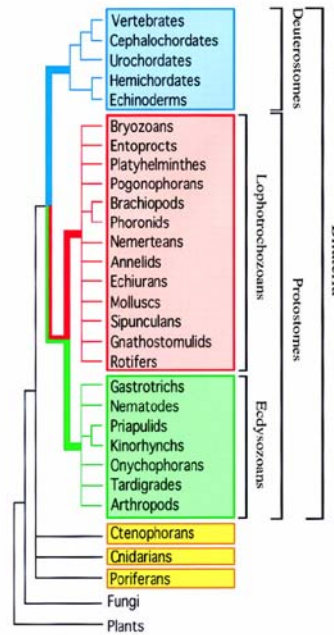
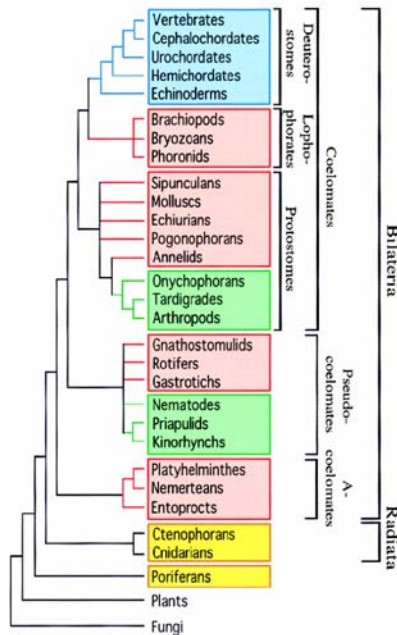


Classical hypothesis

Molecular hypothesis



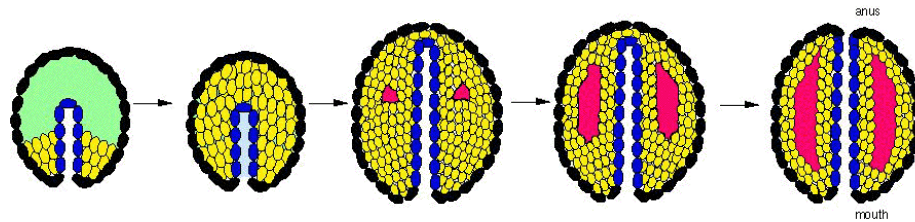
Adoutte 2000 PNAS

Protostome:

Embryonic blastopore becomes mouth

Schizocoelous development

(typical of the protostome coelomates)

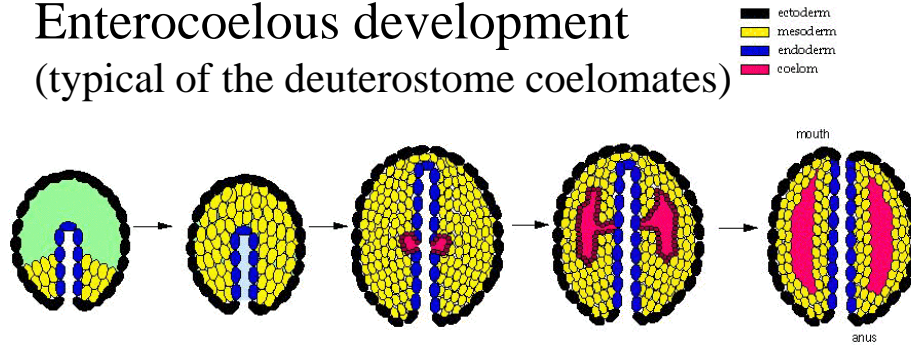


Deuterostome:

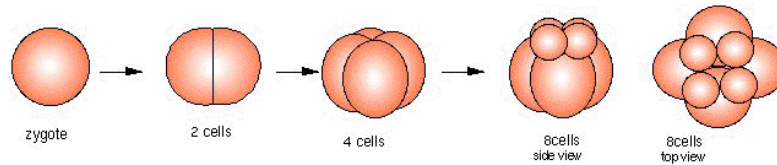
Embryonic blastopore becomes anus.

Mouth forms as secondary opening

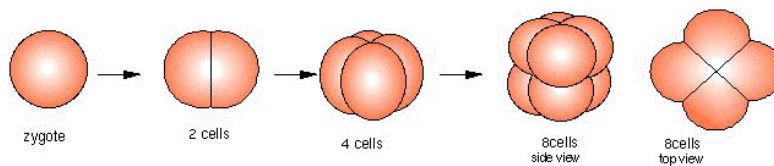
Enterocoelous development (typical of the deuterostome coelomates)



Cleavage



Spiral- third division and subsequent are unequal...typical of protostomes

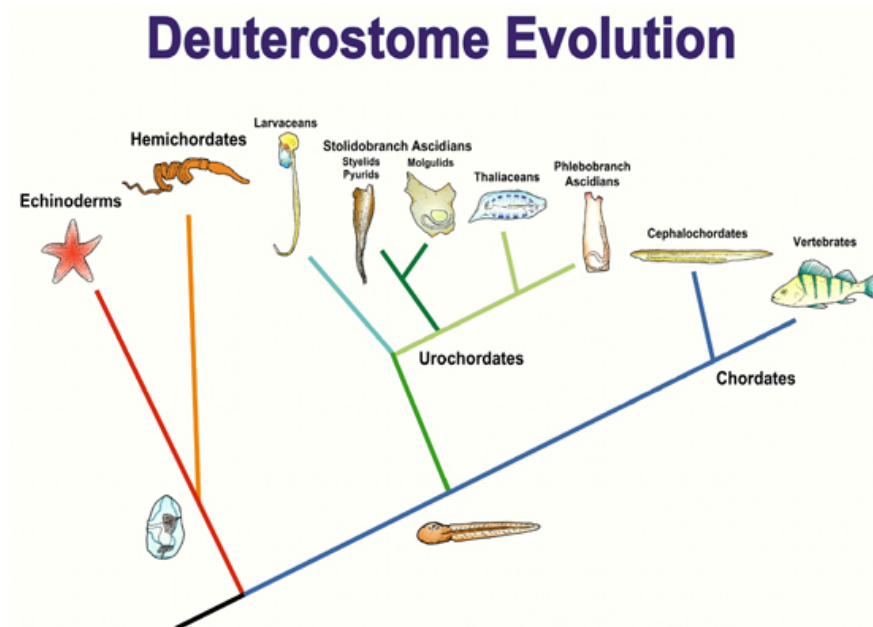


Radial- third division is equal...typical of deuterostomes

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 Echinodermata

~7,000 extant species in five well-defined clades,
~13,000 extinct species and ~15 more classes.

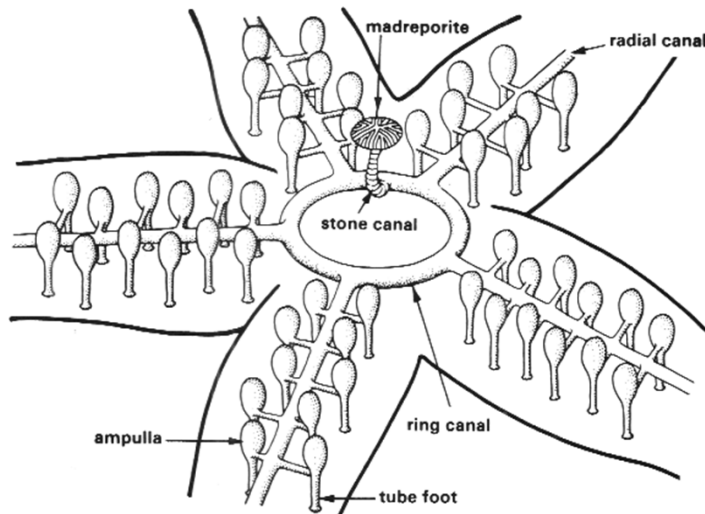
- Asteroidea (starfishes)
- Ophiuroidea (basket stars and brittle stars),
- Echinoidea (sea urchins, sand dollars, sea biscuits)
- Holothuroidea (sea cucumbers).
- Crinoidea (sea lilies and feather stars),
- Concentricycloidea (sea daisies; 2 species),

Synapomorphies of Echinoderms

1. Calcite skeleton composed of ossicles.
2. Water vascular system.
3. Mutable collagenous tissue.
4. Pentaradial body organization in adults.

Also exclusively marine, coelomate, and deuterostome

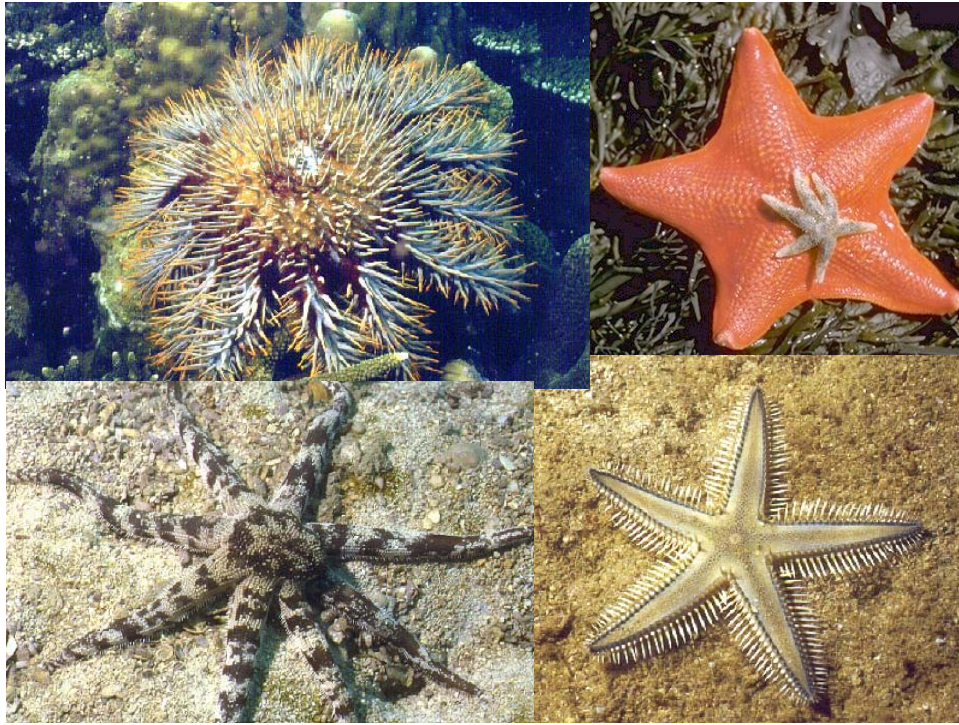
Echinoderm water vascular system



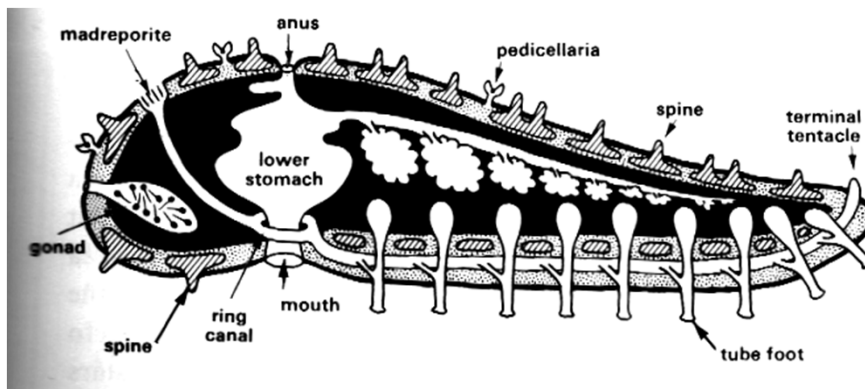
Class Asteroidea (sea stars)



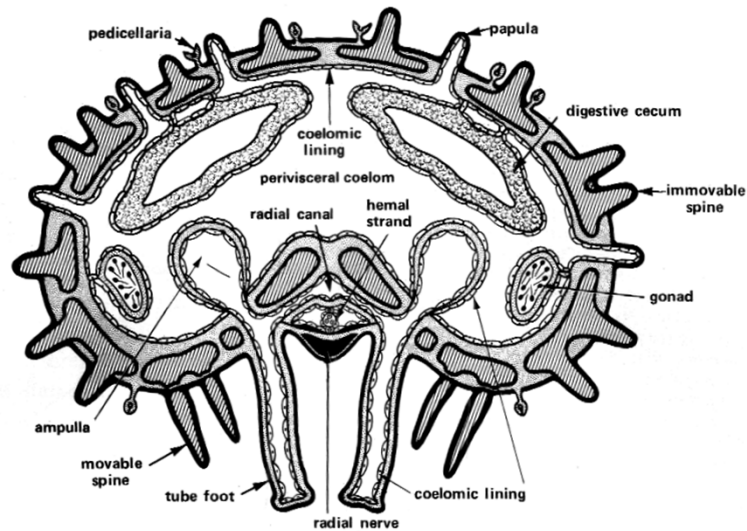
- Mainly carnivorous – evert stomach to carry out digestion without ingestion.
- Locomotion mainly by tube feet- arms move only slowly
- Arms are short and thick, with coelomic extensions containing digestive glands and gonads



Class Asteroidea (sea stars)



Class Asterozoidea (sea stars)



Asterozoidea, cont.

- Respiratory gas exchange via ciliated dermal papillae and coelomic fluid.
- Haemal (“blood”) system – function not understood.
- Capable of extensive regeneration and asexual reproduction in some classes

Class Asterozoa (sea stars)

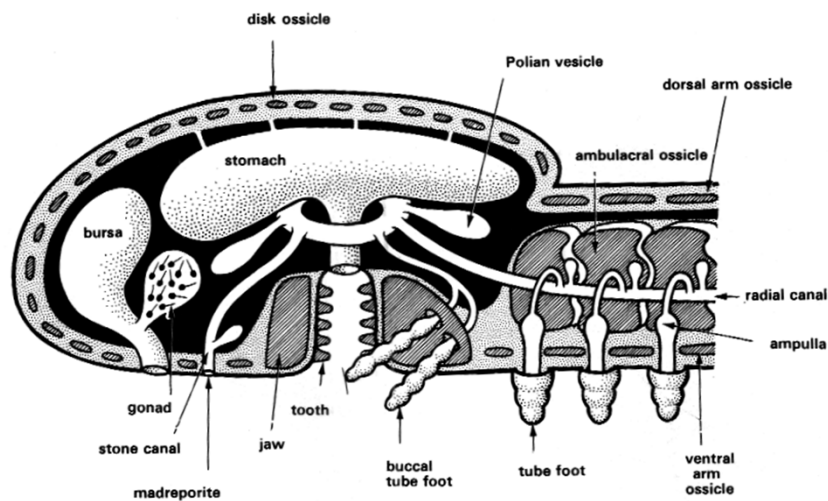


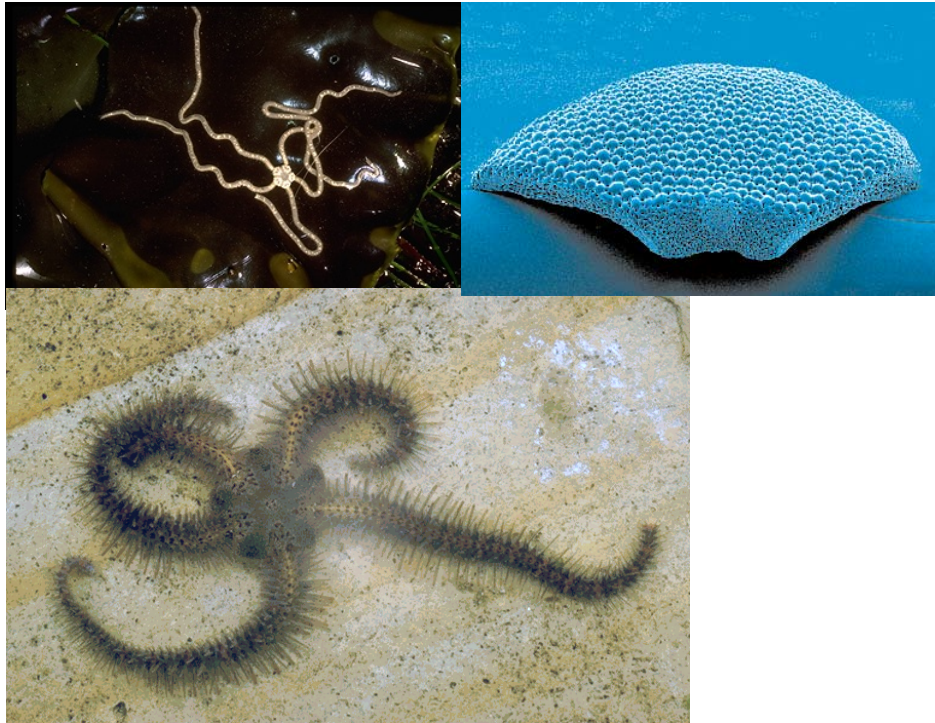
A seastar
(*Asterias*)
opening a
bivalve

Class Ophiuroidea (brittle stars) 

- Most diverse class of echinoderms- ~2,000 species.
- Distinct central disc containing the organ systems.
- Five highly flexible arms, capable of rapid movement by muscle action
- No anus. Deposit, detritus, and suspension feeders.

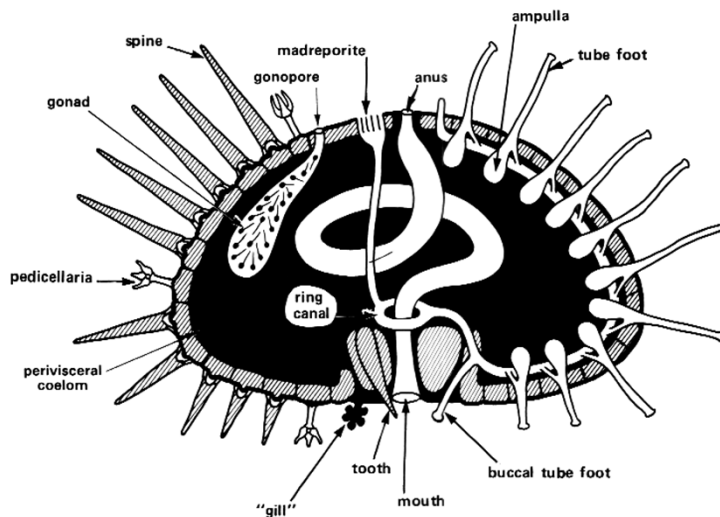
Class Ophiuroidea (brittle stars) 





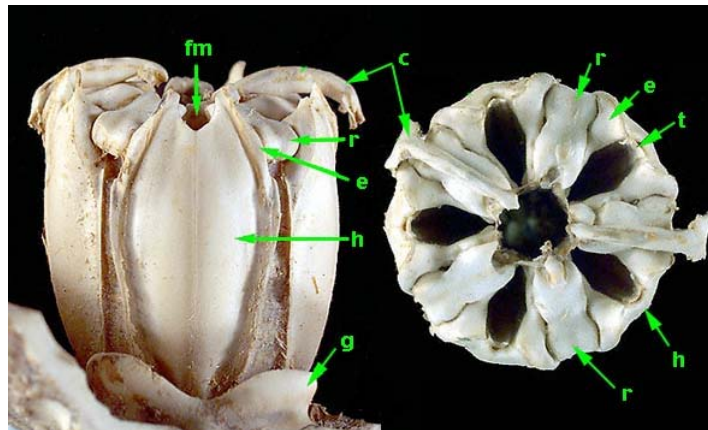
Class Echinoidea (sea urchins, et al.)

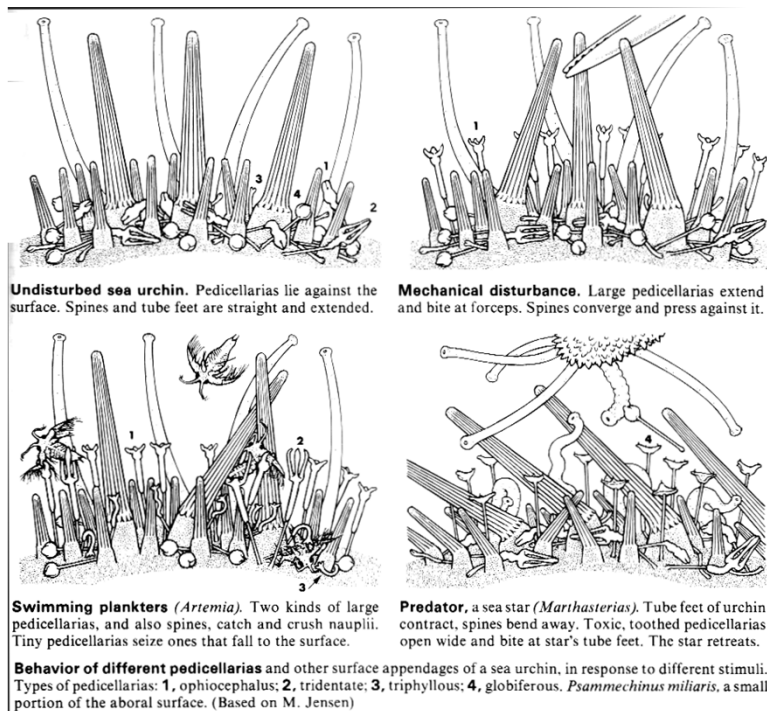
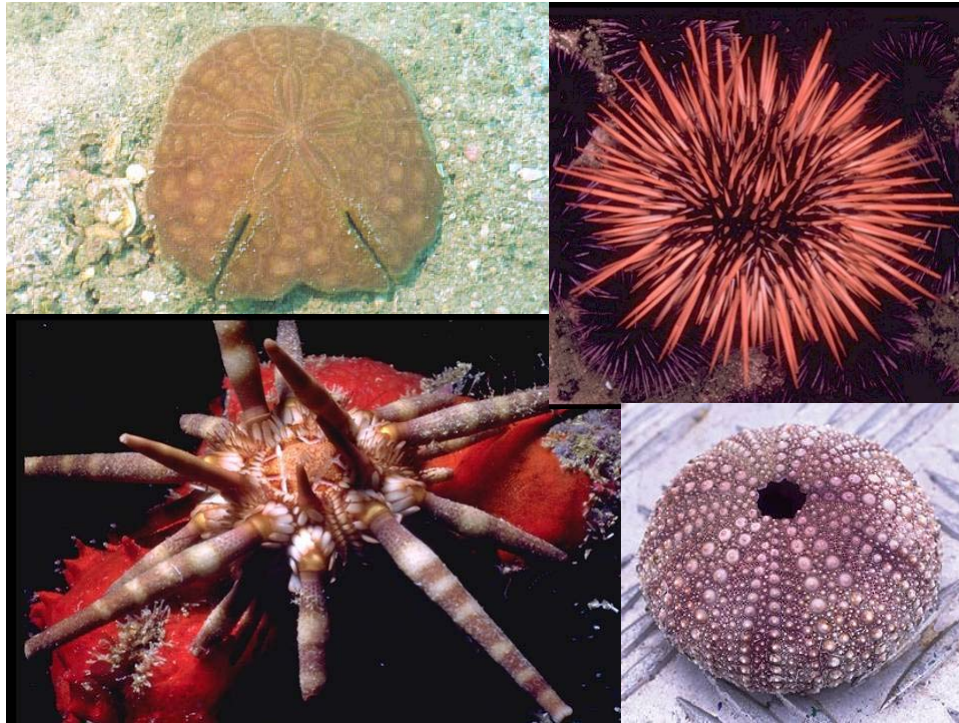
- Globular or flattened echinoderms without arms
- Complex 5-part jaw apparatus (“Aristotle’s Lantern”)
- Mainly grazers on algae, a few feed on bryozoans or sponges.
- Some species harvested as food (the roe is eaten)



Section of a sea urchin, cutting through an interambulacral row of spines on the left and an ambulacrum on the right. The perivisceral coelom is in solid black. Such a section cuts through only one of the 5 teeth of the Aristotle's lantern. Nervous system, hemal system, muscles, and coelomic linings are not shown.

Aristotle's Lantern – 50 ossicles



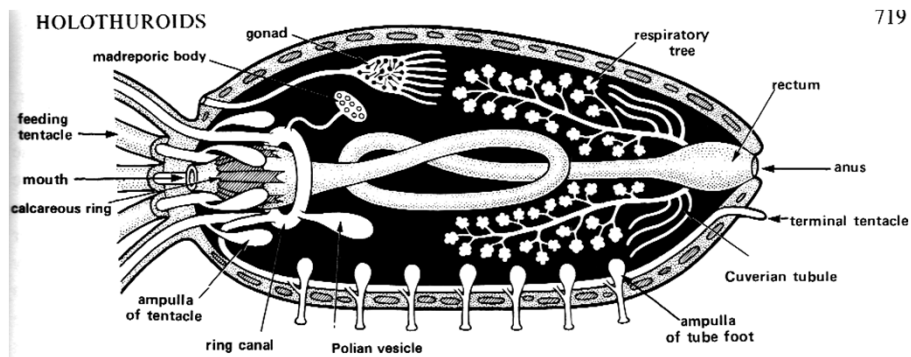


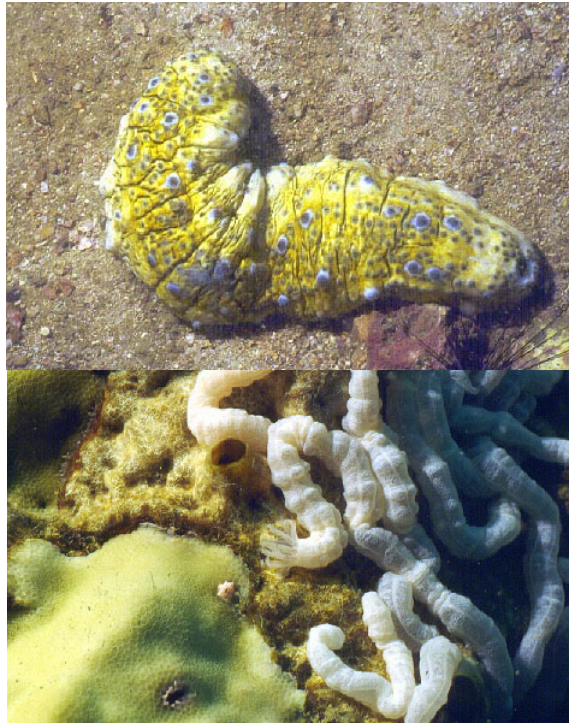
Class Holothuroidea (sea cucumbers)



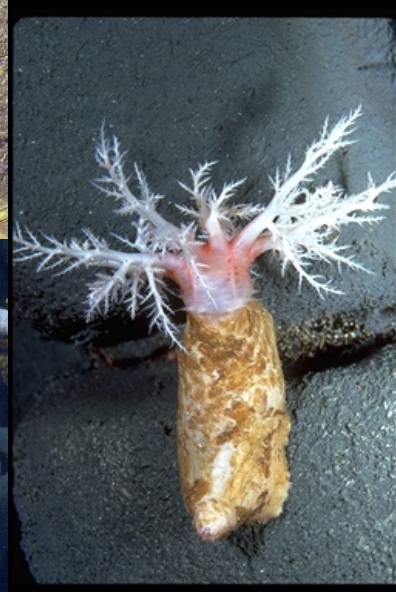
- Endoskeleton reduced
- Elongated, flexible body propelled by 3 of the 5 rows tube feet
- Tube feet around mouth are enlarged and branched to form feeding tentacles that gather food and transfer to mouth.
- Gut has branches for respiration, and Cuvierian threads for defense.

Class Holothuroidea (sea cucumbers)

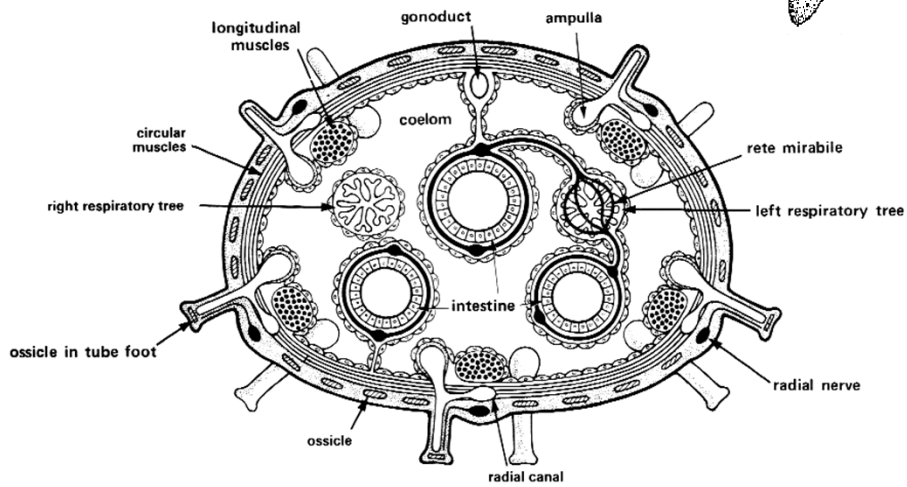




Class Holothuroidea
sea cucumbers



Class Holothuroidea (sea cucumbers)

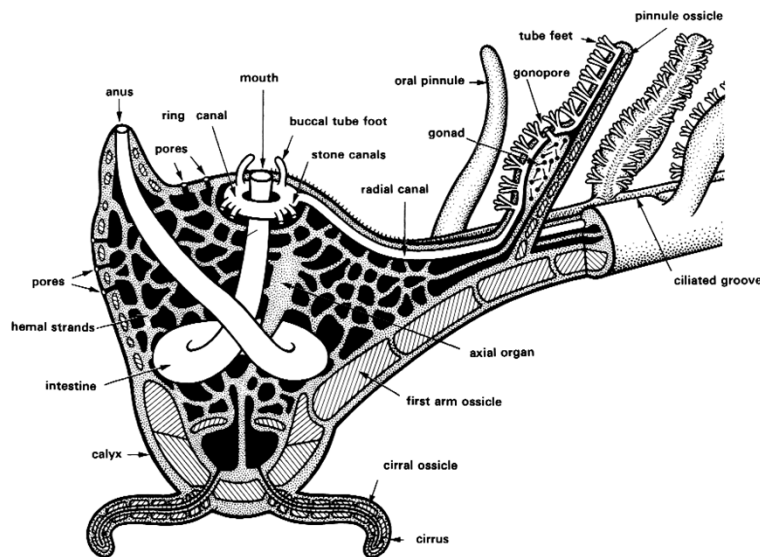


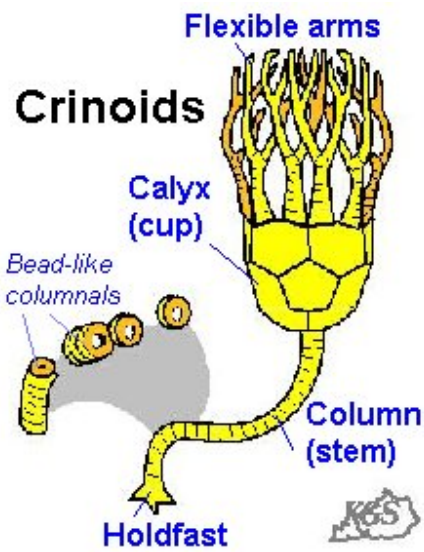
Class Crinoidea (crinoids)



- exaggerated, branched arms used for suspension feeding, oral side up
- Globular body (calyx) partially encased in skeletal plates
- Feather stars (unstalked) and sea lilies (stalked, attached).
- Greatest diversity in Paleozoic, with secondary radiation in Mesozoic after near-extinction

Class Crinoidea (crinoids)







Cyclonema on
Glyptocrinus

Commensal snail
that fed on crinoid
feces

Crinoid calyces from the Burlington limestone



M. C. Barnhart





M. C. Barnhart

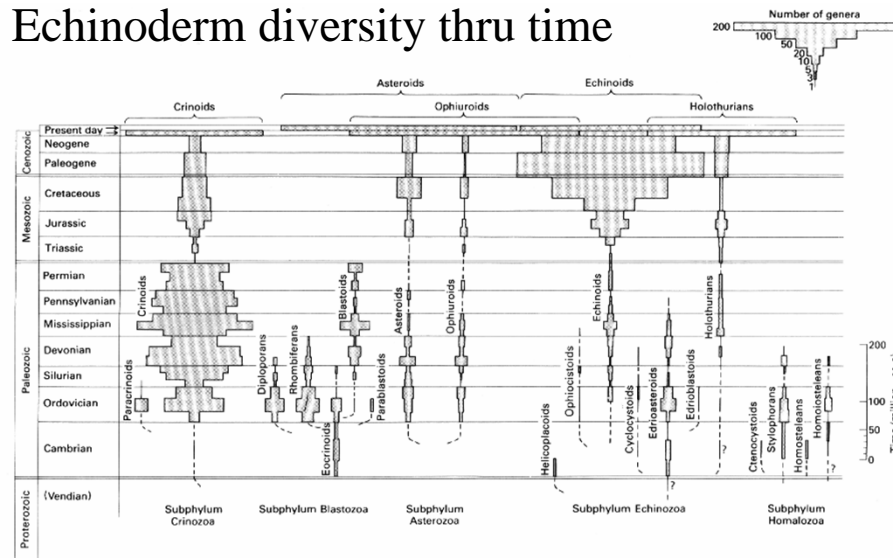
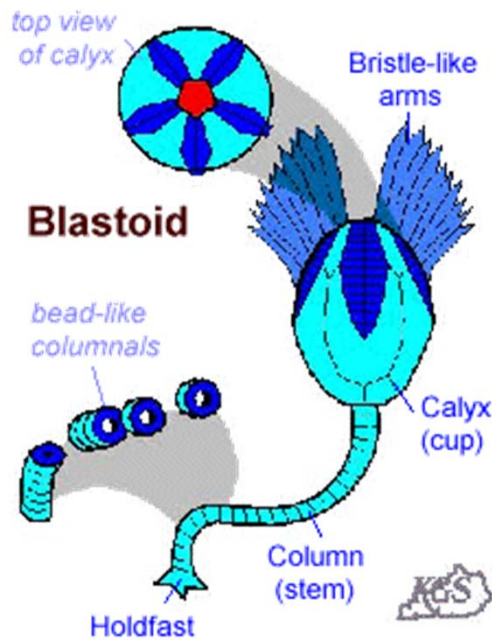


Figure 18.25. The fossil record of echinoderm classes showing their stratigraphic ranges and generic diversities (see scale at top). Note the large number of classes in the early Paleozoic, the decrease in number of classes throughout the late Paleozoic, the dominance of the Paleozoic record by blastozoans and crinozoans (especially crinoids), the dominance of the Mesozoic and Cenozoic record by echinoids, and the diversity of the five echinoderm classes living today. (From Sprinkle, J. *University of Tennessee Studies in Geology* No. 3; 1980.)



There are at least 15 described extinct classes of Echinodermata

The Class Homoiostyelia was world-wide in distribution.

They had a flexible tail, presumably for locomotion, and an arm for handling food.

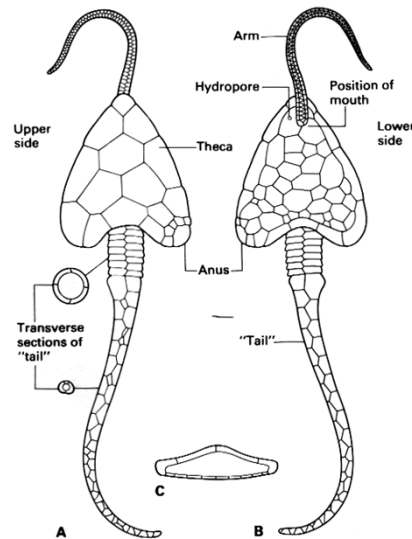


Figure 18.49. A to C, *Iowacystis*, a homoiostelean from the Upper Ordovician of northeastern Iowa showing the upper and lower sides of the theca with its arm and tail appendages and a cross section (C) through the theca. (From Kolata, D. R.; Strimple, H. L.; Levorson, C. O. *Palaeontology* 20; 1977.)