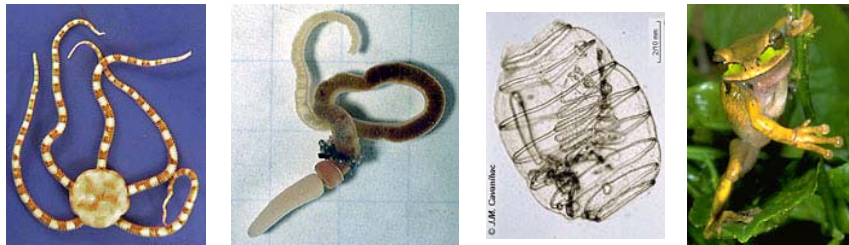


## Roots

- We deuterostomes develop butt-first, and we're proud of it..
- But not many other clades of animals develop this way...



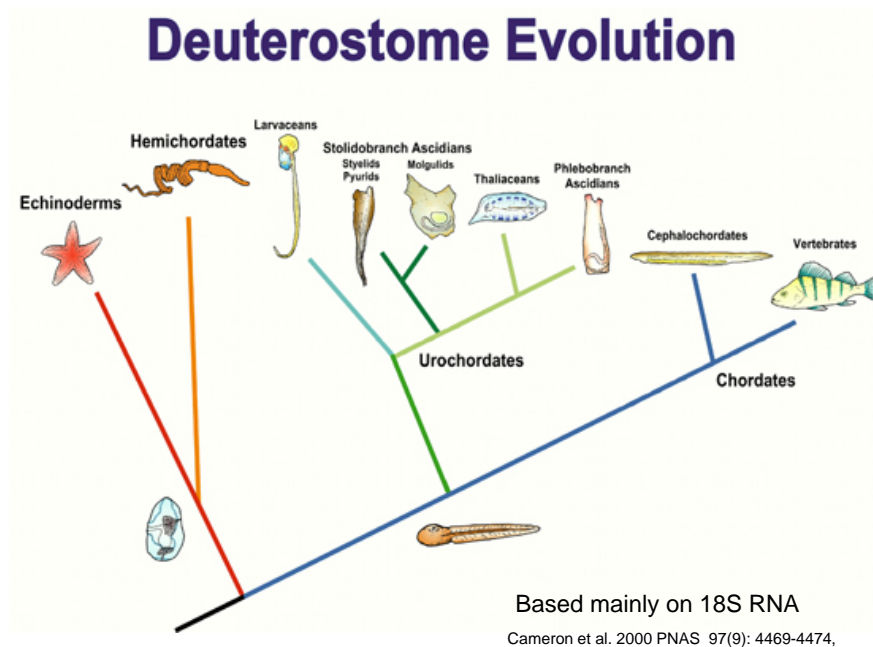
## Deuterostomes

- The major deuterostome clades are Echinodermata, Hemichordata, Urochordata, and Chordata.
- (Lophophorates were formerly, but no longer, considered to be deuterostomes)
- Ancestral deuterostome was probably a burrowing worm, with gill slits and a cartilaginous skeleton.
- Billie Swalla, U. Washington, Chris Cameron, U. South Florida

## 4 Deuterostome phyla\*

- Echinodermata (sea stars, urchins, crinoids, et al.)
- Hemichordata (acorn worms, pterobranchs, extinct graptolites)
- Urochordata (tunicates, salps)
- Chordata (cephalochordates, vertebrates)

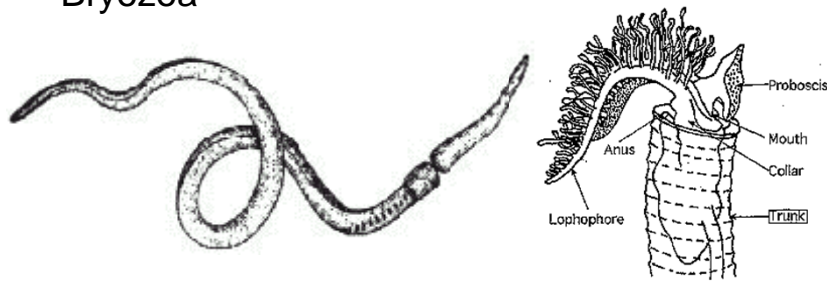
\* Some authors place urochordates in Chordata



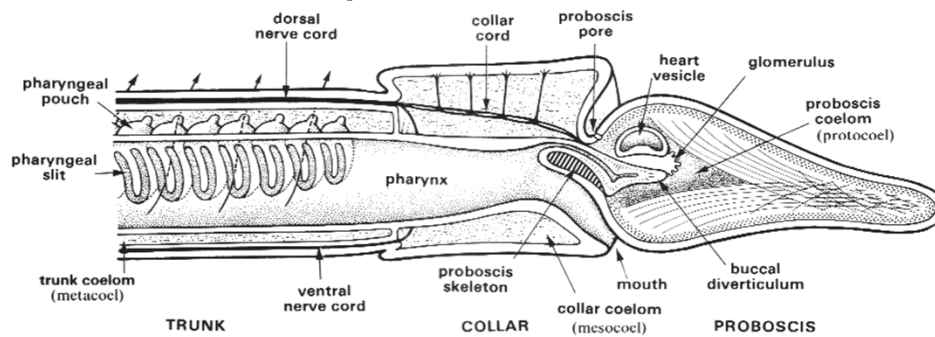
# Phylum Hemichordata

Class Enteropneusta (acorn worms) ~100 species of burrowing, deposit-feeding marine worms

Class Pterobranchia- ~ 20 species of tiny, sessile, tubicolous filter-feeders, superficially similar to Bryozoa



## Class Enteropneusta



- proboscis, collar, & trunk containing the digestive and reproductive organs
- Pharyngeal slits and proboscis skeleton (“stomochord”)

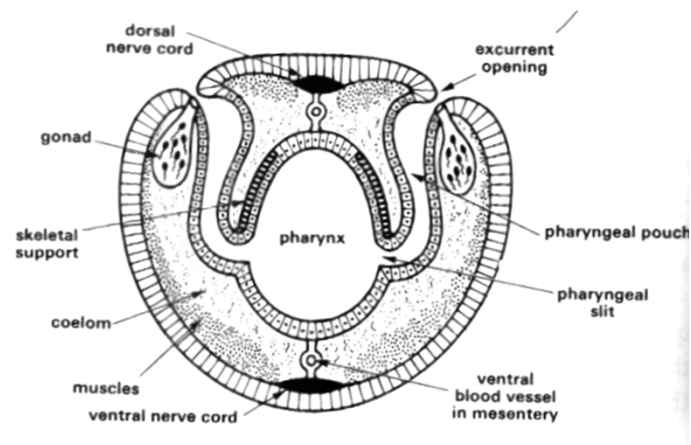
## Enteropneusts

- Acorn worms burrow in sediments
- Some deposit feed, others suspension feed using ciliary tracts.
- Water exits the pharynx through the slits
- ~100 species
- All marine



Cross-section through trunk of an enteropneust hemichordate.

Note coelom, pharyngeal openings

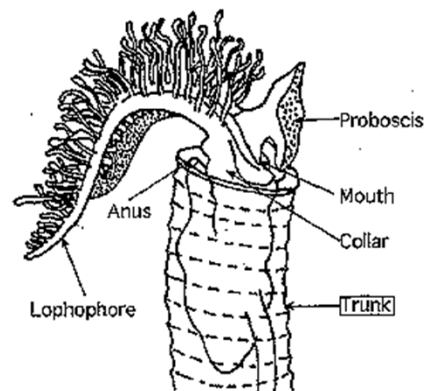
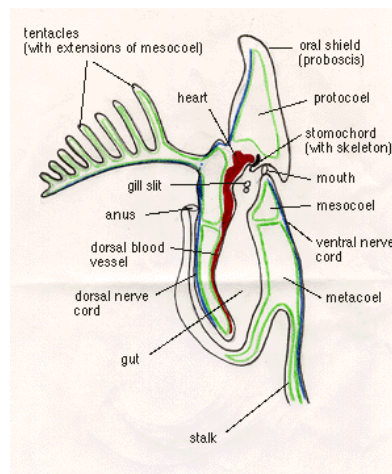


## Class Pterobranchia

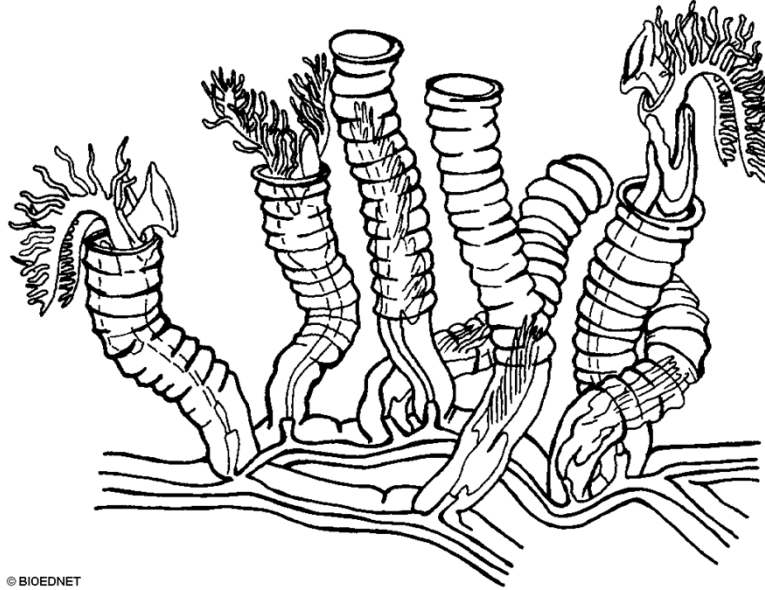
- ~20 species of colonial hemichordates living in secreted tubular coenecia.
- Reproduce by planula shaped larvae or asexual budding.
- originally classified as lophophorates (~Bryozoa) due to convergent anatomy
- Apparently evolved from an acorn worm (enteropneust) ancestor

## Pterobranch anatomy

- “lophophore” apparently analogous structure



## A colony of pterobranch hemichordates



© BIOEDNET

## Graptolithina (graptolites)

Extinct class of colonial Hemichordates,  
thought to be related to Pterobranchs

Sessile and planktonic colonies “like  
tiny sawblades”

Early- mid Paleozoic (mainly  
Ordovician and Silurian) 540-320 mya

Graptolite species were generally  
widespread and short-lived, so valuable  
fossils for correlating strata.



## Class Graptolithina

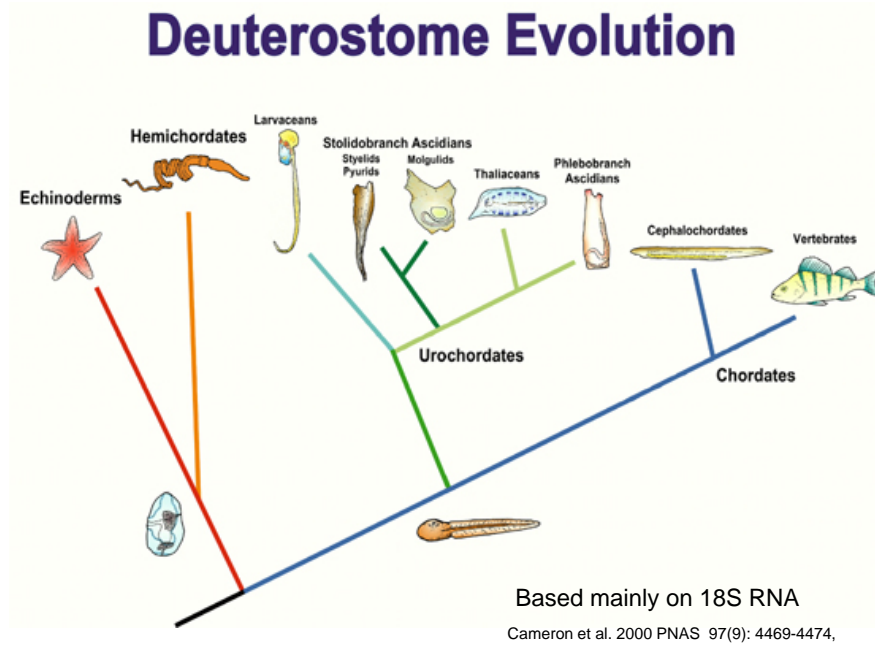


Reconstruction of a planktonic colony of graptolites, suspended from float

Graphein, lithos

## Phylum Chordata

- ~45,000 species, 97% of them are vertebrates
- Subphylum Urochordata
- Subphylum Cephalochordata
- Subphylum Vertebrata



## The invertebrate chordates

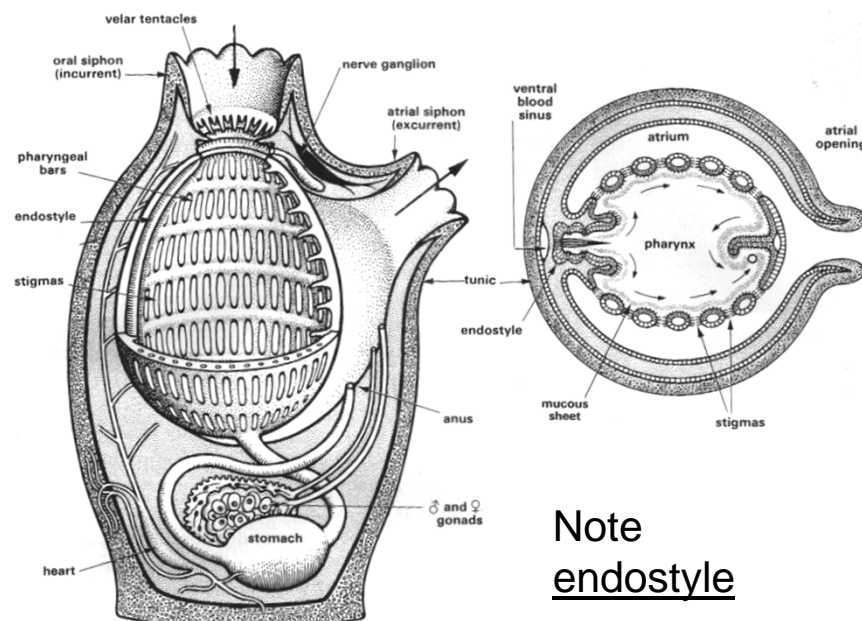




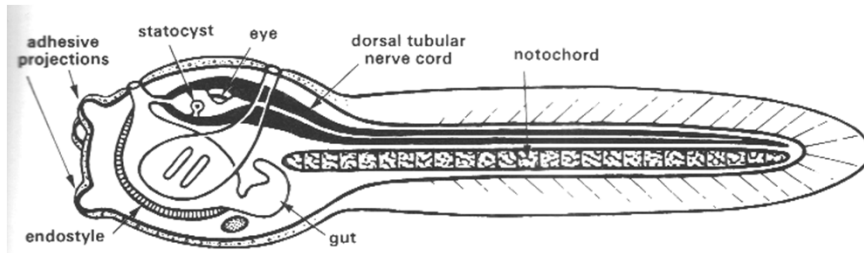
Phylum Urochordata,  
**Class Ascidiacea (tunicates)**

- Sessile, filter feeders with incurrent and excurrent siphons
- Secrete protective bag or test of tunicin (similar to cellulose)
- Pharynx expanded into feeding basket with numerous openings into atrium
- Atrium conducts water out through excurrent siphon
- Solitary, colonial, or compound

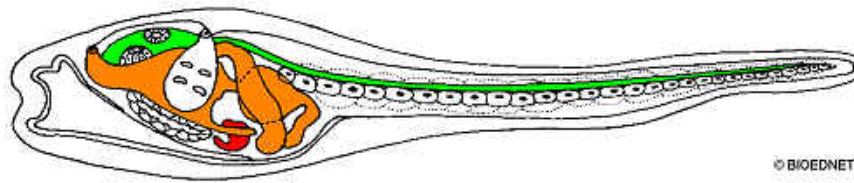
Phylum Urochordata, Class Ascidiacea



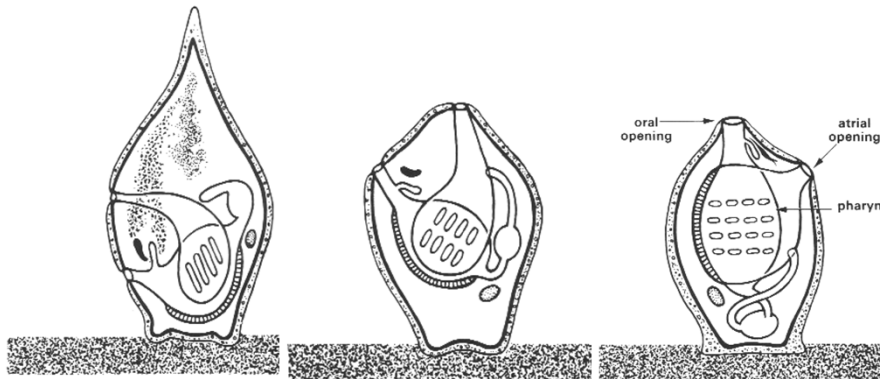
Note  
endostyle



1. Tadpole larva of an ascidian swims for only a few minutes to a few days until it finds a suitable attachment site.



“Tadpole larva” with chordate characters



2. Larva attaches at its anterior and begins **metamorphosis**. Notochord, and most of the nervous system are resorbed.

3. While the ganglion, heart, digestive system, and atrium continue to develop, and pharyngeal slits divide into many smaller openings, ...

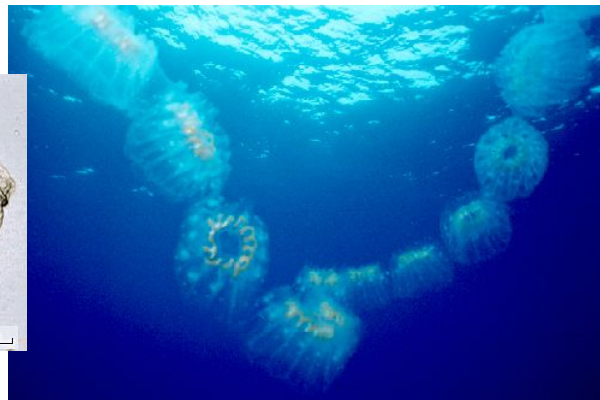
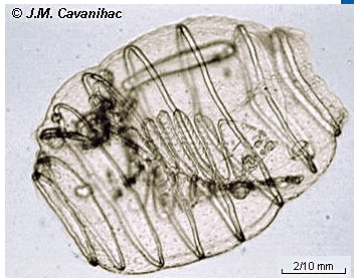
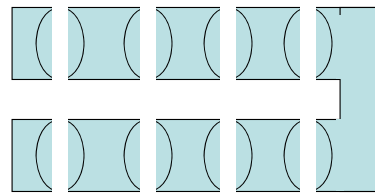
4. ... the siphons and internal organs become rotated about 90° so that the siphons are directed away from the substrate. (Combined from various sources)

### Metamorphosis of an ascidian tadpole



## Class Thaliacea (salps)

- Planktonic urochordates with the atrial and buccal siphons at opposite ends of their bodies.
- the exhalant current from feeding serves as jet propulsion to move them slowly through the water.
- Solitary or colonial



Giant  
luminescent  
salps-  
*Pyrosoma*



Jellies & siphonophores  
Monterey Bay

<http://www.youtube.com/watch?v=pimIbTqJLZc>

[Pyrosome & salps](http://www.youtube.com/watch?v=5EQGA_4BZ5s)

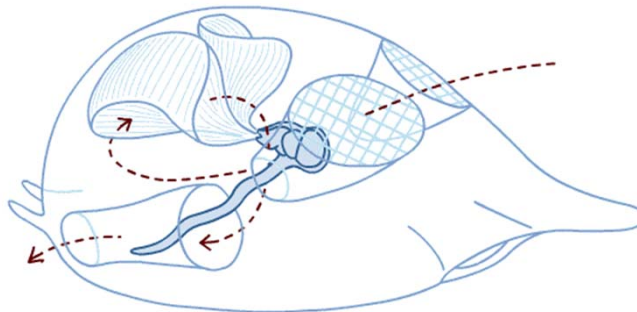
[http://www.youtube.com/watch?v=5EQGA\\_4BZ5s](http://www.youtube.com/watch?v=5EQGA_4BZ5s)

## Class Appendicularia (larvaceans)

- Paedomorphic urochordates
- The adult has morphology somewhat similar to the tadpole larva of tunicates
- Complex secreted “house” of mucus & collagen fibers used for filter feeding

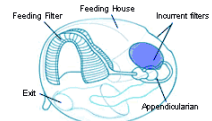
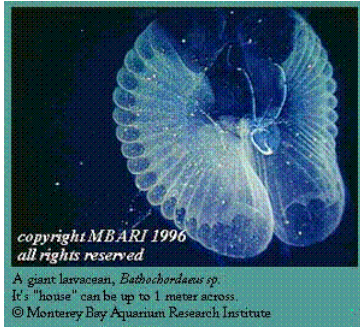


The appendicularian *Oikopleura*





The appendicularian *Oikopleura*



Major features of generalized appendicularian feeding house. [CLICK HERE TO VIEW AN ANIMATED FEEDING AND BACKWASHING CYCLE](#) (presented with Flash 5 plugin)

## Larvaceans are a key trophic link in marine plankton

- Ability to filter submicron particles
- Perhaps also use DOM (dissolved or colloidal organic material)
- Tremendous growth rates, productivity (30X body mass per day, plus 6-12 houses)
- Food for larval fish, other planktonic animals



## Cephalochordata

- Invertebrates most similar to vertebrates
- Infaunal (burrowing) filter-feeders
- 29 species

