

Let's TipToe through the Animal Taxa

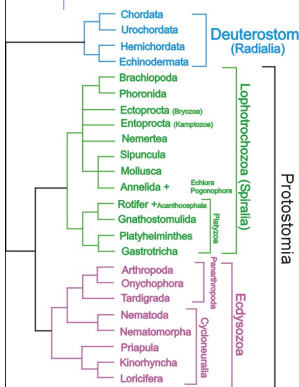
- Keep in mind the following characteristics as they change across phylogenetic groups:

- Tissues, organs, and organ systems:**

- Integumentary system** - protection against mechanical injury, infection, desiccation
 - Digestive system** - food processing
 - Nervous system** - rapid coordination of body activities; response to environmental stimuli

- Muscular system** - movement
 - Reproductive system** - the obvious
 - Excretory system** - removal of nitrogenous waste from body fluid
 - Skeletal system** - structural support
 - Circulatory system** - internal distribution of materials
 - Respiratory system** - gas exchange (O_2 in, CO_2 out)
 - Immune and lymphatic systems** - body defense against pathogens and cancer
 - Endocrine system** - slower coordination of body activities, response to environmental stimuli

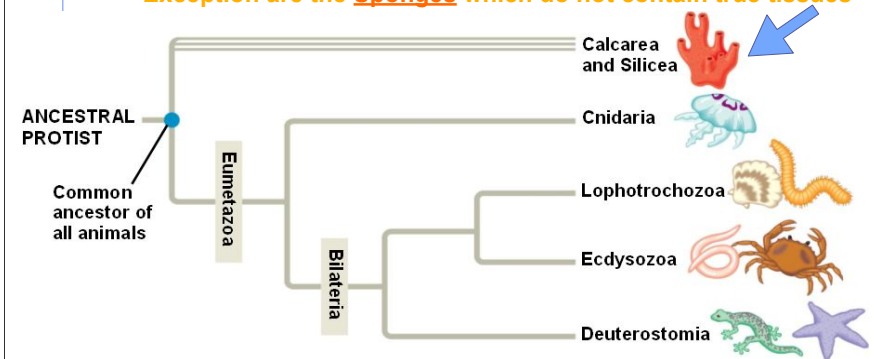
- Body symmetry**
 - Internal body cavity**



AP Biology

Invertebrates

- Animals that **LACK a backbone**
 - Makes up 95% of animal species
 - Found in almost every habitat on earth
- Most in clade **Eumetozoa** = meaning they contain true tissues
 - Exception are the **Sponges** which do not contain true tissues



Invertebrate: Old classification = Phylum Porifera New Classification = Calcarea and Silicea

- Sponges** (Simplest of animals)

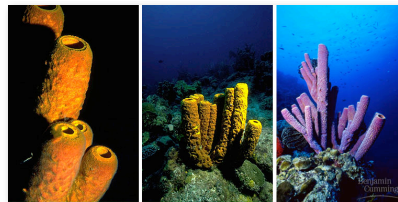
- No symmetry**
 - Diploblastic**
 - Only two cell layers (endoderm and ectoderm)

- no distinct tissues or organs**

- No evidence of any form of nervous system or sense organs
 - Do have specialized individual cells but not groups of cells together that together all do one function**

- Can respond to environmental conditions by opening and closing incurrent and excurrent canals, constricting canal lumen size, reversing water flow, etc.

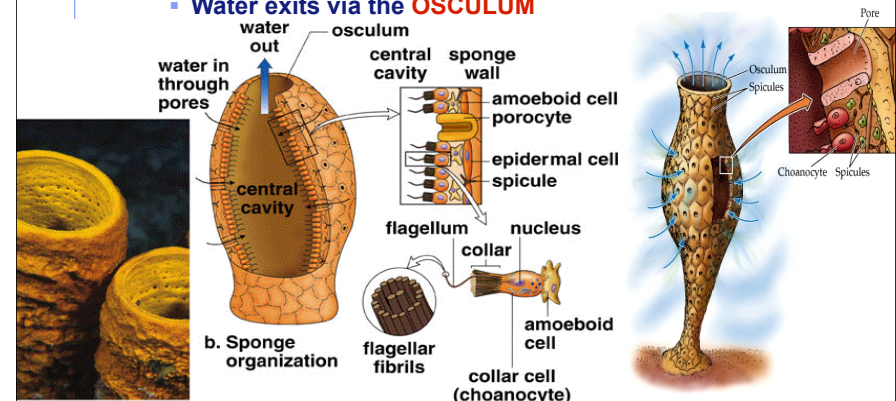
- There is cooperation among cells.



AP Biology

Invertebrate: Old classification = Phylum Porifera New Classification = Calcarea and Silicea

- Totipotent cells** - they can change into all other types of sponge cells
- Sessile (as adults)** - sponges are not mobile
 - Aquiferous System**
 - Incurrent pores draw water into **spongocoel (central cavity)**
 - Water exits via the **OSCULUM**



Invertebrate: Old classification = Phylum Porifera New Classification = Calcarea and Silicae

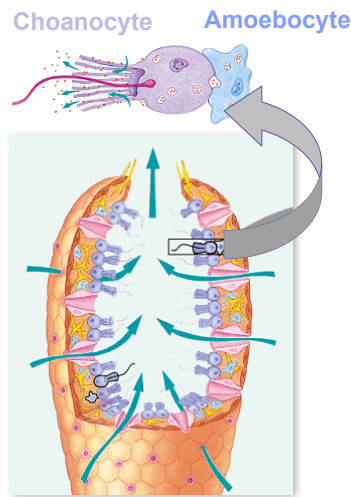
Sponges are **SUSPENSION** or **FILTER FEEDERS**:

Capture food particles suspended in water by passing water through their central body cavity

Fingerlike projections (flagella) of **choanocyte cells** (**COLLAR CELLS**) form a collar that secrete mucus that traps particles of food

Food taken into each cell by endocytosis

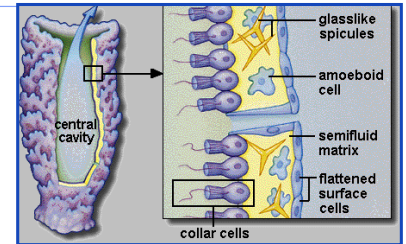
Amebocytes are specialized cells in sponges that can roam to pick up food from choanocytes & distribute it to all other parts of the sponge



Invertebrate: Old classification = Phylum Porifera New Classification = Calcarea and Silicae

Gelatinous interior of sponge is called the **mesohyl**.

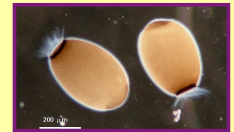
Here, Amebocyte produce **spicules** made from calcium carbonate or silica or flexible fibers made of protein **spongin**



Sponges can reproduce asexually by budding or fragmentation. Sponges also sexually reproduce

Sponges are **hermaphrodites**, each individual functions as both a male and female in sexual reproduction by producing sperm and eggs

- Gametes arise from choanocytes or amebocytes
- Eggs reside in mesophyl
- Sperm carried out by water current
- Fertilization in mesophyl
- Zygote develops in to flagellated, swimming **larvae** that disperses from parent sponge
- On suitable substrate, larva develops into sessile adult



Invertebrate: Cnidaria

■ Tissues but **NO** organs (excluding "skin")

◆ True organs and organ systems

- Integumentary system ('skin') **YES**
- Digestive system **YES**
- Nervous system **YES**

◆ Very simple nerve tissue

- Non-centralized **nerve net**
- No brain

■ Muscular system **YES**

◆ Very simple contractile (muscle-like) tissue

- Use **hydrostatic skeleton** = A pressured skeleton of water in cavity when mouth closed

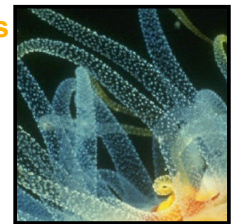
■ Reproductive system **YES**



Invertebrate: Cnidaria

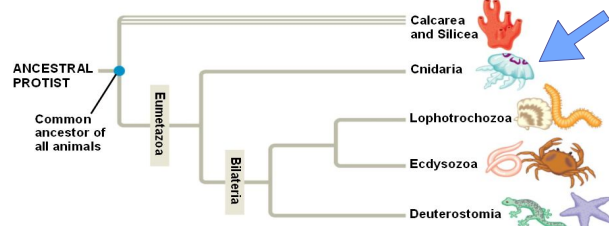
◆ Contains true organs and organ systems

- Excretory system **NO**
- Skeletal system - (hydrostatic only) **NO**
- Circulatory system **NO**
- Respiratory system **NO**
- Immune and lymphatic systems **NO**
- Endocrine **NO**



Invertebrate: Phylum Cnidaria

- Oldest phylum of clade **Eumetazoa** (true tissues)



- Jellyfish, hydra, sea anemone, corals

- Diploblastic** = two cell layers

- Outer layer of epidermis ("skin") from ectoderm
- Inner layer of gastrodermis (from endoderm)

- Radial symmetry

- (radial body plan)



AP Biology

Invertebrate: Phylum Cnidaria

- Body Plan

- Sac with central digestive compartment = **gastrovascular cavity**

- One opening is both mouth and anus

- Carnivorous Predators

- tentacles surround gut opening

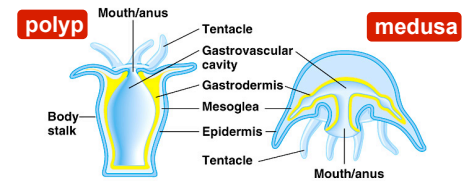
- extracellular digestion

- release enzymes into gut cavity
- absorption by cells lining gut
- Digestion completed inside dermal cell food vacuoles

- Two variations:

- Polyps** = cylindrical forms that adhere to substrates like rocks

- Medusa** = flattened, mouth-down version of polyp that moves freely in water by drifting or contractions

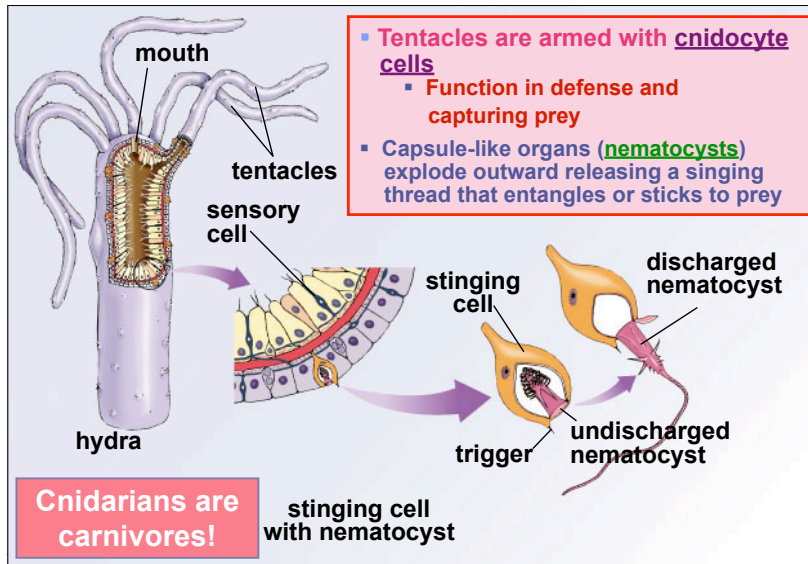


(a) Sea anemone: a polyp

(b) Jelly: a medusa

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Stinging cells of Cnidarians

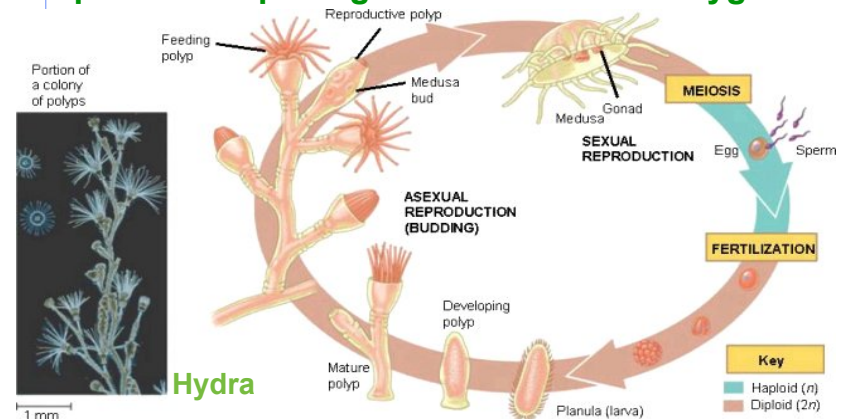


Cnidarians are carnivores!

stinging cell with nematocyst

Sexual & Asexual Reproduction

Diploid Polyps are asexual and reproduce by budding...but diploid medusa are sexual and produce haploid gametes which form zygotes

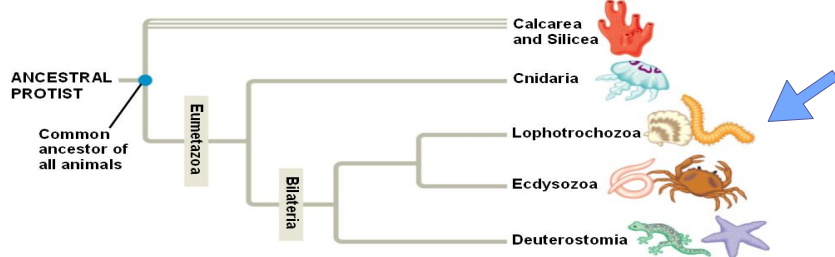


Three clades of bilateral animals exist

All bilateral animals have true tissues

Lophotrochozoa

- Some animals have lophophore - crown of ciliate tentacles that function in feeding
- Others have distinctive developmental stage involving trophophore larva
 - Phylum Platyhelminthes - flatworms
 - Phylum Rotifera - Rotifers
 - Phylum Lophophorates
 - Phylum Mollusca - clams, snails, squids
 - Phylum Annelida - segmented worms

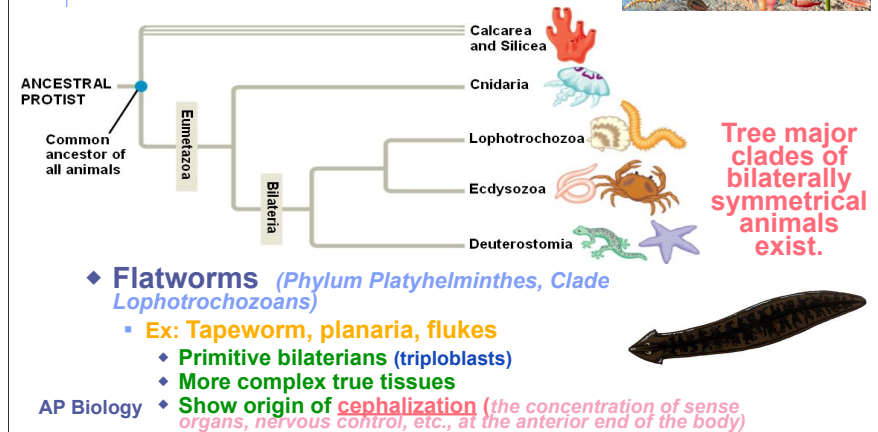


Invertebrate: Platyhelminthes

Vast majority of animals are

bilaterally symmetric and triploblastic

- First appeared during **Cambrian Explosion**



Invertebrate: Platyhelminthes

Live in aquatic or moist environments

Mostly parasitic

- Ex: Tapeworm and flukes

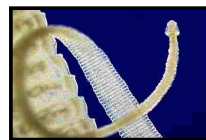
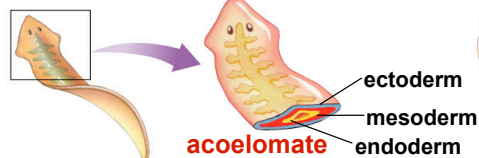
Flattened dorsoventrally

Acoelomates (no body cavity)

Bilaterally symmetrical

- have right & left sides
- Have head (**anterior**) end & **posterior** end
- Cephalization** begins = early development of a brain
- More centralized concentration of sense organs (in head too)

Animals now face the world head on!



Invertebrate: Platyhelminthes

Increase specialization in body plan as seen in flatworm

Integumentary system (skin) YES

Gastrovascular cavity with only one opening

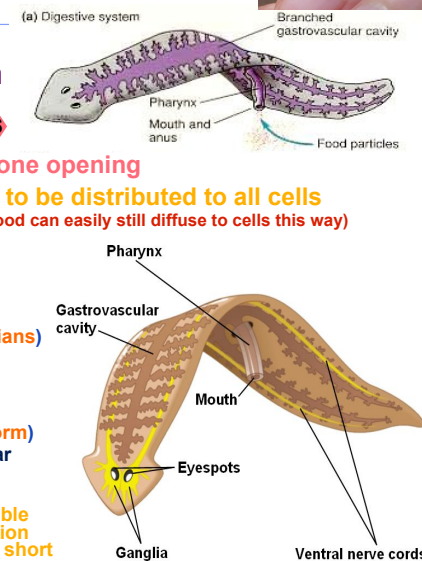
- Finely branches to allow food to be distributed to all cells (no need for circulatory system because food can easily still diffuse to cells this way)

Digestive system YES

- Well developed incomplete digestive tract in Turbellarians (free living planarians)
- Reduced digestive tract in Trematoda (parasitic flukes)
- Digestive tract lost in Cestodes (endoparasite tape worm)

They lost their gastro-vascular cavity and mouth

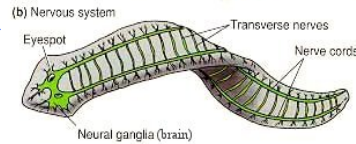
Absorb nutrients across body surface from host possible since body is so flat, diffusion distances to body cells are short



Invertebrate: Platyhelminthes

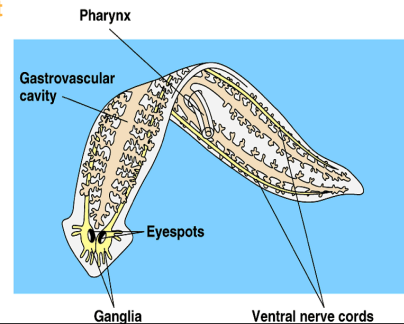
Nervous system YES

- Well developed in Turbellarians (planarian)
- Reduced in Trematodes (flukes)
- Even more reduced in Cestodes (tapeworm)
 - well-developed **cerebral ganglion** (a cluster of nerve cells located at the anterior region - not quite a brain yet but the start)
 - Eyespots** for photoreception allowing the animal to determine the direction of incoming light
 - Can modify response to stimuli



Muscular system YES

- Longitudinal, circular and transverse muscle cells allow contraction in every direction.



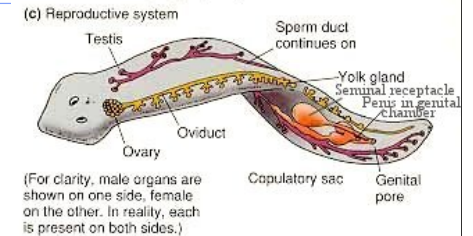
Invertebrate: Platyhelminthes

Reproductive system YES

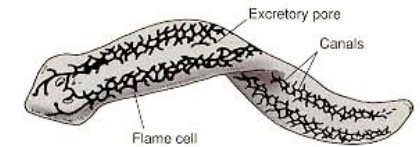
- Hermaphrodites with simple sex organs

Excretory system YES

- In free-living turbellarians, the excretory system consists of a tubular **PROTONEPHRIDIAL** system



(For clarity, male organs are shown on one side, female on the other. In reality, each is present on both sides.)



(d) Protonephridia (flame cells, ducts, and pores.)

Protonephridia:

- A network of tubules with cilia that rings the margin of the body that pull fluid through ducts opening to the outside - **maintains osmotic balance**

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NEPHRIDIOPORES are located along the sides of the animal where **nitrogenous wastes and water** are excreted.

Invertebrate: Platyhelminthes

Circulatory system NO

Organ specialized for gas exchange NO

- Gas (O_2/CO_2 and nitrogenous waste (in the form of ammonia) come and go by diffusion across body surface



Skeletal system (few tiny, calcareous plates) NO

Respiratory system NO

Immune and lymphatic systems NO

Endocrine system NO



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Invertebrate: Phylum Rotifera

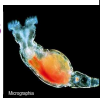
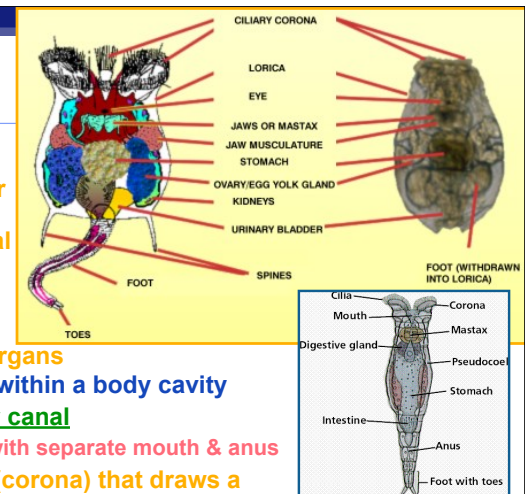
Rotifers

- Freshwater, marine, or damp habitats
- Bilaterally symmetrical
- Exhibit cephalization
- Pseudocoelomates**
- Multicellular with specialized organs

- Internal organs lie within a body cavity
- Have an **alimentary canal**
 - A digestive tube with separate mouth & anus
- Have a crown of cilia (corona) that draws a vortex of water into mouth

- Some species are only females who reproduce from unfertilized eggs through parthenogenesis (**ASEXUAL**)
- Some have primitive males that cannot feed themselves and live only long enough to fertilize an egg (**SEXUAL**)
- Shows **Sexual Dimorphism** (males and females look different)

A true digestive tract...



The Coelemates

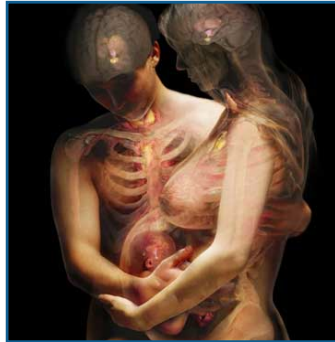
True plane of symmetry: bilateral

♦ Triploblastic

- Three germ layers leading to true tissues

♦ True organs and organ systems exist - IN MOST PHYLA

- Integumentary system
- Digestive system
- Nervous system
- Muscular system
- Reproductive system
- Excretory system
- Circulatory system
- Respiratory system



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The Coelemates

■ SOME coelomate phyla have:

♦ Skeletal system

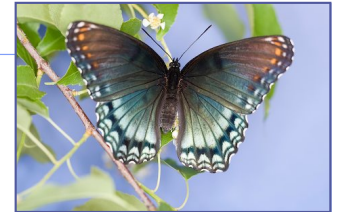
■ PROTOSTOMES:

- ♦ Annelida - coelom provides hydrostatic support (water-based)
- ♦ Mollusca - hydrostatic "skeleton" or secreted shell
- ♦ Arthropoda - jointed chitin exoskeleton

■ DEUTEROSTOMES:

- ♦ Echinodermata - internal calcium carbonate skeleton
- ♦ Chordata - notochord

- Vertebrata - notochord gives way to complex internal skeleton of bone and cartilage (endoskeleton)



Invertebrate: Phylum Mollusca

■ Mollusks

♦ slugs, snails, clams, squid, octopi

- Triploblastic bilaterally symmetrical
 - ♦ Some develop into a form of asymmetry later
- Soft bodies, mostly protected by hard shells made of calcium carbonate
- True **coelem**
 - ♦ increases complexity & specialization of internal organs

- largest phylum (or division) of living organisms outside of the phylum Arthropoda

- True organ system of development

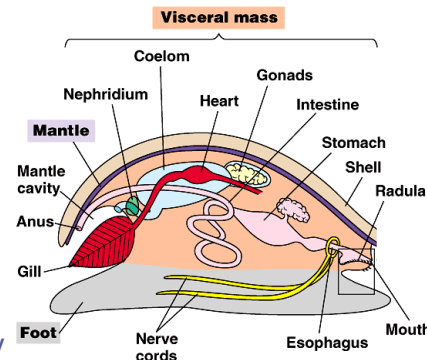


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Invertebrate: Mollusca

■ Three main parts

1. Muscular **foot** used for movement usually
2. **Visceral mass** containing most of the internal organs
3. **Mantle**, a fold of tissue draped over the visceral mass that secretes a shell of CaCO_3 in many cases which hardens



AP Biology

Some major classes of Mollusks

- ♦ **Polyplacophora** - (*poly* = "many"; *plac* = "plate"; *phor* = "to bear")
 - Chitons
 - ♦ All marine, benthic (on ocean floor)



- ♦ **Gastropoda** - (*gastr* = "stomach"; *pod* = "foot")
 - Slugs & snails
 - ♦ Free-living
 - ♦ Marine, freshwater, or terrestrial
 - ♦ High degree of cephalization with well-developed sense organs
 - ♦ Snails produce a single shell, often spiral or conical
 - ♦ Slugs do not produce a shell



AP Biology

Some major classes of Mollusks

Bivalvia - (*bi* = "two"; *valve* = "shell")

- Clams, oysters, mussels, etc.
 - ♦ Marine and freshwater
 - ♦ Gill used for both respiration and gas exchange
 - ♦ All are suspension filter-feeders



Cephalopoda - (*cephalon* = "head"; *pod* = "foot")

- Chambered Nautilus, Squids, Octopus
 - ♦ Exclusively marine
 - ♦ Fast-swimming predators
 - ♦ Camera eye is analogous to the vertebrate eye and forms complex, color images like our own
 - ♦ Comparatively intelligent: Octopus are able to solve problems! *Cephalopods have complex brains...*



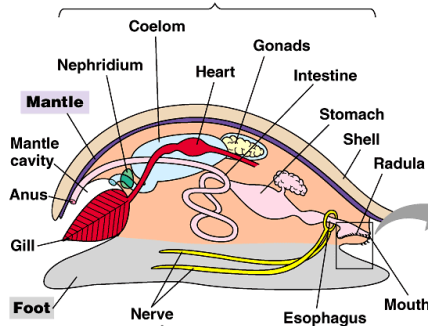
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Invertebrate: Mollusca

- **Organ Systems** (only cephalopod molluscs have closed circulatory system all other molluscs have open circulatory systems)

Open circulatory system

- Has a heart, several major arteries, blood sinuses and respiratory blood pigments.
- The coelom is reduced to a small cavity around the heart.
 - ♦ Heart pumps circulatory fluid called **HEMOLYPH** (only called blood in closed circulatory systems) through **arteries** and into **sinuses** (body spaces).



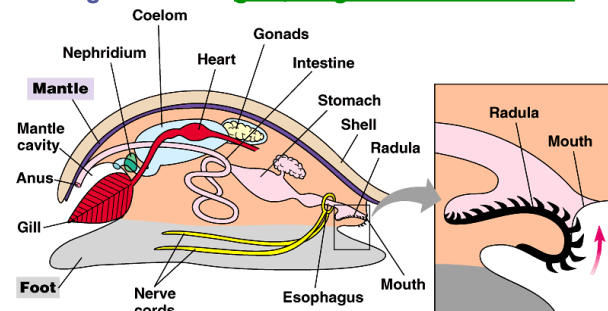
Hemolymph contains **hemocyanin**, a copper-based protein that turns blue from gray in color when oxygenated, instead of the iron-based **hemoglobin** in red blood cells found in vertebrates.

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- Organs bathed directly in hemolymph

Invertebrate: Mollusca

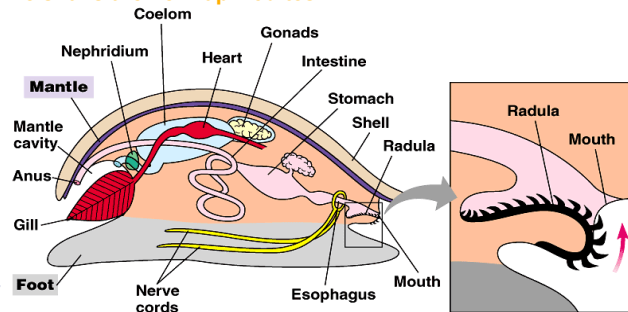
- ♦ Complete digestive system coiled in visceral mass
 - **Extracellular** digestion occurs - enzymes secreted into stomach/intestines.
 - Buccal (mouth) opening with a rasplike chitin based **RADULA** feeding structure (*thrusts outward and retreated - scrapes and scoops*)
- ♦ Nephridia excretory organs (**METANEPHRIDIA**)
 - Remove metabolic waste from hemolymph (*analogous to human kidney*)
- ♦ Gas exchange is across **gills, lungs or the mantle wall**.



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Invertebrate: Mollusca

- ♦ The nervous system - nerve ring around esophagus with two nerve cords extending
 - 3 or 4 pair of ganglia, interconnecting fibers, and sensory cells.
- ♦ The muscles system
 - Muscles pull against the shell or a hydrostatic skeleton.
- ♦ The animals are **dioecious** (Greek: "two households") and reproduce only sexually, there being a distinct male and female.
 - Some snails are hermaphrodites



AP Biology

Invertebrate: Phylum Annelida

earth worm

- ♦ **Segmented worms**
 - Annelida means "little ring"
 - Body like a series of fused rings
 - ♦ Many internal organs and structures are repeated within each segment
 - ♦ Ex: Earthworms, leeches
- ♦ Protostome triploblastic coelomates
- ♦ Segments allow for
 - increase mobility
 - redundancy in body sections
- ♦ Bilaterally symmetrical
- ♦ Body covered with moist **cuticle**



fan worm

leech

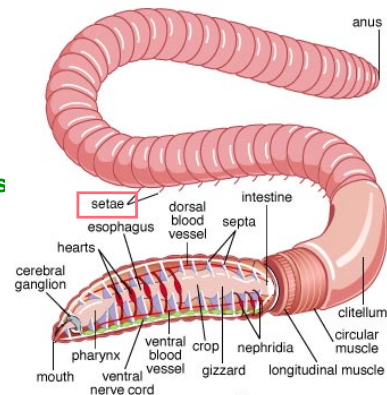


- ♦ outer covering that does not contain cells but is secreted by cells in the skin underneath and is made of tough but flexible **collagen proteins**.
- ♦ it does **NOT molt** unlike arthropods' cuticles which are made rigid chitin resulting in the need for molting (shedding the old layer and building a new one as the animal grows to adult size)

AP Biology

Invertebrate: Annelida

- ♦ Annelid worms (except leeches) **have chitinous setae (chaetae)**, bristles, on their latero-ventral surface.
 - Provide traction for burrowing
- ♦ Annelids are either herbivores or carnivores.
 - The **earthworms feed upon organic matter** in the mud **important detritivore** that helps in decomposing organic materials in nature
 - Marine forms are active hunters
 - The **leeches** are **ectoparasites** of vertebrate animals.



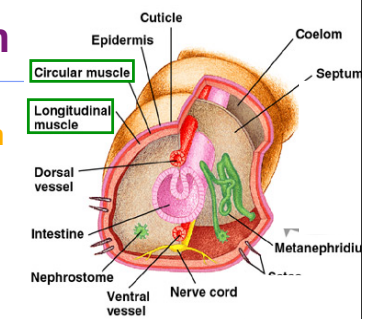
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The Annelid Earth Worm

Organ-system level of organization

- ♦ True coelom separated by **septa** (walls) in between each segment
- ♦ Well-developed digestive system
- ♦ Coelom serving as large, fluid-filled **hydrostatic skeleton**
- ♦ True muscle system
 - The muscles of the body wall and intestinal tract pull against the hydrostatic skeleton of the non-compressible fluid-filled coelom.

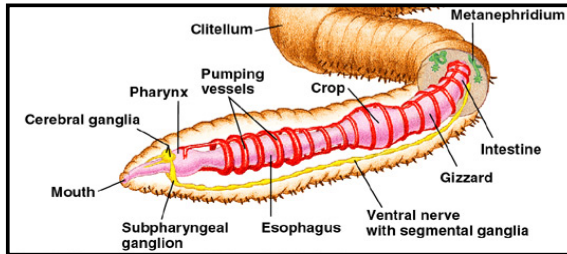


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The Annelid Earth Worm

Besides helping break down organic material, earth worms till the soil (mix), oxygenating it so other organisms can get enough oxygen including plant roots, and their castings (manure) improve the texture & nutrient content of the soil.

- ◆ Well-developed nervous system
 - Cerebral ganglion (pair that acts as a brain) & ventral, ganglionated nerve cords carry messages to muscles and glands down the body
- ◆ Dorsal, **closed** circulatory system with several “hearts”
 - Blood is circulated & the O₂ is transported on respiratory pigments.
- ◆ Excretory system
 - Osmoregulation and excretion are done by paired **metanephridia**
 - ◆ These are **excretory tubes** - one pair per segment
 - Removes wastes from blood and coelomic fluid through exterior pores



AP Biology

Invertebrate: Annelida

- ◆ Respiratory gas exchange is through the skin (earth worm), gills, or fleshy appendages, also called **parapodia**.
- ◆ Full reproductive system
- ◆ The segmented worms can be hermaphroditic or have separate sexes.
 - Fertilization is external
 - ◆ Earth worms are hermaphroditic but they fertilize by aligning themselves in opposite directions to exchange sperm
 - ◆ Some earth worms can reproduce asexually by fragmentation and regeneration



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