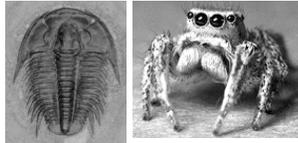
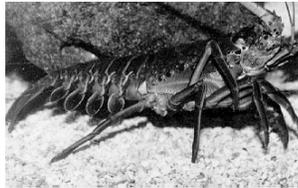


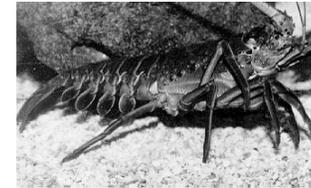
### ARTHROPODA: Jointed-leg animals

- The most species-diverse group of organisms on the tree of life; make up about 75% of all animals and over half of *all* living things
- Chitinous exoskeleton, segmented body, and jointed appendages
- Body segments tend to be organized into tagmata, e.g. head-thorax-abdomen (in insects) and cephalothorax-abdomen (in spiders and relatives)
- Antennae, mouth parts, wings, and legs are all derived from similar appendages. Body segments and appendages show serial homology; the evolutionary history of arthropods probably involved a series of duplications of body segments and appendages
- Four main groups: Crustacea (crabs, shrimp, barnacles); Uniramia (centipedes, millipedes, and insects); Chelicerata (spiders, scorpions, horseshoe crabs, ticks, mites); and Trilobata (trilobites, which are now extinct)



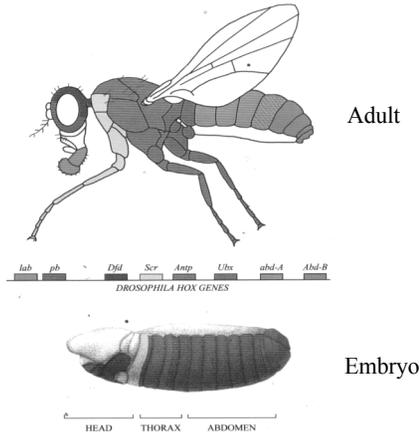
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Arthropods were probably the first animals to colonize the land

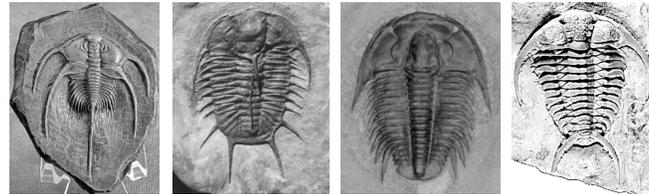
Eight homeobox (*Hox*) genes regulate the identity of regions within the adult and embryo.



Carroll S.B. et al. From DNA to Diversity (2001) Blackwell Science

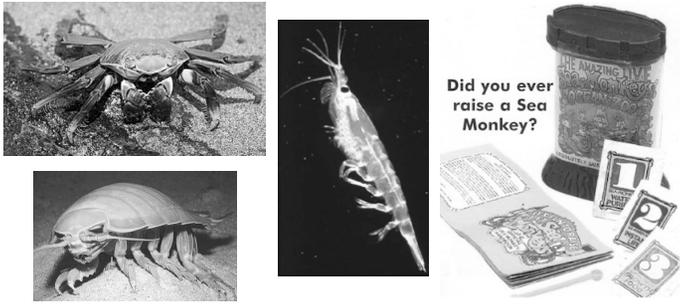
### ARTHROPODA: TRILOBATA - The trilobites (now extinct)

- Were most abundant during the Paleozoic (up to 250 MYA)
- Left a great fossil record; rocks with trilobites *must* be older than 250 million years old (thus they are called index fossils)
- They were strictly marine-living
- Were morphologically diverse



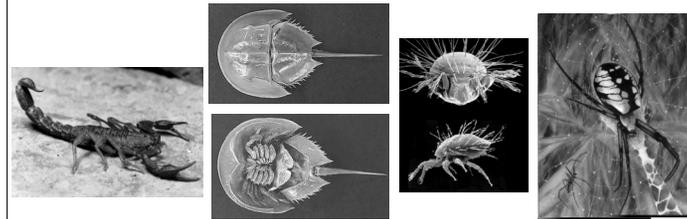
### ARTHROPODA: CRUSTACEA

- Includes: crabs, shrimps, lobsters, barnacles, and others (e.g. the pill bug)
- All have a 2-part carapace covering the head and thorax
- Have antennae on the head, and mandibles as the first pair of mouth parts
- Many have biramous (two-lobed) appendages (contrast with the Uniramia)

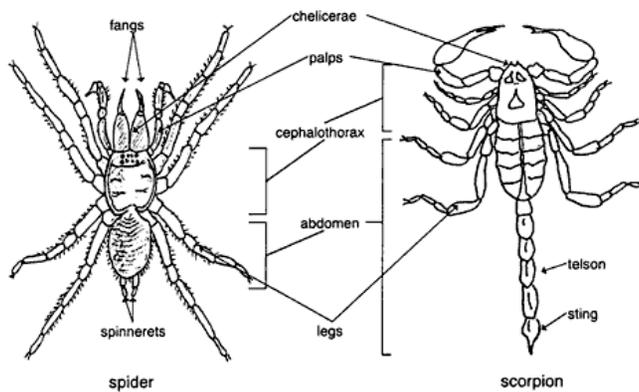


### ARTHROPODA: CHELICERATA

- Includes spiders, ticks, mites, scorpions, and horseshoe crabs
- Do not have antennae; usually have 6 pairs of jointed appendages, the last 4 pairs of which form legs
- A namesake trait is the pair of chelicerae; derived from the first set of appendages, modified as grasping, pincer-like structures
- 2 body regions, usually a cephalothorax and an abdomen
- Most are predators (scorpions, spiders) or parasites (ticks, mites)



### Basic Chelicerate Body Plan



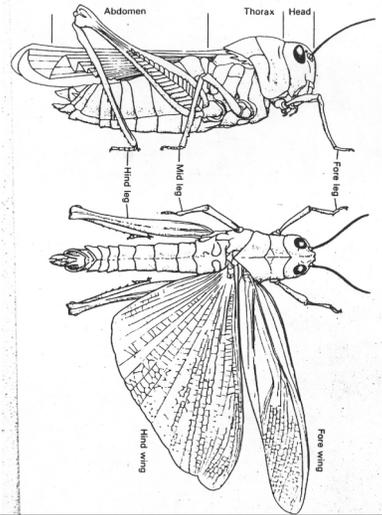
### ARTHROPODA: UNIRAMIA

"myriapods" (many-legged animals) and insects (6-legged animals)

- By far the most diverse group of arthropods, animals, and possibly all of life
- Unbranched (uniramous) appendages
- One pair of antennae
- Three pairs of legs (insects)
- Usually 2 pairs of wings (insects)
- Insect body regions: head, thorax, and abdomen
- Almost strictly terrestrial, although a great number of species have aquatic larvae



Basic insect body plan with 3 regions and specialized appendages

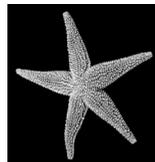
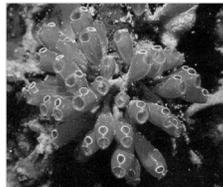


**WHY ARE INSECTS SO DIVERSE? Some ideas:**

- Modular body plan of segments and appendages such as mouthparts
- Adaptive radiation into terrestrial habitats
- Adaptive radiation after the evolution of flight
- Adaptive radiation and coevolution with angiosperms and flowers
- Adaptive radiation and coevolution with the host plants they eat
- Basic insect body plan may be easily evolvable

**DEUTEROSTOMES:**  
Echinodermata and Chordata

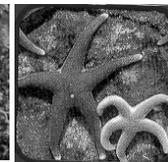
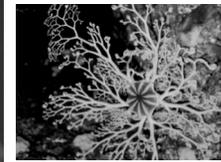
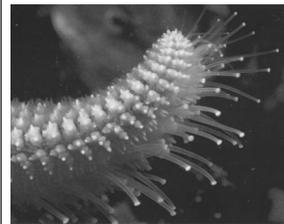
- Radial cleavage of blastula cells
- Blastopore does not become the mouth
- Mesoderm and coelom develop differently



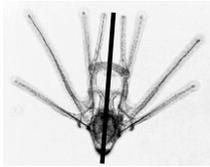
A chicken, starfish, and sea squirt are all deuterostomes. The chicken is more closely related to the sea squirt than either one is to the starfish.

**ECHINODERMATA:**  
Spiny-skinned marine invertebrates

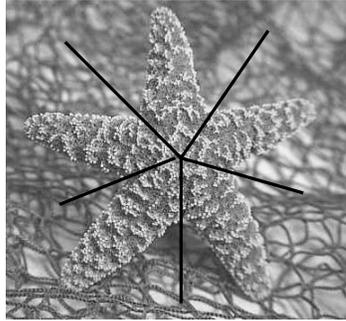
- Sea stars, brittle stars, basket stars, sea urchins, sea cucumbers
- All have tube feet used for feeding and locomotion
- Unique water vascular system causes movement of tube feet and also aids in circulation



Echinoderms appear to have pentaradial symmetry, but the typical echinoderm planula larva is bilaterally symmetrical. Note that any radially symmetrical animal can also be divided bilaterally.



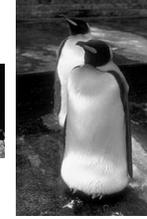
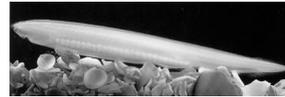
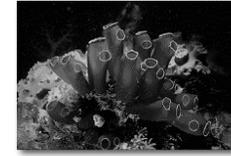
Planula larva



Adult

Chordates are:

- Animals
- Bilateria
- Coelomates
- Deuterostomes
- Sister to Echinodermata
- The group humans belong to



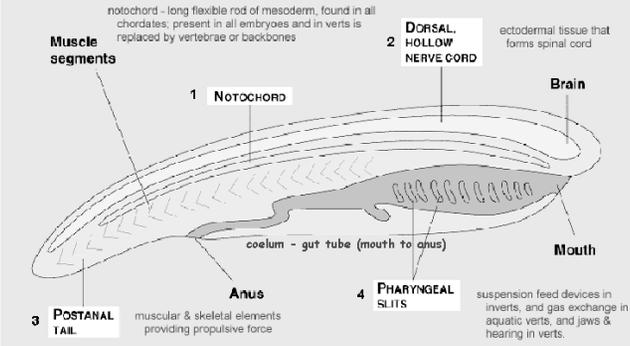
Chordates have:

A hollow **nerve cord** dorsal to a **notochord**; flexible supportive rod running along the back (not necessarily a “backbone”)

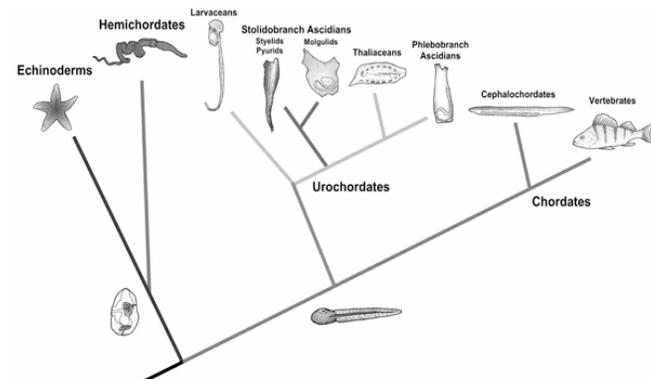
**Pharyngeal “gill” slits** at some point during their development.

A **tail** at some point during their development

**4 traits that characterize chordates**



Chordate traits (notochord, nerve cord, pharyngeal slits, and tail) are all present at some time during chordate development, but may disappear in the embryo before hatching or birth.

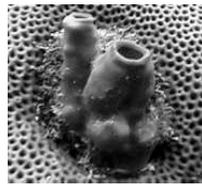
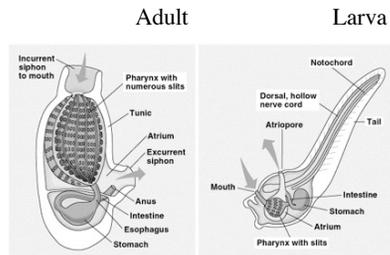


The **vertebrates** (mammals, birds, “reptiles”, amphibians, and fishes) are only one of several lineages of chordates.

**Tunicata:** Tunicates, also known as “sea squirts”

Adults are sessile and don't resemble chordates, but free-swimming tadpole-like larvae have all of the chordate traits

Water flows through an incurrent siphon to the atrium and out the excurrent siphon

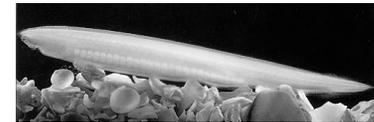
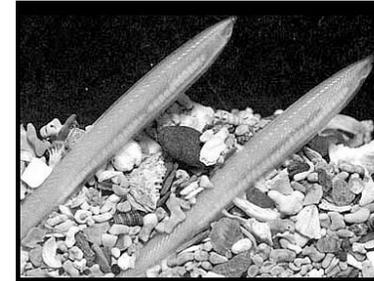


**Cephalochordata:** Lancelets or “amphioxus”

Small fishlike marine animals capable of swimming, but usually found buried in the sand in shallow water.

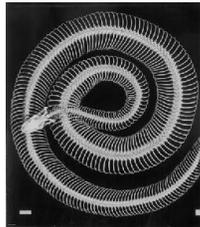
Oxygen is absorbed from water as it passes through pharyngeal slits and through the atrium.

Cephalochordates and vertebrates have a trait most often associated with annelids and arthropods:  
they are **segmented**.



**Vertebrata:** Vertebrates, or animals with backbones

- Includes fishes, amphibians, “reptiles”, birds, and mammals
- Internal skeleton with vertebrae
- Notochord usually in embryo only
- Complex tissues and organs



**Tissues and organ systems in vertebrates:**

**Tissues** are organized groups of specialized cells.

**Organs** are functional, organized groups of tissues.

There are four main kinds of tissues in vertebrates:

Epithelial tissues are coverings and linings (skin, glands, blood vessels, the linings of digestive tract and lungs)

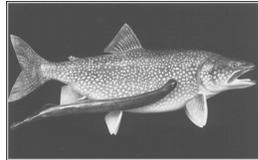
Connective tissues include blood, collagen, fat, cartilage, and bone

Muscle tissues include skeletal, smooth, and cardiac muscle

Nerve tissues include neurons, sensory organs, and brain cells

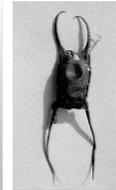
**Agnatha:** Fish without jaws  
Includes lampreys and hagfish

- Do not have scales
- Do not have jaws
- Most are parasitic on other fish
- Teeth are proteinaceous, not bony
- Hagfish can produce massive amounts of slime when disturbed



**Jawed fishes:** Chondrichthyes (cartilaginous fishes) and Osteichthyes (bony fishes)

Chondrichthyes include sharks, skates, and rays. Their skeletons have become secondarily cartilaginous. Most are predators.



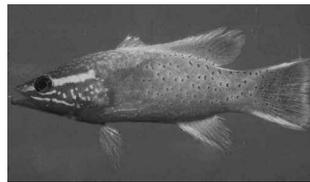
Chondrichthyes have gills, but no lungs. They also lay leathery egg cases that beachcombers often mistake for part of a plant.

**Osteichthyes:** Bony fishes, over 20,000 species and counting.

They have gills, and either lungs or a swim bladder (to control buoyancy). Their skeletons are made of bone.

Contrary to most ancient clades of life, bony fishes probably originated in fresh water, and radiated secondarily into oceans.

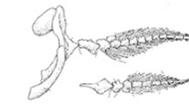
Bony fishes are either ray-finned or lobe-finned. There are very few lobe-finned *fishes* living today... although one could say that all tetrapods (amphibians, “reptiles”, birds, and mammals) are lobe-finned fishes, since they are direct descendants!



Ray fins and ray-finned fishes: probably all the fishes you know of

Lobe-finned fishes have bone-and-socket based fins that evolved into the limbs of tetrapods.

This group includes lungfish, which have a modified swim bladder that allows them to breathe air on land; and also the coelacanth, also known as “old four legs” -- known only from fossils until found alive in 1938!



Australian Lungfish

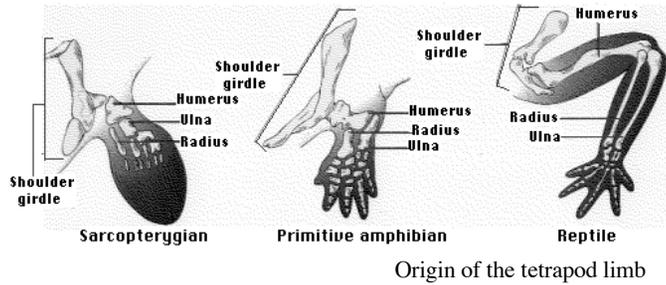


Coelacanth

There are two lobe-finned fishes in this picture



The evolution of tetrapods (four-footed vertebrates: amphibians, “reptiles”, birds, and mammals) involved many specializations for terrestrial life: locomotion on land, breathing air with lungs, and reproduction away from an aquatic medium. The diversification of tetrapods may have resulted from an adaptive radiation into terrestrial habitat types that were still unoccupied.



**Amphibians** include frogs, toads, salamanders, newts, and caecilians. As larvae, they have gills and no limbs, and undergo a metamorphosis into an adult form with lungs. Amphibian reproduction is still dependent on an aquatic medium; they are thus not entirely terrestrial animals.

Amphibian populations appear to be on a serious decline worldwide; the causes are still unclear, but are probably related to human impact on the natural environment (water quality, the ozone layer...)



In the Paleozoic, amphibians were the dominant land animals and some reached gigantic sizes. Large amphibians -- salamanders up to 5 feet in length -- still exist today (e.g. *Andrias* sp. in Asia, the “*Homo diluvii testis*”



*Eryops*



*Homo diluvii testis* :  
The man who saw the flood

**The Amniotes:** “Reptiles”, birds, and mammals

The amniotic egg allowed tetrapods to become completely terrestrial. In an amniotic egg, a membrane called the amnion surrounds the embryo and creates a fluid-filled cavity in which it develops. Other membranes aid in gas exchange, protection, and removal of wastes.

