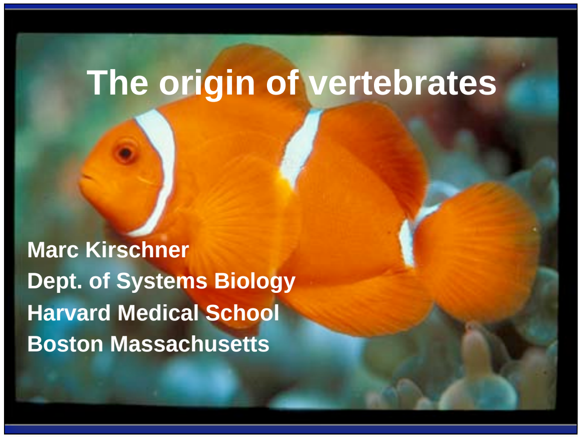


Plan of Lecture

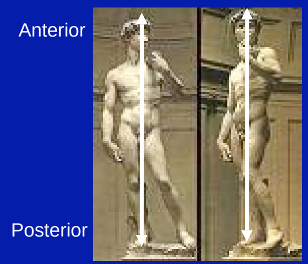
- Introduction: Vertebrate body plans and the odd phylum of *Hemichordates*
- The origin of the vertebrate nervous system: the hemichordate perspective

Plan of Lecture

- Telling the back from the front and what the chordates invented
- How the vertebrates got their chord

What do we vertebrates have in common?
How did these features arise in evolution?

Fundamentally, what we have in common is a body plan



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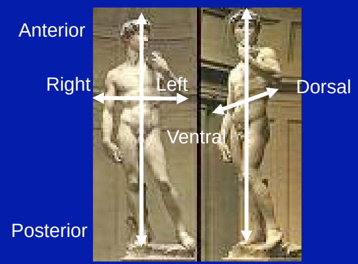
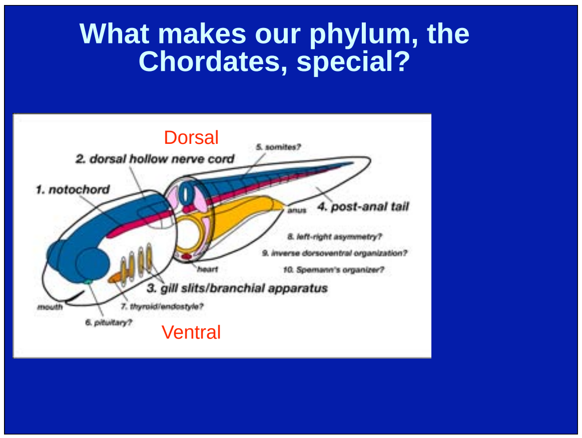
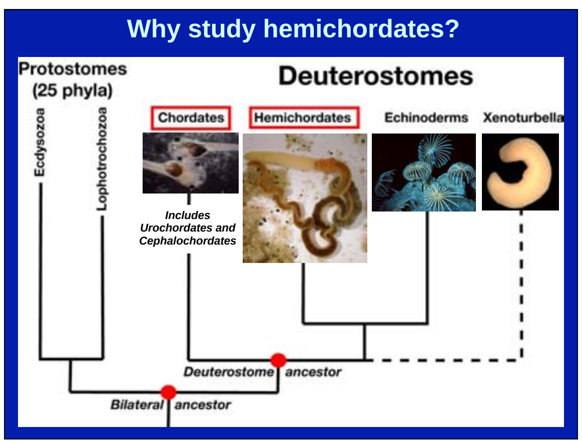






Not many good choices

To understand the Chordate origins, we need to step back from Chordates

- If we are too far, eg. flies, we cannot find the traces of the chordate developmental characters
- If we are too close, eg. within sea squirts, then all we see is the elaboration of these characters

Echinoderms are too weird to inform us about vertebrate body plans


Class: Crinoids; sea lilies

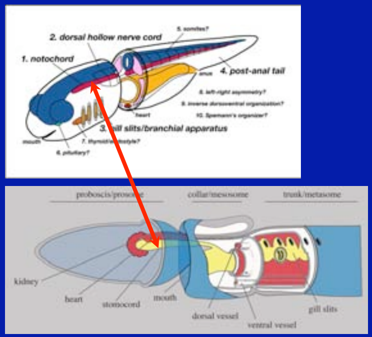

Class: Asteroids; starfish


Class: Echinoids; sea urchins


Class: Ophiuroids; brittle stars


Class: Holothuroids; sea cucumbers

Enter the hemichordates and their not so obvious similarities with chordates



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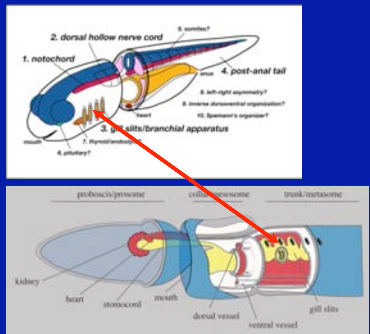
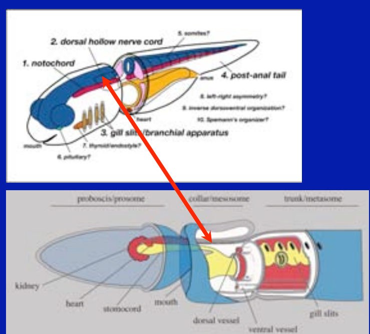
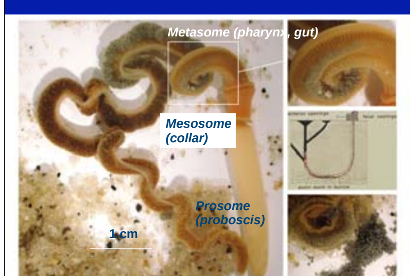


Enter the hemichordates and their not so obvious similarities with chordates



As we shall see, only one of these, gill slits are real homologies

The object of study: the Acorn Worm: *Saccoglossus kowalevskii*



Eggs spawned in the burrows

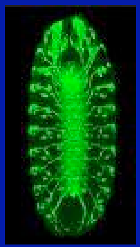
Encapsulated throughout early development

Is this the moment for the hemichordates to make their big contribution?

Part 1. The origin of the vertebrate nervous system

Marc Kirschner
Dept. of Systems Biology
Harvard Medical School
Boston Massachusetts

The long history of hypotheses on chordate origins focus on the origin of the vertebrate nervous system



Drosophila CNS
Ventral side

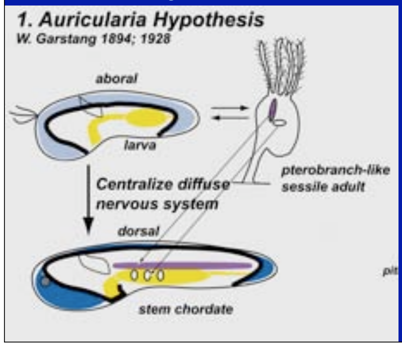
Human CNS
Dorsal side

The classical hypotheses can be basically divided into two groups - one that reconstructs the ancestor of chordates to a larval life history stage on one that derives chordates from adults.

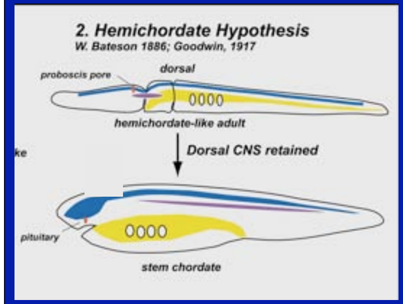
Garstang was very influencial and formed the inspriation for a entire school of thought people like Berrill.

Many of these hypotheses are based on the derivation of nervous system.

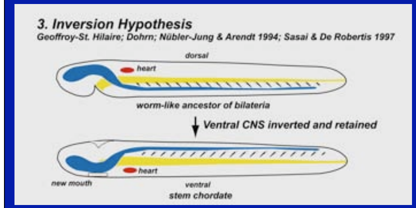
Theories of chordate origins: mostly of historical interest



As a common ancestor for the deuterostome phyla echinoderms (sea urchins and star fish), enteropneusts (hemichordates: acorn worms) and chordates (tunicates, lancelets and vertebrates) Garstang proposed an ancestor resembling an auricularia type echinoderm larva The auricularia possesses a ciliated ring, directly underlain by a nerve cord. This ciliated ring separates an aboral and an oral epithelial region. During the evolution of the chordate branch, the ciliated ring would shift dorsally and fuse in the mid-dorsal region. The ciliated ring of the auricularia would be homologous to the vertebrate neural ridges. The aboral epithelial field, internalised if the neural ridges fuse, were to evolve into the neural plate. Evidence for this view was found in comparative microscopic anatomy studies between echinoderms, hemichordates and amphioxus. Ultrastructural correspondences were found between the so-called multipolar cells – part of the larval ciliated band – of the studied echinoderm and



Due to molecular studies this bizarre one is of great interest

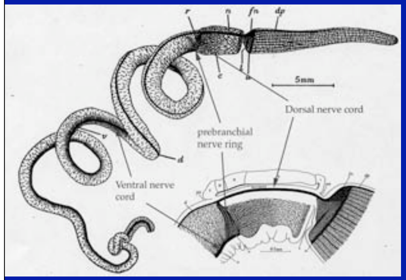


Our experimental strategy

- Find the worms
- Work out the early embryology
- Identify interesting genes
- Examine gene expression
- Design RNAi experiments
- Interpret the results

The organization of the nervous system in Saccoglossus is nothing like vertebrates or insects

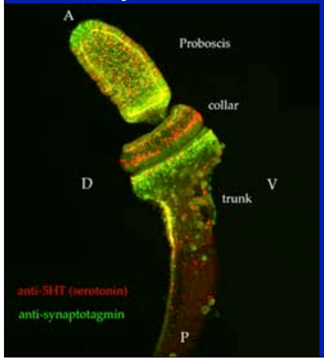
It is a diffuse nerve net
Dorsal and ventral cords are axon tracks

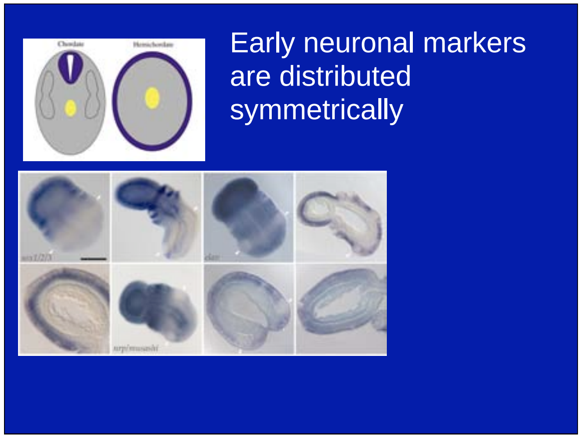


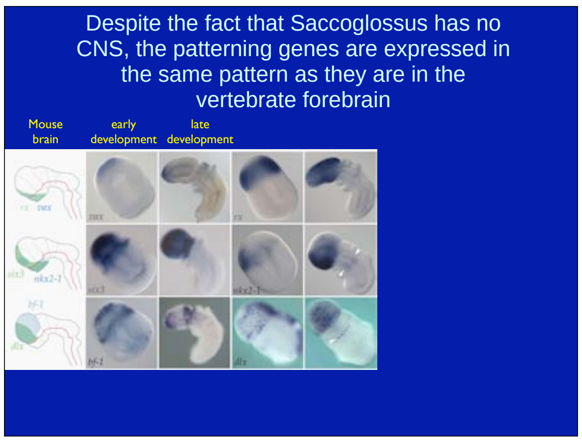
E. Knight-Jones
1952

We have been focusing on nervous system organization as the two cords have been variously proposed as the homologue of the chordate dorsal nerve cord.

The nerve cells are not localized but symmetrical around the body

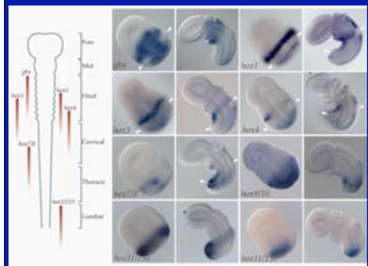


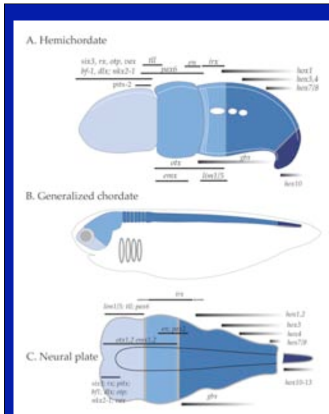




Notice a marked shift in the posterior limit of expression of this group of genes in hemichordates.

For Hox gene expression in more posterior regions the homologies persist

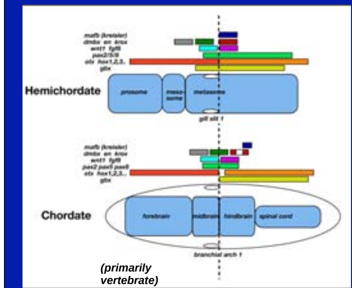




A conserved domain map in Hemichordates and Vertebrates

Important signaling centers are conserved- eg. the vertebrate midbrain-hindbrain boundary in a brainless hemichordate

The remarkable ancestry of the midbrain-hindbrain boundary



The hemichordate pattern is more vertebrate-like than amphioxus or ascidians. Yet the hemichordate has nothing resembling a midbrain or hindbrain…

Conclusions

- Conservation of transcriptional pattern despite the fundamental organizational differences
- Patterning genes are not reliable markers of any specific neuroanatomical organization
- Much of the regulatory networks involved in vertebrate brain regionalization were established early in deuterostome history.
- Nerve nets may be complex

Are we correct to think that a decentralized nervous system was the ancestral state?

Or did centralization occur once in an early ancestor and did the vertebrates merely shift the dorsal/ventral axis?