

Protostome Division

- Genome analysis, supports a major division of the Protostomia

1. Clad Lophotrochozoans

- flatworms (Platyhelminthes)
- annelids (Annelida)
- mollusks (Mollusca).



2. Clad Ecdysozoans

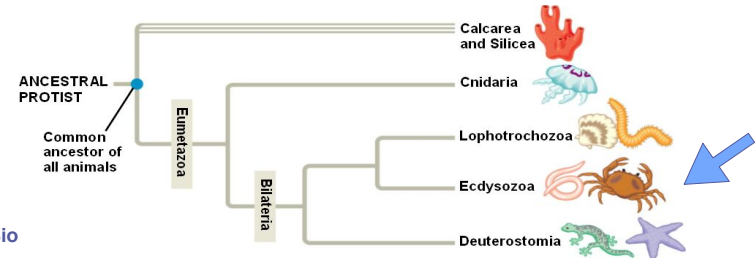
- roundworms (Nemadodia)
- athropods (Arthropodia)



AP Biology

Three clades of bilateral animals

- All bilateral animals have true tissues**
 - Clade Ecdysozoa**
 - Animals secrete external skeletons (exoskeletons)
 - As the animal grows, it molts, squirming out of its old exoskeleton and secreting a larger one
 - Phylum Nematoda - Roundworms
 - Phylum Arthropoda - crustaceans, insects, spiders



AP Bio

Invertebrate: Phylum Nematoda

Roundworms

- Bilaterally symmetrical
- Body cavity
 - pseudocoelom** = simple body cavity
- Unsegmented bodies
 - Blunt end anterior with a tapered end posterior
- Covered in tough **cuticle**
 - Periodically sheds it & secretes a new one = **MOLTING** (also referred to as **ecdysis**)
- Lack circulatory systems
 - Pseudocoelom is continuous fluid filled cavity
 - Nutrients transported in this fluid
- Longitudinal muscles in body wall
 - Result in sinusoidal thrashing body motion.
- Full one way digestive tracts from mouth to anus
- Dioecious** - separate males and females



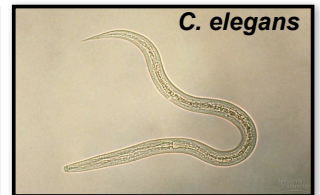
Invertebrate: Nematoda

Roundworms

- Hugely abundant
- Most are free-living, but many are **parasitic**
 - Hookworm, pinworm
- Sexual reproduction
 - Internal fertilization
 - Zygotes can resist harsh conditions
- Important in decomposing organic material and nutrient cycling in nature
 - Caenorhabditis Elegans (C. Elegans)** is an important research organism used in labs



A sign of hookworm is severe edema (swelling).
The hookworm uses its sharp cutting teeth to grasp firmly to the intestinal wall, and while remaining fastened in place, ingests the host's blood, thereby, causing the sufferer to become anemic due to blood loss.



C. elegans

Invertebrate: Phylum Arthropoda

Spiders, insects, crustaceans...

- ◆ **most successful animal phylum**
 - A billion billion varieties (mostly insects)
 - ◆ Order Coleoptera (beetles): 350,000+ species!
 - Protostomes with bilateral symmetry
 - Triploblastic coelomates



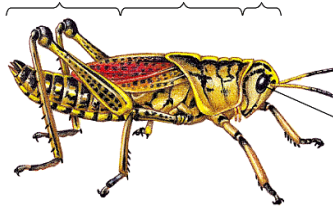
Great Success attributed to...

1. Their "jointed appendages"
2. Segmented bodies

- The body is typically separated into a **head**, **thorax** and **abdomen** although one or more of these regions may be fused.
- Allows for jointed appendage
 - One pair to a segment
 - Used for locomotion, feeding, sensation, reproduction, weaponry

Arthropoda means jointed feet

Abdomen Thorax Head

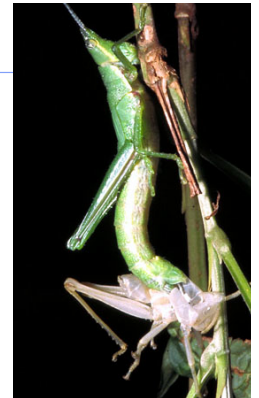


AP Biology 3. Exoskeleton

Invertebrate: Arthropoda

Organ-system level of organization

- ◆ **Skeletal system: exoskeleton**
 - Made of lipids, chitin, and proteins
 - ◆ **Calcium carbonate** may be added to harden it further
 - ◆ **Chitin** (Polymer of N-acetylglucosamine (NAG) + protein)
 - Exoskeleton is the point of **attachment for muscles** to move appendages
 - Prevents **desiccation**
 - ◆ Allowed for their great success on land - insects have spread around the world
 - Must be shed as animal inside exoskeleton grows = **MOLTING**
- ◆ **Muscle system**
 - The arthropods have well developed striated and smooth muscles
 - ◆ **Highly efficient locomotion**

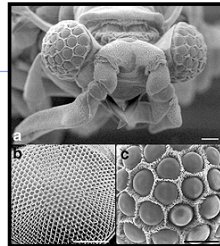


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Invertebrate: Arthropoda

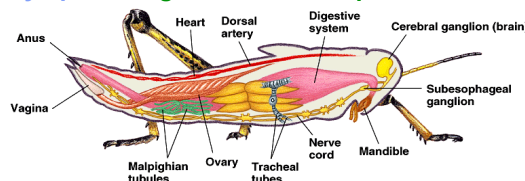
Well-developed nervous system with sensory organs (anterior like annelids)

- ◆ Lateral compound (faceted) eyes & olfactory (smell) receptors
 - Most have antennae for touch and smell



Main body cavity is the hemocoel, part of the OPEN CIRCULATORY SYSTEM

- Heart pumps **hemolymph** through arteries into spaces called **sinuses** that surround the tissue and organs



Complete digestive system

- ◆ Digestion is **extracellular** with enzymes secreted into digestive tract

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Invertebrate: Arthropoda

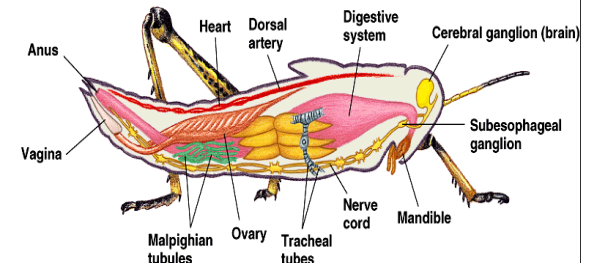
Excretory system

- ◆ **Green glands or malpighian tubules**

Reproduction usually involves

dioecious organisms (separate male vs female organism).

- ◆ Fertilization is internal
- ◆ Development often involves one or more **metamorphic changes**.



AP Biology

Metamorphosis

Incomplete Metamorphosis (3 stages)

- ♦ **Egg** - A female insect lays eggs with egg case which protects the eggs and holds them together
- ♦ **Nymph** - The eggs hatch into nymphs. Nymphs look like small adults, but usually don't have wings.
 - Nymphs shed or molt their exoskeletons (outer casings made up of a hard substance called chitin) and replace them with larger ones several times as they grow.
- ♦ The insects stop molting when they reach their **adult** size.
- ♦ By this time, they have also grown wings.



AP Biology

Metamorphosis

Complete Metamorphosis (4 stages)

- ♦ Seen in 88% of all insect species
- ♦ **Egg** - A female insect lays eggs.
- ♦ **Larva** - Larvae hatch from the eggs with a worm-like shape.
 - Caterpillars, maggots, and grubs are all just the larval stages of insects.
 - Larvae molt their skin several times as they grow slightly larger.
- ♦ **Pupa** - Larvae make cocoons around themselves.
 - Their bodies develop into an adult shape with wings, legs, internal organs...
- ♦ **Adult** - Inside the cocoon, the larvae change into adults.
 - After a period of time, the adult breaks out of the cocoon.

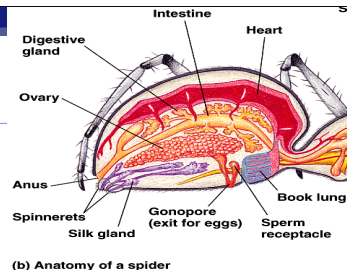


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Invertebrate: Arthropoda

Respiration system

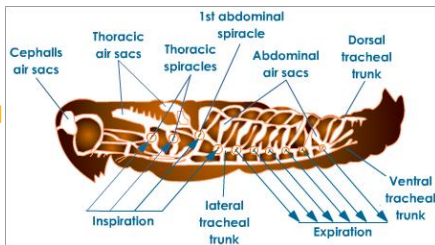
- ♦ **Gills** (aquatic species), **book lungs** (arachnids) and **trachea** (insects).
- Tracheal system has branched air ducts leading to interior of body from pores in cuticle
 - ♦ Oxygen diffuses directly from the atmosphere into the air-filled tubes, diffusing from there into hemolymph fluid that bathes cells.
 - ♦ Diffusion through air is 300,000 times more efficient than the diffusion through water



(b) Anatomy of a spider

TRACHEAL SYSTEM

- The tracheal system is composed of chitin-ringed called tracheae that connect directly to the air through openings in the called spiracles.



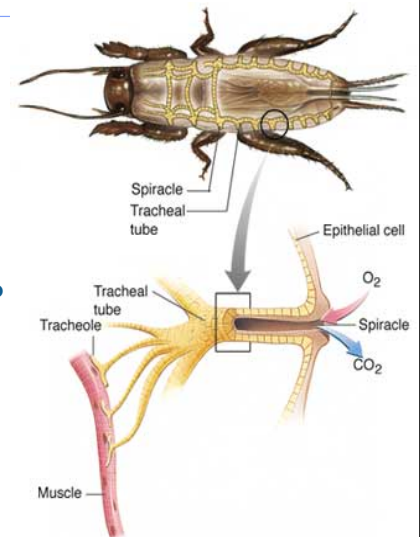
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Insect Tracheal System

Inefficient, open circulatory system has no closed vessels to carry oxygen to body parts

- ♦ Centralized respiratory system, such as lungs, would not meet the respiratory demands
 - Have small tubes instead of lungs that channel O₂ directly to the different parts of the body.

The tracheae branch into smaller and smaller tubes, called **tracheoles**, that eventually terminate on the plasma membrane of every cell in the insect's body.



AP Biology

Invertebrate: Arthropoda

- There are **four** main lines of Arthropod lineage

- Trilobites** (all extinct)
- Chelicerates** (Horseshoe crabs, scorpions, ticks and spiders)
- Uniramians** (Centipeds, millipeds, and insects)
- Crustaceans** (Crabs, lobsters, shrimps, barnacles and many others).



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Invertebrate: Arthropoda

Chelciformes (Greek: cheilos = lips, cheir = arm)

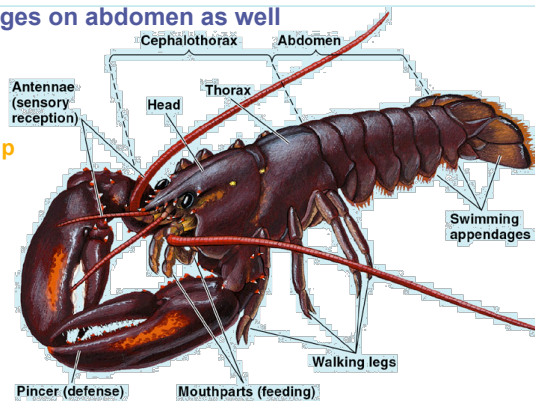
- Horseshoe crabs, scorpions, ticks and spiders**
 - Anterior head and thorax segments fused into one body region called the **cephalothorax**.
 - The first pair of appendages - the **chelicerae** - are claw like feeding appendages serve as pincers of fangs and sometimes in sensing or reproduction.
 - Most have simple eyes
- Arachnids**
 - 8-legged** (instead of 6 like other arthropods)
 - Scorpions, mites, ticks, spiders, daddy longlegs.
 - Have 2 body segments with **book lungs**
 - respiration organ, air-filled cavity, for atmospheric gas exchange inside ventral abdominal connected with the air through a small opening
 - Make up of stacks of alternating air pockets and leaves of tissue filled with hemolymph (the arthropod equivalent of blood)
 - Tissue folds maximize the surface exposed to air, and thereby maximize the amount of gas exchanged with the environment.



Invertebrate: Arthropoda

Crustacea

- Most are **aquatic with gills**
- 2 body segments and two antenna
- Have appendages on abdomen as well
 - Crayfish, lobsters, barnacles, crabs, shrimp



Invertebrate: Arthropoda

Myriapoda

- Unbranched appendages.
- Includes **centipedes** (one leg per body segment and carnivores) and **millipedes** (two legs per body segment and herbivores)



Hexapoda - the insects

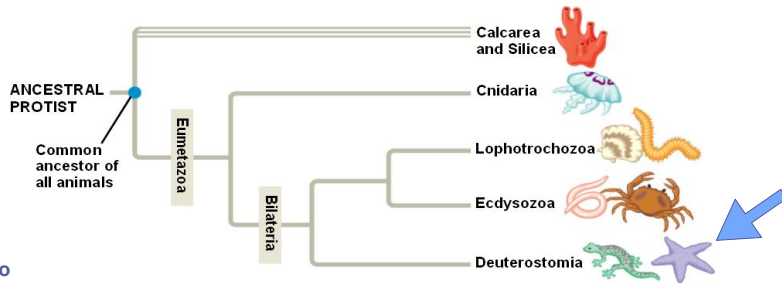
- Body segments grouped into **head, thorax, and abdomen**.
- Each of the 3 **thoracic segments** carries a pair of legs (hence the 6-legged "hexapoda")
- Many have wings, usually 2 pairs (only one pair in flies - diptera).
- Gas exchange through a tracheal system.
- Most intensively-studied representative: **Drosophila melanogaster, the fruit fly**



AP Biology

Three clades of bilateral animals

- **All bilateral animals have true tissues**
 - ◆ **Deuterostomia**
 - Refers to the mode of development with radial cleavage and formation of the mouth at the end of the embryo opposite the blastopore
 - ◆ Phylum Echinodermata - sea stars, sea urchins
 - ◆ Phylum Chordata - lancelets, tunicates, vertebrates



AP Bio

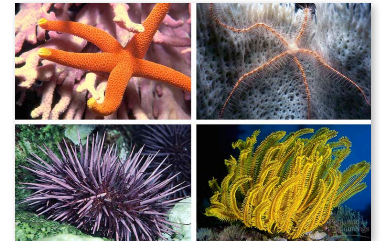
Invertebrate: Phylum Echinodermata

- The “spiny-skinned animal” (*echin - spiny, derma - skin*)
 - ◆ Starfish, sea urchins, sea cucumber
 - Deuterostome invertebrate!!! (*Humans are deuterostome vertebrates*)
 - Radially symmetrical as adults but still considered a **BILATERAL COELOMATE**
 - ◆ Larva is bilateral

loss of bilateral symmetry?

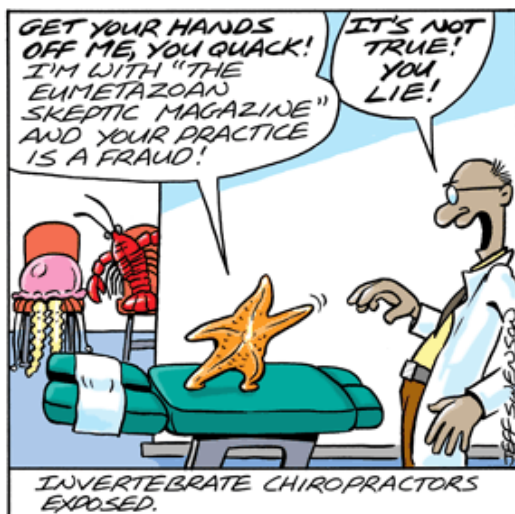
Skeletal System

- ◆ Thin epidermis covers an internal spiny endoskeleton constructed of calcium carbonate plates (not bones) called **OSSICLES**



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Invertebrate: Echinodermata



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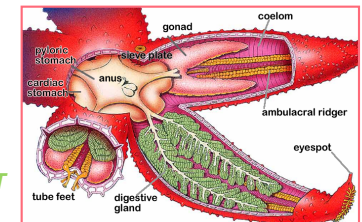
Invertebrate: Echinodermata

Water Vascular System

- ◆ Network of hydraulic canals branching into extensions called **tube feet**
 - Used in locomotion, feeding and gas exchange.



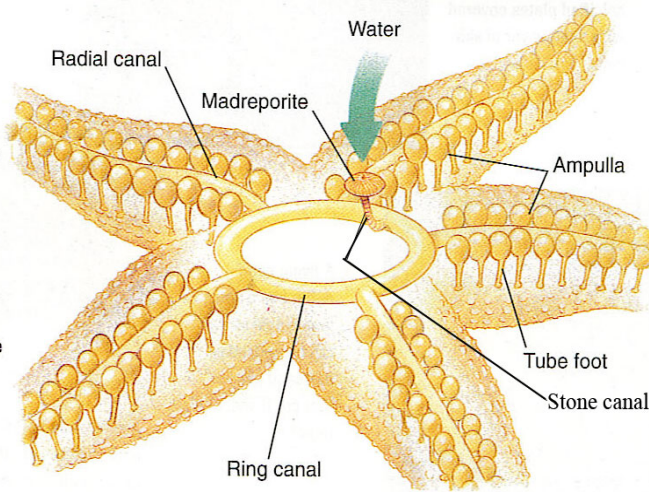
- Complete digestive tract
 - ◆ Anus generally on aboral side, away from the substrate (floor)
- Excretory system is secondarily lost
- Reduced or absent circulatory system
 - ◆ Composed of coelomic tissue, but **NOT** related to the water-vascular system



- Nervous system diffuse and decentralized
 - ◆ Typical in radially symmetrical animals.
- Mostly dioecious (separate males and females) with **external fertilization**

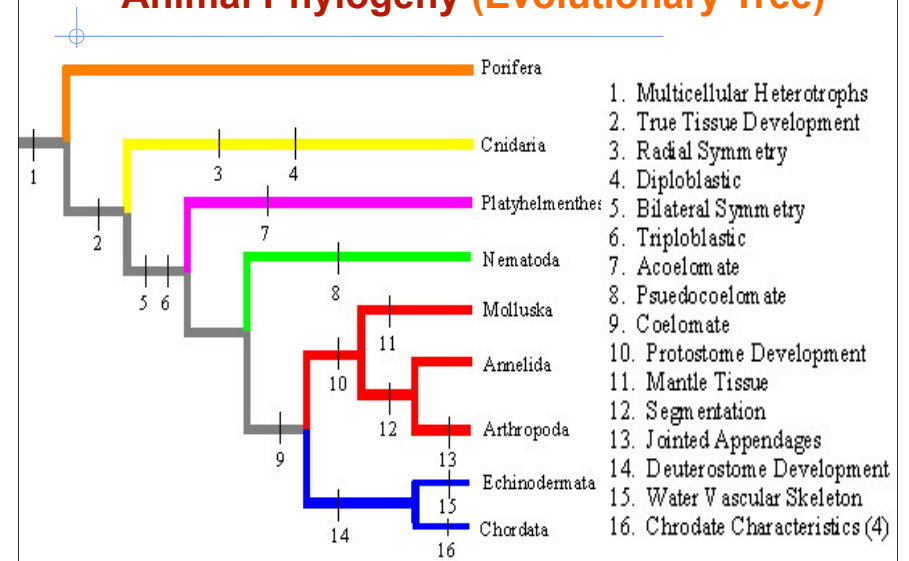
Invertebrate: Echinodermata

The starfish's water vascular system provides the water pressure that operates the animal's tube feet. From the madreporite, water moves into the ring canal, then into the rays through radial canals, and finally to the tube feet. The canals are like a network of water pipes attached to the tube feet. Water also exits the body through the madreporite.



AP Biology

Animal Phylogeny (Evolutionary Tree)



Invertebrate quick check...

Invertebrates: Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Mollusca, Arthropoda, Echinodermata

1. Which group includes snails, clams, and squid?
2. Which group includes the sponges?
3. Which group includes the flatworms?
4. ...the segmented worms?
5. ...the roundworms?
6. Which group has jointed appendages & an exoskeleton?
7. Which two groups display radial symmetry?
8. What is the adaptive advantage of bilateral symmetry?
9. Which group has no symmetry?

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