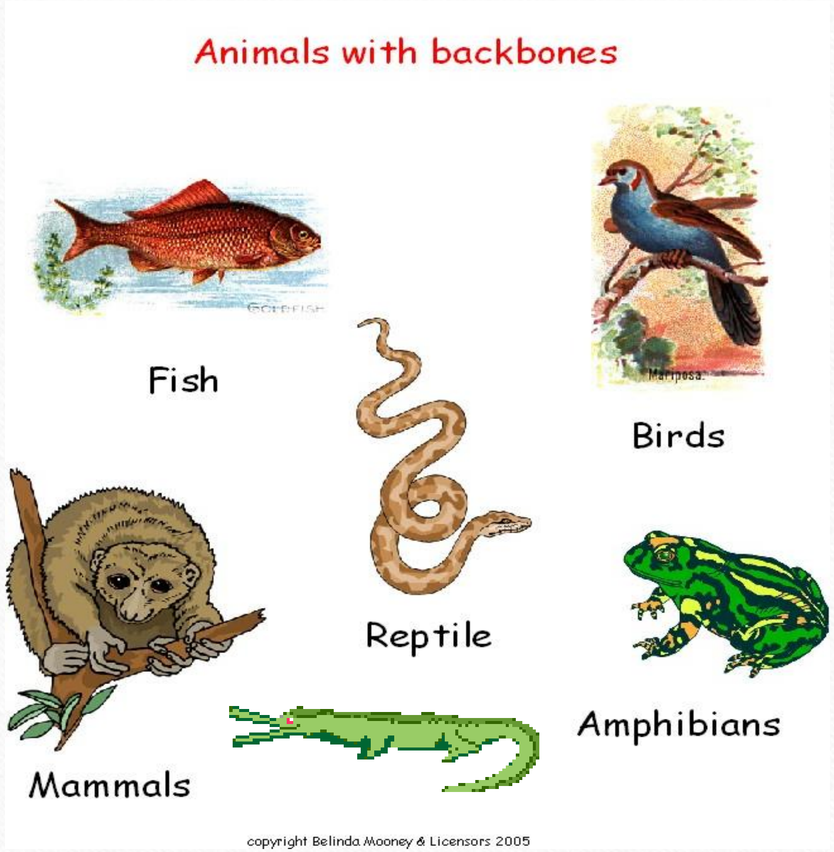


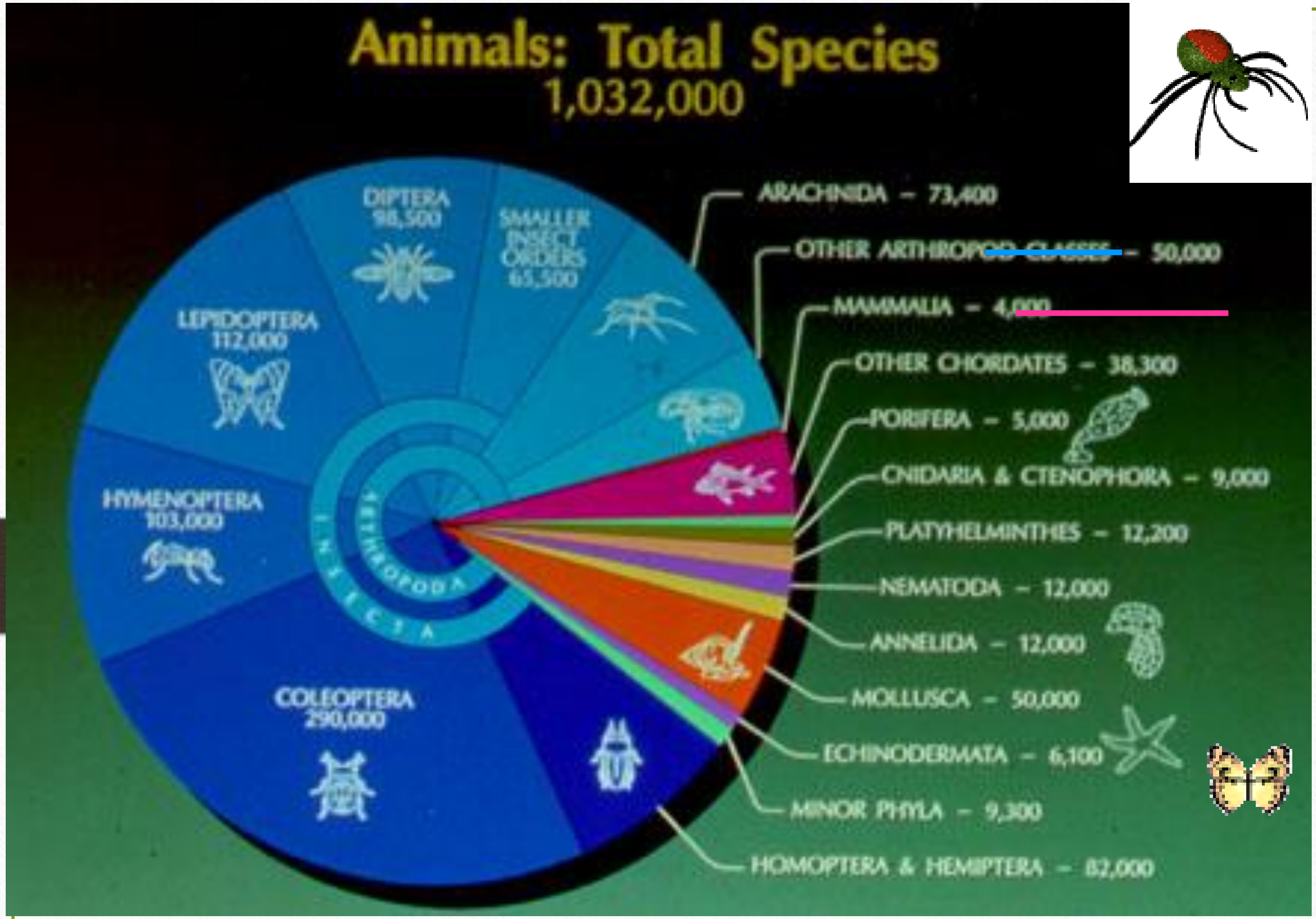
ANIMALS

Invertebrates (no backbone)

Vertebrates (backbone)







As you can see, we **mammals** (4000 species) are far outnumbered by the other **vertebrates, or chordates** (38,300). And **vertebrates** (42,300) are definitely outnumbered by **invertebrates** (989,700 species). The biggest categories of invertebrates: INSECTS!

Why Classify?

- To make it easier to **study life!**
- Taxonomy- the assigning of a universally accepted name to a species.
- **Binomial nomenclature-** An organism's classification is based on its Genus and species names. The Genus is ALWAYS capitalized, and the species name is NEVER capitalized.
- E.g. *Homo sapiens* (humans), *Odocoileus virginianus* (White tailed deer)

Early Classification Systems

Aristotle was the first scientist to develop a classification system for organisms.

He divided animals into three groups: Those that fly, those that swim, and those that walk, crawl or run.

He then further divided these groups into subgroups such as by where they live.

Which groups would the previous three animals fall under?

What is the problem with this system?

As you could see that even though all the organisms in a group moved in a similar way, they were different in many other ways. Aristotle then used there differences to further divide each group into subgroups. Smaller groups of organisms that shared other similarities.

Early Classification Systems continued.

- Carolus Linnaeus was a Swedish scientist who expanded on Aristotle's idea of classification.
- He placed them in groups based on their observable features.
- He devised a naming system called **Binomial nomenclature** where each organism is given a two-part name.

Linnaeus

We use a system today that was originally created by Carl **Linnaeus**. Linnaeus- (1707-1778) A botanist who created a classification system of organisms based on their physical similarities with each other. Originally, Linnaeus only had two Kingdoms, or major categories-Plant and Animal.

Binomial Nomenclature

(by NOH mee ul NOH men klay chur)

This two-part naming system is made up of the **genus** and **species** name.

The **genus** name is always capitalized and the species name is either written in italics or underlined.

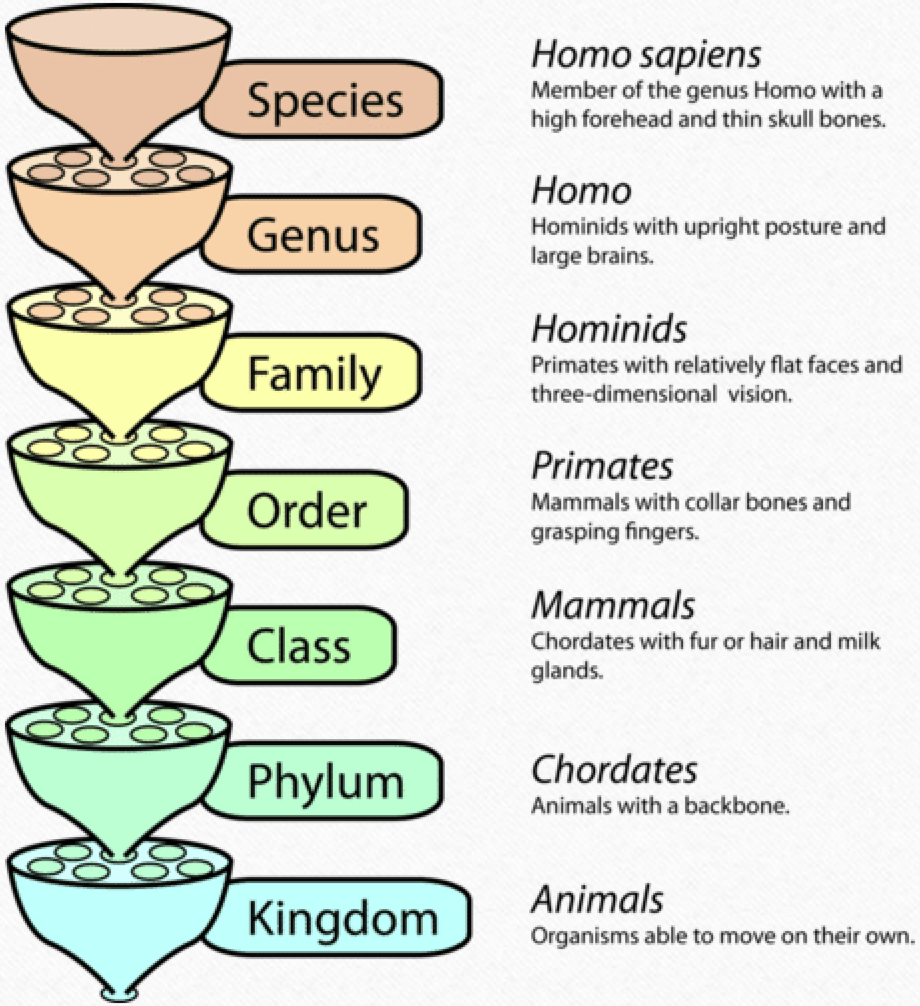
EX: Felis *domesticus*

Most scientific names are Latin. Why do you think they are written this way?

LINNAEUS AND THE ORIGIN OF CLASSIFICATION

Carolus Linneaus (**1707-1778**) was a Swedish doctor, botanist, and explorer who extensively studied taxonomy, which is the study of the names and classifications of living organisms. He made two major contributions to the subject, namely the **Linnaean Classification System** and the **binomial system of naming species**. These systems of Linnaean taxonomy continue to be used for classifications of newly discovered species today.

All modern classification systems have their roots in the Linnaean classification system. It was developed by Swedish botanist **Carolus Linnaeus in the 1700s**. He tried to classify all living things that were known at his time. He grouped together organisms that shared obvious physical traits, such as number of legs or shape of leaves. For his contribution, Linnaeus is known as the "**father of taxonomy**."



The Linnaean system of classification consists of a hierarchy of groupings, called **taxa** (singular, taxon). **Taxa range from the kingdom to the species.** The **kingdom is the largest and most inclusive grouping**. It consists of organisms that share just a few basic similarities. Examples are the plant and animal kingdoms. The **species** is the smallest and most exclusive grouping. **It consists of organisms that are similar enough to produce fertile offspring together. Closely related species are grouped together in a genus**.

History of Classification- Carolus Linnaeus

Considered by many to be the father of Modern Taxonomy.

Provided 2 contributions:

- Binomial Nomenclature
- Classification System

Contributions of Linnaeus

Binomial Nomenclature

- System of naming organisms
- Gives each species a 2 worded Latin name

- Genus: a species first name (first letter always capitalized)
- Species: a species second/last name (always lower-case)

Contributions of Linnaeus

- Classification System
  - Created a natural system of classification that uses morphology (structure) of an organism to arrange them into hierarchal categories

Taxon: the named taxonomic unit at any level

Example: Sapien is the species level of humans

Linnaeus' Classification System

Phylum

- Group of similar classes
- Organisms share a common body plan

Class

- Group of similar orders
- Based on a major variation in the body plan adapted to a specific way of life

Phylum

– Group of similar classes

– Organisms share a common body plan

Class

– Group of similar orders

– Based on a major variation in the body plan adapted to a specific way of life

Order

– Group of similar families

Family

– Group of similar genera

– Reflect an adaptation to a particular habitat or feeding

Genus

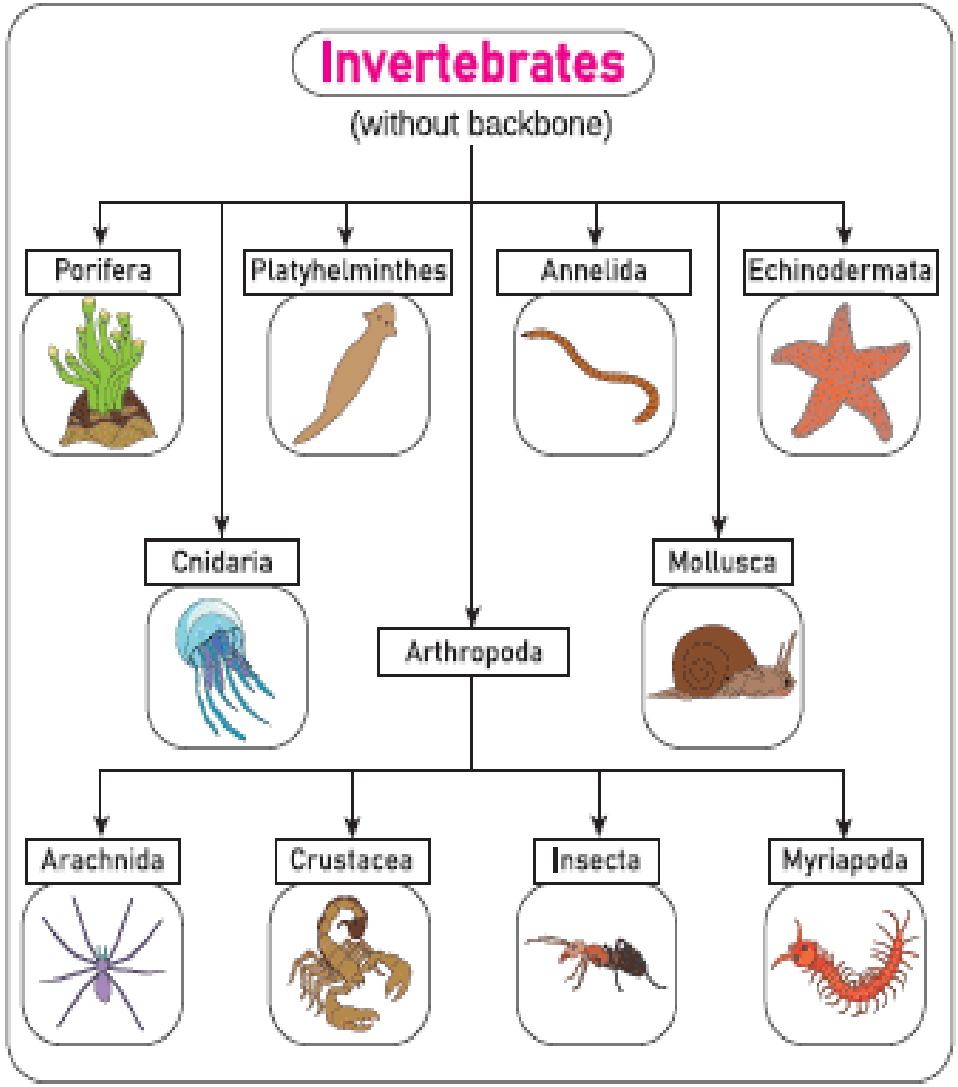
- Group of similar species
- First name of a species according to binomial nomenclature (B.N.)

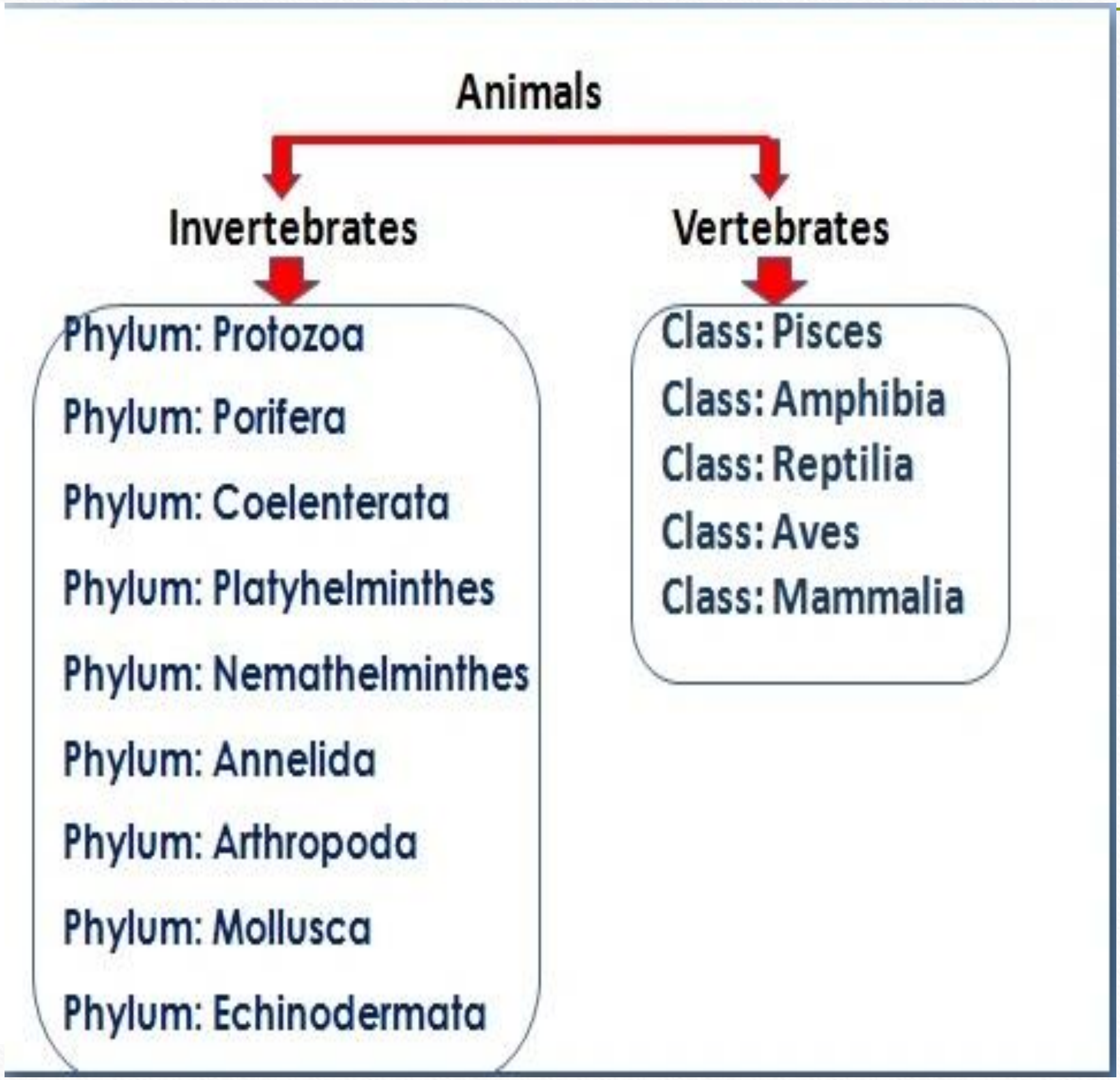
Species

- Population of an organism that can reproduce and produce fertile offspring
- Second name of a species according to B.N.
  - There can be variation among members of the same species (not age or sex)

Benefits of Classification

1) Organized
2) Compares similarities and differences of organisms
3) International usage
4) Shows evolutionary relationships


Invertebrates
(without backbone)
Porifera
Platyhelminthes
Annelida
Echinodermata
Cnidaria
Mollusca
Arthropoda
Arachnida
Crustacea
Insecta
Myriapoda


Animals
Invertebrates
Vertebrates
Phylum: Protozoa
Phylum: Porifera
Phylum: Coelenterata
Phylum: Platyhelminthes
Phylum: Nemathelminthes
Phylum: Annelida
Phylum: Arthropoda
Phylum: Mollusca
Phylum: Echinodermata
Class: Pisces
Class: Amphibia
Class: Reptilia
Class: Aves
Class: Mammalia

Asterias rubens Linnaeus 1758

Kingdom	: Animalia
Phylum	: Echinodermata
Class	: Asteroidea
Order	: Forcipulatida
Family	: Asteriidae
Genus	: *Asteria*
Species	: *A. rubens*

TAXONOMIC CHARACTERS AND RECONSTRUCTION OF PHYLOGENY

A taxonomic characteristic may be defined **as any expressed attribute of an organism that can be evaluated and that has two or more discontinuous states or conditions**. The taxonomic value of a characteristic is increased if the biological significance of the characteristic has been determined.

KINDS OF CHARECTERS

- ✓ Morphological characters
- ✓ Physiological characters
- ✓ Ecological characters
- ✓ Behavioral characters
- ✓ Geographical characters
- ✓ Molecular characters

Morphological characters

General external morphology

Special structures (e.g. genitalia)

Internal morphology (anatomy)

Embryology

Karyology and other cytological factors

Physiological characters

Metabolic factors

Body secretions

Genic sterility factors

Ecological characters

Habit and habitats

Food, Parasites and hosts

Seasonal variations

Behavioral characters

Courtship and other ethological isolating mechanisms

Other behavior patterns

Geographic characters

General biogeographic distribution patterns

Sympatric-allopatric relationship of populations

Molecular characters

Immunological distance

Electrophoretic differences

Amino acid sequences of proteins

DNA hybridization

DNA and RNA sequences

Restriction endonuclease analyses

Other molecular differences

PHYLOGENY RECONSTRUCTION

A phylogeny is the evolutionary history of a group of entities. Given that this can only truly be known in exceptional circumstances, the main aim of phylogeny reconstruction is to describe evolutionary relationships in terms of relative recency of common ancestry. Four inference methods based on three optimization criteria are commonly used to reconstruct evolutionary history from molecular data: **neighbor joining** (NJ), **minimum evolution** (ME), **maximum parsimony** (MP), and **maximum likelihood** (ML).

Phylogenetic Reconstruction Methods

Distance-based Methods

Character-based Methods

- non-statistical
  - a. parsimony
- statistical
  - a. maximum likelihood
  - b. Bayesian inference

Phylogenetics is important because it enriches our understanding of how genes, genomes, species (and molecular sequences more generally) evolve.

Distance-based methods

UPGMA (Unweighted Pair Group Method with Arithmetic mean)

Neighbor Joining

Fitch-Margoliash

Character-based methods

Maximum Parsimony

Maximum Likelihood (Probability-based)

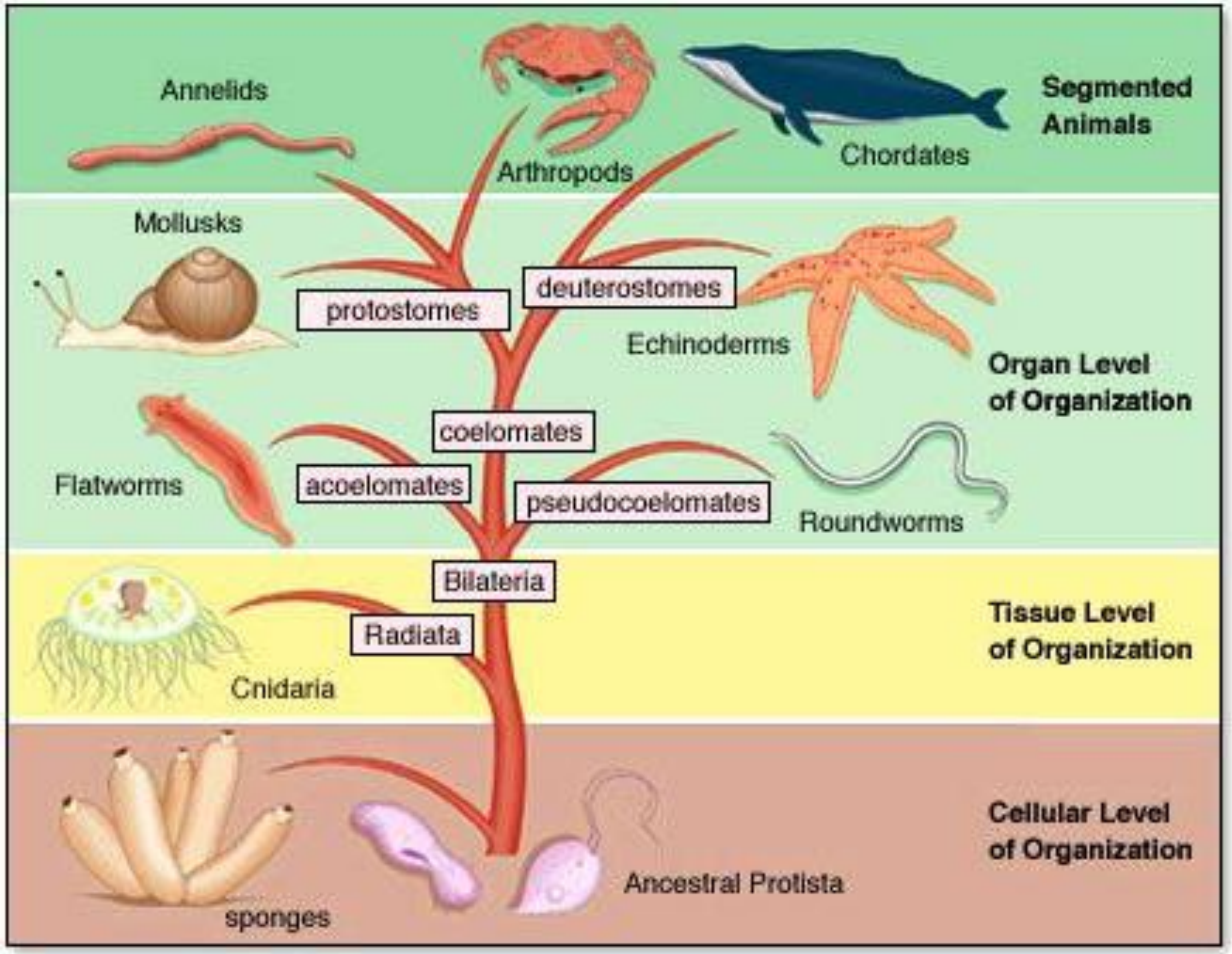
Bayesian Inference (Probability-based)

STEPS

1. Selection of organisms or a gene family
2. Choosing appropriate molecular markers
3. Amplification, sequencing, assembly
4. Alignment
5. Evolutionary model
6. Phylogenetic analysis
7. Tree construction
8. Evaluation of phylogenetic tree

LEVEL OF ORGANIZATION

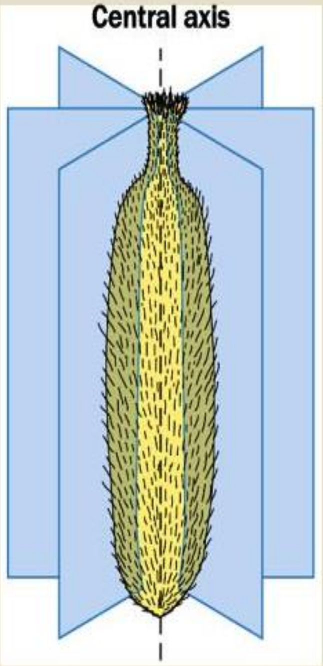
Levels of organization are structures in nature, usually defined by part-whole relationships, with things at higher levels being composed of things at the next lower level. An organism is made up of four levels of organization: **cells, tissues, organs, and organ systems**. These levels reduce complex anatomical structures into groups; this organization makes the components easier to understand.



Cell level organization

PHYLUM PORIFERA
*CELLULAR LEVEL OF ORGANIZATION

- Organisms in the phylum Porifera are among the simplest animals
  - Many sponges are **radially symmetrical**
    - Their parts are arranged around a **central axis**
  - **Choanocytes** are specialized cells that make up poriferans.



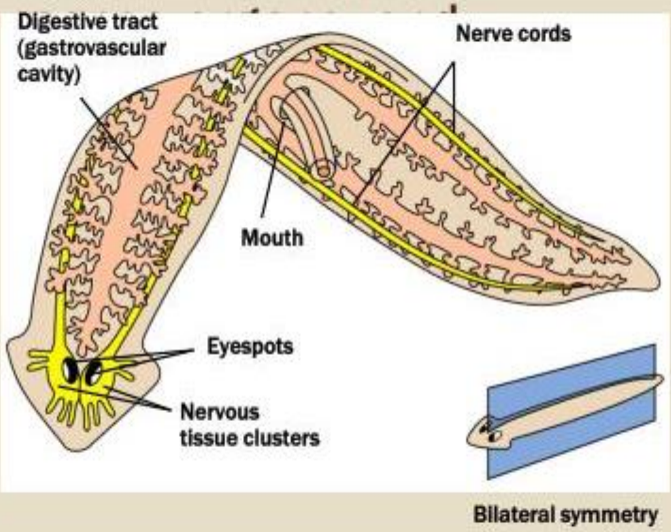
Tissue level organization

Organ level organization

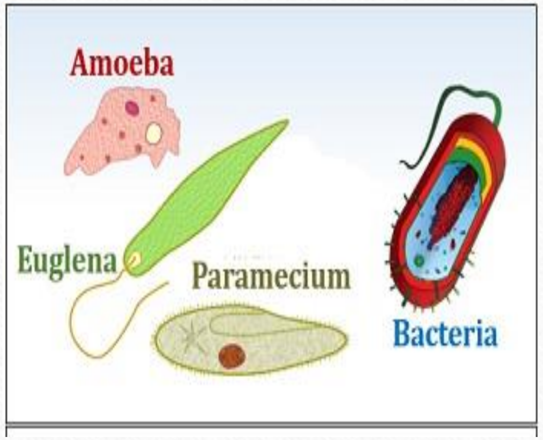
Mollusca, Echinoderms and Platyhelminthes

*ORGAN LEVEL OF ORGANIZATION

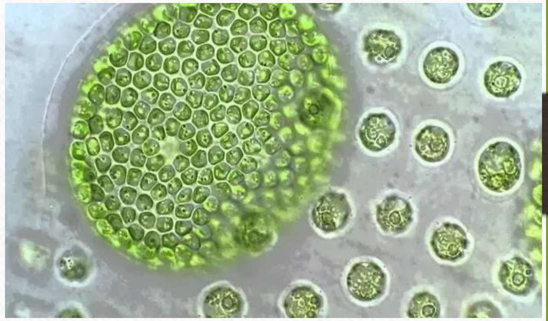
- **Flatworms are the simplest bilateral animals.**
- **Flatworms have organs.**
- Planarians have a simple nervous system consisting of a brain branching nerves.
- As in cnidarians, the mouth of a flatworm is the only opening for its gastrovascular cavity.



UNICELLULARITY



A condition or state in which an organism carries out all functions within one cell. These unicellular organisms are mostly invisible to the naked eye, hence, they are also referred to as microscopic organisms. Most of the unicellular organisms are also prokaryotes. Bacteria, amoeba, Paramecium, archaea, protozoa, unicellular algae, and unicellular fungi are examples.

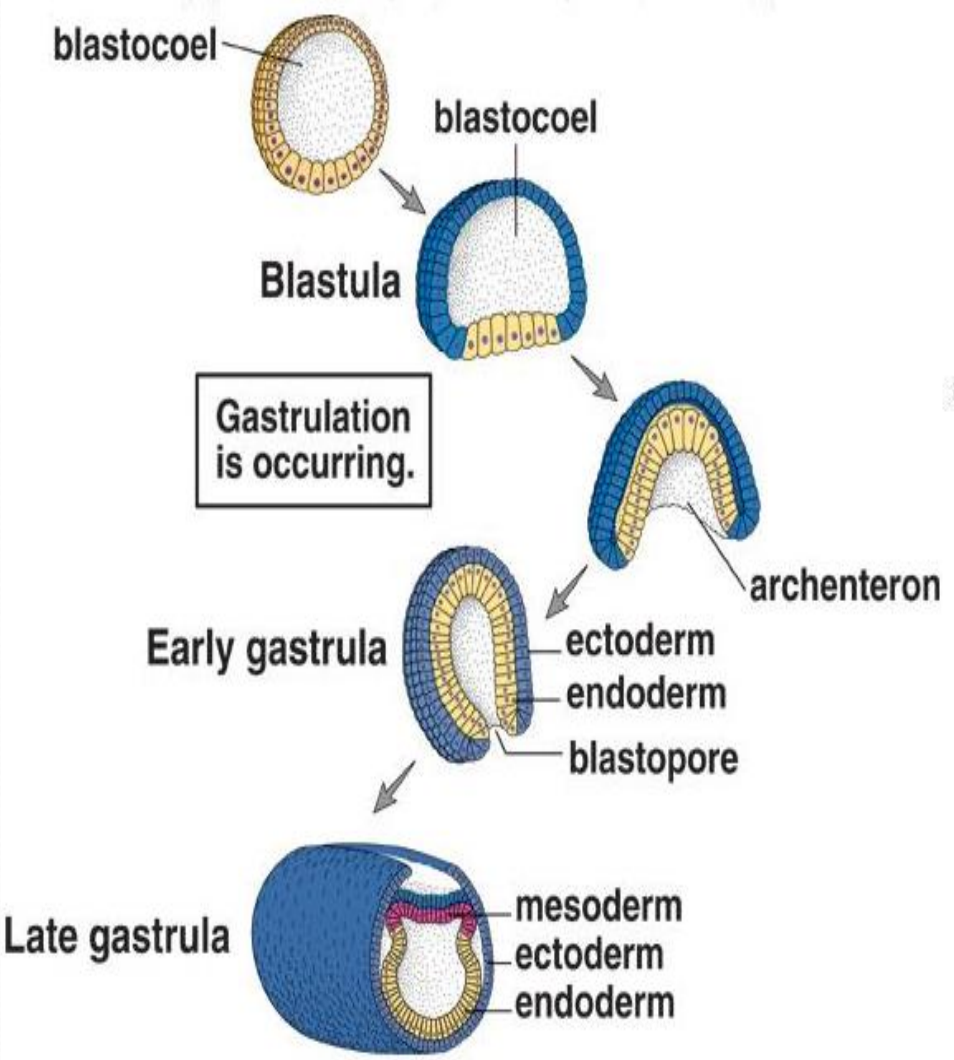


MULTICELLULARITY

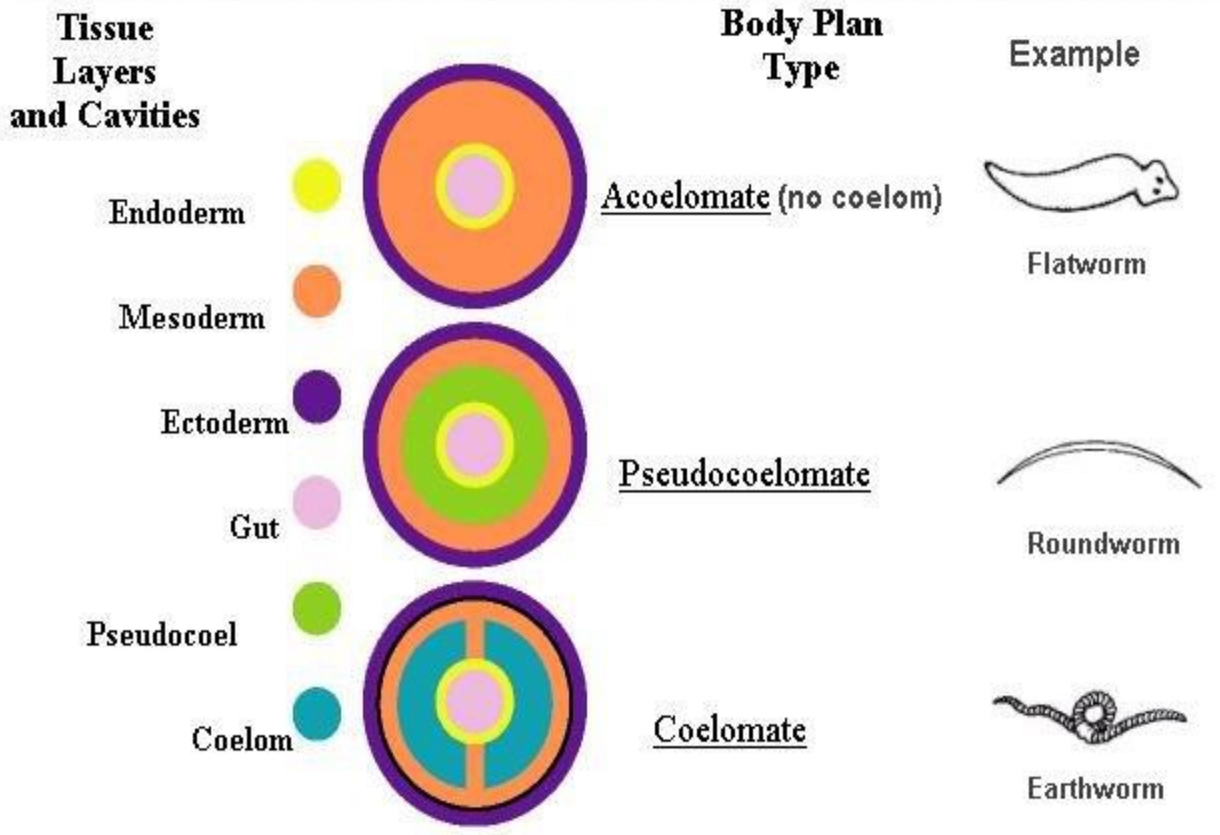
Multicellular organisms are composed of more than one cell, with groups of cells differentiating to take on specialized functions. They possess distinct organs and organ systems. They are eukaryotes including humans, animals, and plants.

COLONIZATION AND ORGANIZATION OF GERM LAYERS

The germ layers develop early in embryonic life, through the process of gastrulation. During gastrulation, a hollow cluster of cells called a blastula reorganizes into two primary germ layers: an inner layer, called endoderm, and an outer layer, called ectoderm.



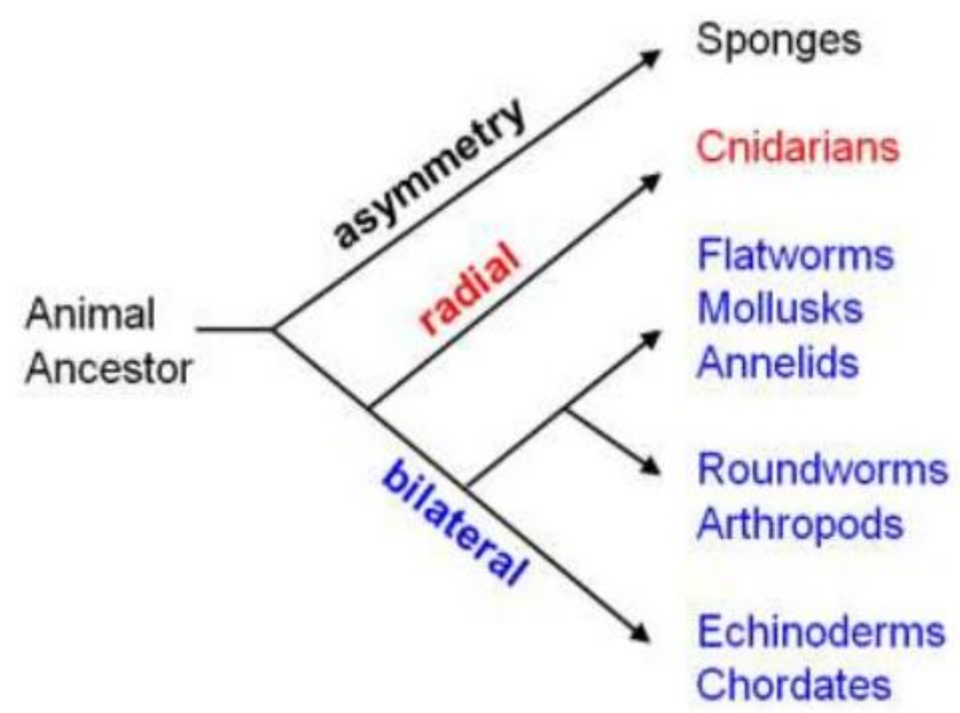
In all animals, except for organisms of the phylum Cnidaria, the endoderm and ectoderm interact to produce a third germ layer, called mesoderm

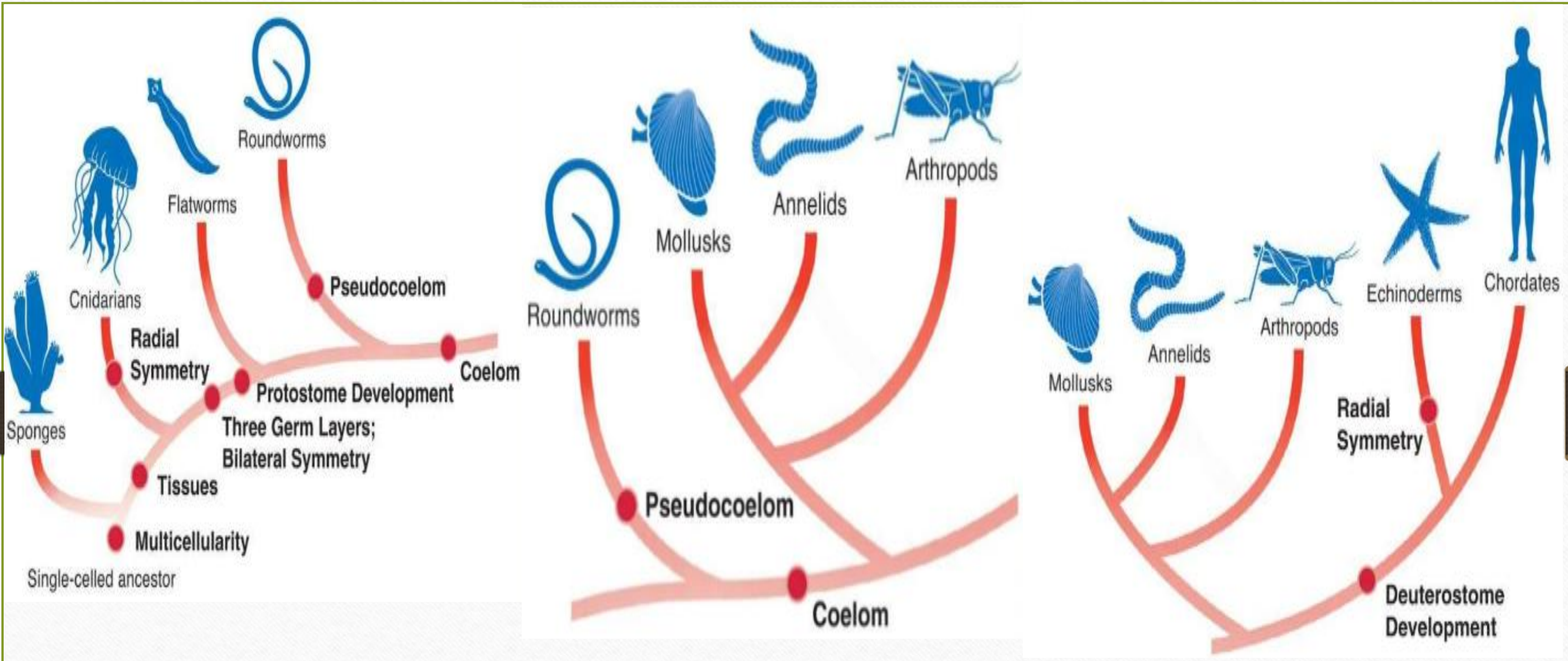


DIVISION OF LABOUR AND ORGANIZATION OF TISSUES

Division of labour is adaptation of different parts of an organism to carry out different functions. The complex tissues which are made up of different types of cells show good division of labour. The different cells in such tissues perform different functions and give the overall combined property to the tissue. Almost all cells specialized in performing related roles are classified together as tissues in the body.

ORGANIZATION OF TISSUES





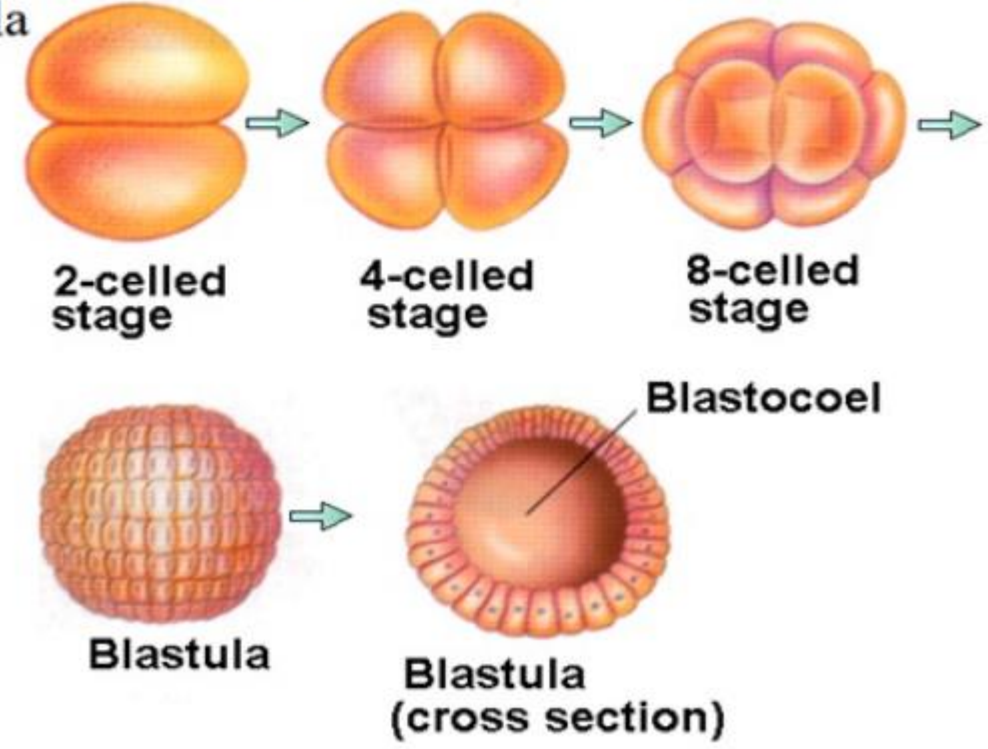
ORGANIZATION OF TISSUES

cleavage - divisions of the zygote immediately after fertilization

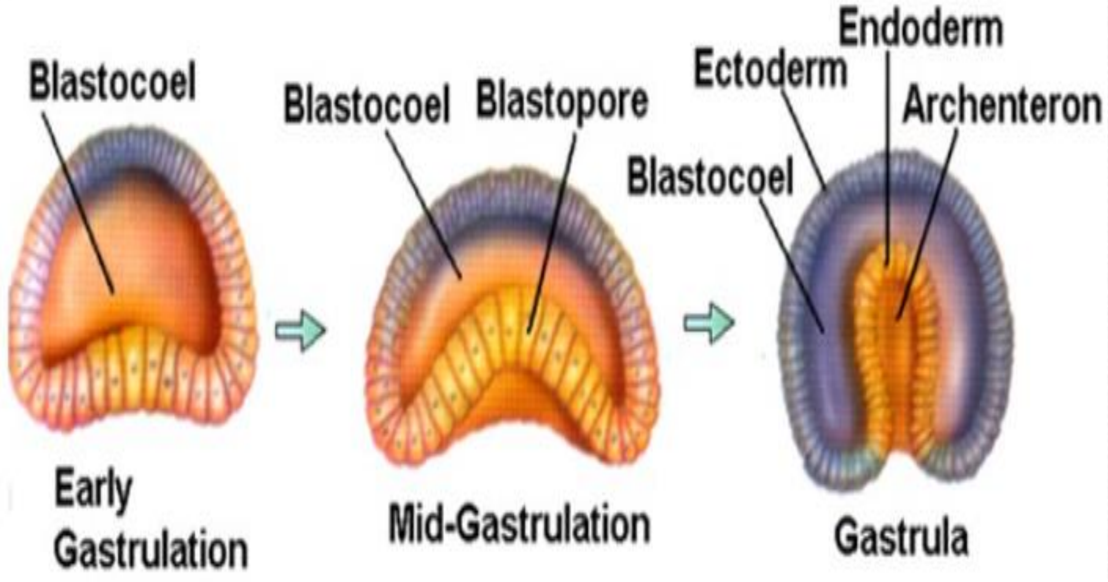
blastula stage – hollow sphere of cells

blastocoel - central cavity of the blastula

blastopore -infolded or indented region of the blastula



gastrulation – transformation of the blastula into a multilayered embryo. The bastula folds inward and forms a cup-shaped cavity called the archenterons. This cavity forms the gut.

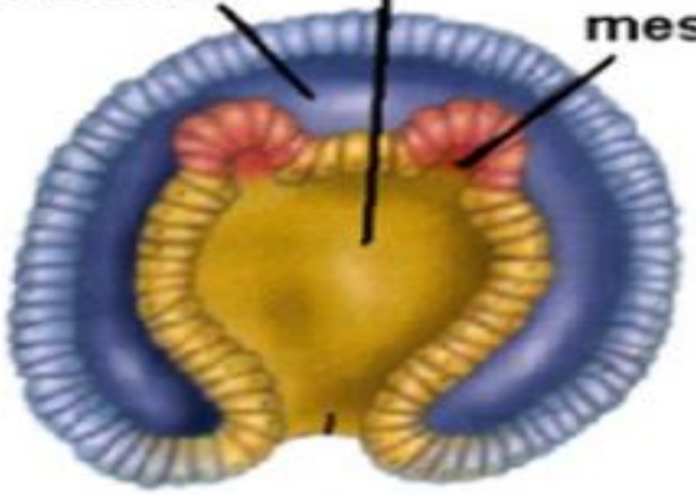


As a result of gastrulation, three primary layers form: (Fundamental tissue types found in embryos of all animals except sponges which have no true tissues)

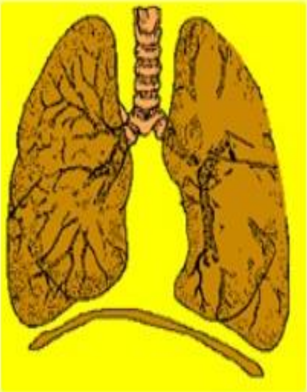
Endoderm – inner layer

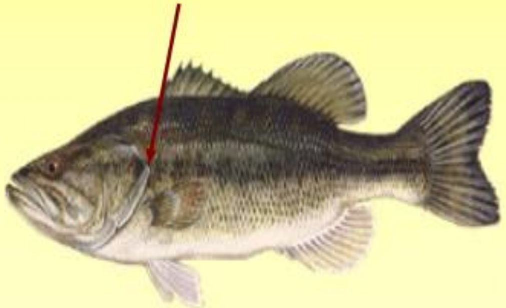
Mesoderm – middle layer

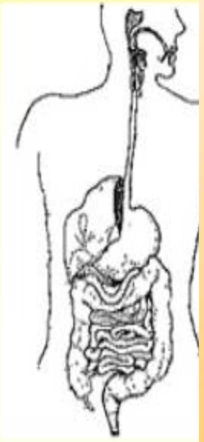
Ectoderm – outer layer



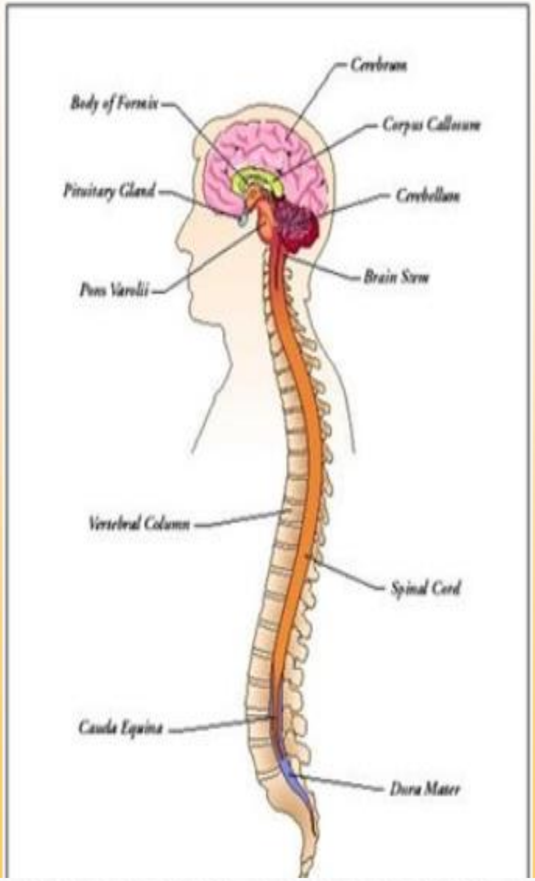
- **endoderm** inner layer - The archenteron, surrounded by endoderm forms the throat passage, gills, lungs and gut and associated organs such as pancreas, and liver. (lines digestive tract & much of respiratory system.)

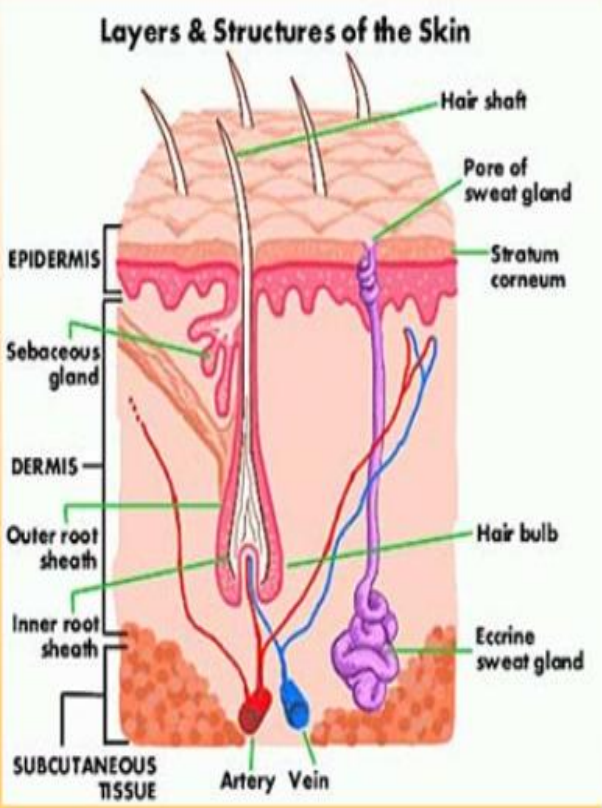




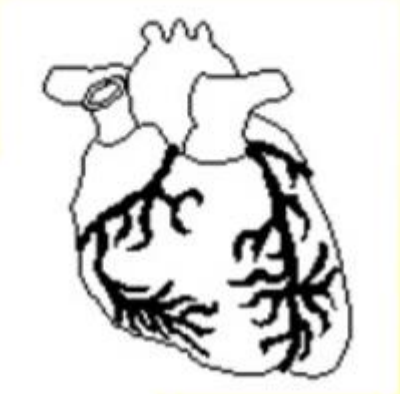


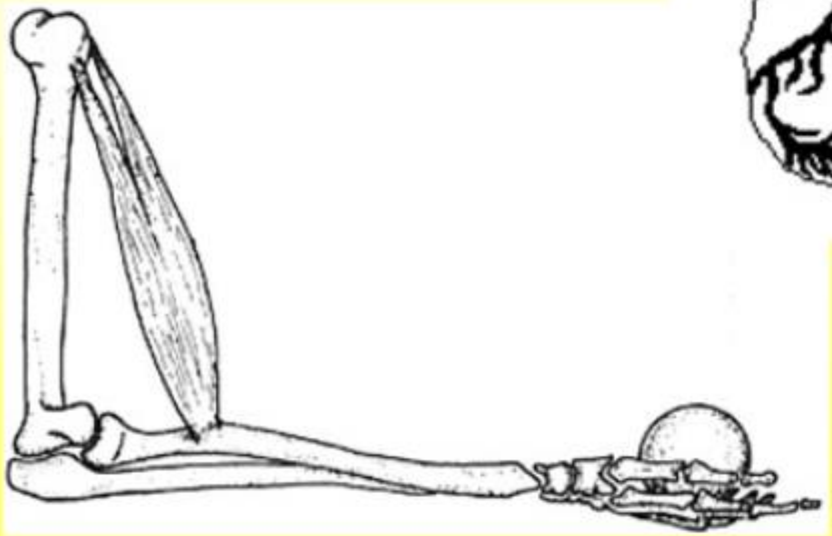
- **ectoderm** – outer layer – forms skin, hair, nails, and nervous system





- **mesoderm** which forms between the other layers, forms skeleton, muscles, inner layer of skin, circulatory system, and lining of the body cavity (also reproductive system & excretory system).





DEVELOPMENT OF COELOME AND ACOELOMATA

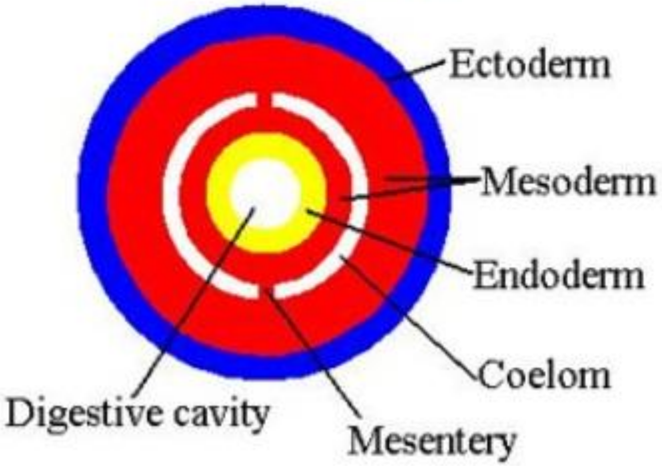
coelom

a) a true hollow, fluid-filled cavity completely surrounded by mesoderm.

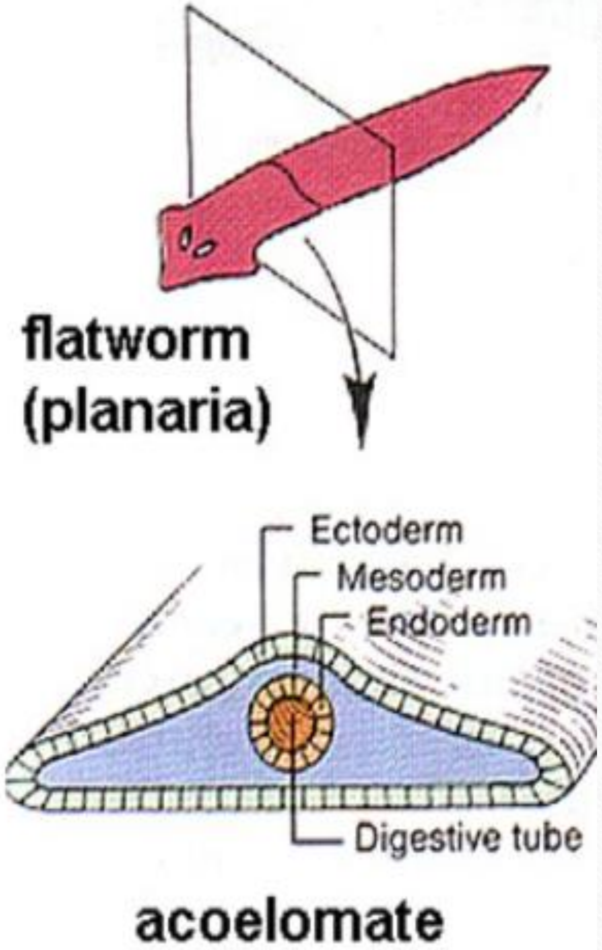
b) The muscles of the body wall are separated from those of the gut.

c) The body walls can contract without hindering t movement of food in the gut (digestive tract).

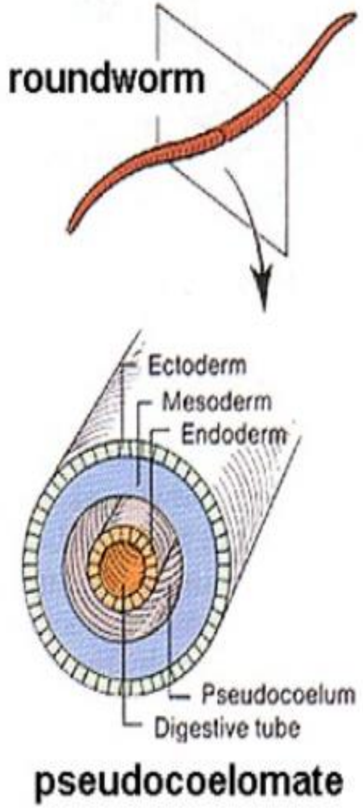
Coelomates

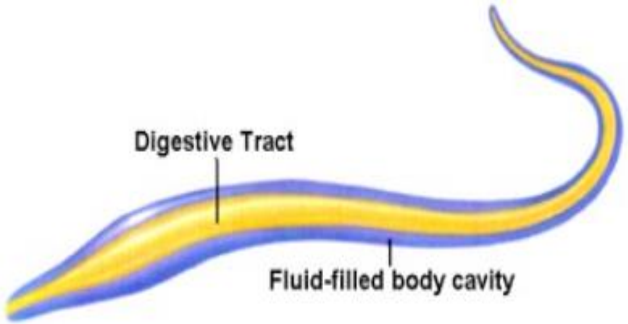


- **acoelomate** – no body cavity flatworms



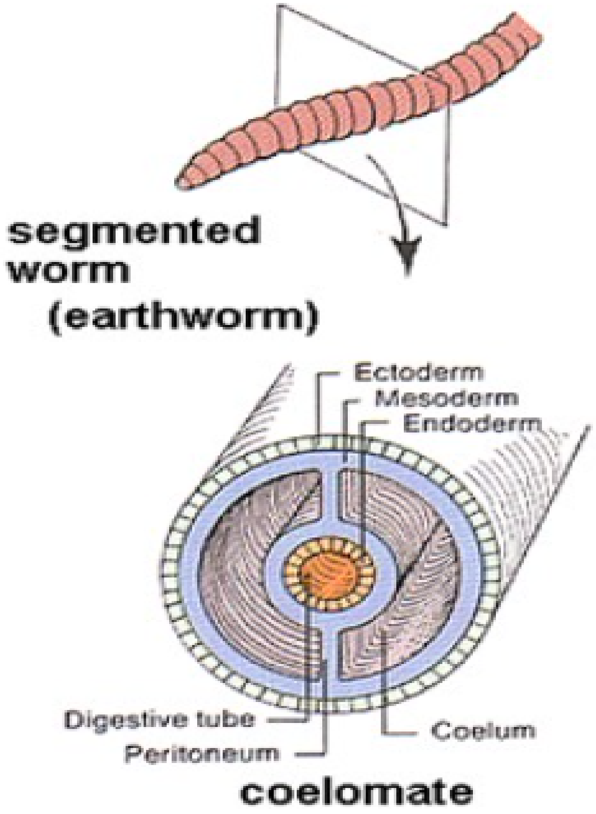
pseudocoelomate – "false body cavity" mesoderm lines an endodermic gut suspended in a fluid filled coelom cavity.

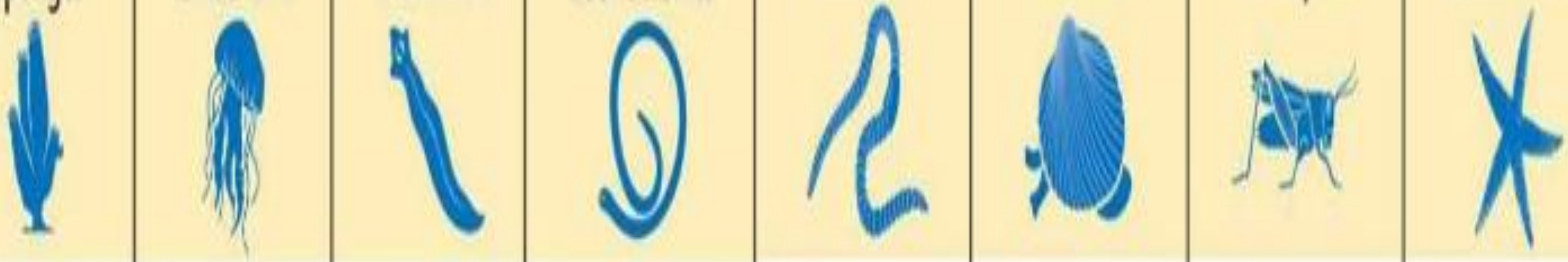




- **coelomate** – **true body cavity** - An endodermic gut – is surrounded & supported by a body cavity of mesoderm. The mesoderm forms tissues or attachments for organs located in the true body cavity, such as the liver, lungs, etc.

Mollusks, arthropods, chordates, & echinoderms are coelomate animals.





	Sponges	Cnidarians	Flatworms	Roundworms	Annelids	Mollusks	Arthropods	Echinoderms
Germ Layers	Absent	Two	Three	Three	Three	Three	Three	Three
Body Symmetry	Absent	Radial	Bilateral	Bilateral	Bilateral	Bilateral	Bilateral	Radial (adults)
Cephalization	Absent	Absent	Present	Present	Present	Present	Present	Absent (adults)
Coelom	Absent	Absent	Absent	Pseudocoelom	True coelom	True coelom	True coelom	True coelom
Early Development	—	—	Protostome	Protostome	Protostome	Protostome	Protostome	Deuterostome

BODY SYMMETRY

a) Spherical

b) Radial

c) Bilateral

Protozoan Radiolaria and Heliozoa.

Spherical Symmetry

– The organism is the shape of a sphere and the parts are arranged around and radiate from the center of the sphere

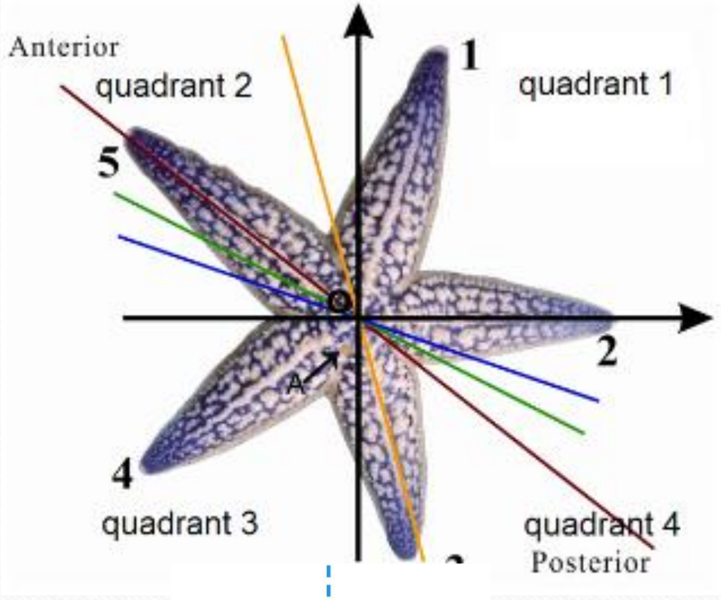
– Everything is the same in all directions

– The organism has no ends or sides

– Found in some protozoan groups

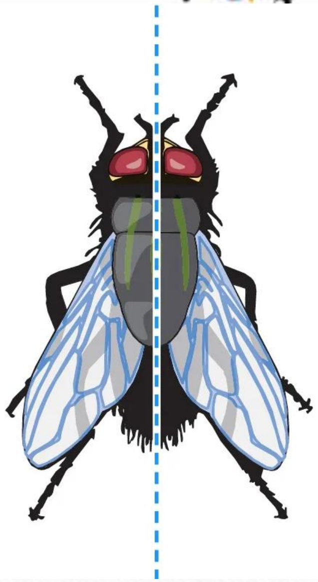
Radial Symmetry

- Parts are arranged around a central axis
- Allows for the organism to interact in all directions
- Has a top and bottom, but no left or right
- Examples: cnidarians (sea anemones, jellyfish..)



Bilateral Symmetry

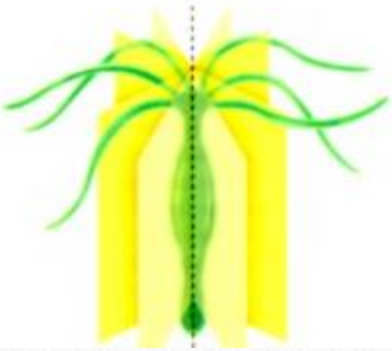
- One plane (sagittal cut) will divide the body into mirror image halves
- Has a top and bottom and a left and right side
- Examples: arthropods and chordates



Body Symmetry:

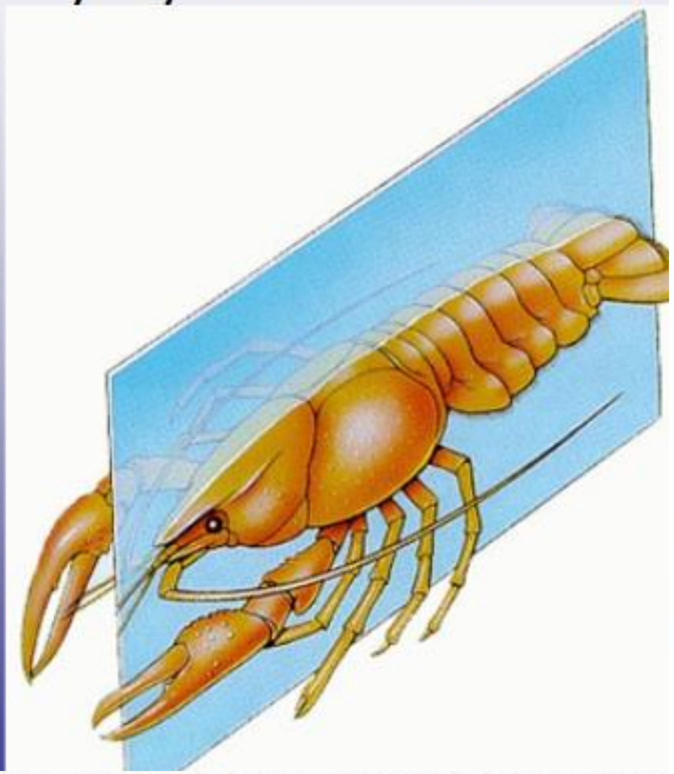
- **None** – Sponge (asymmetrical)

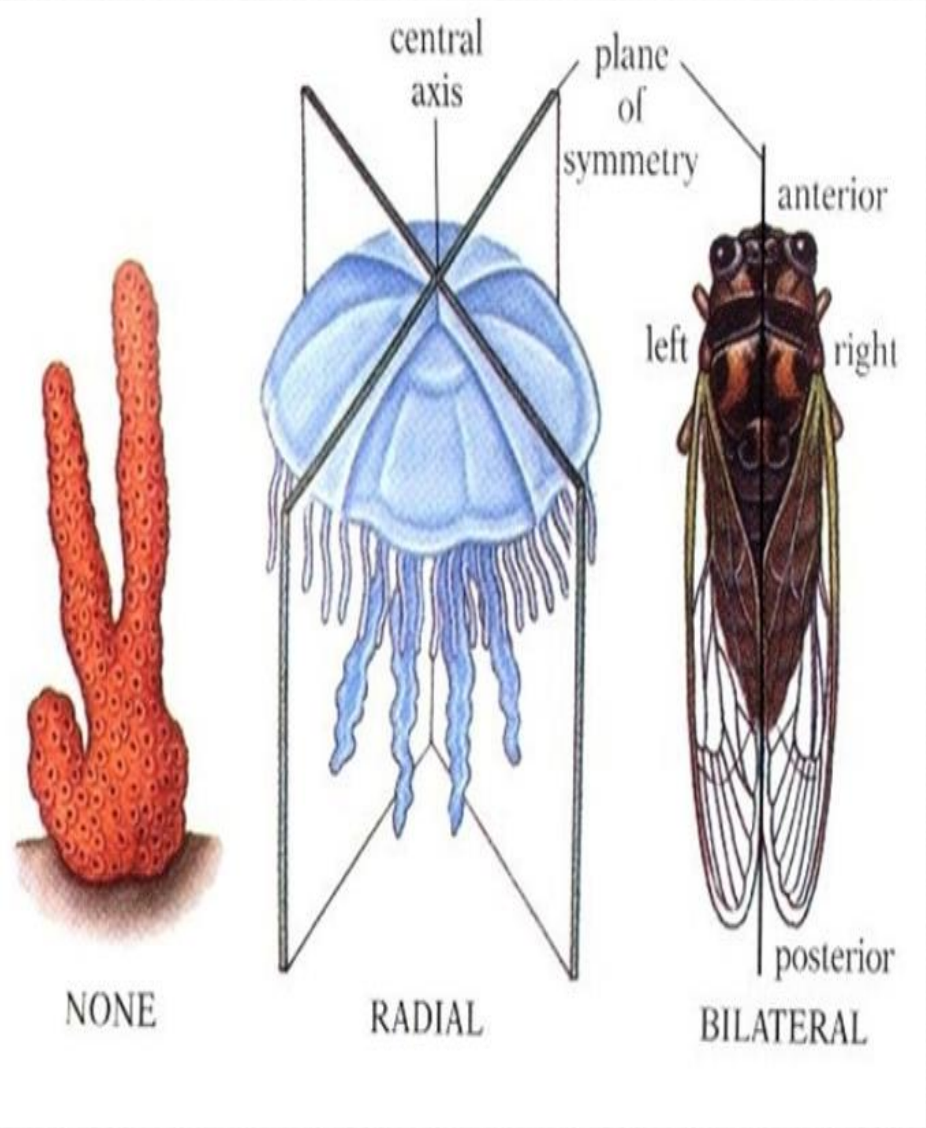
- **Radial** –similar parts branch in all directions. -Hydra, Jellyfish,



Pentaradial

Bilateral , two similar halves in either side of a central plane of symmetry moth, primates etc. Bilaterally symmetrical

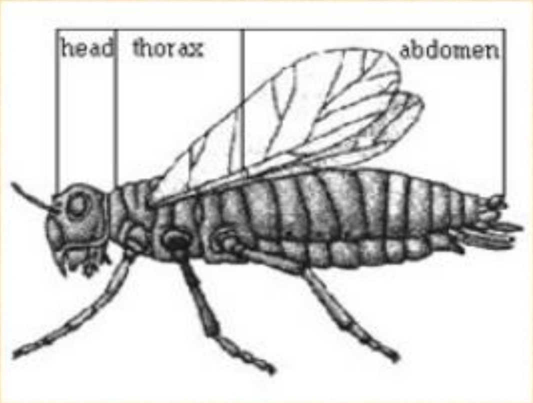




SEGMENTATION AND CEPHALIZATION

Body Segmentation

Segmentation of the body allows development of various specialized limbs, such as antennae, pincers, walking legs, claws, wings, etc.



Cephalization is the concentration of nervous tissues in one location which eventually produces a head region with sensory organs and a brain.

Cephalization

- Differentiation of the head region
- Sense organs localized on the head region
- Found in bilaterally symmetrical animals