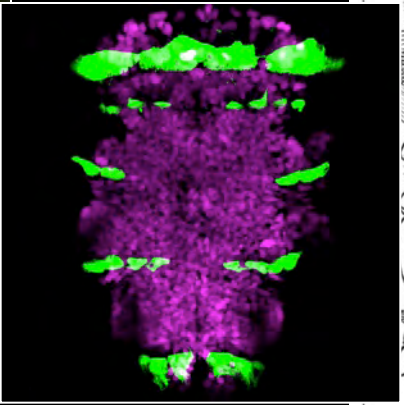
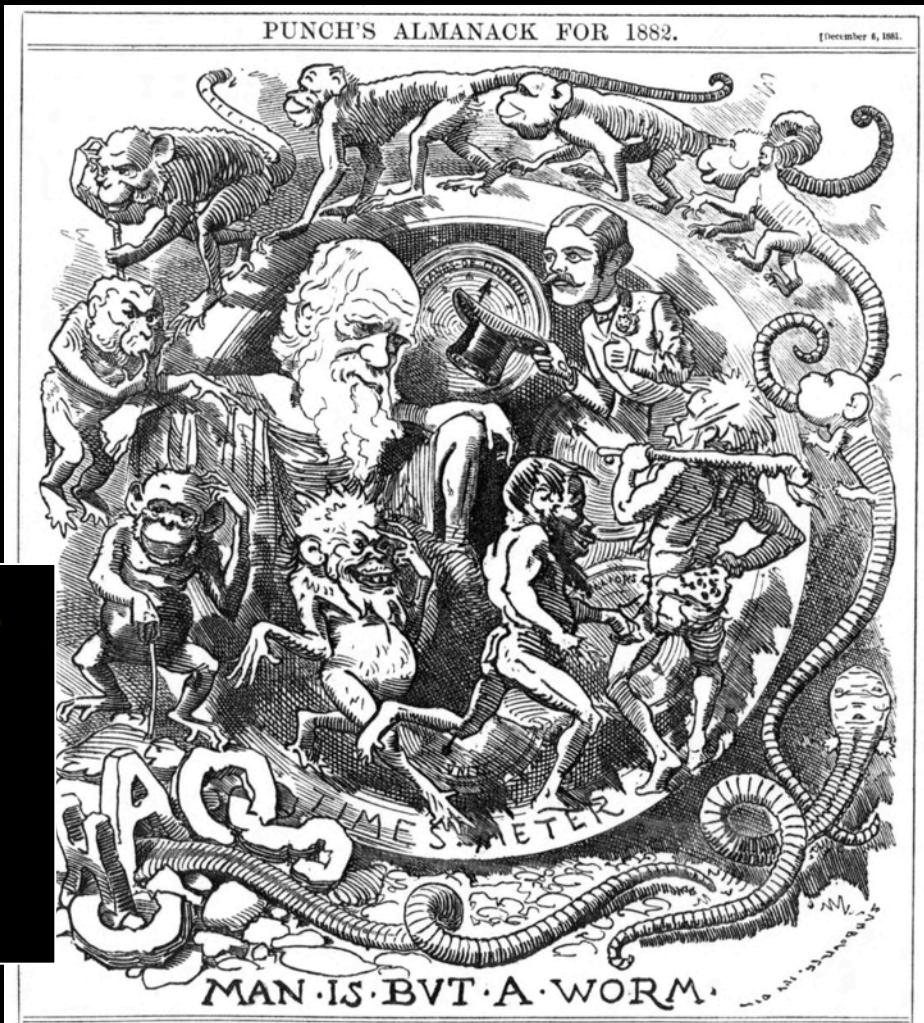
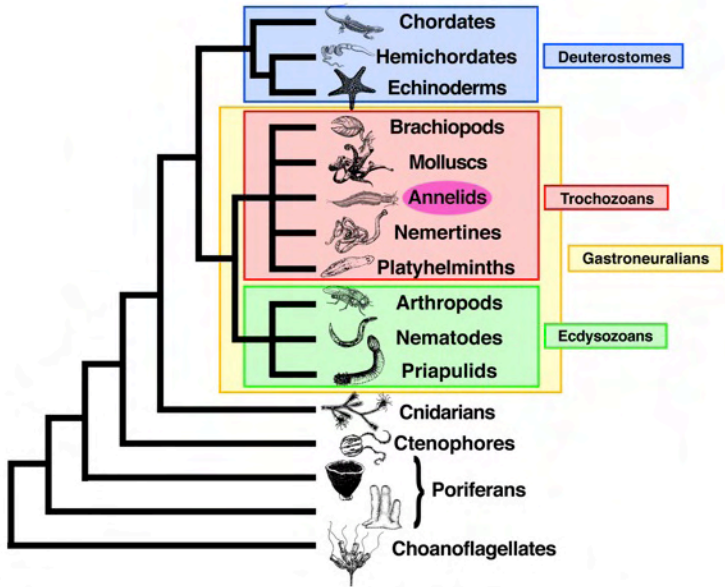


Man is descended from a worm but from which sort of worm ?

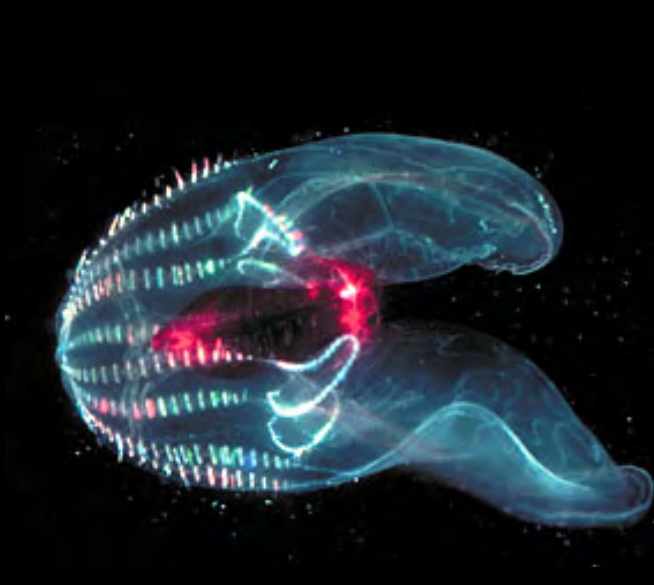
Guillaume Balavoine
Institut Jacques Monod
CNRS / Université Paris Diderot



The bilaterians: complex animals



The deeper branches of the animal tree: sponges, cnidarians and comb jellies



NATIONAL BESTSELLER

Wonderful Life

The
Burgess
Shale
and the
Nature
of
History

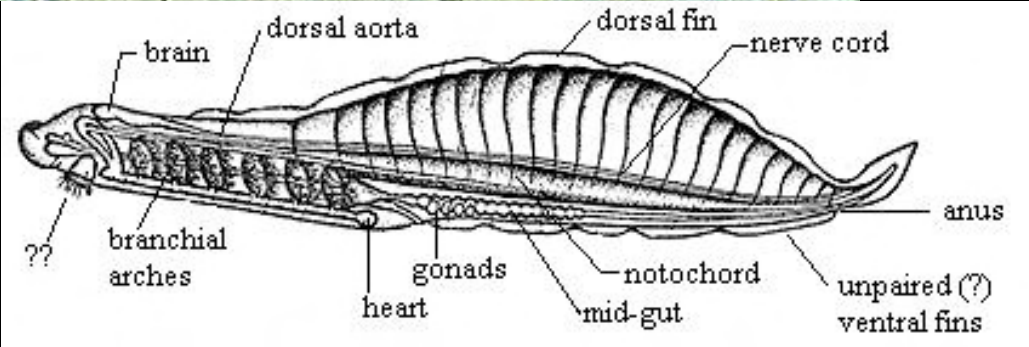


STEPHEN JAY GOULD

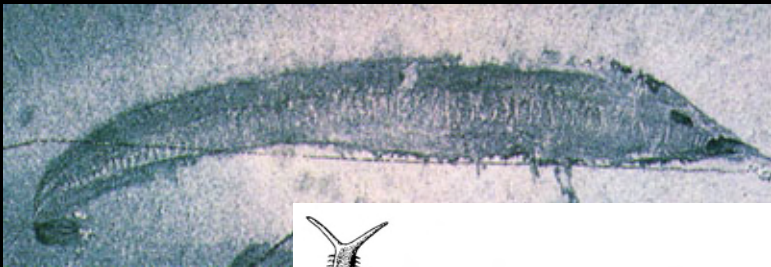
Chordates already there back in Cambrian time !



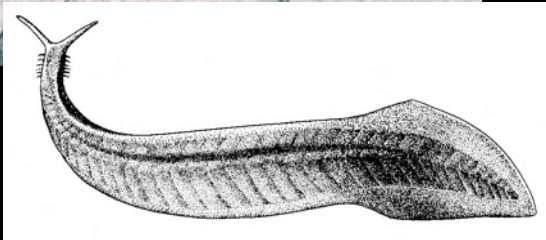
Haikouella

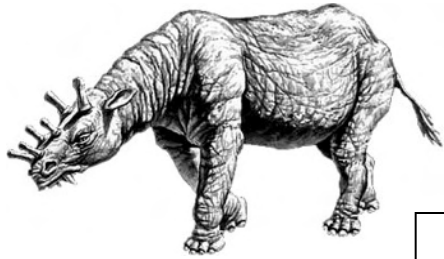
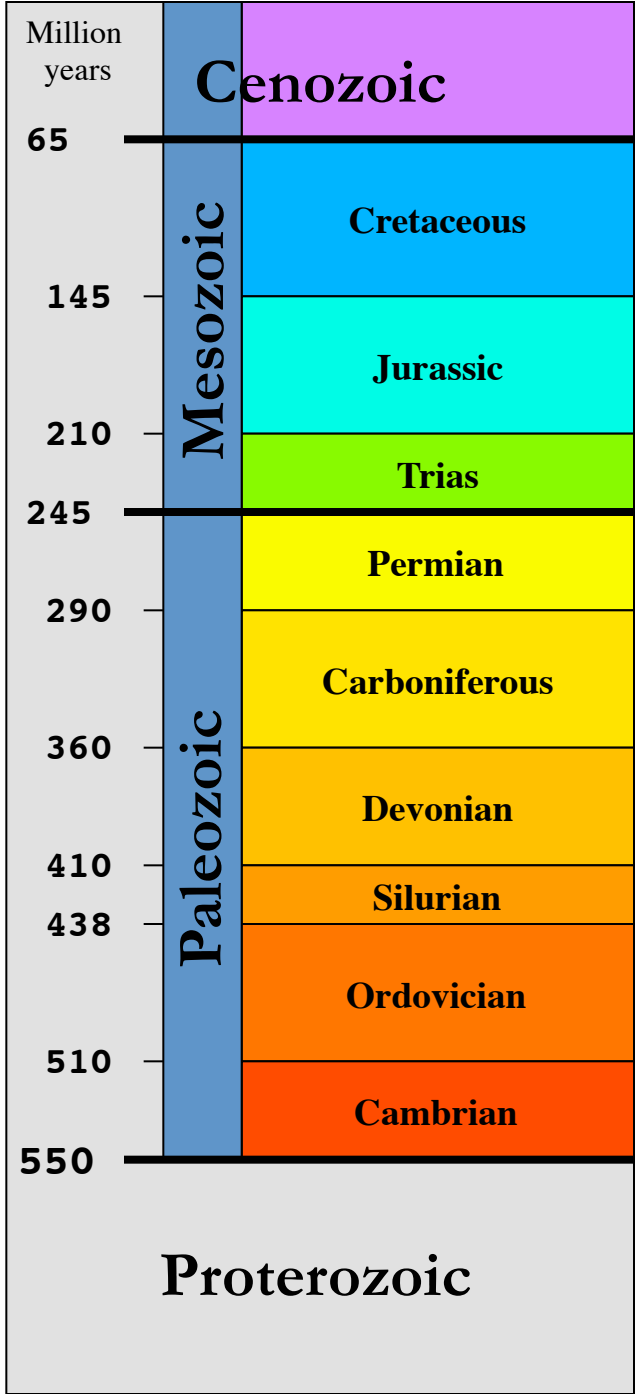


euconodont

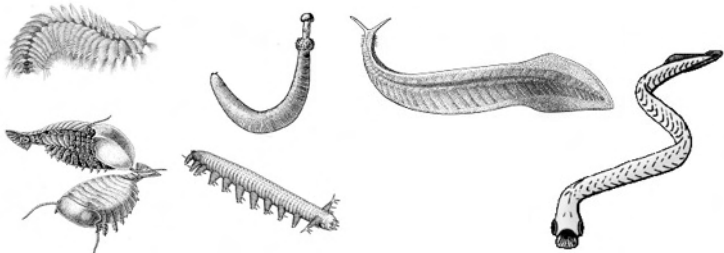


Pikaia

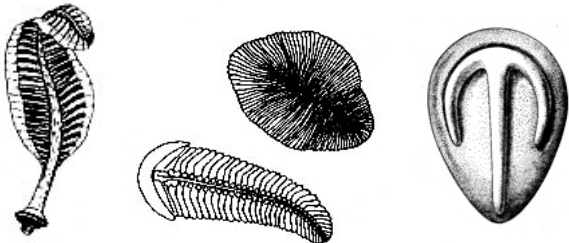




Bilaterians appear in the Cambrian

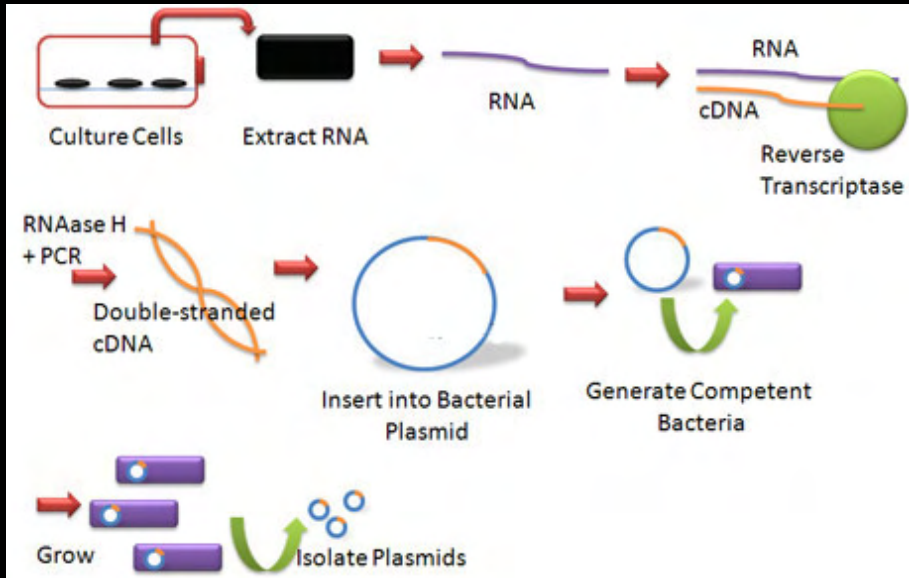


Cambrian Explosion



Ediacara « Fauna »

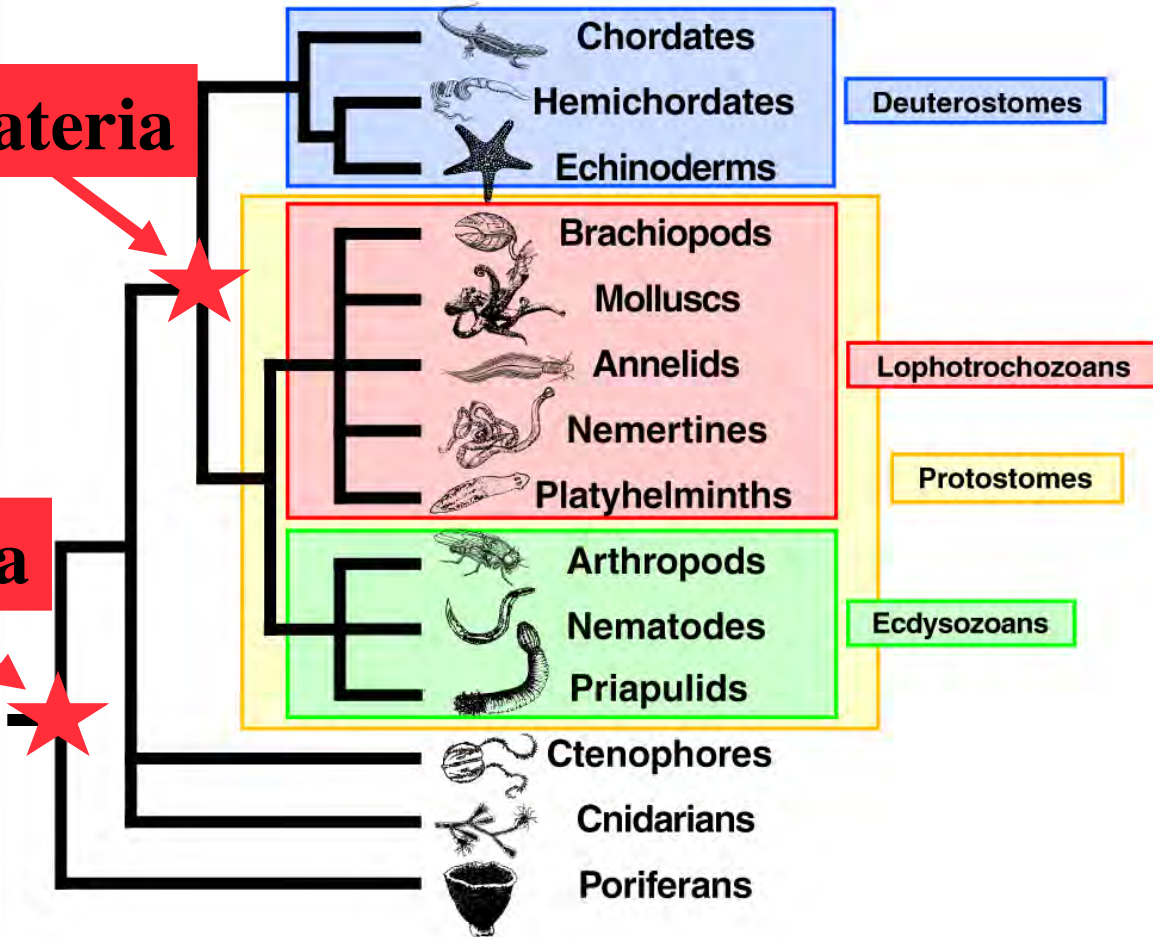
Complementary DNA mass sequencing



A simplified tree of animal life

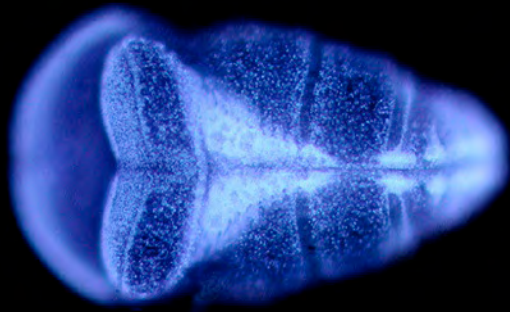
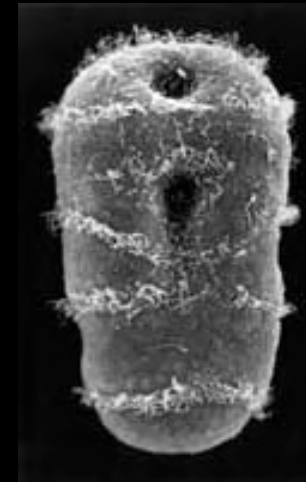
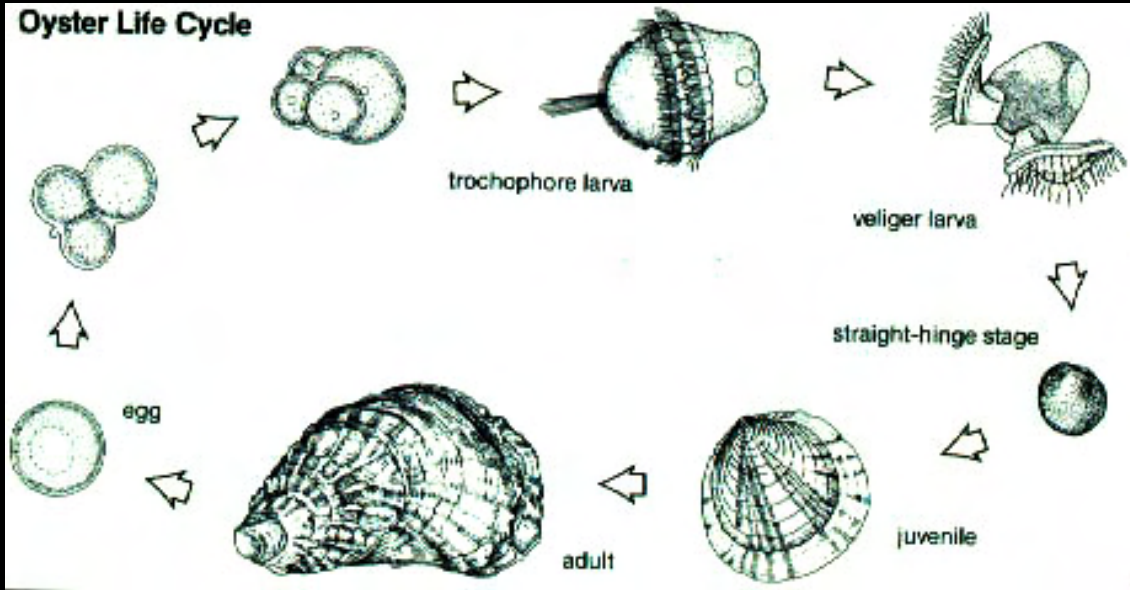
Urbilateria

Urmetazoa

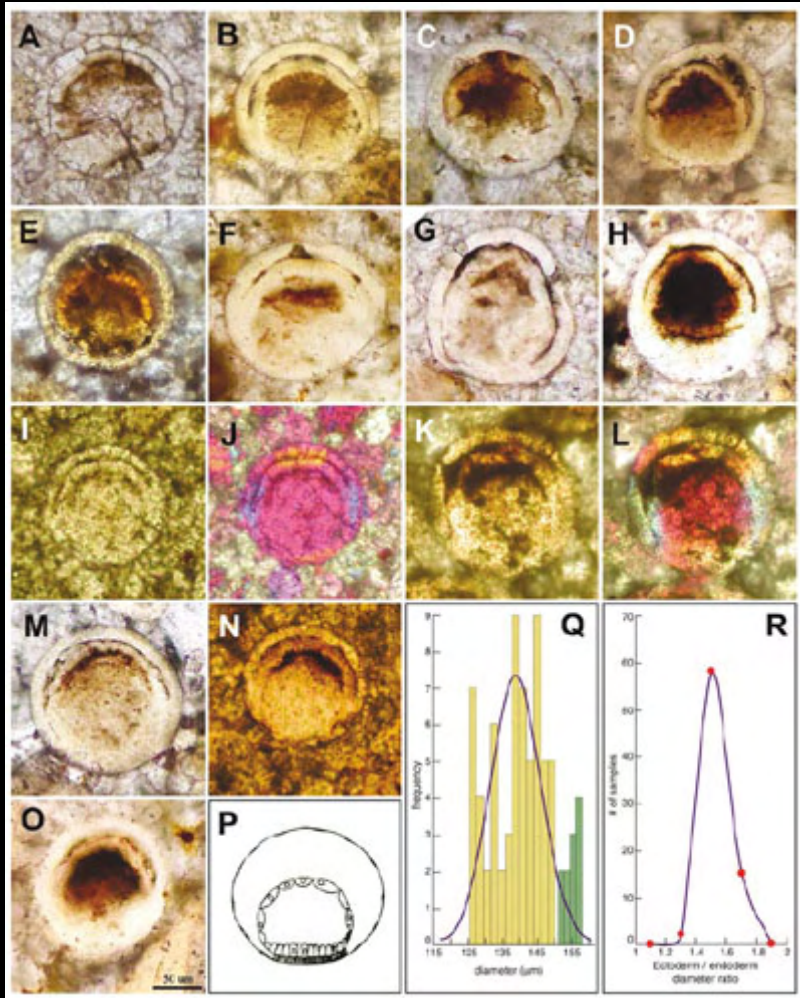


After
Adoutte *et al.*,
1999

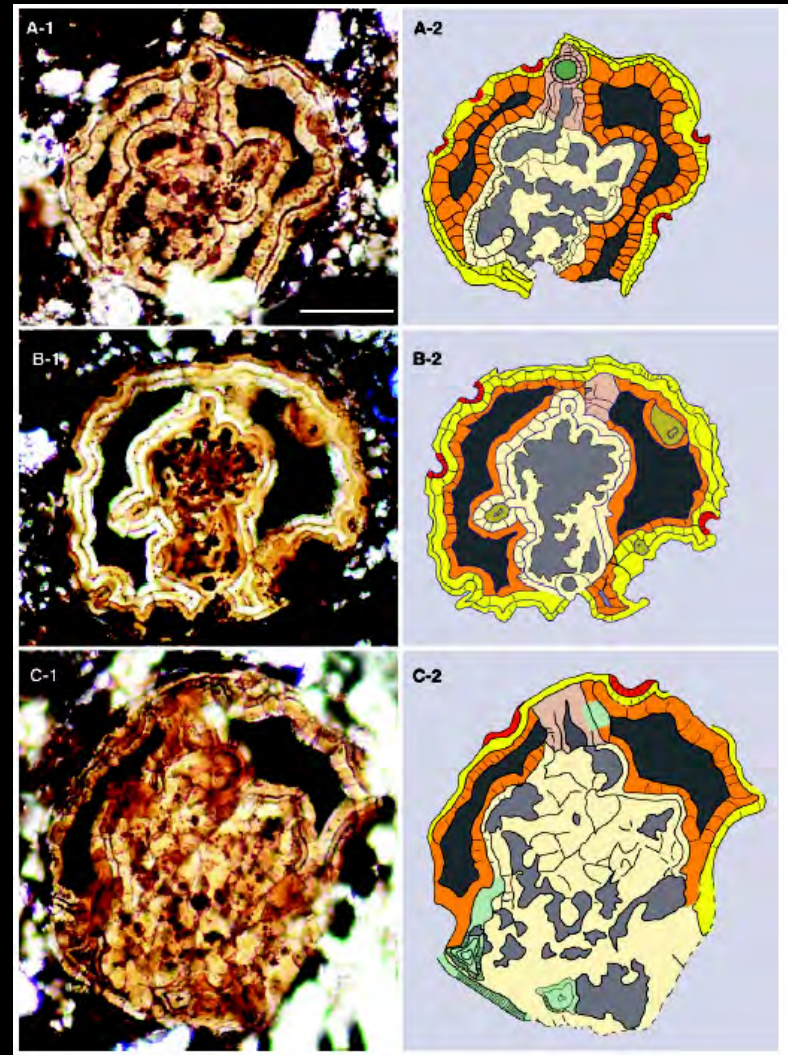
Were our ancestors larvae ?



Controversial Precambrian microfossils (Dushantuo)



« cnidarian gastrulas »
Chen et al., 2002



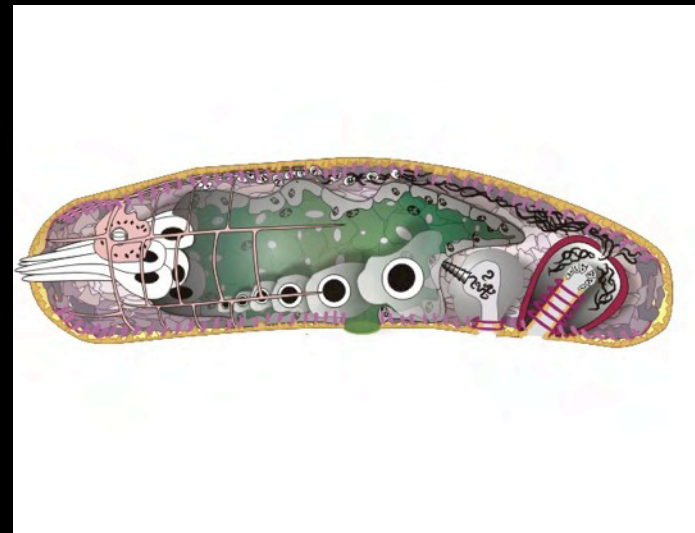
« Micro-Bilaterian »
Chen et al., 2004

Were our ancestors flatworms ?

The acoel *Symsagittifera*

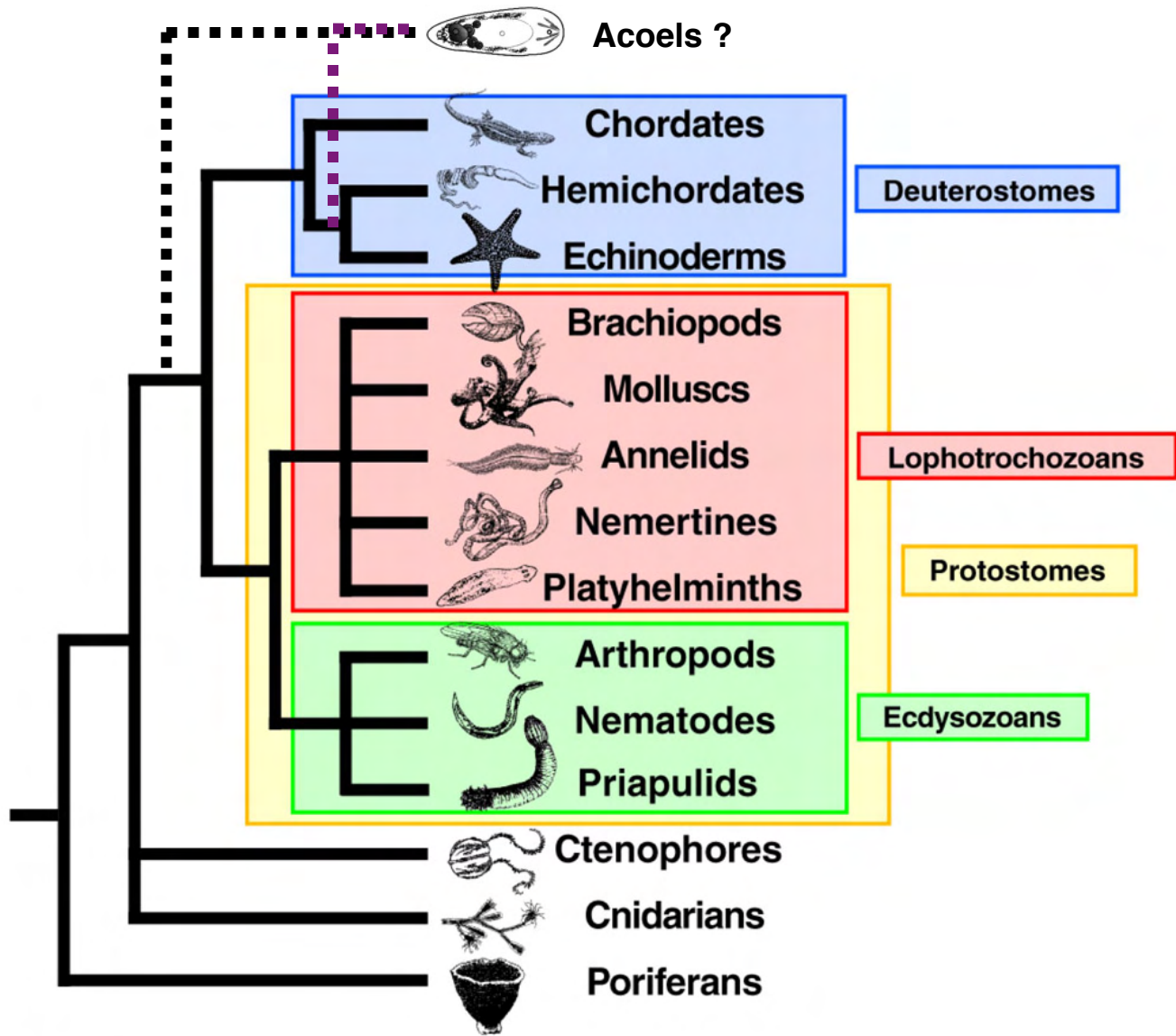


The acoel *Convolutriloba*



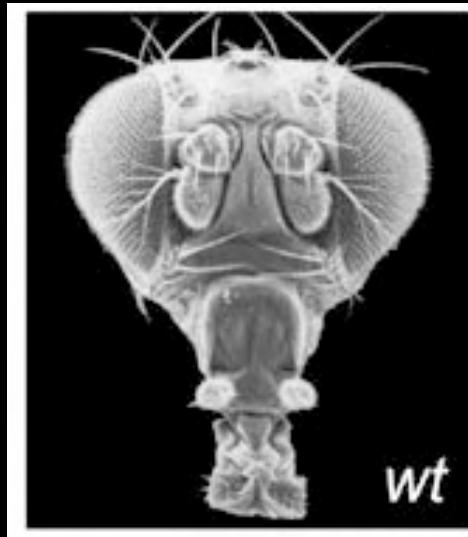
Anatomy

The acoels : are they the deepest branch of bilaterians ?

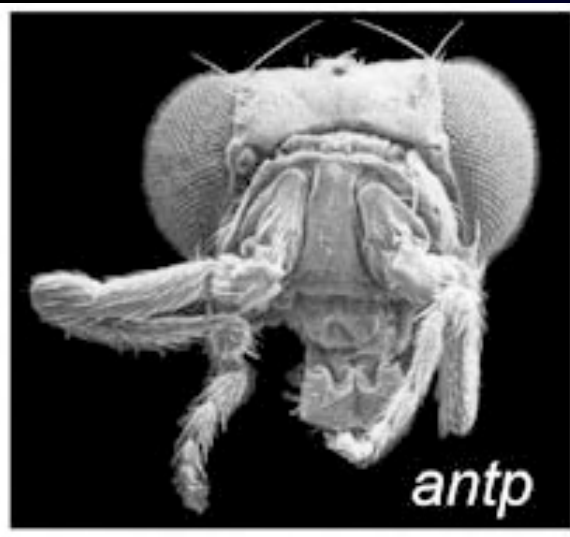


Or a divergent secondarily simplified offshoot of the deuterostomes ?

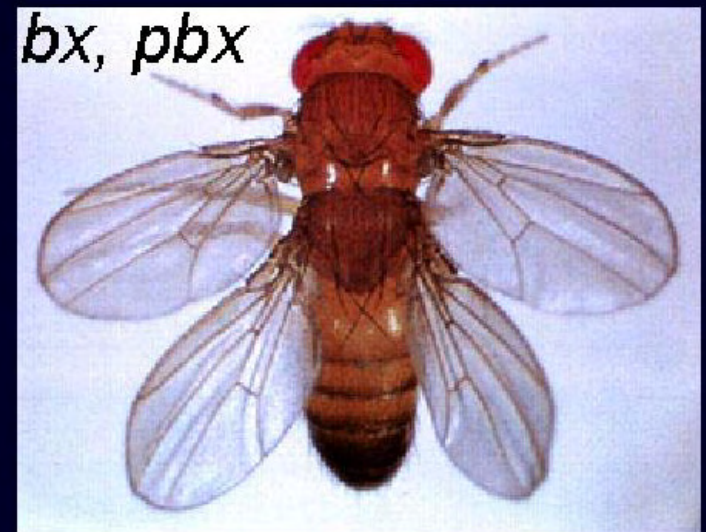
The first « architect genes » discovered: the homeotic genes of the fruitfly *Drosophila*



Normal fly head



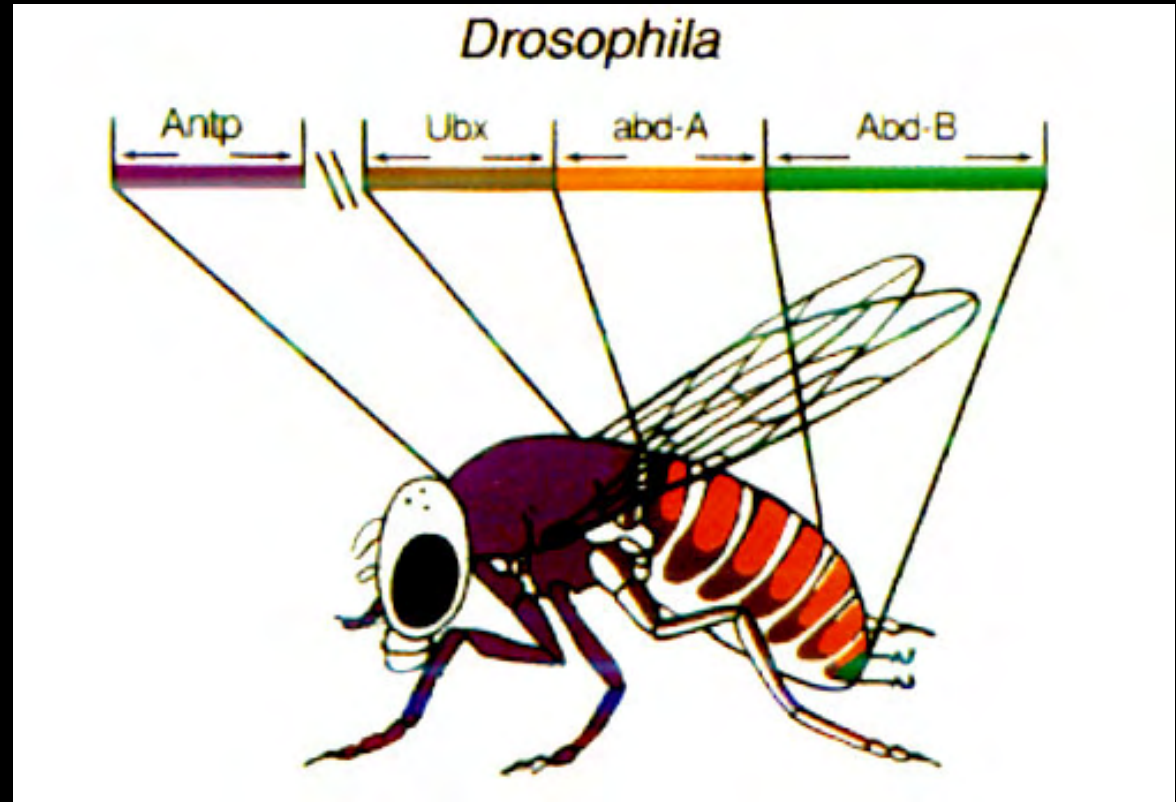
Fly head in an *Antennapedia* mutant



Four-winged fly: *Ultrabithorax* mutant

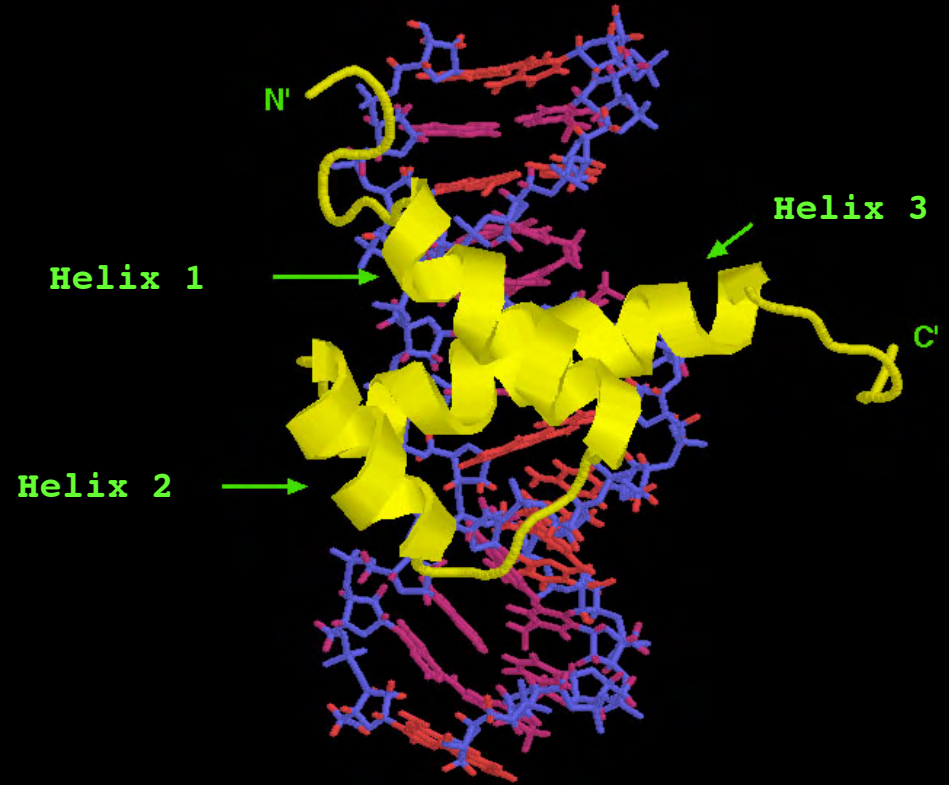
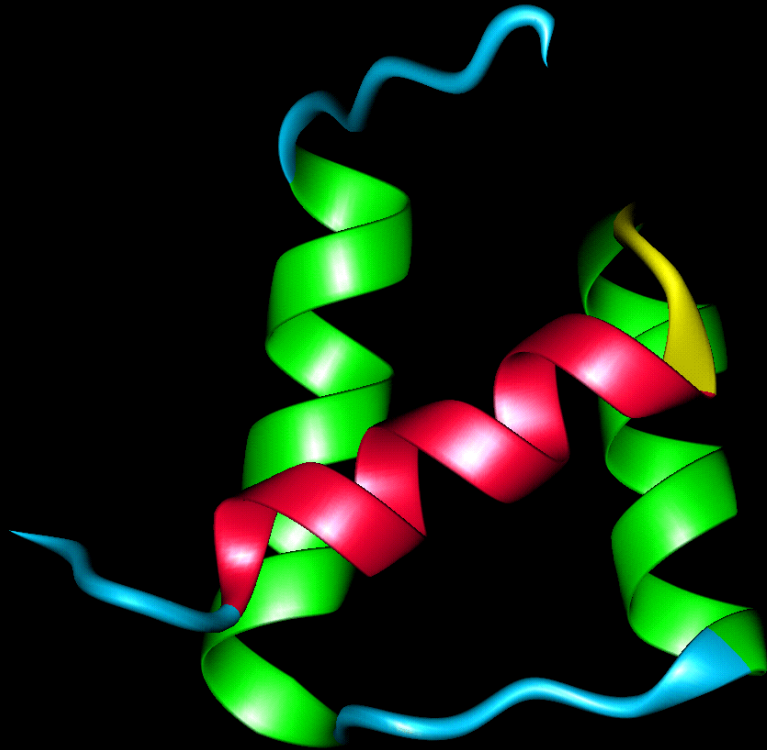
Edward B. Lewis

Nobel Price 1995

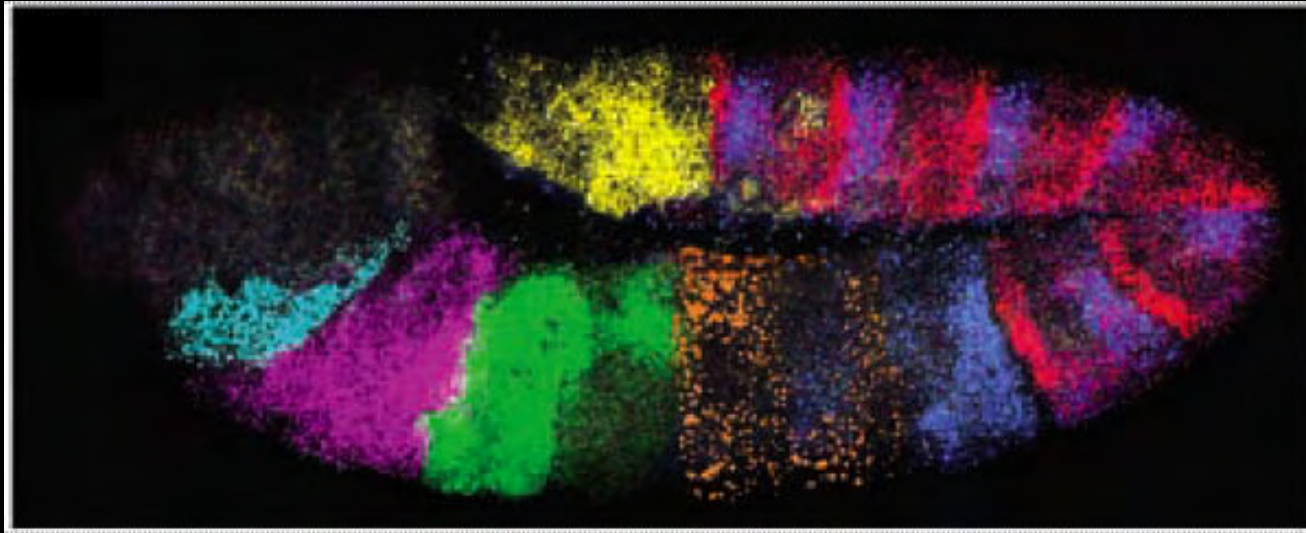


- ◆ Homeotic genes are organized in complexes on the chromosome
- ◆ Homeotic genes are expressed according to the rule of colinearity: they influence segment shape along the anterior/posterior axis in the same order as they are found in the chromosome

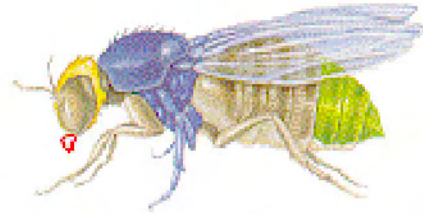
Homeotic genes code for transcription factors : proteins that bind to chromosomal DNA and regulate genes nearby



Expression of homeotic genes in a fly embryo revealed by fluorescent staining



The Hox/homeotic clusters of the fly and vertebrates are homologous



Fruitfly



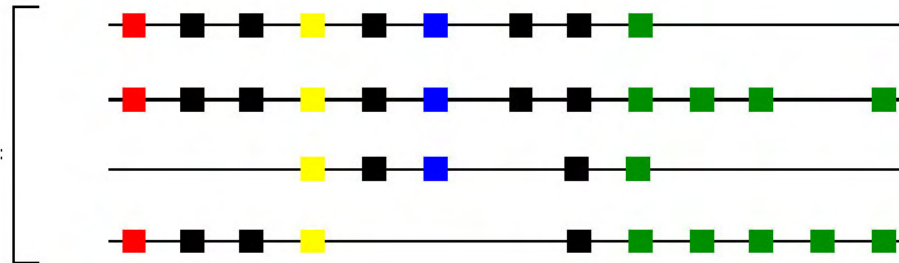
Fruitfly embryo

Antennapedia Complex Bithorax Complex

Fruitfly chromosome



Mouse chromosomes



Mouse embryo



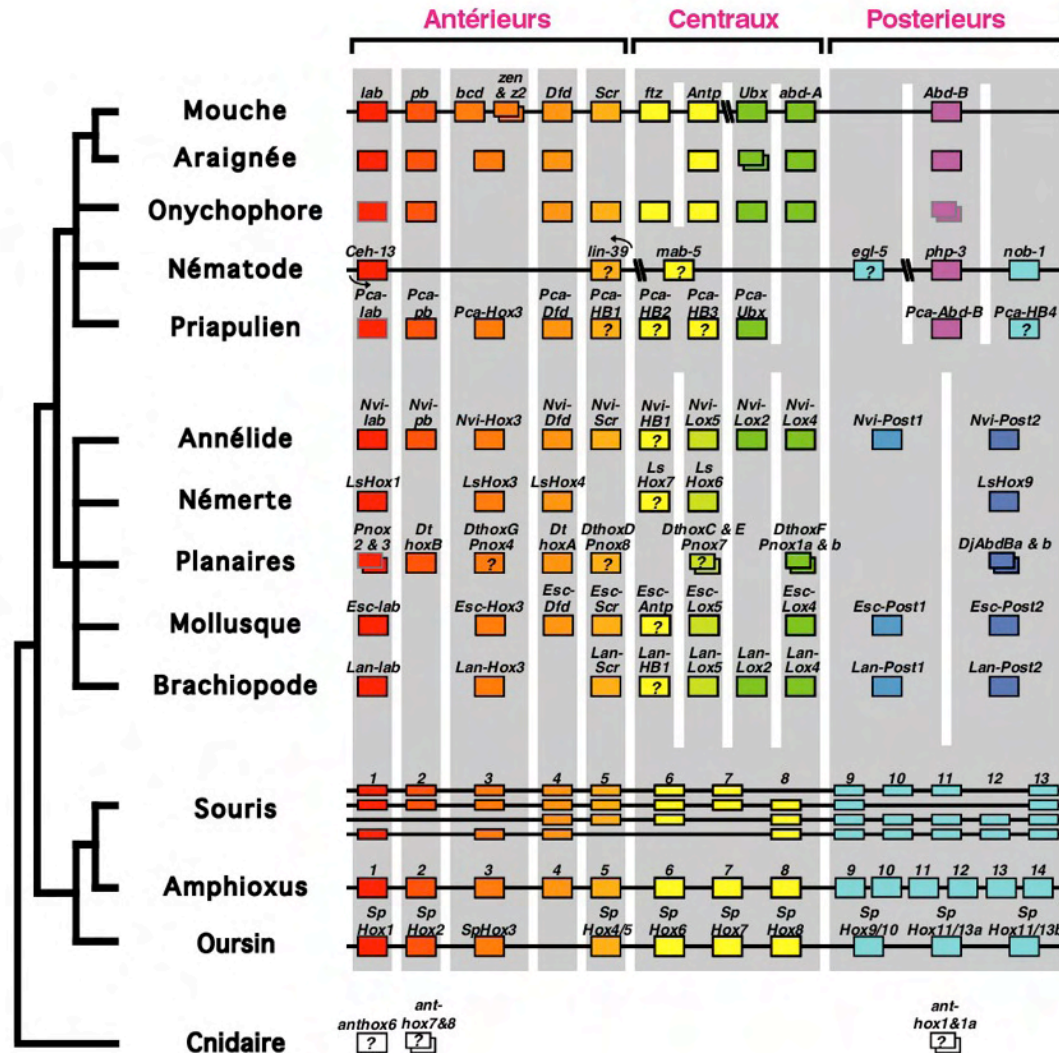
Mouse

Composition of the *Hox* gene family in the animal tree

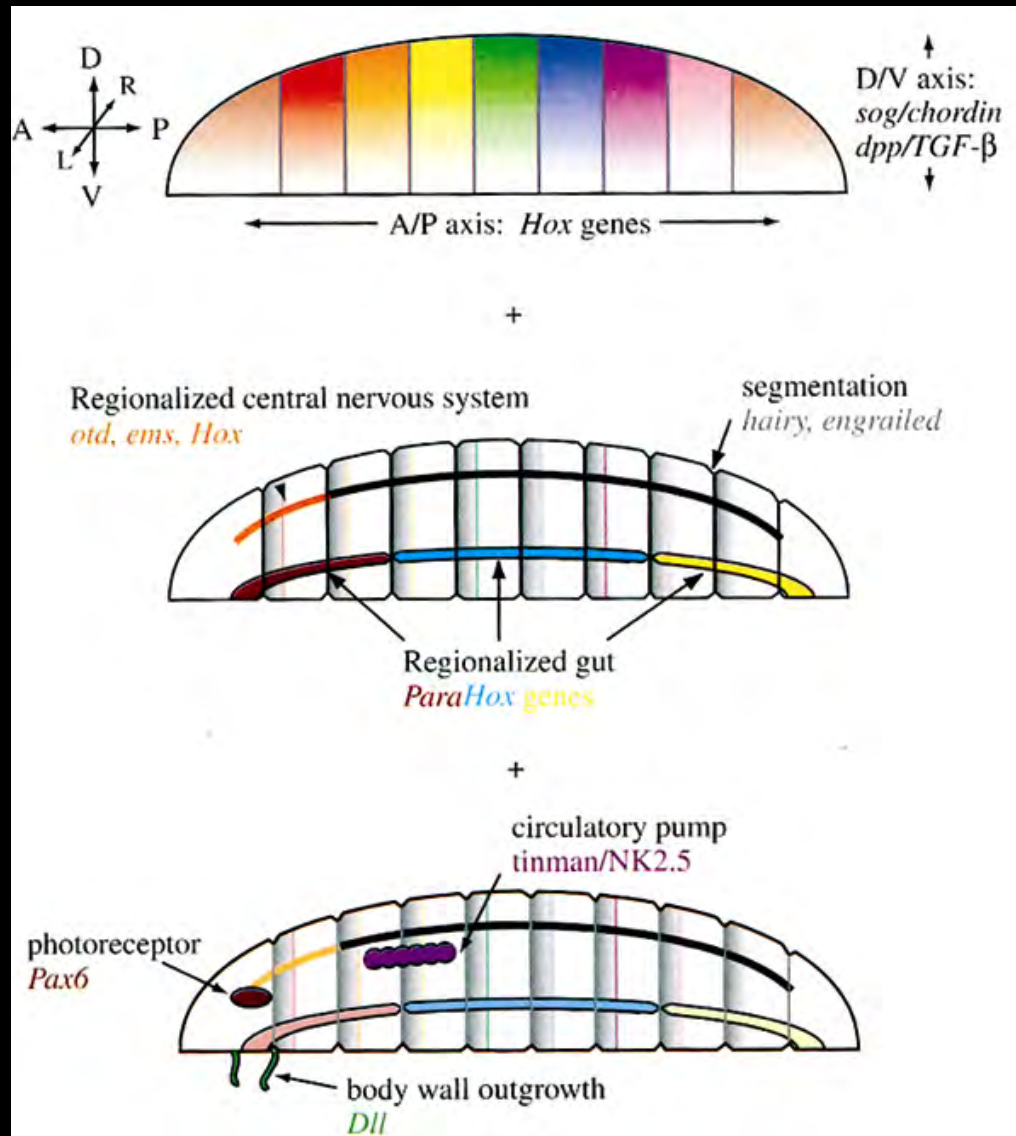
- Bilaterians typically have more than 10 Hox genes

- Cnidarians have few Hox genes of derived types

- Sponges have no Hox genes



Hypothetical *Urbilateria* Bauplan (Carroll et al., 2001)

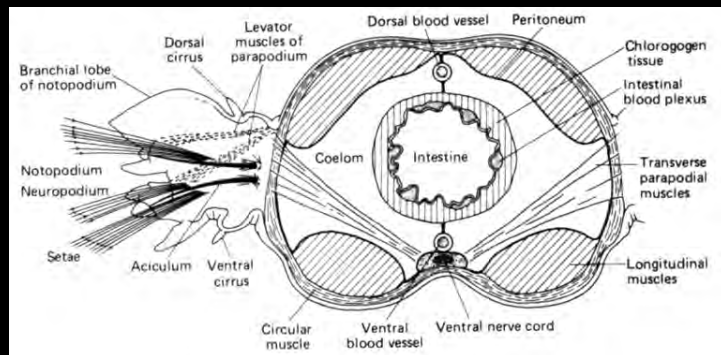
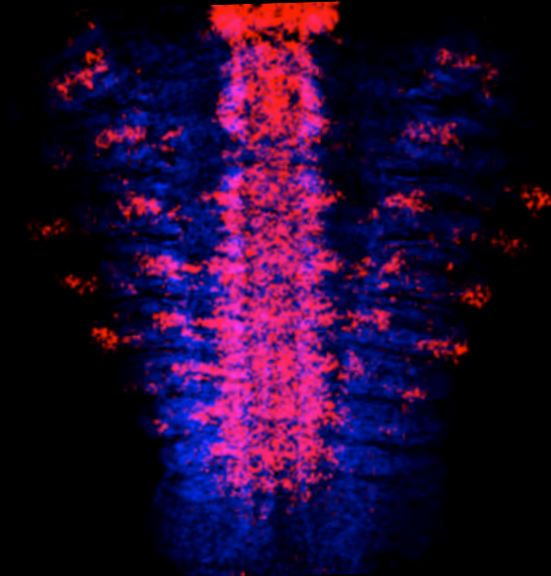
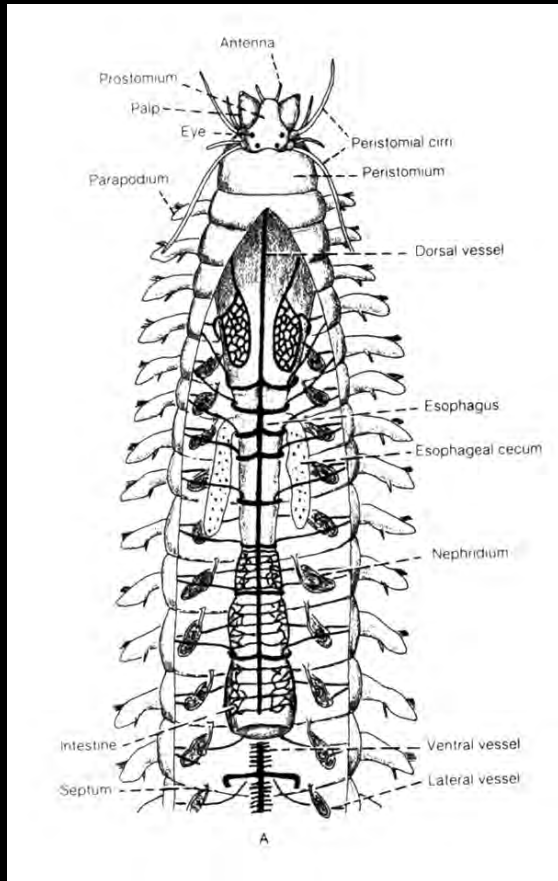


Segmentation, metamerism or seriation ?

The most metameric of all : annelids



Metameric organization of a nereididae



- segmented trunk
- paired appendages (parapodia)
- metameric nephridia
- metameric circulatory system
- ventral nerve cord = chain of ganglia
- metameric coelom
- metameric muscles

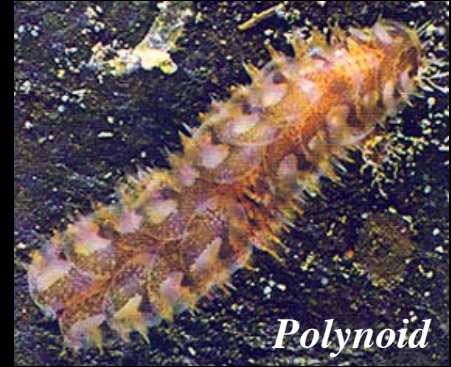
Diversity of annelids



Platynereis dumerilii



Eulalia viridis



Polynoid



Serpulid



Chaetopterid



Riftia

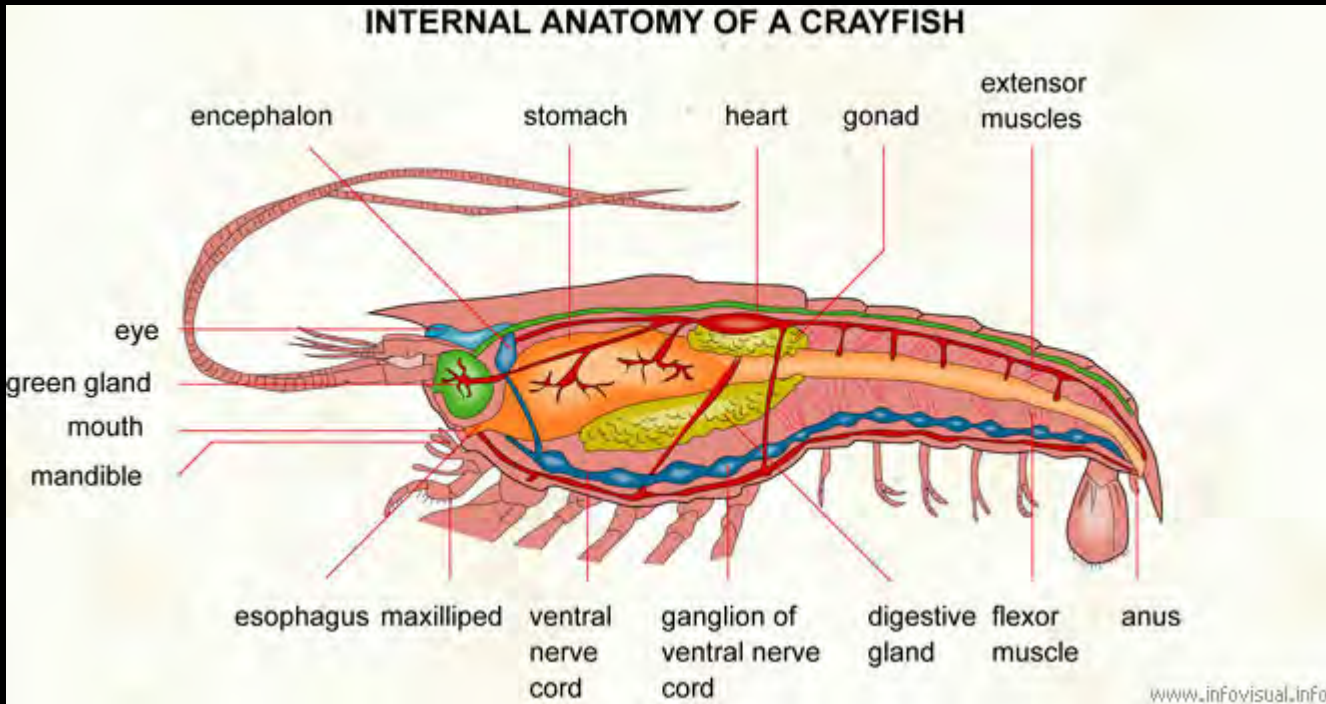


Lumbricus

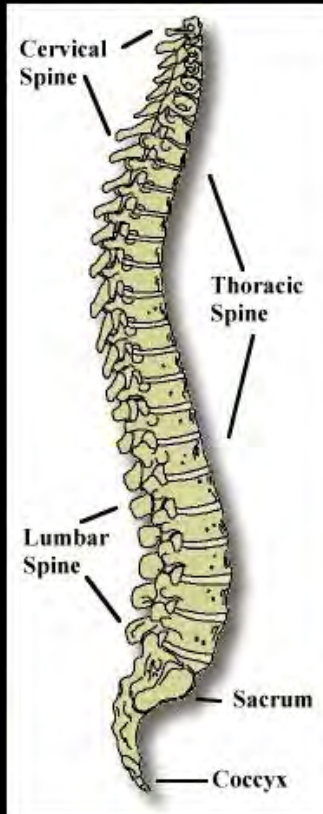


Bonellia viridis

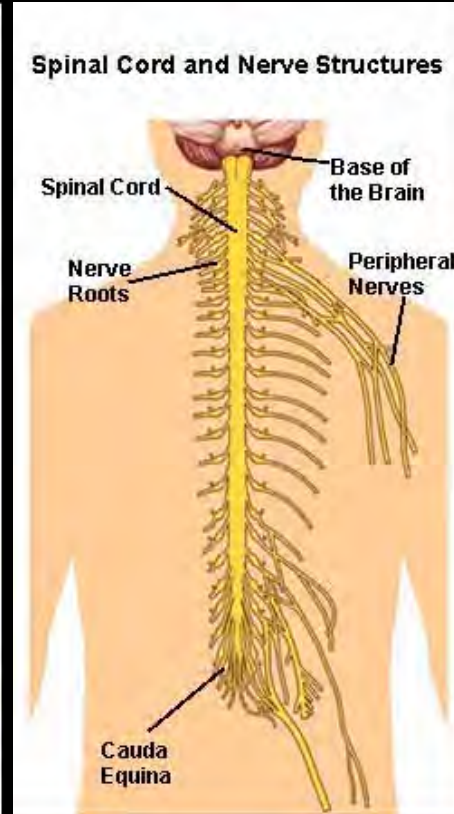
Segmentation : the arthropods



Segmentation in vertebrates



vertebrae



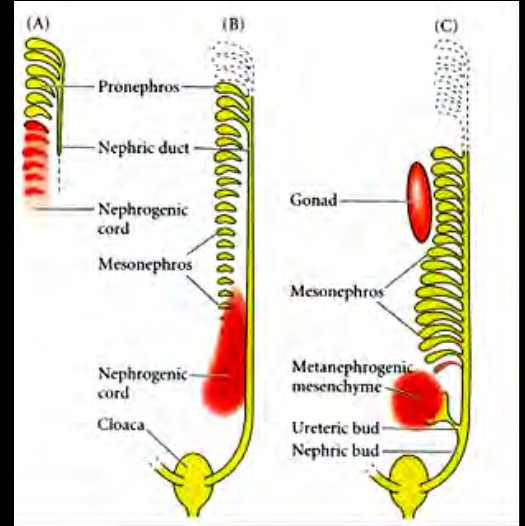
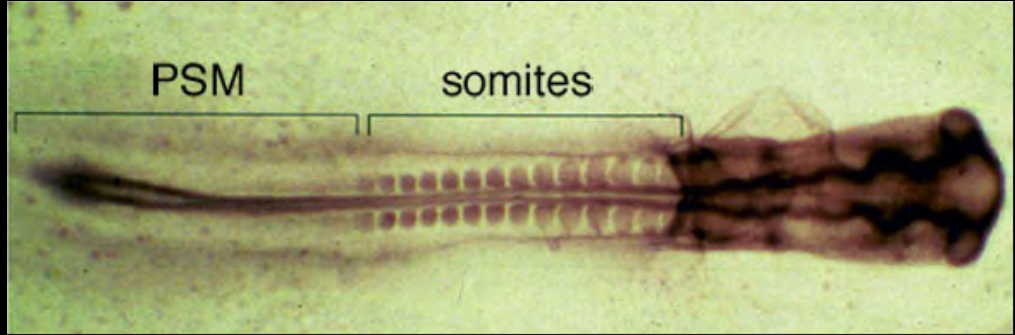
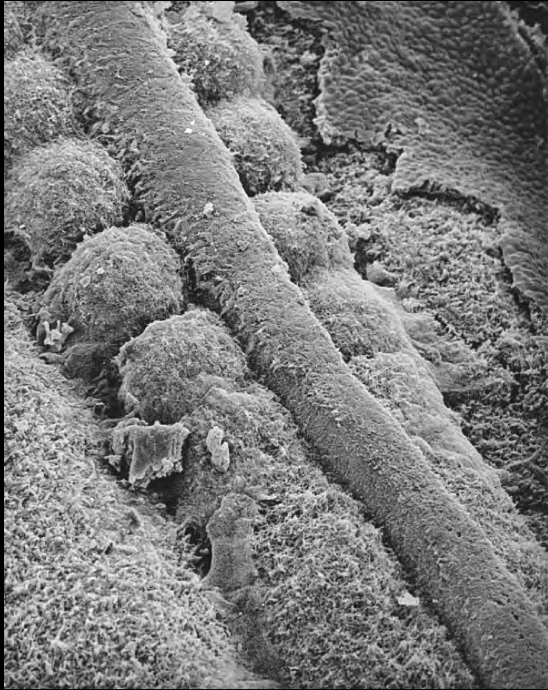
spinal nerves



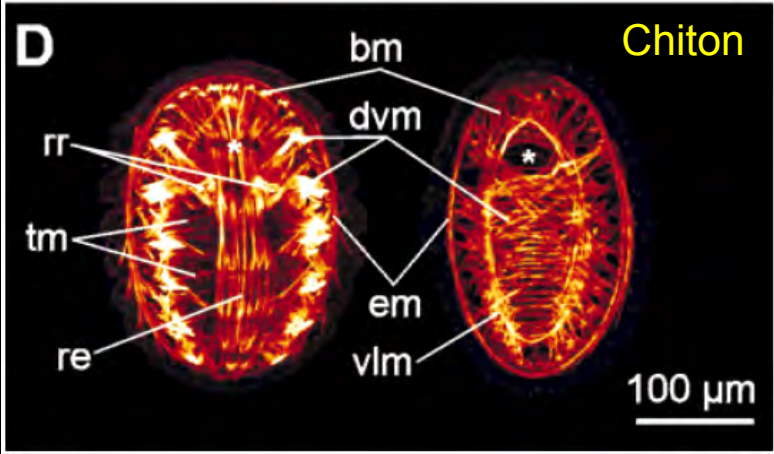
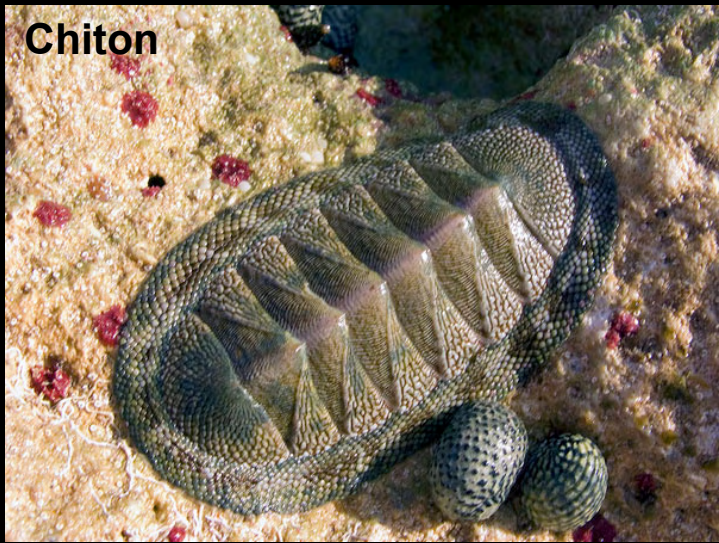
trunk muscles

Segmentation in vertebrates

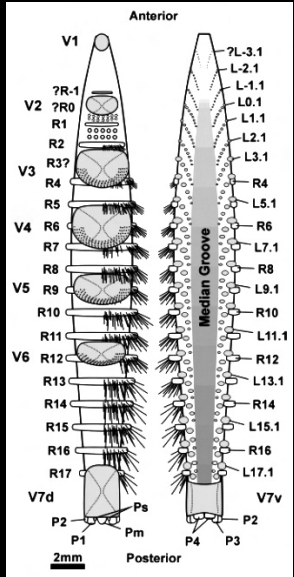
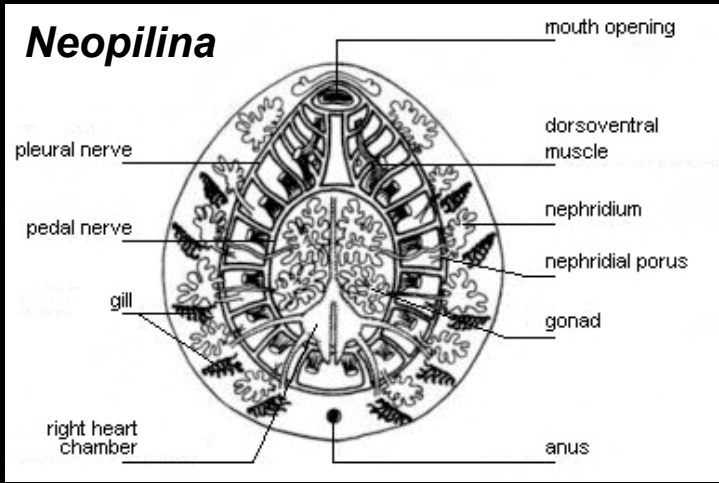
The trunk development



Segmented mollusks



Wanninger & Haszprunar, 2002



Acaenoplax, Silurian

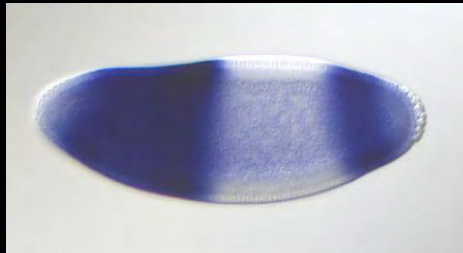
Sutton et al, 2001

Segmentation genes in the fruitfly

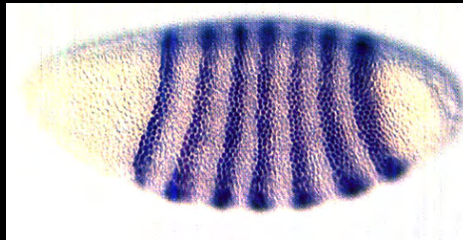
Maternal morphogens



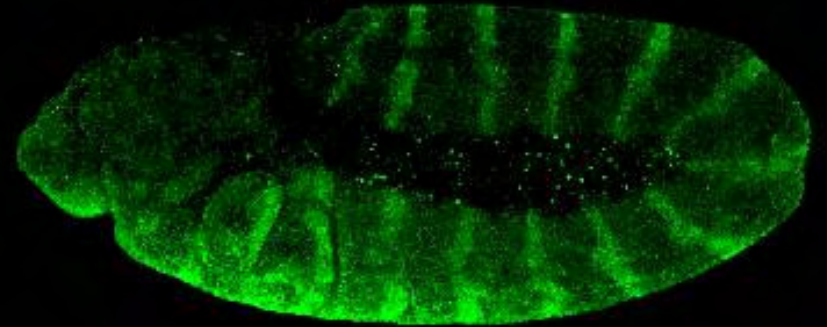
Gap genes



Pair-rule genes



Segmental polarity genes



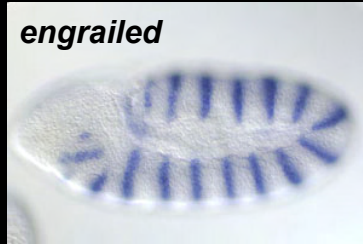
Expression of the gene *engrailed* in a fly embryo

Segmentation genes with conserved functions in arthropods

Hexapods



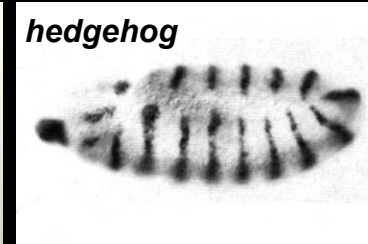
engrailed



wingless



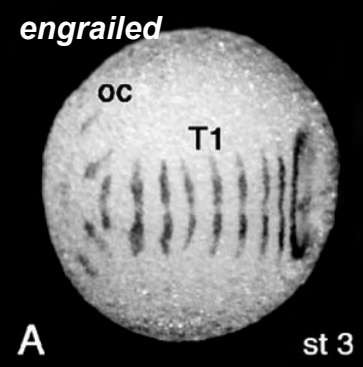
hedgehog



Myriapods



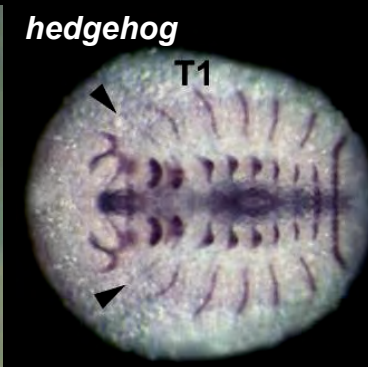
engrailed



wingless



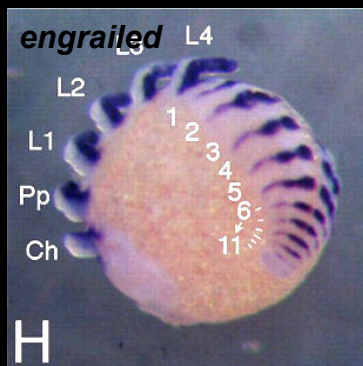
hedgehog



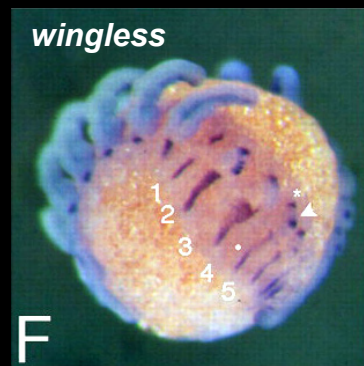
Chelicerates



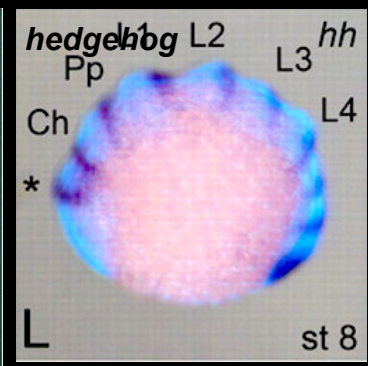
engrailed



wingless



hedgehog



The life cycle of *Platynereis dumerilii*

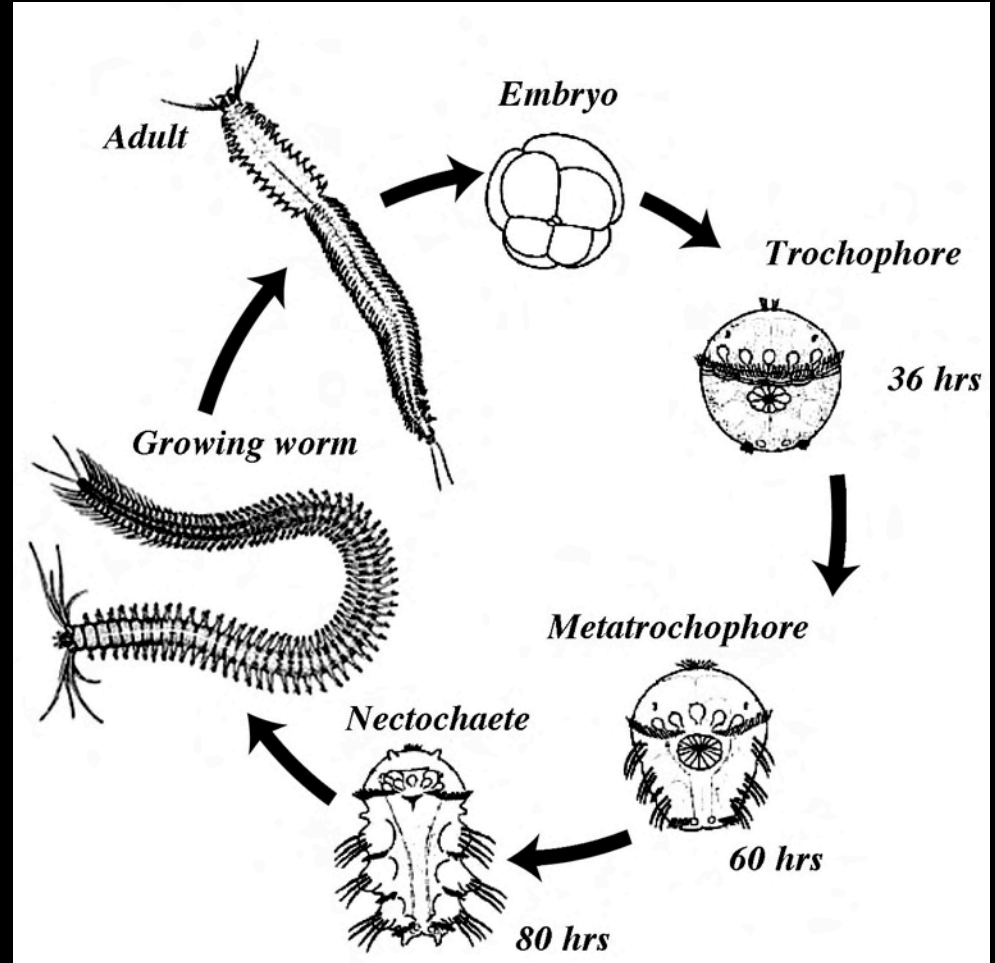
juvénile



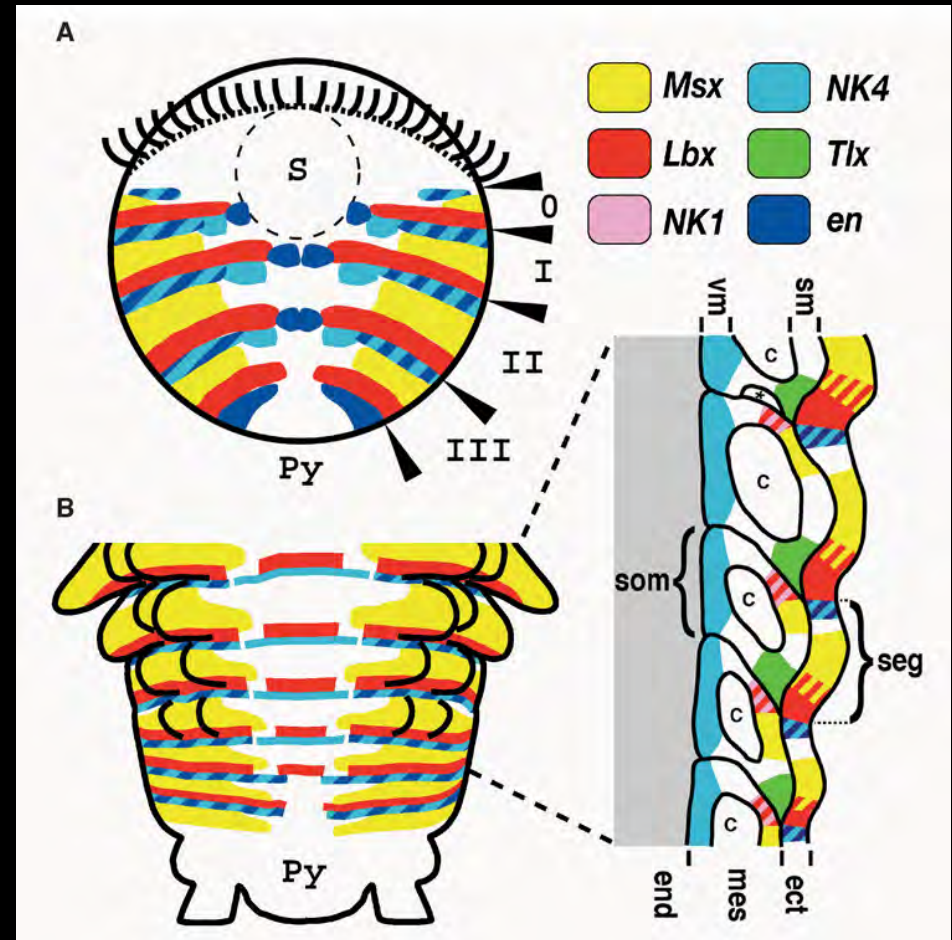
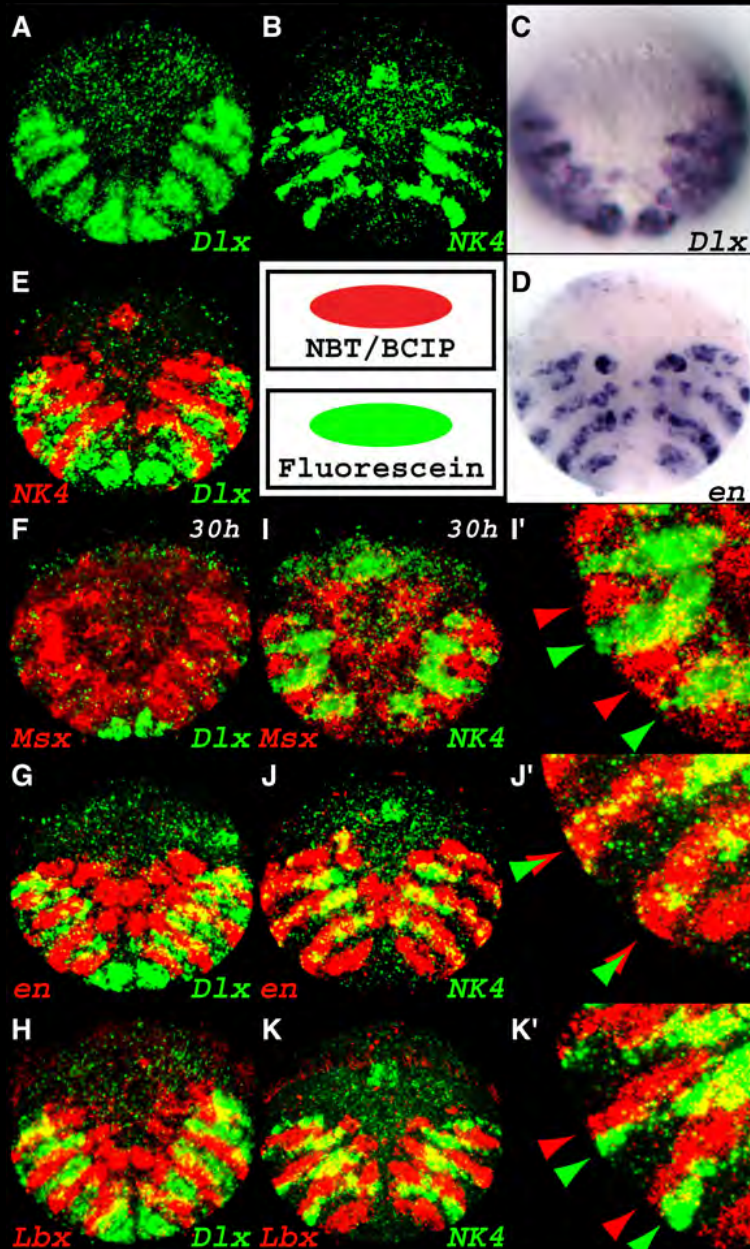
femelle



mâle

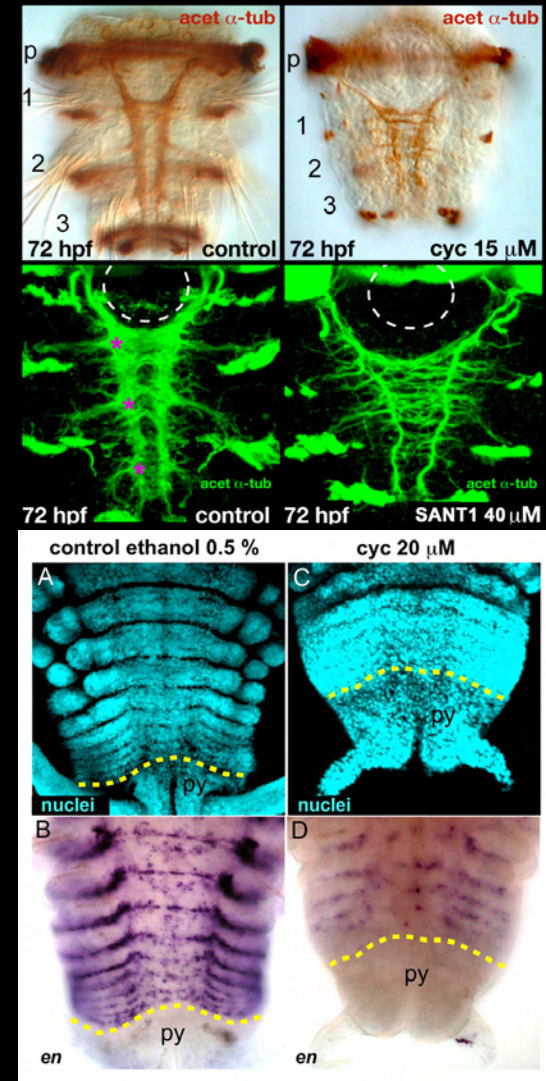
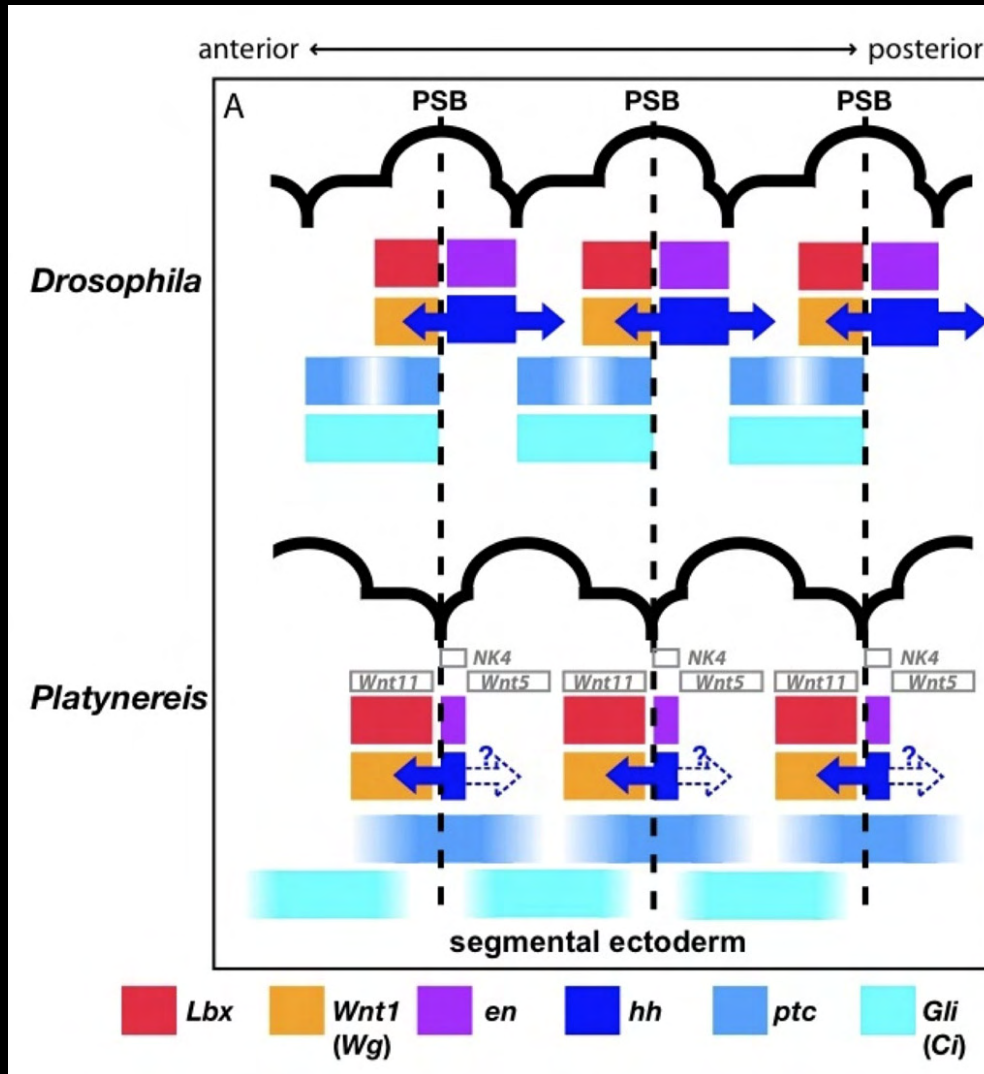


Segmentation genes in the annelid *Platynereis*

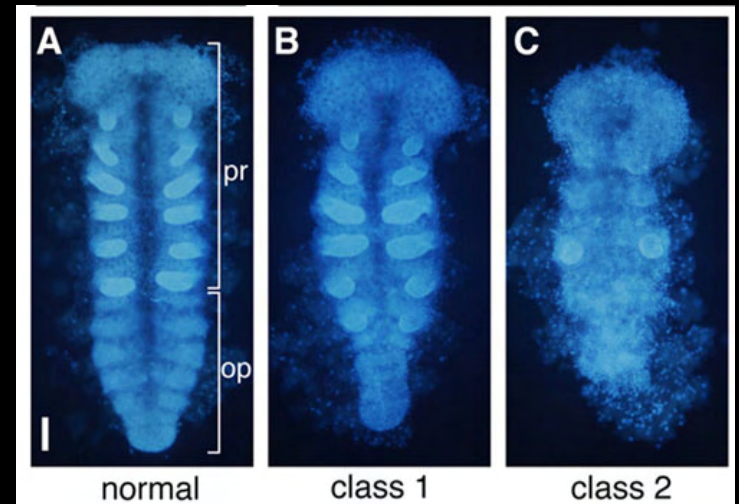
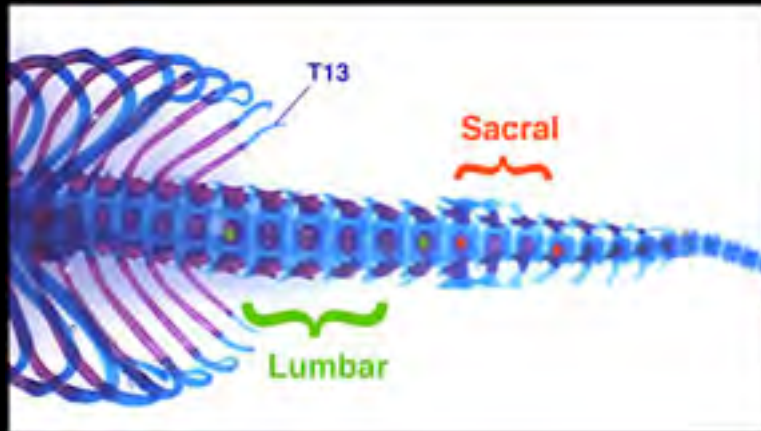


Saudemont, Dray et al, Dev Biol, 2008

Common segmentation genes in annelids and arthropods



Common segmentation genes in arthropods and vertebrates



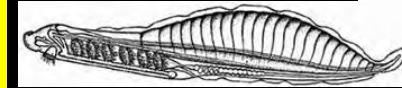
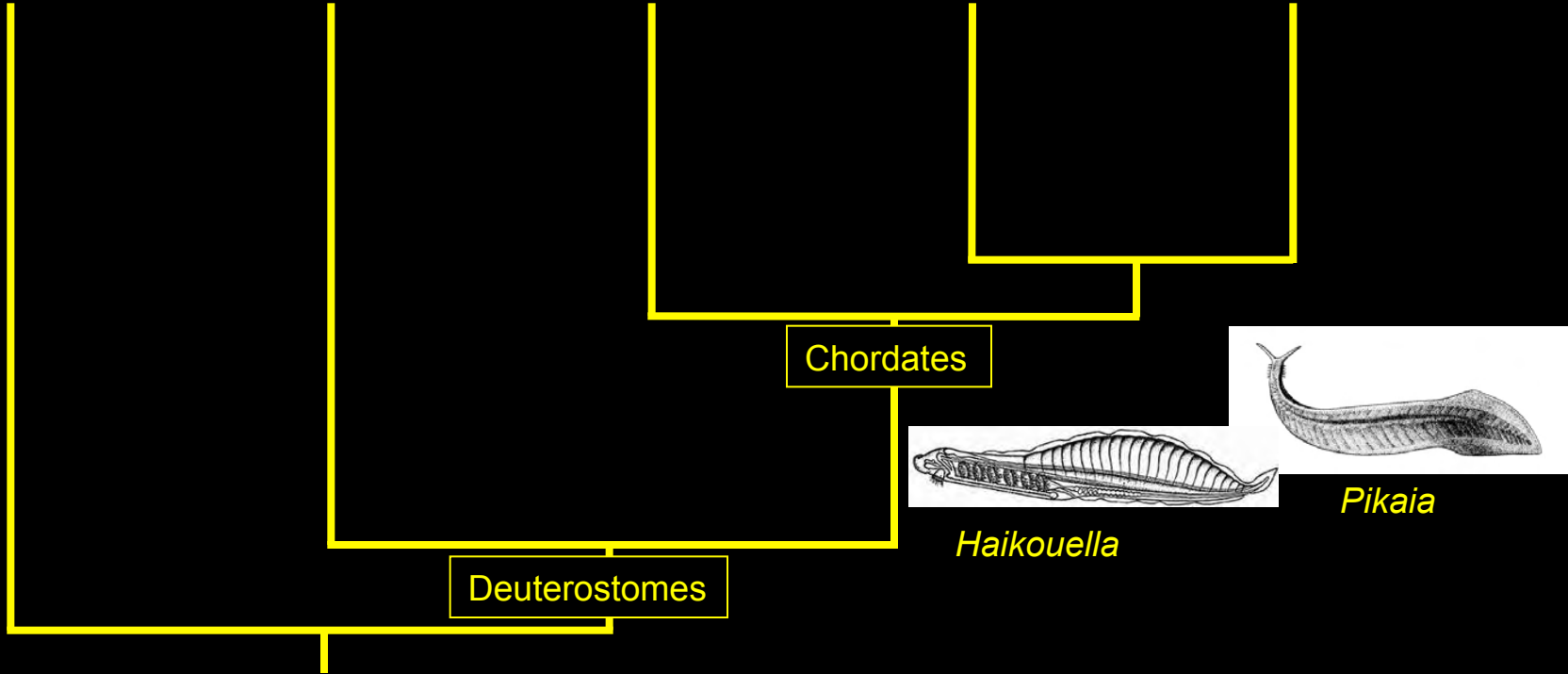
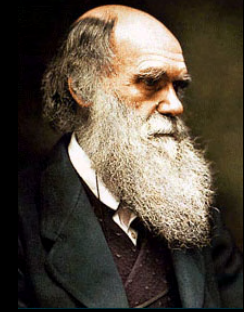
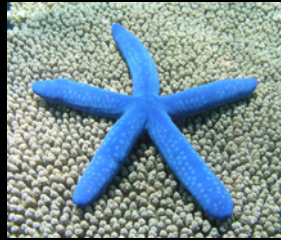
Protostomes

Echinoderms

Cephalochordates

Urochordates

Vertebrates



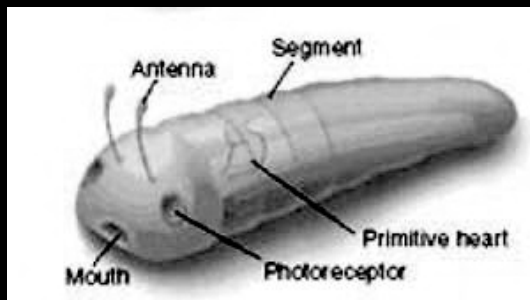
Haikouella



Pikaia

Deuterostomes

Chordates



Urbilateria

An annelid-like bilaterian ancestor: why it matters