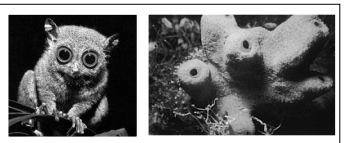
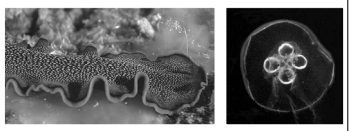
The Animals, or **Metazoa**

- Are some of the best-studied organisms
- Comprise over a million known species
- Originated c. the Cambrian (~550 MYA)

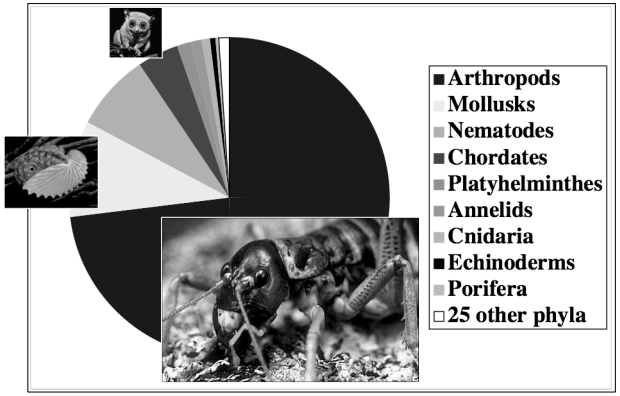
Most animal **phyla** are marine; however, due to the diversity of insects, most known animal **species** are terrestrial.





Animals have the following characteristics:

- Multicellular
- Heterotrophic
- Diploid
- Two kinds of haploid gametes
- Sperm cells fertilize egg cells
- Begin development as a **blastula**



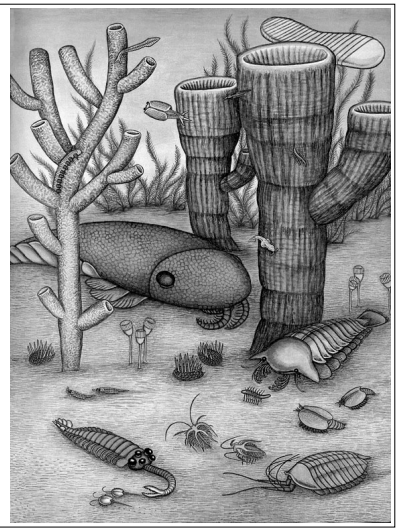
Approximate proportions of animal species **presently known**; The true diversity of animals may be more than 90% Arthropods

The Cambrian Explosion could be called the "Big Bang of Animal Evolution"

All of the basic animal *bauplan*s on Earth today appeared during a relatively short period of time

Some *bauplan*s went extinct while others -- for unknown reasons -- became the animal phyla that exist today

Understanding the origin of diverse animal *bauplan*s requires an understanding of the mechanisms of animal development.



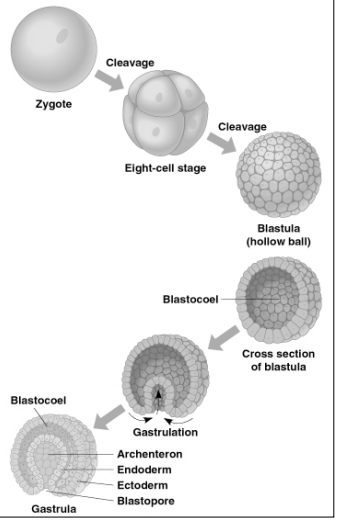
Basic Animal Development:

The fertilized egg becomes a diploid zygote, the first cell of a new organism.

The zygote multiplies into a multicellular mass through mitotic cleavage, which may be either radial or spiral

After several stages of cleavage, a hollow ball of cells called a blastula is formed. It is rarely larger than the original zygote.

Then, the process of gastrulation gives the developing animal internal tissue (endoderm), external tissue (ectoderm), and a digestive tract (archenteron) with one opening to the outside (blastopore).

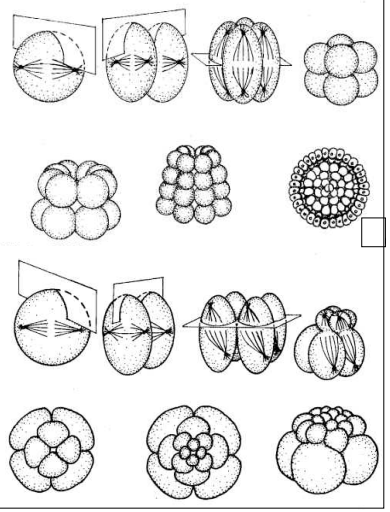


Radial cleavage:

Each mitotic division occurs parallel or at right angles to the polar axis of the embryo; cells of each layer are arranged directly above each other.

Spiral cleavage:

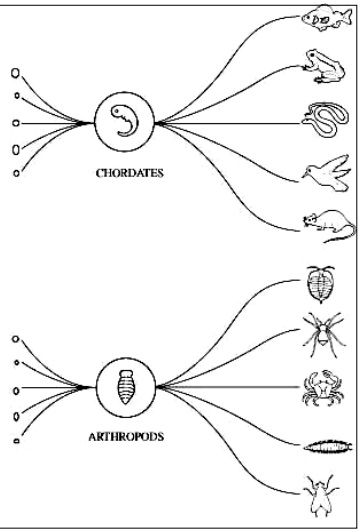
Each mitotic division occurs at an oblique angle to the polar axis of the embryo; cells of each layer are located above the junctions between cells in the layer below.



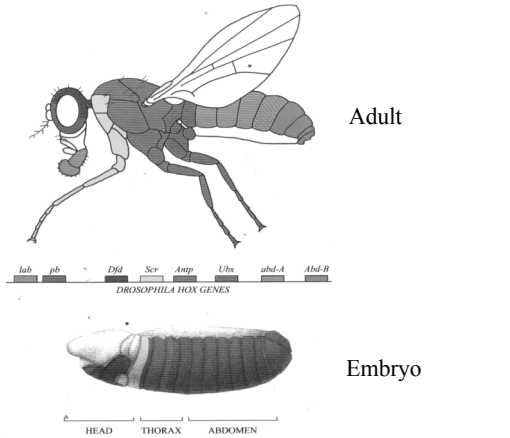
In animal development, early changes in the **gastrula** result in a **phylotypic** embryo that establishes the unique *bauplan* of each animal phylum.

After that, **morphogenic** proteins made by developmental genes determine **cell fate** and post-embryonic development

An important class of animal developmental genes are the ***Hox* genes**; they exist in all animals, and determine which cells of the developing body will be affected by different morphogenic proteins.

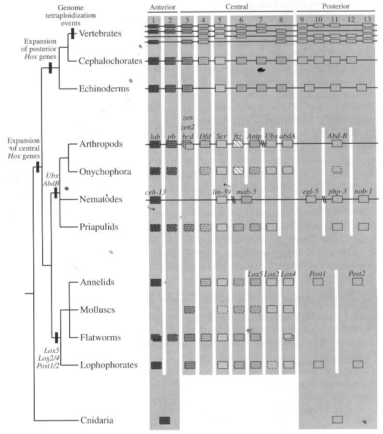


Eight homeobox (*Hox)* genes regulate the identity of regions within the adult and embryo.



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

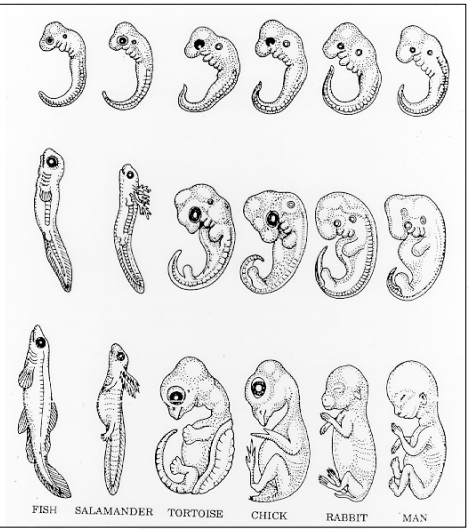
Evidence 2: Vertebrates have 4 copies of the *Hox* cluster



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

Biologists have long noted that, to a certain degree, ontogeny recapitulates phylogeny -- in other words, that during the course of development, an embryo passes through several stages similar to those of embryos from more ancient lineages of organisms.

The evolution of development represents a series of additions and modifications to pre-existing processes.

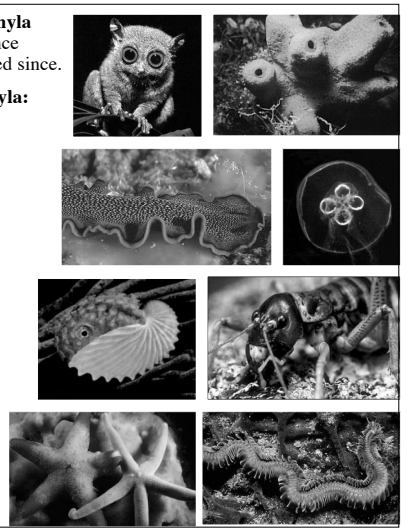


There are over 30 different animal **phyla** (sing. phylum) that have survived since the Cambrian; no new phyla appeared since.

We will look at about 1/4 of the phyla:

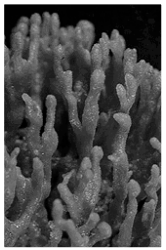
Porifera
Cnidaria
Ctenophora
Platyhelminthes
Nematoda
Arthropoda
Tardigrada
Mollusca
Annelida
Echinodermata
Chordata

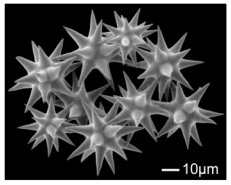
As well as some of the many marine phyla artificially known as "worms"



PORIFERA: The sponges

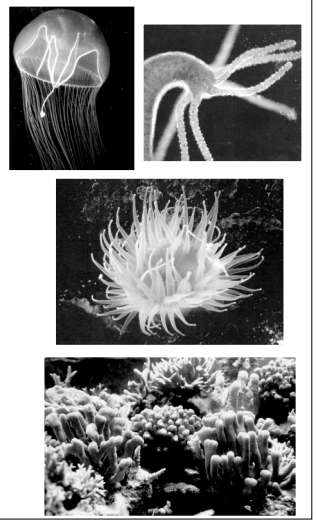
- Cell aggregates with **no symmetry**
- Have **no organs or tissues**
- **Filter feeders**
- **Mostly marine**, some freshwater
- **Larvae** are free-swimming
- Adults are **sessile**

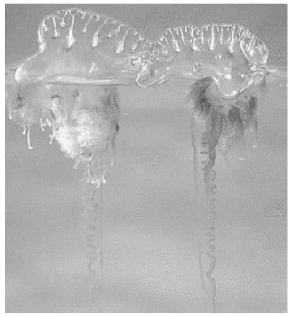


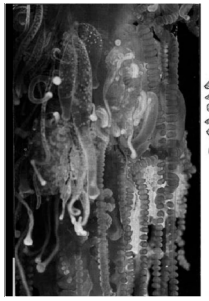


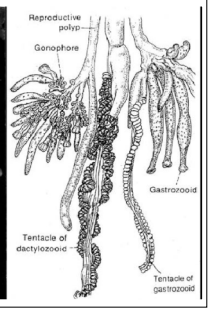
CNIDARIA: Jellyfish, hydras, sea anemones, and corals

- Soft bodies with **radial symmetry**
- Most with stinging cells: dart-like **nematocysts** in a ring around the mouth
- Jellyfish and hydras with both swimming **medusa** and sessile **polyp** life stages
- Jellyfish, anemones, and hydras tend to be individuals, while corals are **colonial** (an exception: Portuguese Man o' War)
- Calcium carbonate exoskeleton is formed by some corals, assisted by symbiotic and photosynthetic dinoflagellates
- Corals alter marine geology through **reefs,** but ancient reefs were not made of corals





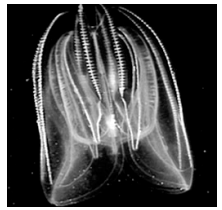




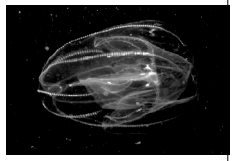
Portuguese Man o' War, a colonial "jellyfish" of several polyp types

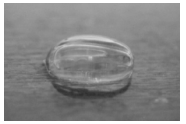
(Cnidaria: *Physalia* sp.)

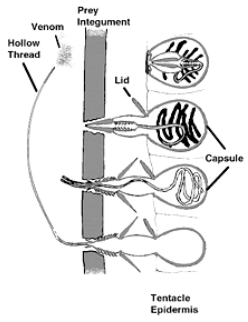
CTENOPHORA: Comb Jellies



- A **fully separate lineage** of "jellyfish"
- **Radial symmetry**
- **No** medusa/polyp stages, or nematocysts
- Two tentacles covered with **colloblasts**; lasso-like cells for entangling and capturing prey
- Unlike cnidarians, ctenophores have **true muscles**
- Many are **bioluminescent**





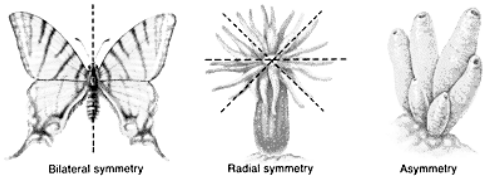


Nematocysts: Cnidaria only

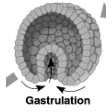
Colloblasts: Ctenophora only

After divergence of the Porifera (asymmetry), Cnidaria (radial symmetry) and Ctenophora (radial symmetry), animals evolved bilateral symmetry, a trait that persisted throughout the rest of animal evolution.

We thus call this clade of bilaterally symmetrical animals the Bilateria.

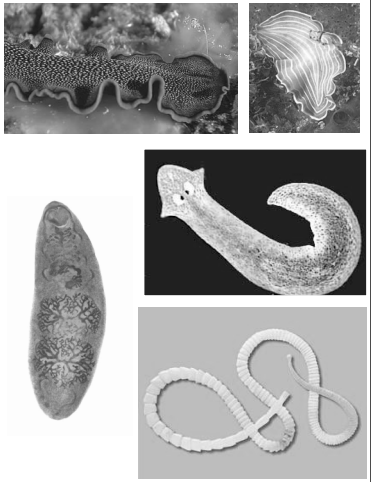


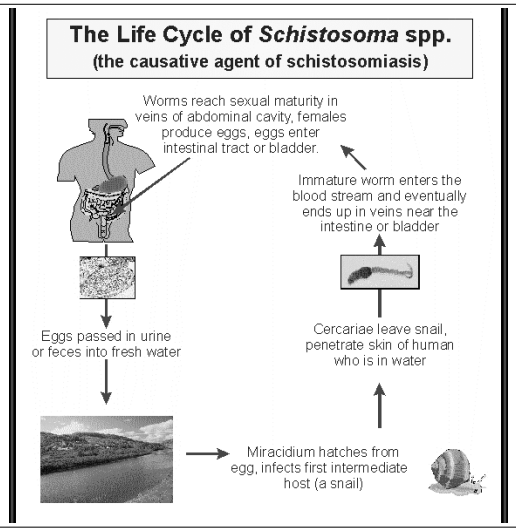
All Bilateria except the Echinodermata and Chordata are protostomes, meaning that the blastopore that forms during development will become the animal's mouth.



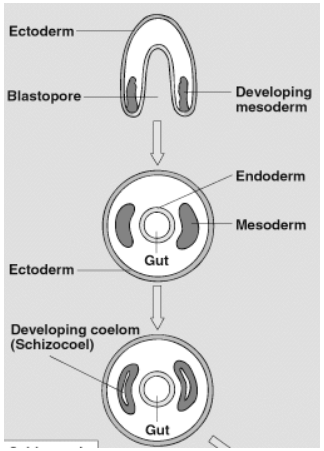
PLATYHELMINTHES:
Flatworms, tapeworms, flukes

- do not have a coelom (space between the digestive tract and body wall)
- dorsoventrally flattened
- have simple nervous systems
- can "learn" simple information
- many are parasites of humans and other vertebrate animals
- includes schistosomes, the animals responsible for diseases such as Schistosomiasis





In all of the animals we will talk about next, a coelom, or body cavity, develops from mesoderm cells after gastrulation.



COELOMATE PROTOSTOMES I:
THE **LOPHOTROCHOZOA**

Includes:
Mollusca
Annelida
} Have a trochophore larva

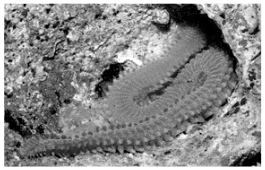
COELOMATE PROTOSTOMES II:
THE **ECDYSOZOA**

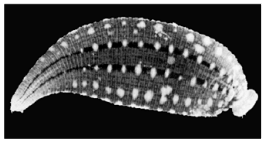
Includes:
Nematoda
Onycophora
Tardigrada
Arthropoda
} Molting animals

THE DEUTEROSTOMES (Coelomate)

Includes:
Echinodermata
Chordata
} Blastopore does not become the mouth

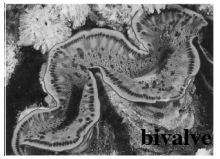
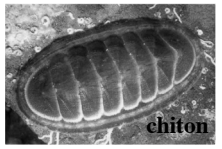
ANNELIDA:
the segmented worms

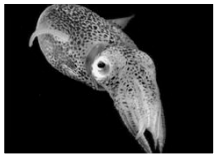



- only one of several phyla called "worms"
- bodies composed of ringlike segments, each with repeated digestive and reproductive organs
- include marine polychaetes; terrestrial oligochaetes (earthworms) and leeches of all kinds
- all annelids except leeches can undergo regeneration and can reproduce by "budding", as well as by sexual reproduction

MOLLUSCA
Clams, snails, slugs, octopi, and squids

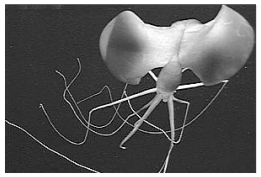

bivalve

chiton

gastropod



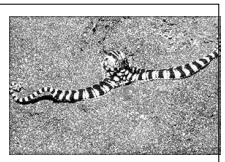
banana slug

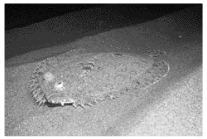
- second only to Arthropods in species diversity
- internal or external shell
- muscular "foot" for locomotion
- chitinous radula for feeding
- some are filter feeders; others are predators; others are scavengers
- cephalopods are highly visual animals with complex nervous systems, and are extremely intelligent



A "mystery squid" first discovered only in 2001

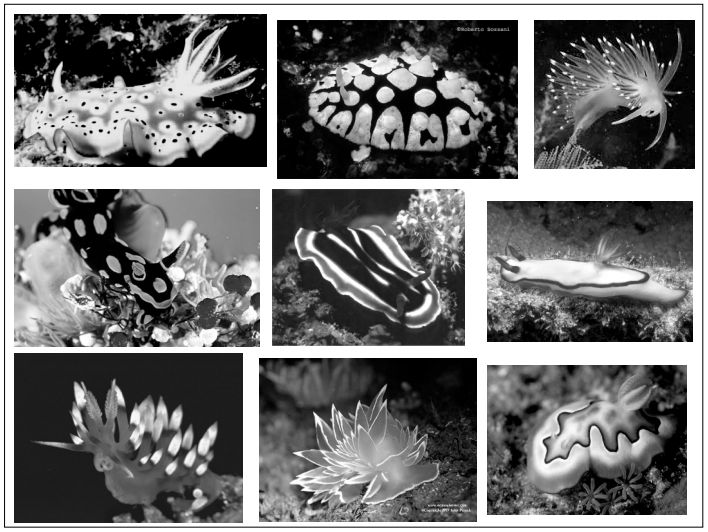
Swims with "fins" and has long, spindly tentacles with "elbows"


The mimic octopus as sea snake, lionfish, and flounder (or sole)

Would you believe me if I told you that
sea slugs
(nudibranchs)
are among the most
beautiful creatures on earth?

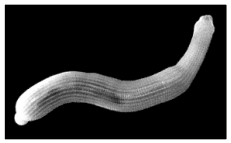


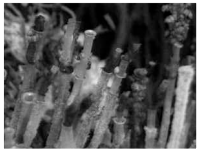

Nemertina


Gastrotricha


Priapulida


Phoronida


Sipuncula


Vestimentifera

Six examples of more than eleven totally different phyla that are generally referred to as "marine worms". Each of these phyla has a unique *bauplan*, and thus should not be grouped with other "worms"

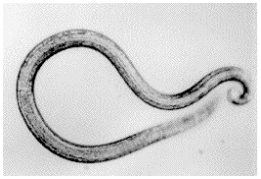
ECDYSOZOA: Animals that molt their cuticles (bilaterally symmetrical, protostomes, coelomates)

- Nematoda
- Tardigrada
- Arthropoda

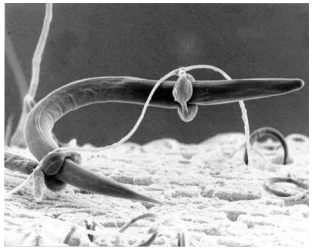
DEUTEROSTOMES: "Second-mouth" developers (bilaterally symmetrical; coelomates)

- Echinodermata
- Chordata

NEMATODA: roundworms

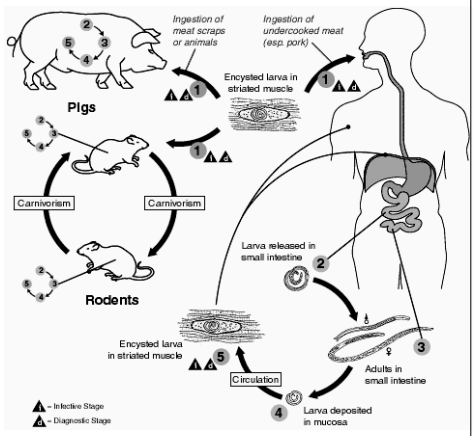


- Up to a million species may exist
- Most are small but some may reach 1 m
- No segmentation or cilia
- Longitudinal, not circular muscles, make nematodes incapable of "inching along". They move by flipping over.
- Reproduction is always sexual
- Many are parasites on humans and other vertebrates; hookworms, heartworms, stomach worms, pinworms, and roundworms are all nematodes
- Diseases caused by nematodes include elephantiasis and trichinosis



Diseases caused by Nematodes

Elephantiasis; spread by mosquitoes, causes blockage and swelling of blood vessels and lymph ducts



The life cycle of *Trichinella*, cause of trichinosis

TARDIGRADA: "Water Bears"

- Strange but cute things with 4 pairs of stumpy, clawed legs they use to walk about
- All species smaller than 2 mm in length, and some are much smaller
- Often live walking among wet places such as algae, bark, moss, or lichens
- Tardigrades can turn themselves into a dormant, dry, barrel-shaped form called a tun that is highly resistant to extreme conditions. They can survive up to 100 years in this state!
- Tardigrades are highly resistant to extreme temperatures (-270 C to 151 C); to dessication (drying out); and to X-rays; they can survive over 1000 times higher of an X-ray dose than humans can
- For these reasons, tardigrades could probably travel well through outer space. Could Earth meteors carrying tardigrades have arrived on other planets?