Possibly not-so-fun, but necessary chalkboard review of gene/genome duplications, and concepts of gene orthology and paralogy; “different levels” of homology

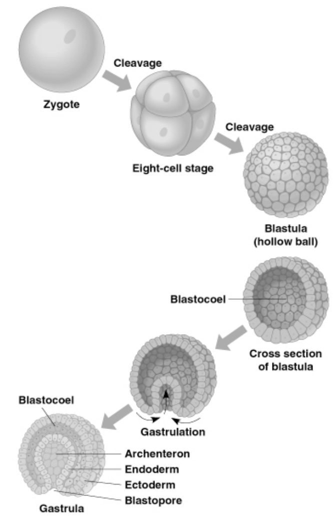
<u>Basic Animal Development:</u>

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.

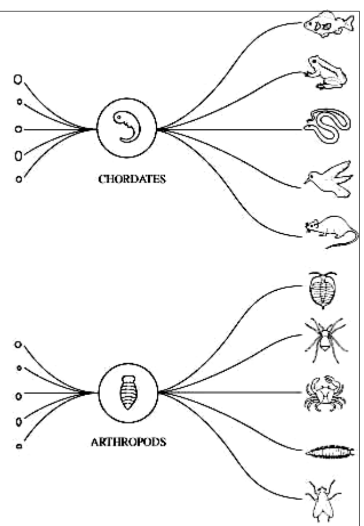
Then, the process of gastrulation gives the developing animal internal tissue (endoderm), external tissue (ectoderm), and a digestive tract (archenteron) with one opening to the outside (blastopore).



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

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

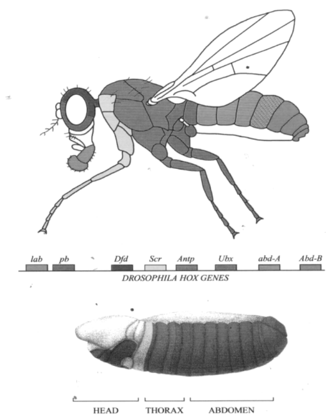
An important class of animal developmental genes are the ***Hox* genes**; they exist in all animals, and determine which cells of the developing body will be affected by different morphogenic proteins.



The evolution of biodiversity is probably due more to the evolution of *regulatory* relationships and gene *interactions*, rather than strict and simple evolution of gene sequences.

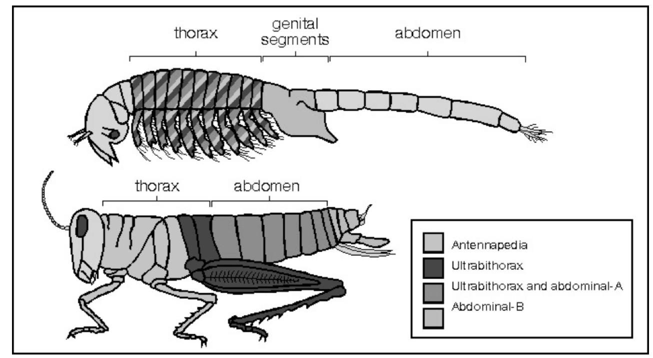
Morphological diversity seems to be more the result of regulatory differences during development, rather than the result of raw gene sequence differences

Adult

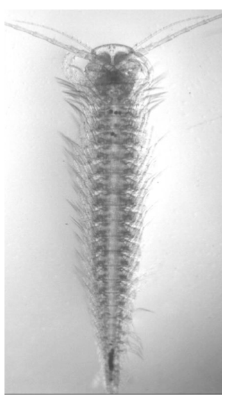


Embryo

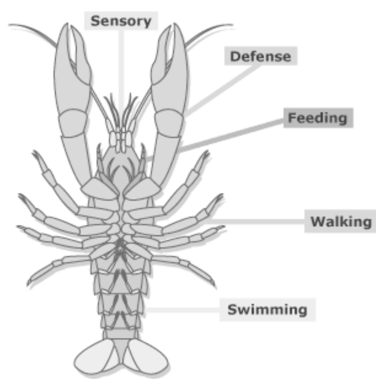
Expression patterns of *Hox* genes, and their relationships with downstream targets, are what generated body plan diversity



Origin and diversification of crustacean appendages (or "limbs")



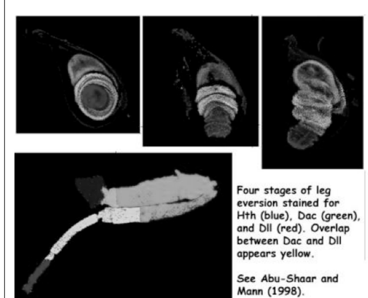
Remipede



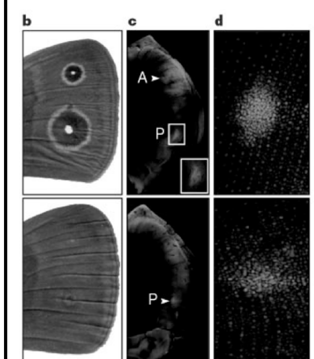
Crayfish

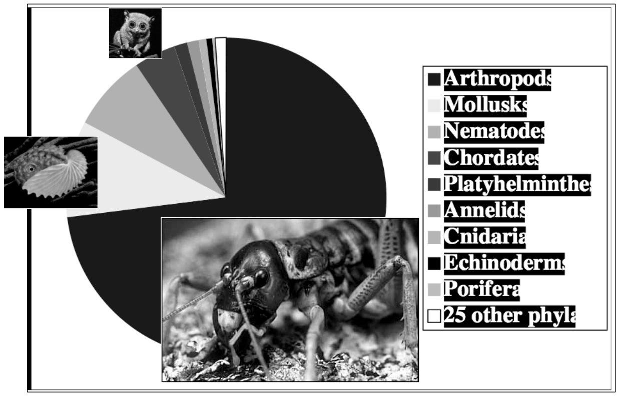
Evolving regulatory relationships can result in old genes having new functions (example: developmental gene *distalless* (*dll*)

dll in appendage development

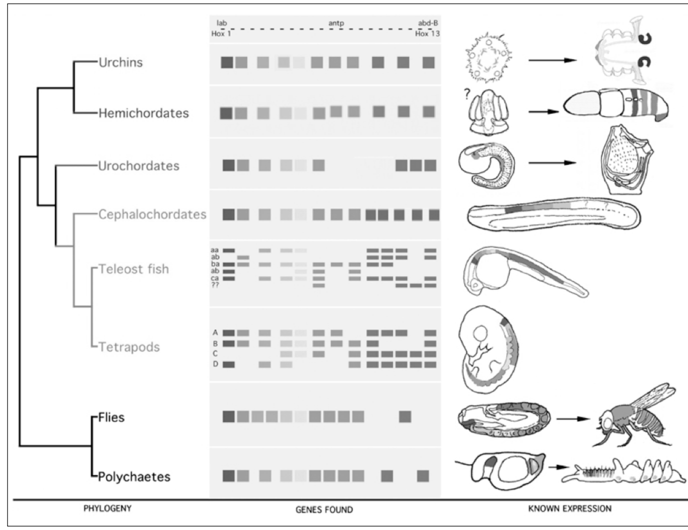


dll in wing eyespot development

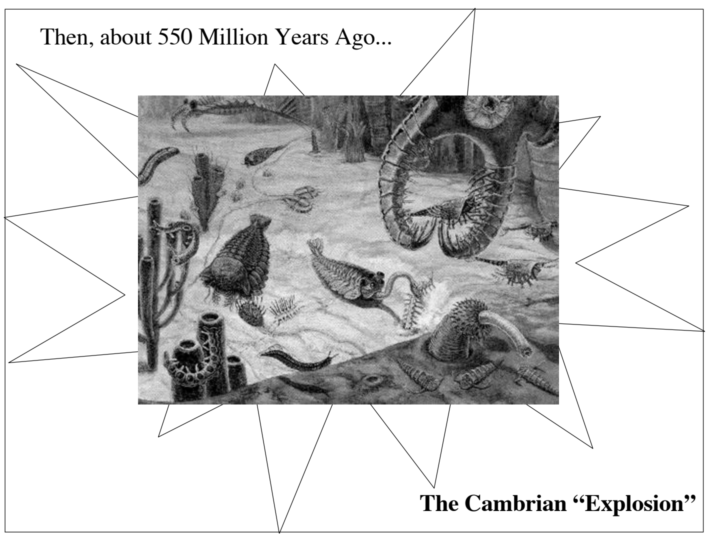




Approximate proportions of animal species **presently known**;
The true diversity of animals may be more than 90% Arthropods



Then, about 550 Million Years Ago...



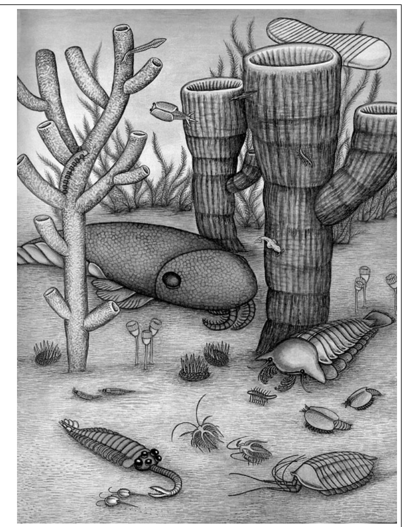
The Cambrian "Explosion"

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

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

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

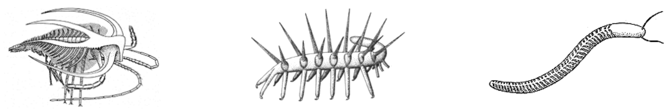
Understanding the origin of diverse animal *bauplans* requires an understanding of the mechanisms of animal development.



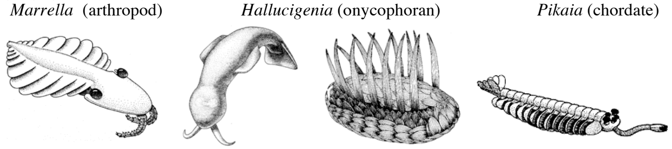
During the Cambrian explosion, all of the animal phyla present today appeared within a very short period of time.

(Phyla: Arthropods, Mollusks, Chordates, “Worms”, etc.,)
Each phylum has its own characteristic bauplan (body plan)

But the Cambrian explosion also produced a lot of bizarre body plans that are now extinct; those animals cannot be assigned to any phyla that exist today. They were unique “kinds” of animals.



Marrella (arthropod) *Hallucigenia* (onycophoran) *Pikaia* (chordate)

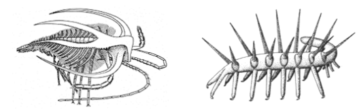


Anomalocaris *Amiskwia* *Wiwaxia* *Opabinia*

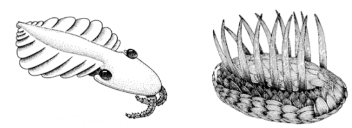
A Lesson from the Cambrian Explosion: contingency (again)

Like modular molecules in the early RNA World, Cambrian animals were random experiments in animal design. Why some phyla survived and others went extinct is unknown. The phyla that survived were probably just lucky.

Why should arthropods and onycophorans have survived to the present day, but not the phyla represented by *Anomalocaris* and *Wiwaxia*?

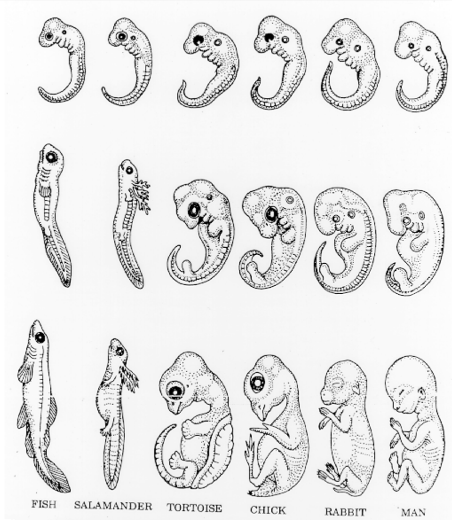


If we could “rewind” and “play” the history of life again, it would be a completely different world today -- perhaps with animals like *Anomalocaris* and *Wiwaxia*.



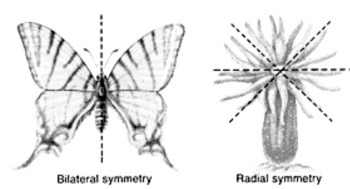
Biologists have long noted that, to a certain degree, ontogeny recapitulates phylogeny -- in other words, that during the course of development, an embryo passes through several stages similar to those of embryos from more ancient lineages of organisms.

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

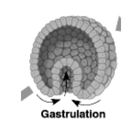


After divergence of the Porifera (asymmetry), Cnidaria (radial symmetry) and Ctenophora (radial symmetry), animals evolved bilateral symmetry, a trait that persisted throughout the rest of animal evolution.

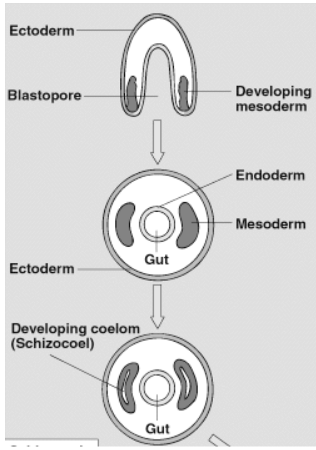
We thus call this clade of bilaterally symmetrical animals the Bilateria.



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

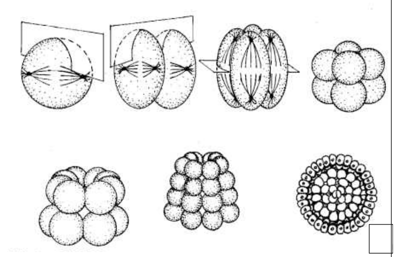


In all animals that arose after Platyhelminthes (flatworms), a coelom, or body cavity, develops from mesoderm cells after gastrulation.



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.