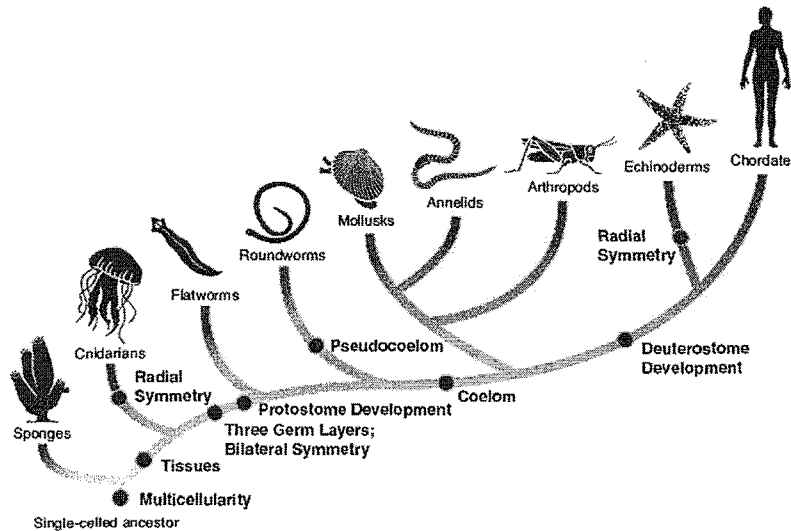


# The Animal Kingdom

## Introduction

In simplest terms, animals are organisms that are **eukaryotic, multicellular heterotrophs that lack cell walls**. The appearance of each phylum of the animal kingdom represents the evolution of a new and successful body plan. When examining the various animal phyla, a trend emerges that illustrates how animal phyla move from organisms that are simple in design to those that are amazingly complex with integrated organ systems which carry out necessary life functions. These different phyla are related to one another by common evolutionary heritage as illustrated below:



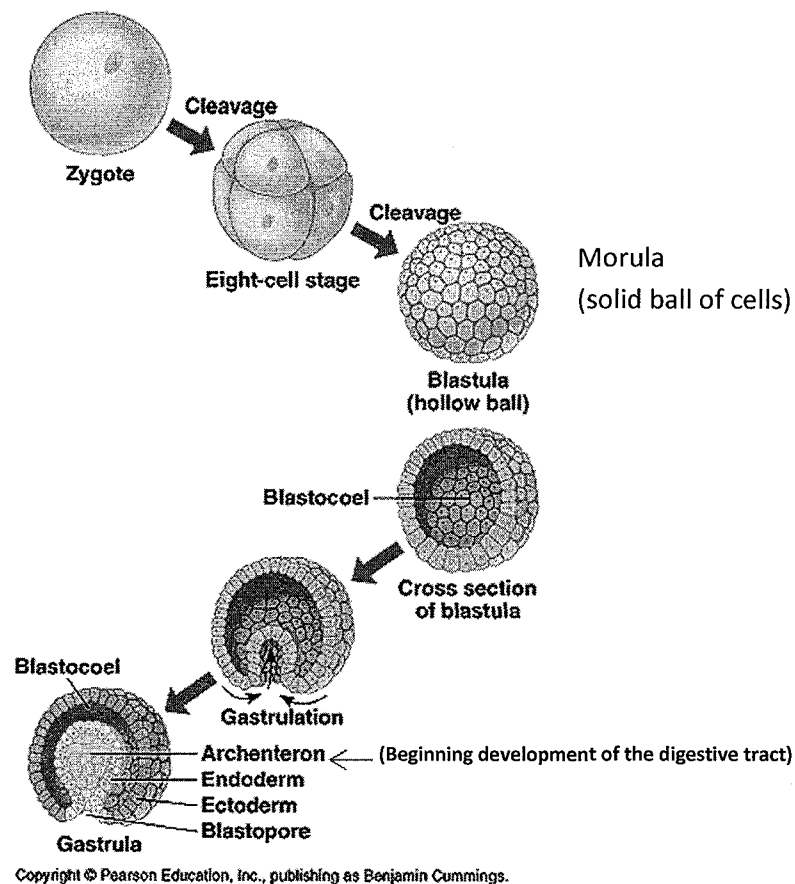
As we move from simple organisms such as sponges to more complex organisms, such as **chordates** we see changes in:

- ✓ Body organization (cells organized into tissues, organs and organ systems)
- ✓ Number of **germ** (embryonic) layers (tissues from which more specialized tissues develop)
- ✓ Body symmetry
- ✓ A complete or incomplete digestive tract
- ✓ Development (or not) of an internal cavity called a **coelom**

## Germ Layers

Germ layers are the main layers that form during embryonic development.

1. Once the sperm and egg meet a fertilized egg, known as a **zygote** is formed.
2. The **zygote** immediately begins to divide through a process called **cleavage** (cell division without growing phase of cells to maturity) over and over again, eventually forming a solid ball of cells called the **morula**.
3. The **morula** hollows out to form a single layer ball of cells called the **blastula**.
4. The **blastula** indents (pushes inward) to form the **gastrula** through the process of **gastrulation**.
5. In simpler animals, there are only **2 layers** formed – the inner layer called the **endoderm** and the outer layer called the **ectoderm**.
6. In more complex organisms, **3 layers** are formed – **endoderm (inner layer)**, **mesoderm (middle layer)** and the **ectoderm (outer layer)** (see diagram on next page)



- The **ectoderm** develops into the **skin and nervous system** including the **nerve cord and brain**.
- The **endoderm** develops into the linings of the **digestive and respiratory systems**, and the **liver and pancreas**.
- The **mesoderm** becomes the **circulatory, reproductive, and skeletal systems**.

### ***Diploblastic organisms (two layers)***

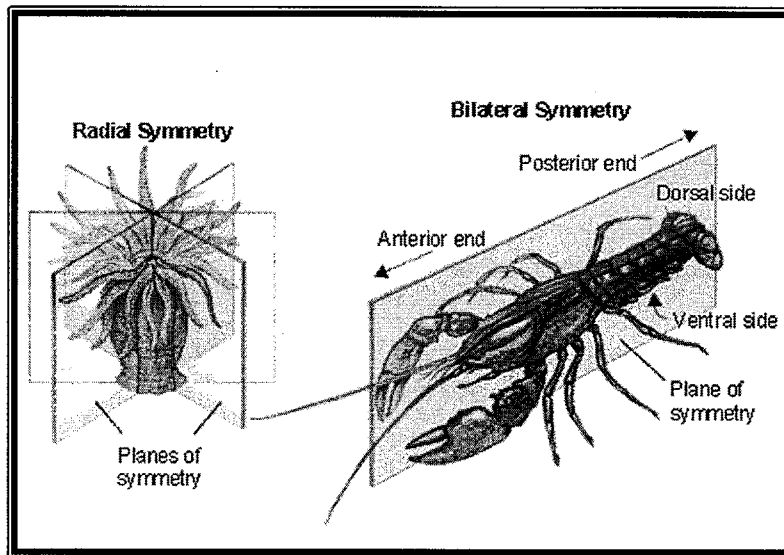
The bodies of sponges (**porifera**) and jelly fish, coral, and hydra (**cndarians**) have only 2 cell layers, consisting of **ectoderm, endoderm and mesoglea (middle glue)** which holds the two layers together.

### ***Triploblastic organisms (three layers)***

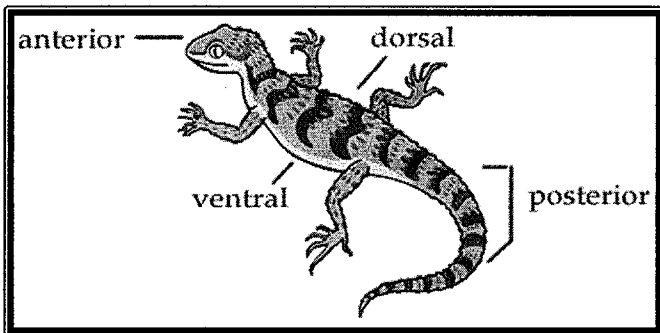
Most other animals have bodies with 3 layers, consisting of **ectoderm, mesoderm and ectoderm**.

### **Body Symmetry (see diagram below)**

- Primitive (simple) animals exhibit **radial symmetry** where body parts are organized around a central axis.
- More advanced animals have **bilateral symmetry** where body parts are arranged along a longitudinal axis and the left and right sides of the body are mirror images.
- Echinoderms (sand dollar, sea urchin, starfish)** are an exception to this trend as they are considered an advanced phylum exhibiting **bilateral symmetry as larvae but reverting back to radial symmetry as adults**.



### Terms Associated with Bilateral Symmetry



1. **Dorsal**: top or back of organism
2. **Ventral**: belly or underside of organism
3. **Anterior**: front part of organism
4. **Posterior**: rear part of organism

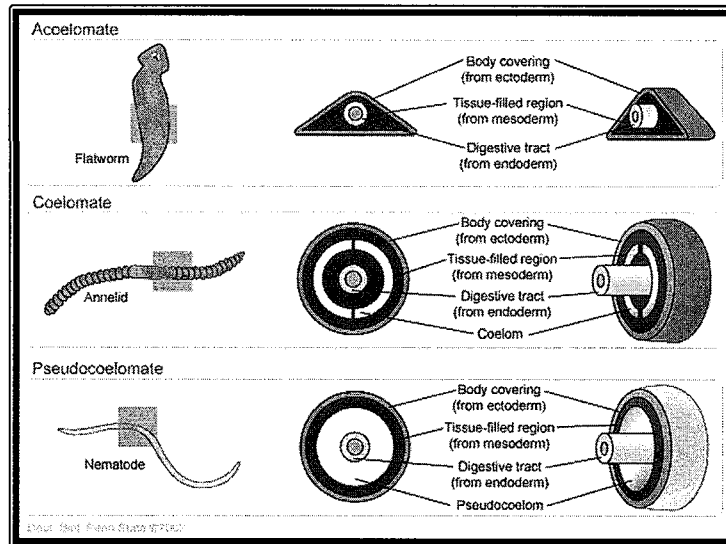
### Cephalization (development of a head)

1. Along with bilateral symmetry, come development of the head (anterior) and rear (posterior) end.
2. Sensory apparatus and the brain or in simpler organisms (ganglia which are clusters of nerve cells) are found in the anterior end.
3. Digestive, excretory, and reproductive structures are located toward the posterior end, allowing animals to move faster to flee or capture prey more successfully.
4. Simple animals (porifera and cndarians) do not have a head end.
5. Cephalization is seen beginning with flatworms.

### Development of the Coelom (body cavity formation)

1. **Coelom**: a fluid-filled body cavity that is completely surrounded by a middle layer of tissue called mesoderm. The coelom is important in the development of advanced animals because it provides a space for complex organ systems to develop.
  - ✓ Provides space for the development of organ systems; major organs could not develop without a coelom between the germ layers

- ✓ **Acoelomates:** primitive animals who do not have a coelom (ex. Flatworms)
- ✓ **Pseudocoelomates:** animals that have a fluid filled tube between the endoderm and the mesoderm. The pseudocoelom is NOT completely lined with mesoderm (ex. Nematodes & roundworms).
- ✓ **Coelomates:** most complex organisms in the animal kingdom. Include the phyla Annelids, Mollusks, Arthropods, and Chordates

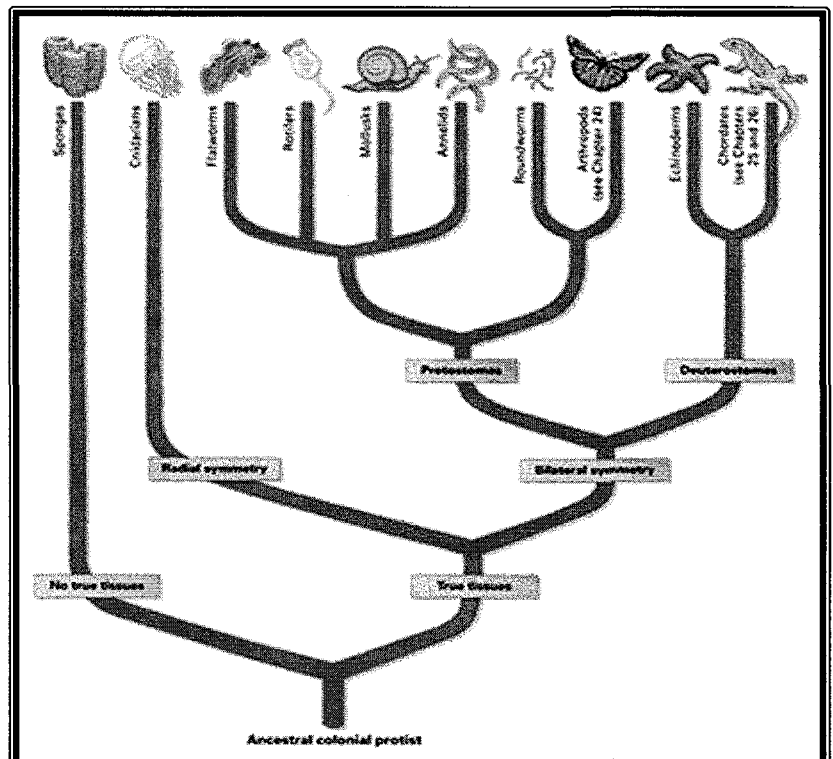


### Development of the Mouth and Anus

- ✓ The simplest animals have a single opening that acts as a mouth and anus
- ✓ Complex animals have a gastrovascular cavity (gut) with a mouth and anus

### Invertebrate Developmental Trends Overview

1. Simple to complex as organisms evolve.
2. Simplest have asymmetry, more complex are often radial and most complex have bilateral symmetry.
3. Organisms (from simplest to complex) go from having no coelom, to a false body cavity, to a true coelom.
4. Simple organisms may reproduce **sexually and asexually**. More complex animals use only sexual reproduction.



5. Simple animals have only two tissue layers (germ layers), complex animals have three tissue layers.
6. Simple tend to be non-motile (**sessile**) while more complex animals tend to be **motile** (they move around).
7. Simple animals have no tissue, more complex animals have tissues (which can be specialized) and form systems.

**Note: Many invertebrates are hermaphrodites (both male and female parts) but rarely can they self-fertilize.**

**The 9 most studied phyla of the animal kingdom include the following:**

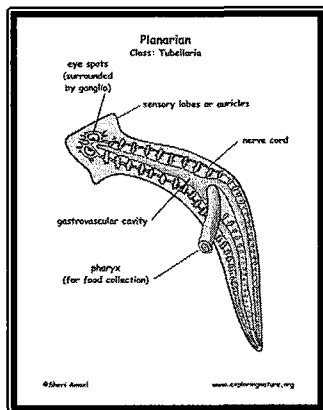
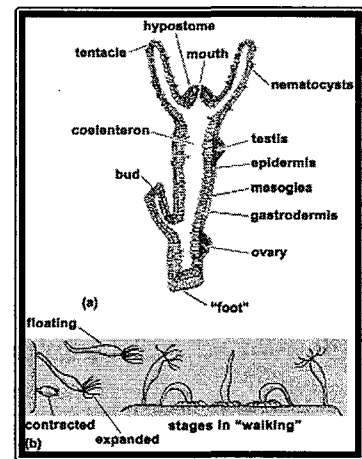
**1. Porifera (sponges)**

- ✓ Have no symmetry, specialized cells but no true tissue, and are **sessile** (do not move)
- ✓ Filter nutrients from water drawn into central cavity
- ✓ Diploblastic (2 layers connected by mesoglea)
- ✓ Reproduce asexually by fragmentation

**2. Cnidaria (jellyfish, hydras, sea anemones, Portuguese man-of-wars, and corals)**

- ✓ Radial symmetry
- ✓ Body plan is a **polyp** (vase shaped) which is mostly sessile & **medusa** (upside down bowl shaped) which is mostly motile
- ✓ Diploblastic, all cells in contact with the environment
- ✓ Have stinging cells (cnidocytes) with stingers (called nematocysts)

**Hydra**

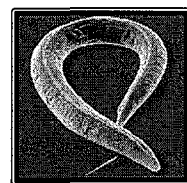


**3. Platyhelminthes (flatworms, planaria, flukes, & tapeworms)**

- ✓ Simplest of animals that display bilateral symmetry, also have 3 distinct cell layers
- ✓ One opening for ingestion/egestion
- ✓ Flat solid body with no room for organ systems. Even though they have 3 cell layers, they are so flat that many body cells can exchange nutrients and wastes by diffusion with the environment.
- ✓ Reproduce asexually by **regeneration** – cut a planarian in 4 pieces, will grow into 4 new planaria

**4. Nematoda (roundworms, rotifers)**

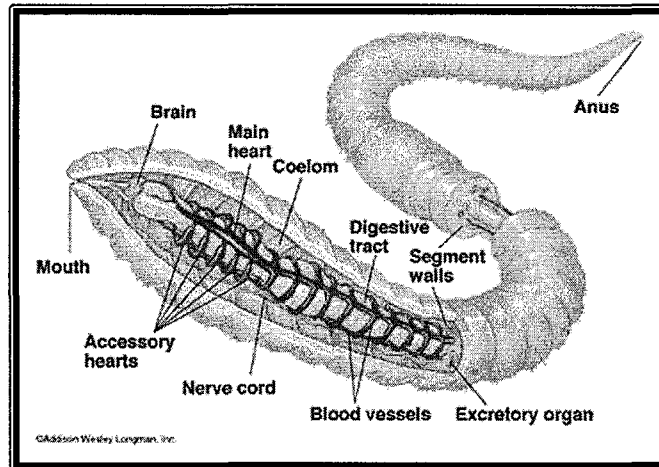
- ✓ Bilateral symmetry, unsegmented, little sensory apparatus
- ✓ Many are parasitic (ex. *Trichinella* causes trichinosis, contracted by eating undercooked pork)
- ✓ *C. elegans* is a nematode that is widely used as an animal model in studying genes & embryonic development



*C. elegans*

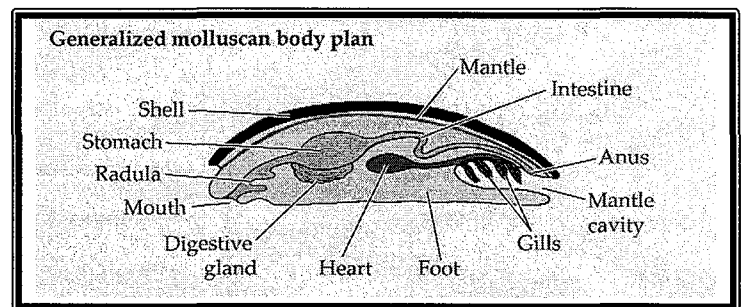
## 5. Annelida (segmented worms, including earthworms, leeches, and marine worms)

- ✓ Bilateral symmetry with little sensory apparatus
- ✓ First time a **tube-within-a tube one way digestive system** (mouth to anus with crop, gizzard & intestine)
- ✓ **Closed circulatory system** (blood is within vessels, never in contact with cells) heart consists of 5 pairs of aortic arches
- ✓ **Blood contains HEMOGLOBIN** (carries oxygen to cells)
- ✓ Diffusion of oxygen & carbon dioxide through moist skin
- ✓ **Nephridia** (prs of organs that excrete nitrogenous wastes, urea)
- ✓ Ventral nerve cord with ganglia in each segment; anterior brain made up of fused ganglia
- ✓ **Hermaphrodites**



## 6. Mollusca (mollusks, including bivalves, snails and slugs, and octopuses and squids)

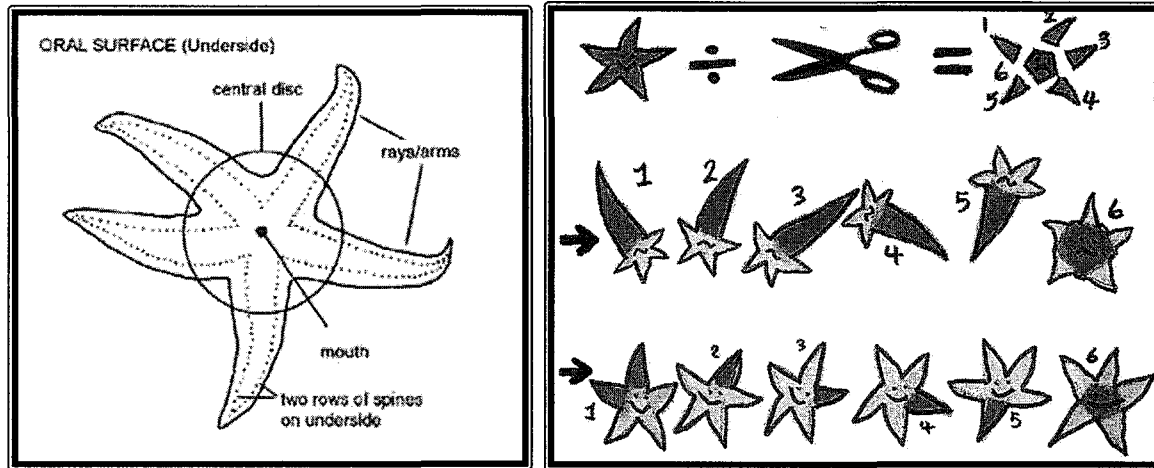
- ✓ Have soft body parts protected by hard calcium-containing shell
- ✓ **Open circulatory system** (*blood-filled spaces called hemocoels or sinuses bath cells directly*)
- ✓ Bilateral symmetry with 3 body zones:
  - head-foot**: contains both sensory and motor organs
  - visceral mass**: contains organs of digestion, excretion, & reproduction
  - mantle**: specialized tissue that surrounds the visceral mass & secretes the shell
- ✓ Has a **radula**, movable tooth-bearing structure that acts like a tongue
- ✓ Most have gills and nephridia



## 7. Echinodermata (including sea stars, sea cucumbers, sand dollars, and sea urchins)

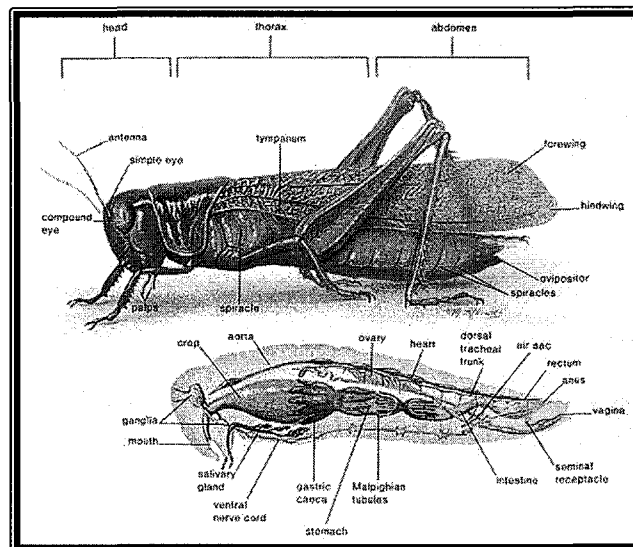
- ✓ Either sessile or slow moving
- ✓ Bilateral symmetry as embryo; revert to radial symmetry as an adult (adaptive for sedentary life)
- ✓ Sexual reproduction with external fertilization
- ✓ Can also reproduce by **asexual fragmentation and regeneration** (for example, any part of a star fish that contains the central canal will form a completely new adult)

## Process of Regeneration in Starfish



### 8. Arthropods (Insects, crustacean – shrimp, crab, arachnida- spider)

- ✓ Largest animal phylum with the most species
- ✓ Characterized by jointed appendages, segmented body into head, thorax, and abdomen
- ✓ Has more sensory apparatus such as a tympanum (simple ear), antennae
- ✓ **Exoskeleton** made out of chitin (complex carbohydrate)
- ✓ Open circulatory system with tubular posterior heart that empties blood into open hemocoels in anterior portion in head
- ✓ Tracheal tubes bring air in from environment to hemocoels for oxygen circulation (blood bathes cells directly)
- ✓ Ventral nervous system with 2 cords (more developed than annelids)



### 9. Chordata (animals with nerve chords - this group includes the vertebrates such as fish, amphibians, reptiles, birds, and mammals)

- ✓ Most species in the **Chordata phyla** are **vertebrates** however, there are a few species that are in this phyla that are invertebrates.

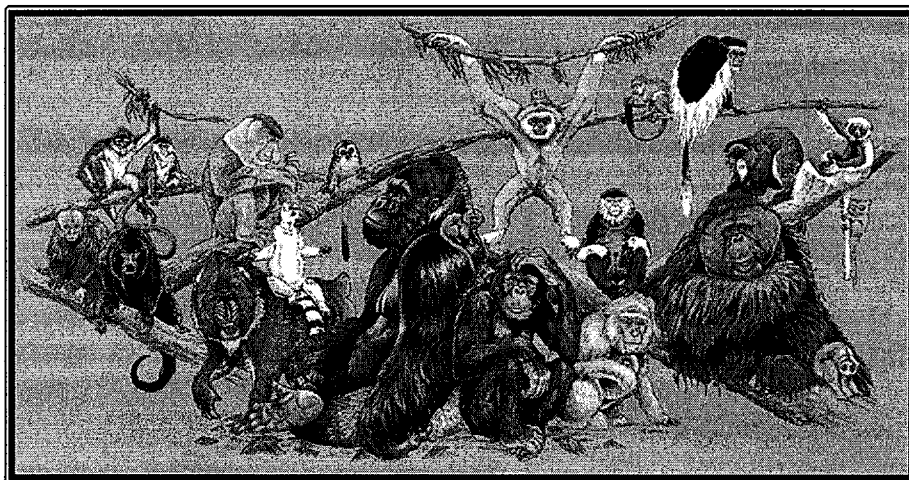
- ✓ Has a notochord (a cartilaginous skeletal rod) supporting the body in all embryonic and some adult chordate animals
- ✓ Also has a hollow dorsal nerve cord (lies above the notochord)
- ✓ Tail that aids in movement and balance. The coccyx bone in humans is a vestigial remnant of a tail.
- ✓ **Homeotherms:** animals that maintain a consistent body temperature (birds and humans)
- ✓ Most other chordates are **coldblooded** (fish, amphibians, reptiles) though some reptiles are **endotherms:** can raise their body temperature internally

### Mammals (chordate phylum; vertebrate subphylum)

- ✓ Have hair or fur
- ✓ Feed young with milk from **mammary glands** (breasts)
- ✓ Endotherms with closed circulatory systems and well developed nervous systems
- ✓ **Monotremes:** egg laying mammals, have a common duct (**cloaca** for urination, defecation, and reproduction) – duckbilled platypus
- ✓ **Marsupials:** offspring born in early embryonic state and must make their way into the mother's pouch to complete its development receiving nourishment from the mother's mammary glands
- ✓ **Placental:** offspring develop completely inside the mother's **uterus** connected to the mother via the placenta from which the embryo/fetus receives all nourishments and rids itself of wastes. Offspring are born fully developed. Off all animals, receive the most parental care.

### Primates (examples include humans, gorillas, chimpanzees, orangutans, gibbons Old world & New World Monkeys)

- ✓ It is believed that primates descended from small tree-dwelling mammals
- ✓ Have opposable thumbs and dexterous hands (good for fine motor tasks)
- ✓ Nails instead of claws
- ✓ Hands and fingers contain many nerve endings and are very sensitive
- ✓ Eyes are front facing, close together, fostering face-to-face communication
- ✓ Close set eyes responsible for overlapping fields of vision, which enhance depth perception & hand & eye coordination
- ✓ Most intensive parenting of any mammal
- ✓ Generally have single births & nurture young for a long time





**Check your Understanding: (separate paper please and in full sentences)**

1. Discuss the trend that is seen in the classification of animals from sponges to vertebrates.
2. Define the following terms:
  - a. zygote
  - b. cleavage
  - c. blastula
  - d. gastrulation
  - e. germ layer
3. Explain what parts of an organism the ectoderm, mesoderm, and endoderm develop into during embryonic development.
4. Differentiate between diploblastic and triploblastic.
5. What is the function of the mesoglea?
6. Hypothesize as to how cells can differentiate into different kinds of tissue (liver cells, brains cells)?
7. How does radial symmetry differ from bilateral symmetry?
8. Distinguish between dorsal and ventral AND anterior and posterior with respect to an organism's body plan.
9. How did cephalization enable organisms to become more complex?
10. What is the function of a coelom?
11. Distinguish among an acoelomate, pseudocoelomate, and coelomate.
12. Define the process of regeneration and provide an example of an organism that can reproduce by this means of asexual reproduction.
13. What is meant by a tub-within-a tube system such as exhibited by an earthworm?
14. Earthworms have hemoglobin. What is the function of hemoglobin? To what group of organic compounds does hemoglobin belong?
15. Differentiate between a closed and open circulatory system.
16. What is the difference between a homeotherm and an endotherm?
17. What is a hemocoel?
18. Animals in which phylum exhibit start to exhibit more sophisticated sensory apparatus?
19. Are all chordates vertebrates? Explain your answer.
20. Discuss the reproductive differences among monotremes, marsupial, and placental mammals.