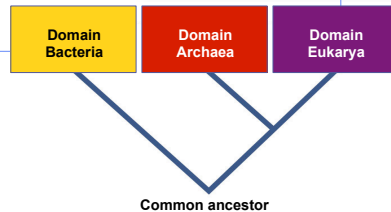
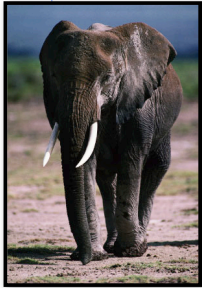


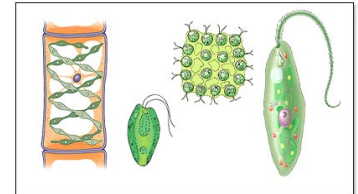
Kingdom: Animals Domain Eukarya



Eukaryotic Kingdoms

Kingdom Protista

- The **endosymbiosis theory** explains how organisms developed organelles
- ♦ Heterotrophic or Autotrophic
- ♦ Unicellular or Multicellular
- ♦ Mostly aquatic
- ♦ Mostly asexual
- ♦ Motile or Nonmotile
- Ex: Euglena, Amoeba, Paramecium, Algae, Slime Molds



AP Biology

Eukaryotic Kingdoms

Kingdom Fungi

- ♦ Heterotrophic
- ♦ Unicellular (*yeasts*) or Multicellular
- ♦ Mostly Terrestrial
- ♦ Asexual or sexual
- ♦ Nonmotile
- Important **decomposers** in the environment
- Form important associations with plants called **mycorrhizae**
 - ♦ Ex: Mushrooms, molds, yeasts



AP Biology

Eukaryotic Kingdoms

Kingdom Plants

- ♦ Autotrophic
- ♦ Multicellular
- ♦ Mostly Terrestrial
- ♦ Asexual or sexual
- ♦ Nonmotile
- Important **producers** in the environment
 - ♦ Ex: Trees, mosses, ferns, flowering plants



AP Biology

Kingdom Animal Characteristics

1. Multicellular

- ♦ **Complex bodies**

2. Nutritional mode

♦ **Plants**

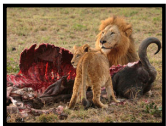
- Autotrophic eukaryotes who can produce their own organic molecules through **photosynthesis**

♦ **Fungi**

- Heterotrophs that grow on or near their food and feed by **absorption** (often releasing enzymes that digest food outside their bodies)

♦ **Animals**

- Heterotrophs** that get their organic molecules by eating others (living or deceased organisms) or by eating nonliving organic material
 - ♦ Animals do not feed by absorbing through skin but **ingest** their food and use enzymes to **digest** it in their bodies.



Animal Characteristics

3. Plants and fungi have cell walls

- ♦ **Animals have NO cell walls**

- Allows active movement!

- Have specialized **nerve and muscle cells**

- Allow nerve impulses to be conducted (sent)
- Allows animal to coordinate movement

- Cells held together by **structural proteins**

- Ex: Collagen in Extra-Cellular Matrix

4. Sexual reproduction

- Most reproduce **sexually**

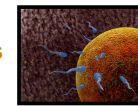
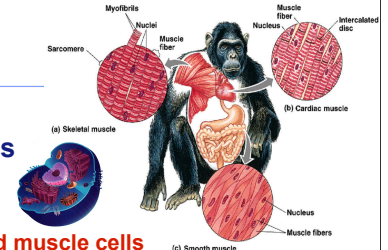
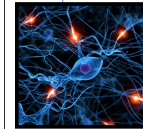
- No alternation of generations as seen in plants

- No haploid gametophyte

- Gametes do not undergo mitosis

- In animals, haploid gametes fuse to form new diploid zygote

- Diploid stage dominates the life cycle of animals



AP Biology

Animal Characteristics

- 5. Animals have distinct 'body plans' controlled by a unique **homeobox family of genes**, a.k.a. **Hox genes**, which direct the formation of many body structures during early embryonic development.

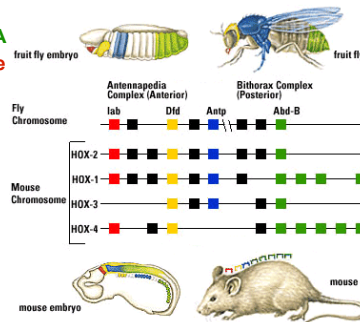
- As **transcription factor genes**, these genes regulate the expression of other genes and thus act as major on off switches inside cells

- Many contain common sequences of DNA
- Found in clusters on chromosomes in the embryo they are controlling.

- Genes at the beginning of the cluster control development of the thorax, those in the middle control development of the proximal part of the abdomen, while genes at the end of the cluster control the more distal parts of the abdomen.

- Products of these genes are **transcription factors**

AP Biology

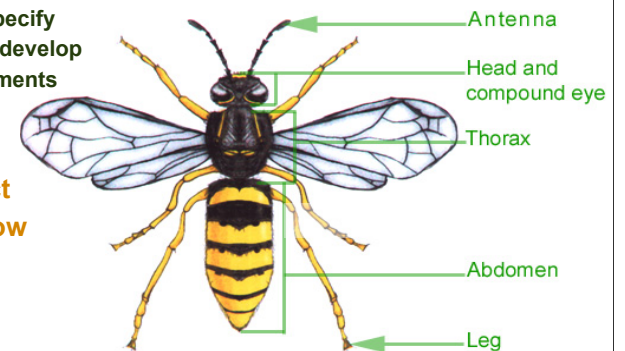


Hox Genes

- Hox genes play an important role in development of animal embryo since they control expression of large amounts of other genes that influence animal morphology (anatomy)

- While an embryo grows, arms, legs, or wings, heads, abdomens,, thoraxes and more develop differently due to the actions of homeotic genes, which specify how structures develop in different segments of the body

- In **arthropods**, hox genes direct segments to grow legs, wings, or antennae



AP Biology

Hox Genes

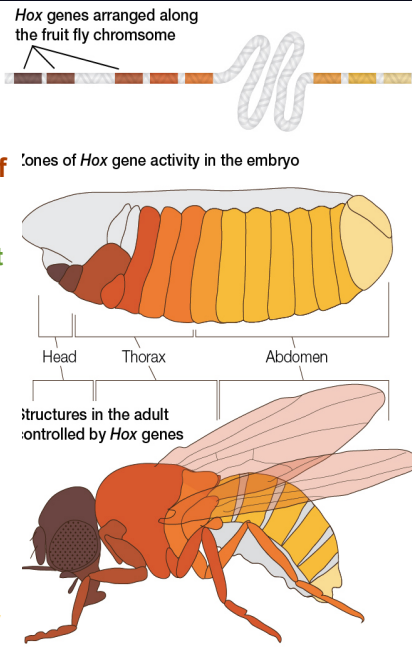
- Fruit flies begin life as worm-like embryo in the embryo made up of repeating units, or **segments**.

- Every cell contains the same copy of genes/DNA, but different hox genes are switched on in different cells.

- Early in development, Hox genes are switched on in different segments.

- Patterns of Hox gene activity give each segment an identity, telling it where it is in the body and what structures it should grow.

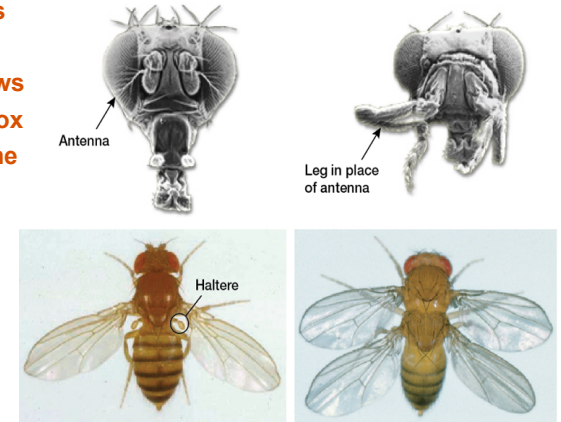
- Ex: genes that are active in the head direct the growth of mouth parts and antennae, while genes that are active in the thorax direct the growth of legs and wings.



Hox Genes

- Changes to Hox gene expression change a segment's identity.

- For example the first segment of the thorax normally grows legs, the second grows legs and wings, and the third grows legs. When the Hox gene activity in the third segment is made the same as that in the second, both segments grow legs and wings.



AP Biology

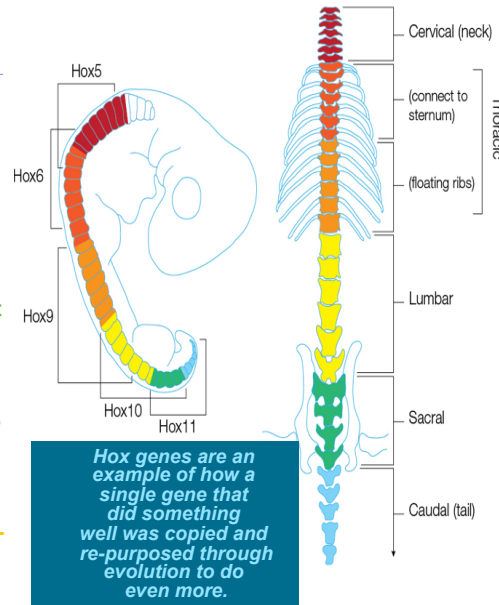
Hox Genes

Hox genes in **vertebrates** direct segments to grow ribs (or not) or bones that fuse together to form a sacrum.

- In mouse embryos, the Hox10 genes, for instance, turn the "rib" program off. The genes are normally active in the lower back, where the vertebrae don't grow ribs, and inactive in the mid-back, where the vertebrae do grow ribs.

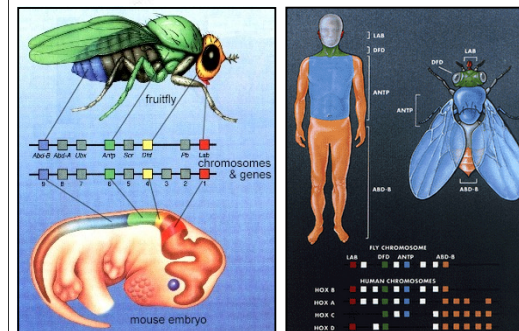
- When the Hox10 are experimentally inactivated, the vertebrae of the lower back to grow ribs.

- Something similar may have happened in nature: In snakes, Hox10 genes have lost their rib-blocking ability, which may be why they grow ribs from head to tail.

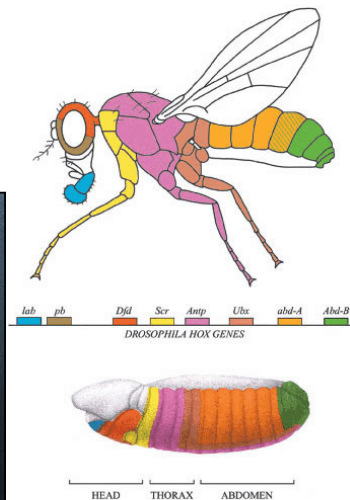


Hox genes are an example of how a single gene that did something well was copied and re-purposed through evolution to do even more.

Figure 1. The eight Hox genes of the fruit fly (abbreviated lab, pb, Dfd, etc.). Hox genes have a critical part in determining the body plan of the fly. The top of the illustration shows the adult fly; the middle, the genes; at the bottom is the embryo. Each gene regulates the development and identity of a specific region of the fly's body in the embryo and in the adult fly. For example, the green Abd-B gene controls the development of the rear of the embryo (green) and the rear of the adult fly (green); the red Dfd gene controls development of the head region of the embryo (red) and the head of the adult (red). The order of the Hox genes corresponds to the head-to-tail order of the regions under their control.



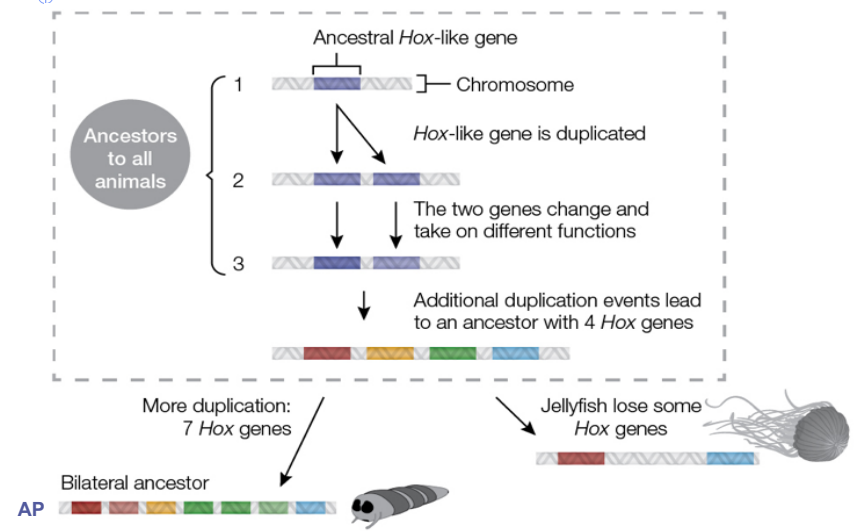
Hox Gene Clusters in animals



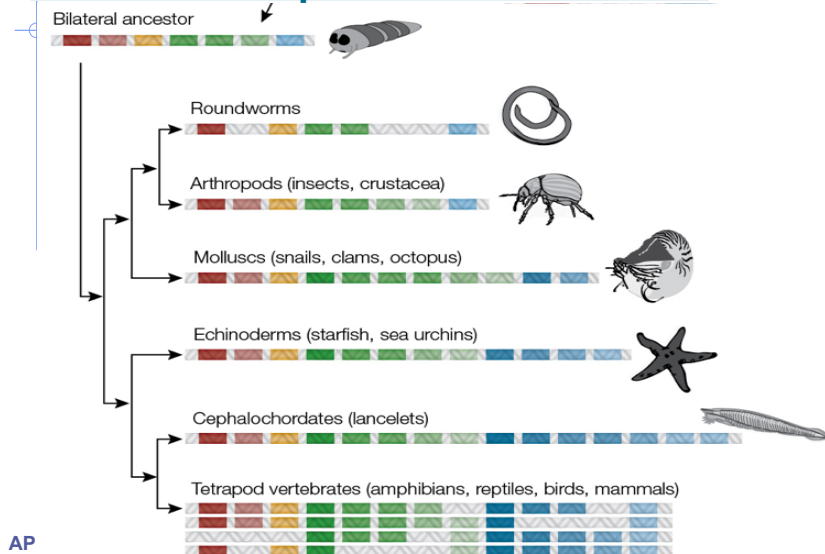
Hox Genes Duplications & Evolution

- Genetic sequences maintained over evolutionary time are thought to be especially important to the basic development of even distantly related organisms.
 - The similarities among Hox genes in different animal species from jellies to humans suggest that they all arose from a single ancestral gene that was duplicated multiple times.
 - After each duplication event, the genes gradually changed, taking on slightly different jobs. This process is known to evolutionary biologists as **"duplication and divergence."**
 - The ancestor to all animals living about a billion years ago had at least 4 Hox genes. By 600 million years ago, in the ancestor to all modern animals that have bilateral symmetry, the number grew to at least 7. Animals descended from this ancestor have homologues of these genes.
 - Additional duplication events happened in some branches of the animal family tree. In insects, for example, a gene near the right end of the cluster was duplicated. In vertebrates, the entire Hox cluster was duplicated—three times in mammals and up to 8 times in some types of fish.
 - The duplicate genes were then free to take on new functions as mutations accumulated in them over time, often leading to more-complex body structures.

Hox Genes Duplications & Evolution



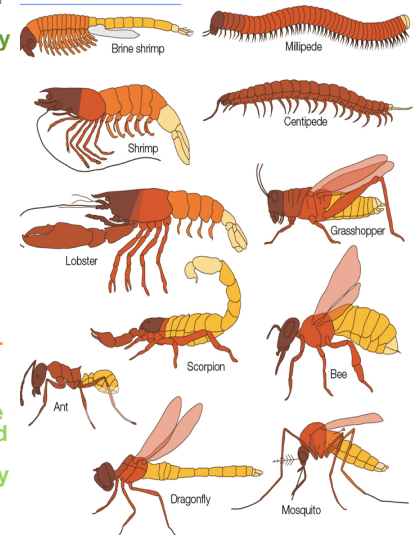
Hox Genes Duplications & Evolution



Hox Genes Duplications & Evolution

Within arthropods, variations on the number of body segments & the genetic program activated have given rise to diversity of body types.

- The regions of color highlight body segments that have similar identities; each color running a different genetic program: a "leg" program or an "antenna" program.
 - One program for building a structure can be reused elsewhere simply by shifting Hox gene expression. Adding some segments and running the "leg" program in them can build an organism with a few more sets of legs.
 - And the genetic programs themselves can be modified through mutations to build structures that are a little different. For instance, the "wing" program didn't come about from scratch—it's simply a modified "leg" program.
- A genetic change that leads to a change in body shape might more effectively capture or predator avoidance, giving it a reproductive advantage. Its genes may be preferentially passed along to the next generation, influencing evolution.



Animals can be categorized by symmetry

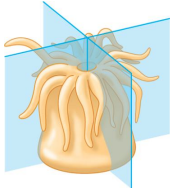
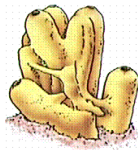
- Though most sponges lack any symmetry, most animals can be classified as having one of two types of symmetry

Radial Symmetry

- no ventral or dorsal (front or back) sides
- no left or right sides

- Animals are often sessile (non-motile)
 - Live attached to substrate or planktonic (drifting or weakly swimming)
- Able to meet their environment equally well from all sides

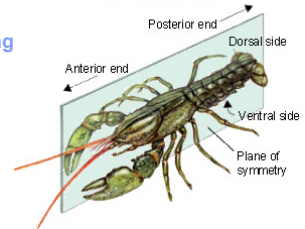
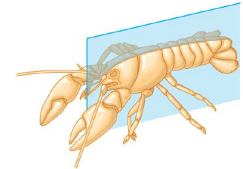
Asymmetrical



Animals can be categorized by symmetry

Bilateral Symmetry

- Two axis of orientation
 - Dorsal (top) and ventral (bottom) sides
 - Left and right sides
 - Anterior (front end with mouth) and posterior (back) ends
 - Many bilateral animals have undergone cephalization (Greek - "kephale" = head)
 - Trend of sensory equipment being concentrated at the anterior end (including in many a central nervous system "brain" in the head)
- Move more actively from place to place



Almost All Animals Have Tissues

- True tissues are collections of specialized cells isolated by membranous layers

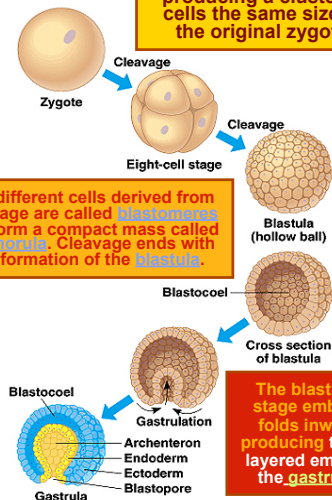
- Sponges are the only animal that lack true tissues

- All other animals' embryos become layered through a process known as gastrulation
- Resulting three germ layers form ALL tissues and organs

- Ex: Ectoderm, Mesoderm, Endoderm

CLEAVAGE:

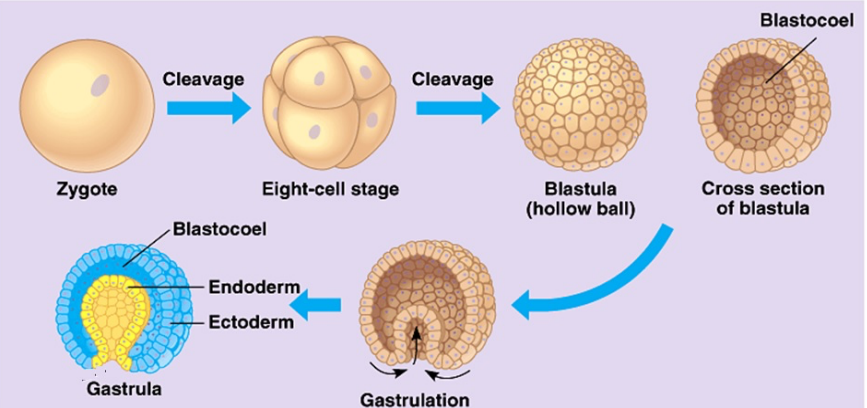
The zygote of many species undergo rapid cell cycles with NO significant growth, producing a cluster of cells the same size as the original zygote.



The different cells derived from cleavage are called blastomeres and form a compact mass called the morula. Cleavage ends with the formation of the blastula.

The blastula-stage embryo folds inward producing three-layered embryo the gastrula.

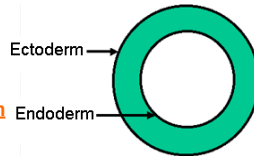
Cleavage: The rapid initial divisions of the zygote & first few embryonic cells to quickly form the multicellular embryo, which then continues to divide by mitosis as cell pass through the cell cycle at a normal rate. (The zygote is able to pass through G1 faster since it doesn't need to grow in size during G1 because the fertilized egg formed with extra cytoplasm due to unequal meiotic divisions during egg formation in females)



Organization of tissues

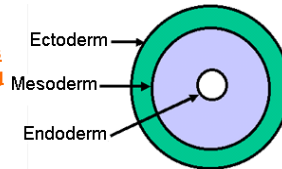
♦ **Diploblastic** animals have **two germ layers**

- **Ectoderm**
 - ♦ Germ layer covering **surface of embryo**
 - Becomes the **outer covering of adult animal**
 - May also develop into **central nervous system**
- **Endoderm**
 - ♦ Inner most germ layer
 - ♦ Lines developing **digestive tube (archenteron)**
 - Becomes the **lining of digestive tract and organs like liver and lungs of vertebrates**
- Found in radially symmetrical or asymmetrical animals



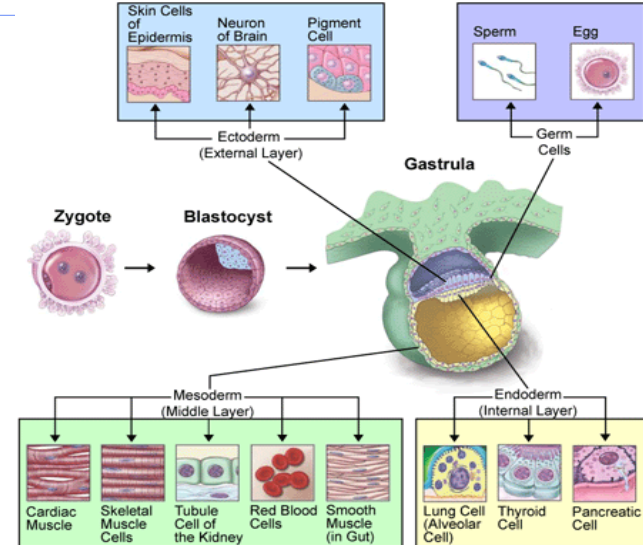
♦ **Triploblastic** animals have an additional **third germ layer**

- **Mesoderm**
 - ♦ Between ectoderm and endoderm
 - Forms the **muscles and most other organs between digestive tract and outer covering of animal**
- Found in all bilaterally symmetrical animals



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Each of the three Germ Layers Develops into specific Organs and Tissues

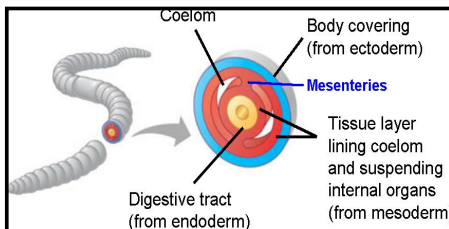


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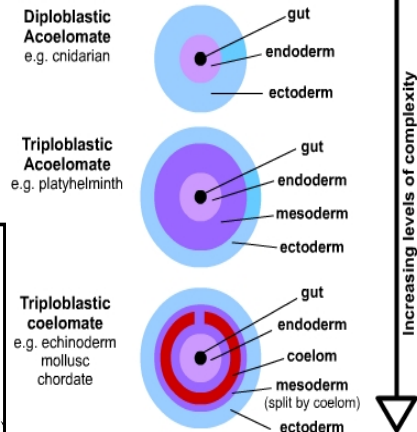
Body Cavities Exist in Triploblasts

▪ **Most triploblastic animals possess a body cavity: A.K.A. the Coelom** (from Greek "Koilos" = hollow)

- ♦ A true coelom forms entirely from the **Mesoderm** germ layer
- ♦ It is a fluid or air-filled space separating the digestive tract from the outer body wall
 - ♦ Animals with a true coelom = **coelomates**

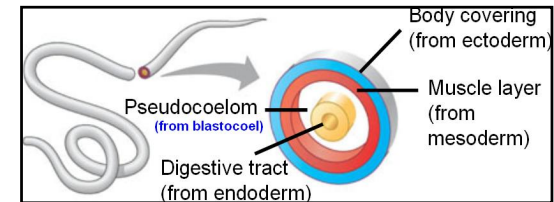


Classification Body plans

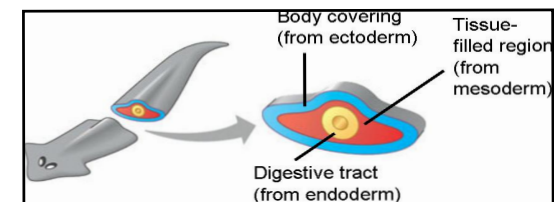


Body Cavities

- If body cavity is formed from mesoderm and endoderm = **pseudocoelom** (from Greek "pseudo" = false)



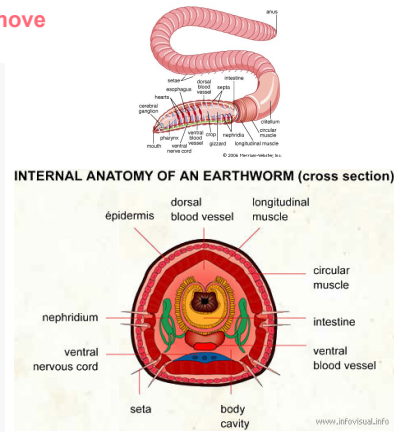
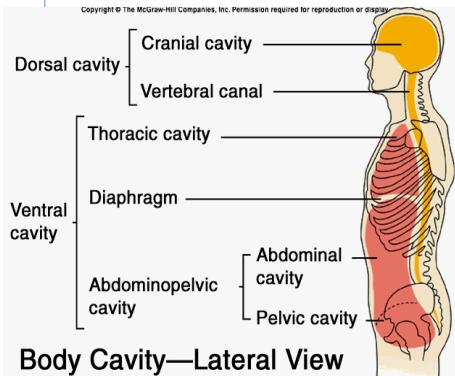
- Some triploblasts have no body cavity at all = **acoelomates** (from Greek "a" = without)



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Body Cavity functions

1. Fluid cushions the suspended organs, helping to prevent internal injury
2. In soft-bodied coelomates with no endoskeleton, like earthworms, the coelom contains non-compressible fluid that acts like a skeleton against which muscles can work to push and move the body
3. Enables internal organs to grow and move independently of the outer body wall



The Protostome vs. Deuterostome Development

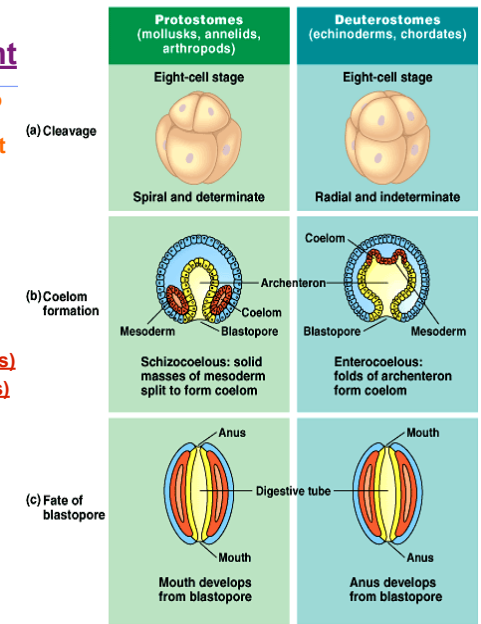
- Coelomates can be divided into two evolutionary lines with different modes of development

1. **Protostomes** (Greek: "protos" FIRST "stoma" MOUTH)
 - Mollusks, annelids, and arthropods (**Invertebrates**)
2. **Deuterostomes** (Greek: "deuteros" SECOND "stoma" MOUTH)
 - The echinoderms (**Invertebrates**) and the chordates (**Vertebrates**)

Main differences:

1. Form of Cleavage
2. Coelom formation
3. Fate of the Blastopore
 - The indentation that during gastrulation leads to the formation of archenteron (digestive tract)

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The Protostome vs. Deuterostome Development

Determinate cleavage of Protostomes:

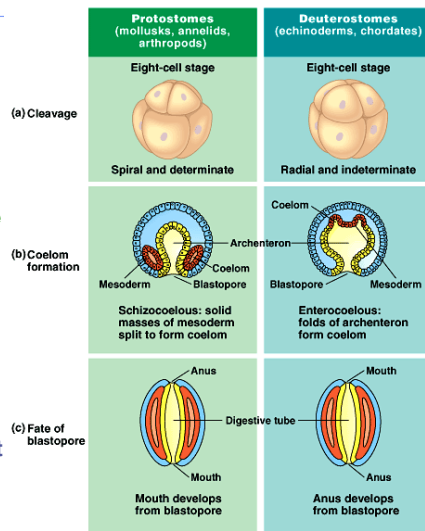
- After the first cell division of the zygote, the two daughter cells are already differentiated and different.
 - If the embryo was split at this stage, neither cell would be able to produce a new individual.
 - Each cell is already designated to become one part of the body

Indeterminate cleavage of Deuterostomes:

- At the 2, 4 or 8 cell stage, the embryo can be split and each cell will act as a zygote and start the development process all over again

AP Biology Ex: The way identical twins in humans are able to form

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The Protostome vs. Deuterostome Development

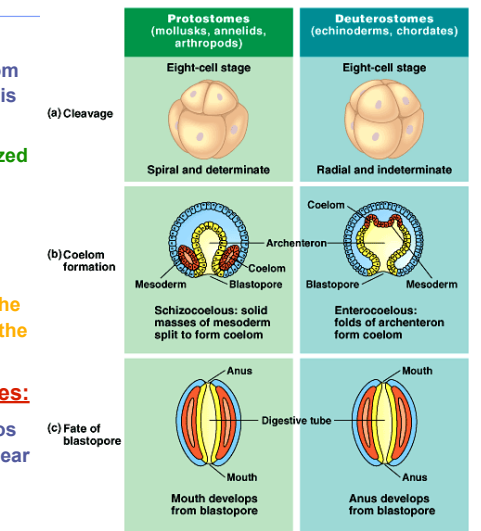
Spiral cleavage in Protostomes:

- The cytokinesis, when going from the 4 to 8, 16 and 32 cell stages is unequal.
 - Embryo that appears polarized
 - Small cells on top and larger cells below
- The cytokinesis is also oblique
 - Top cells appear over the intercellular spaces of the cells below.

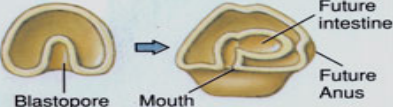
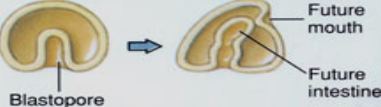


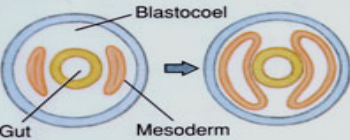
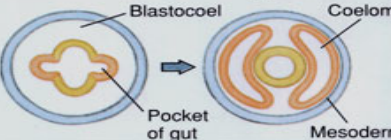
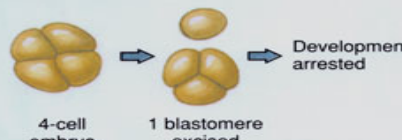
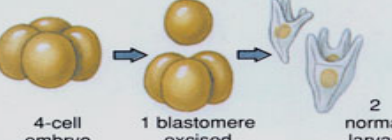
Radial cleavage in Deuterostomes:

- The cytokinesis in these embryos is equal and the upper cells appear directly above the lower cells

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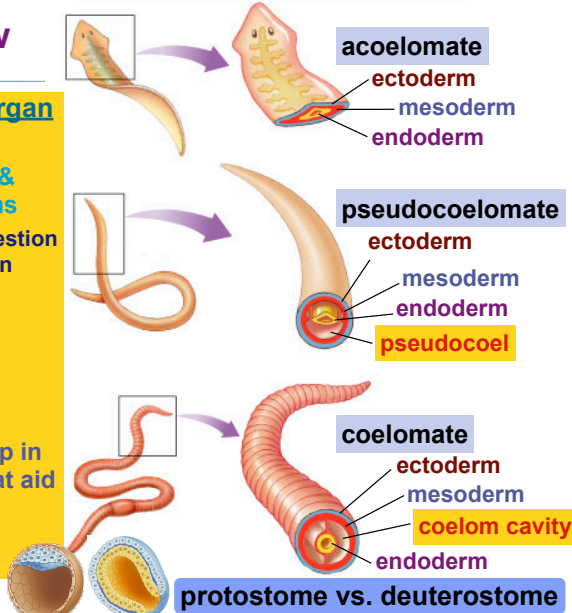


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PROTOSTOME	DEUTEROSTOME
1 Blastopore becomes mouth, anus forms secondarily 	1 Blastopore becomes anus, mouth forms secondarily 
2 Spiral cleavage 	2 Radial cleavage 
3 Coelom forms by splitting (schizocoelous) 	3 Coelom forms by outpocketing (enterocoelous) 
4 Mosaic embryo 	4 Regulative embryo 

Quick Review

- Evolving space for organ system development**
 - increases digestive & reproductive systems
 - increases food ingestion capacity & digestion efficiency
 - increases gamete production
- Coelem**
 - allows complex structures to develop in digestive system that aid digestion
 - ex. stomach



acoelomate
ectoderm
mesoderm
endoderm

pseudocoelomate
ectoderm
mesoderm
endoderm
pseudocoel

coelomate
ectoderm
mesoderm
coelom cavity
endoderm

protostome vs. deuterostome

AP Biology

Protostome Phyla in the Kingdom Animalia

Phylum Mollusca

- " Class Gastropoda - snails, slugs
- " Class Cephalopoda - squids, octopus
- " Class Bivalvia - Clams, oysters



Phylum Annelida -- segmented worms

- " Polychaetes - marine predators with parapodia
- " Oligochaetes - terrestrial worms and leeches



Phylum Arthropoda - segmented bodies, exoskeleton, jointed appendages, largest phyla

- " Subphylum Crustacea - crabs, lobsters
- " Subphylum Uniramia - insects (Class Insecta), millipedes, centipedes
- " Subphylum Chelicerata - spiders, scorpions



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Deuterostome Phyla in the Kingdom Animalia

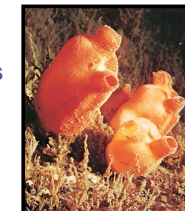
Phylum Echinodermata (starfish)

- Echinoderms have radial symmetry and a unique water vascular system for locomotion



Phylum Chordata - has notochord (dorsal nerve cord)

- Lanceletes & Seas Squirts are non-vertebrate chordates, whereas humans are examples of vertebrate chordates



AP Biology

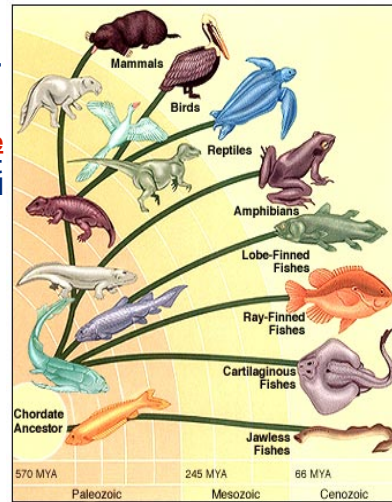
Phylum Chordata contains the **Subphylum Vertebrata**, which includes the Class **Agnatha** (jawless fishes), Class **Chondrichthyes** (cartilaginous fishes), Class **Osteichthyes** (bony fishes), Class **Amphibia** (amphibians), Class **Reptilia** (reptiles), Class **Aves** (birds), Class **Mammalia** (mammals)

■ **Phylum Chordata - has notochord (dorsal nerve cord)**

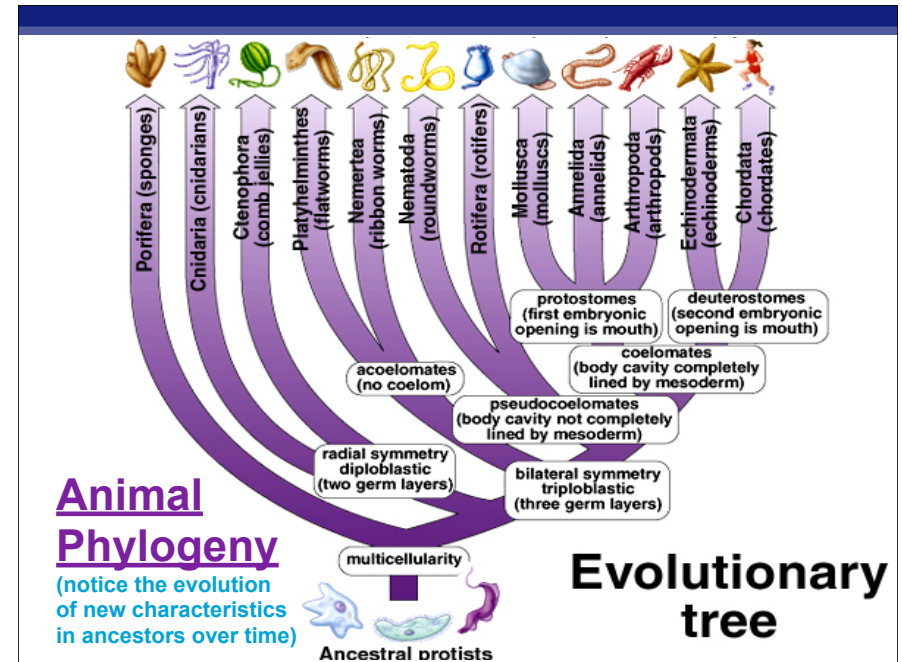
◆ **Subphylum Vertebrata**

- In vertebrates, the **notochord is replaced by the bony vertebral column**. Most vertebrates also have a head region, endoskeleton, and paired appendages.

- ◆ 1. Jawless Fishes (lamprey & hagfish)
- ◆ 2. Cartilage Fishes (sharks & rays)
- ◆ 3. Bony Fishes (salmon, goldfish, carp)
- ◆ 4. Amphibians
- ◆ 5. Reptiles
- ◆ 6. Birds
- ◆ 7. Mammals



AP Biology



Animal Evolution

