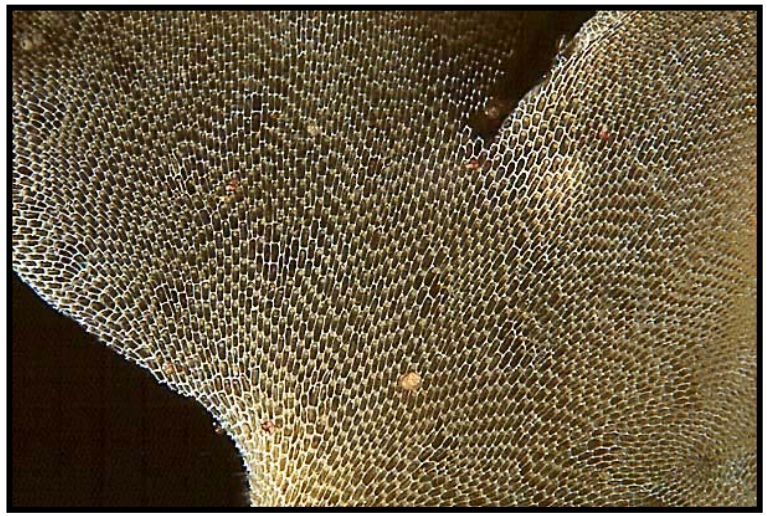


Phylum Bryozoa

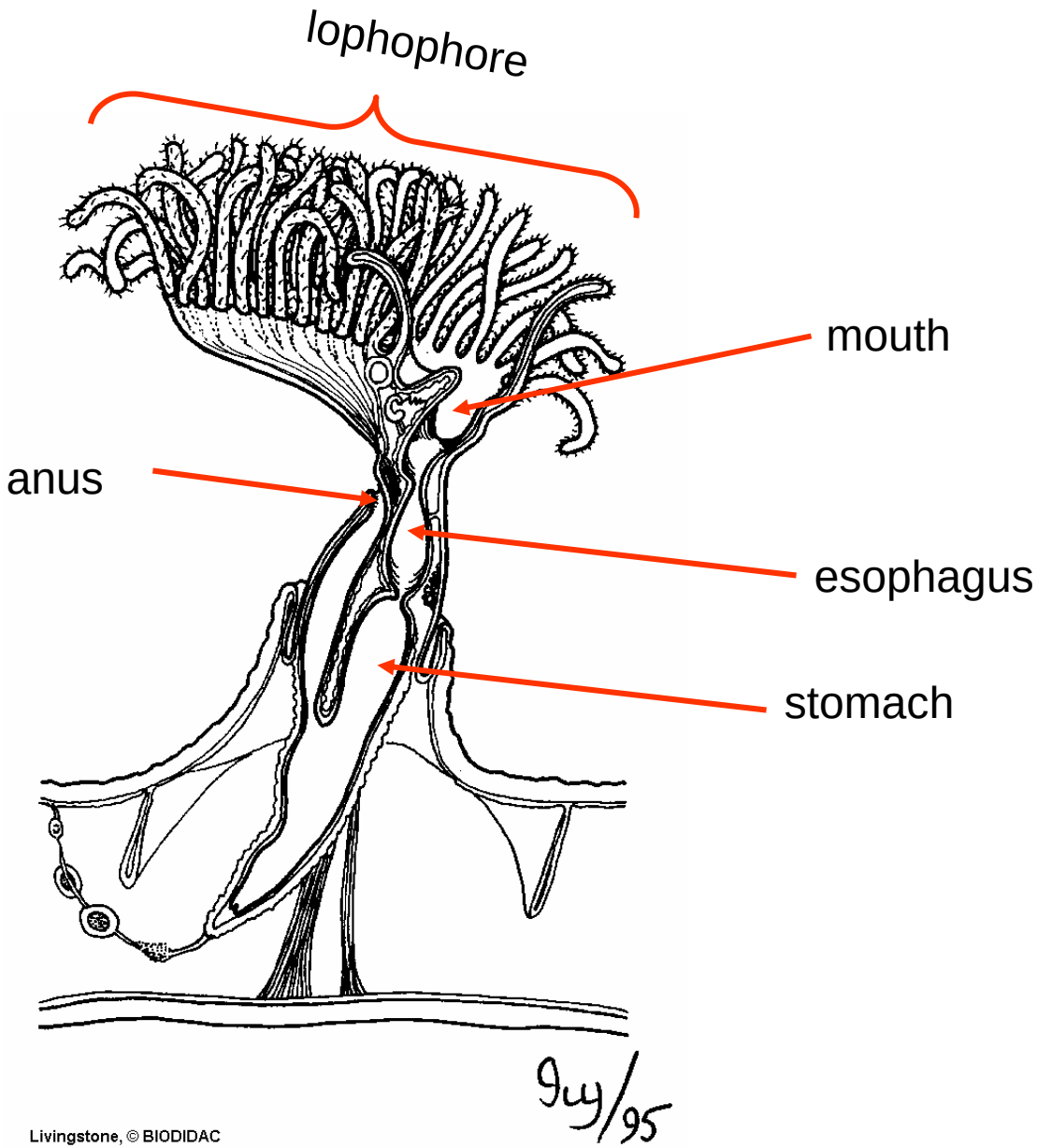
“moss animals”

Bryozoa Characteristics

- Approximately 4000 pecies of Bryozoans

- All are aquatic (marine or freshwater)

Body Plan


lophophore
mouth
anus
esophagus
stomach
Livingstone, © BIODIDAC

Bryozoa Characteristics

Gas Exchange

- lophophore

Circulatory System

- no organs, coelomic fluid

Excretion

- no organs, simple diffusion

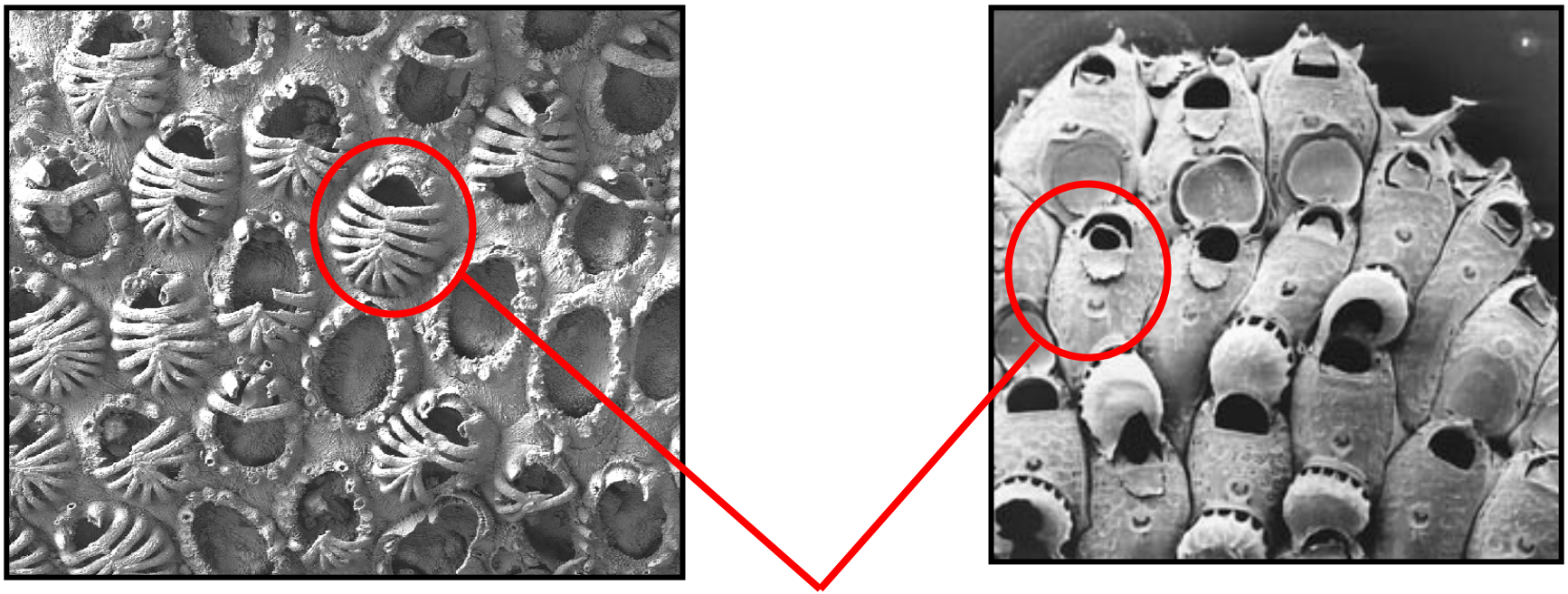
Nervous system

- nerve ring surrounding pharynx and nerves in tentacles (no sensory organs)

Bryozoa Characteristics

Skeletal system

- most have a cuticle composed of chitin or calcium carbonate (zoecium)

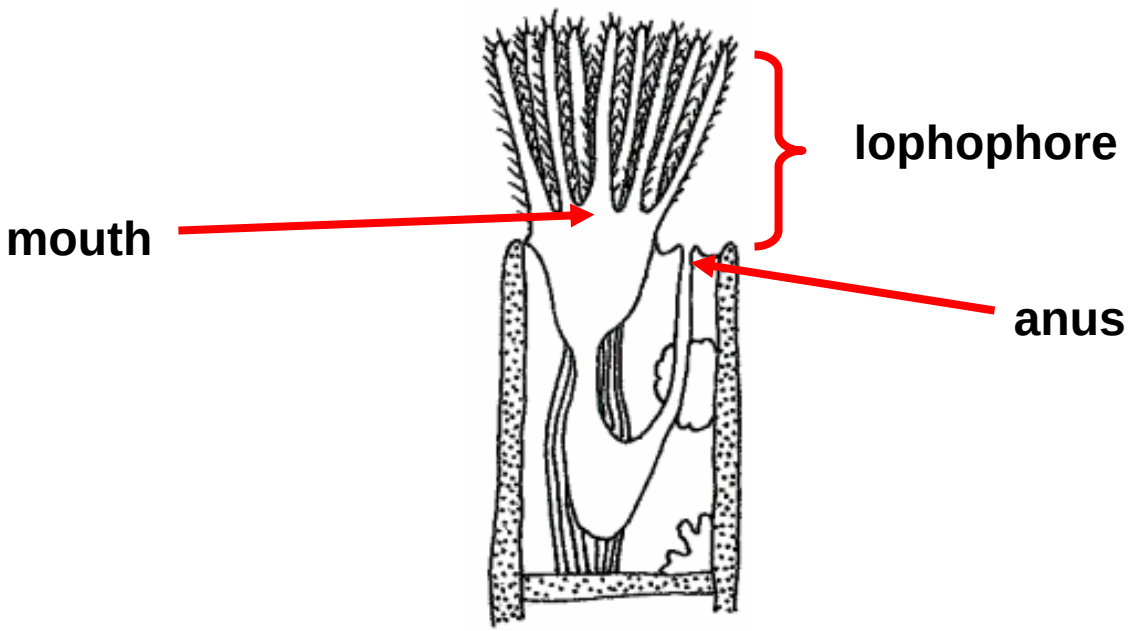


zoecium

Bryozoa Characteristics

Digestive System

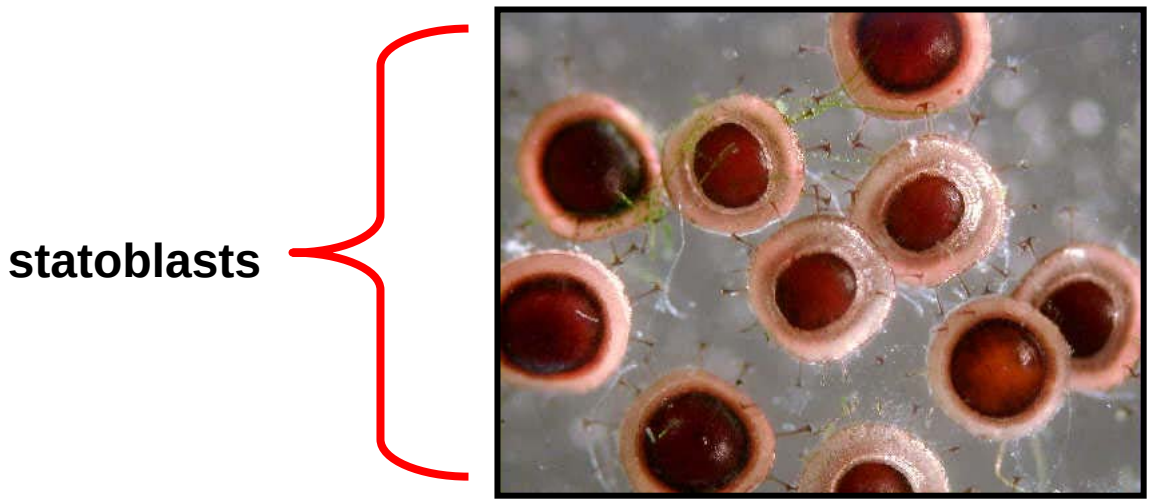
- lophophore: a contractile ring of ciliated tentacles surrounding the mouth
- complete digestive system
- U-shaped with anus outside lophophore (ectoproct)



Bryozoa Characteristics

Reproduction

- most are monoecious
- most species brood their eggs externally or within special cavities in their bodies
- freshwater species are capable of asexual reproduction using statoblasts (similar to gemmules)

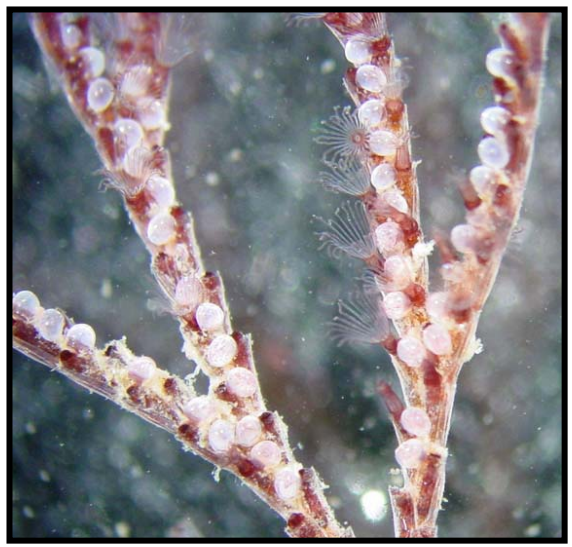


Bryozoa Characteristics

Colonial

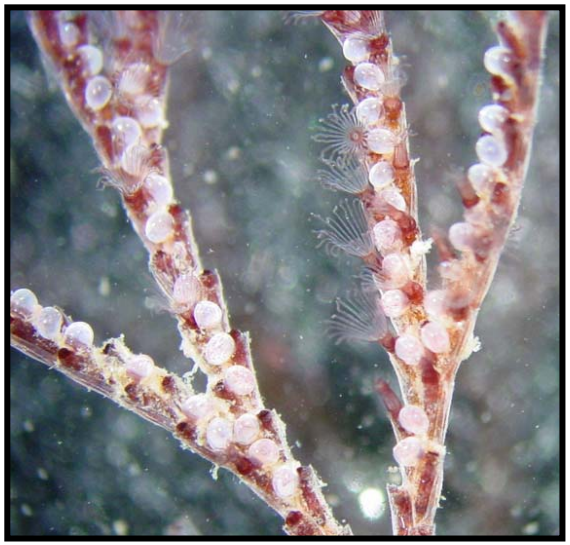
- bryozoans are sessile and live in colonies (zoarium)
- colonies can be encrusting (thin sheets) or stoloniferous (plant-like)

encrusting bryozoan

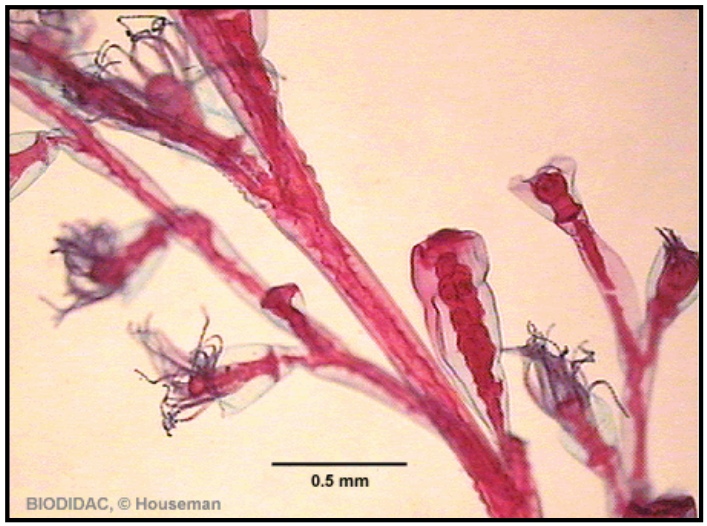


stoloniferous bryozoan

Bryozoa Characteristics



stoloniferous Bryozoan



Hydrozoan

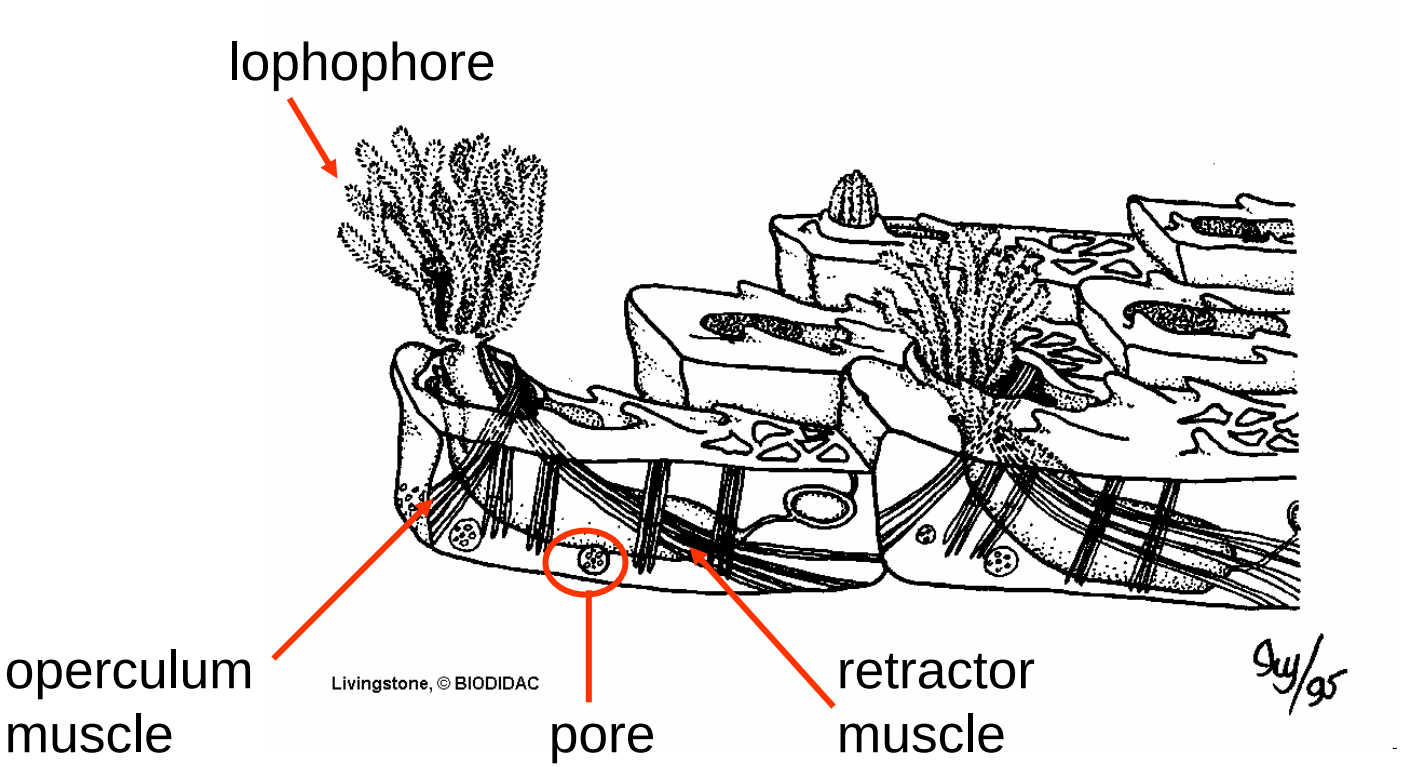
Superficially, stoloniferous Bryozoans resemble colonial Hydrozoans

Major differences include: the structure of the digestive system, the zoecium, the number of tissue layers…

Bryozoa Characteristics

Colonial

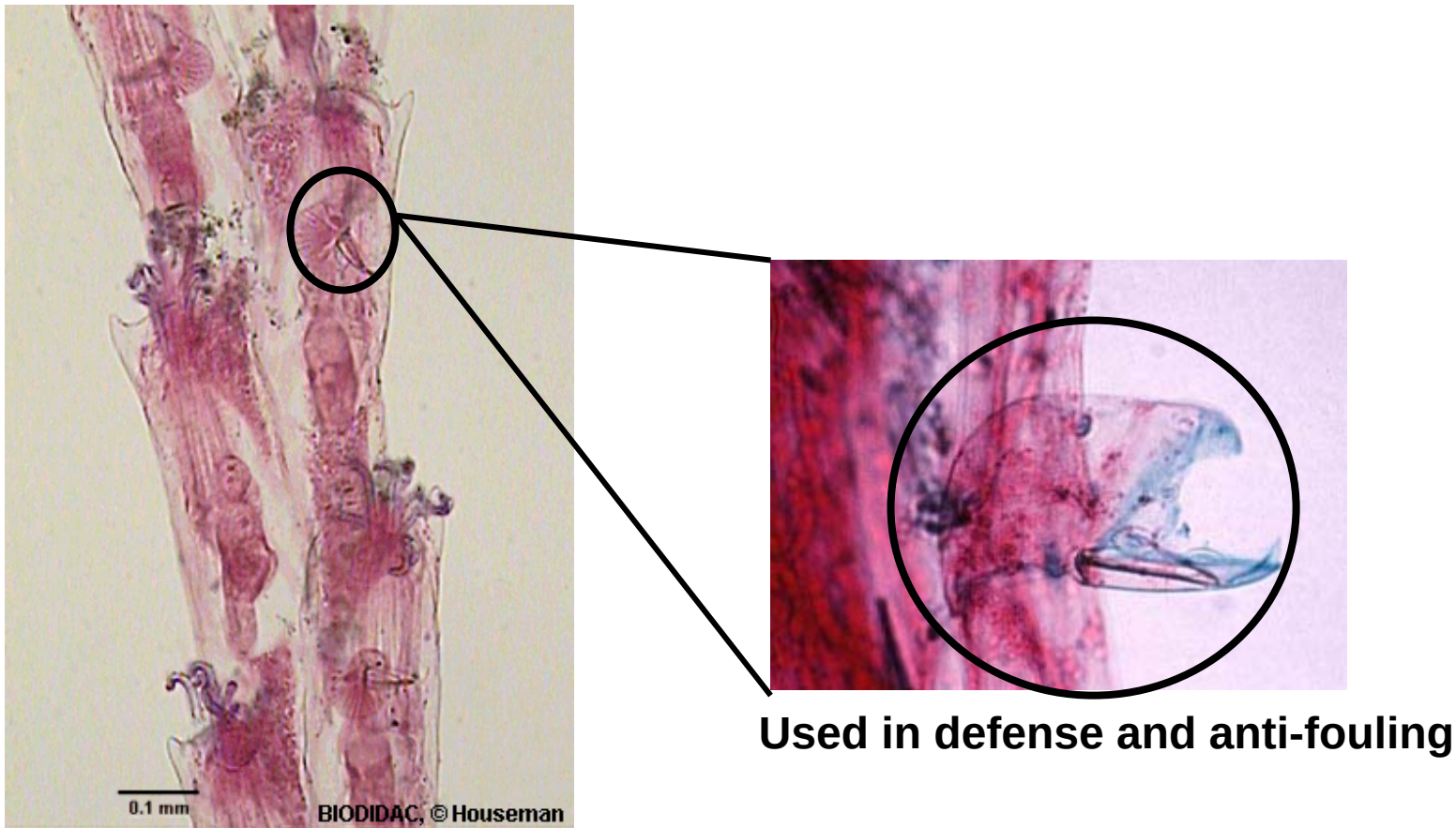
- all zooids within a colony (zoarium) are connected by pores in each individuals zoecium



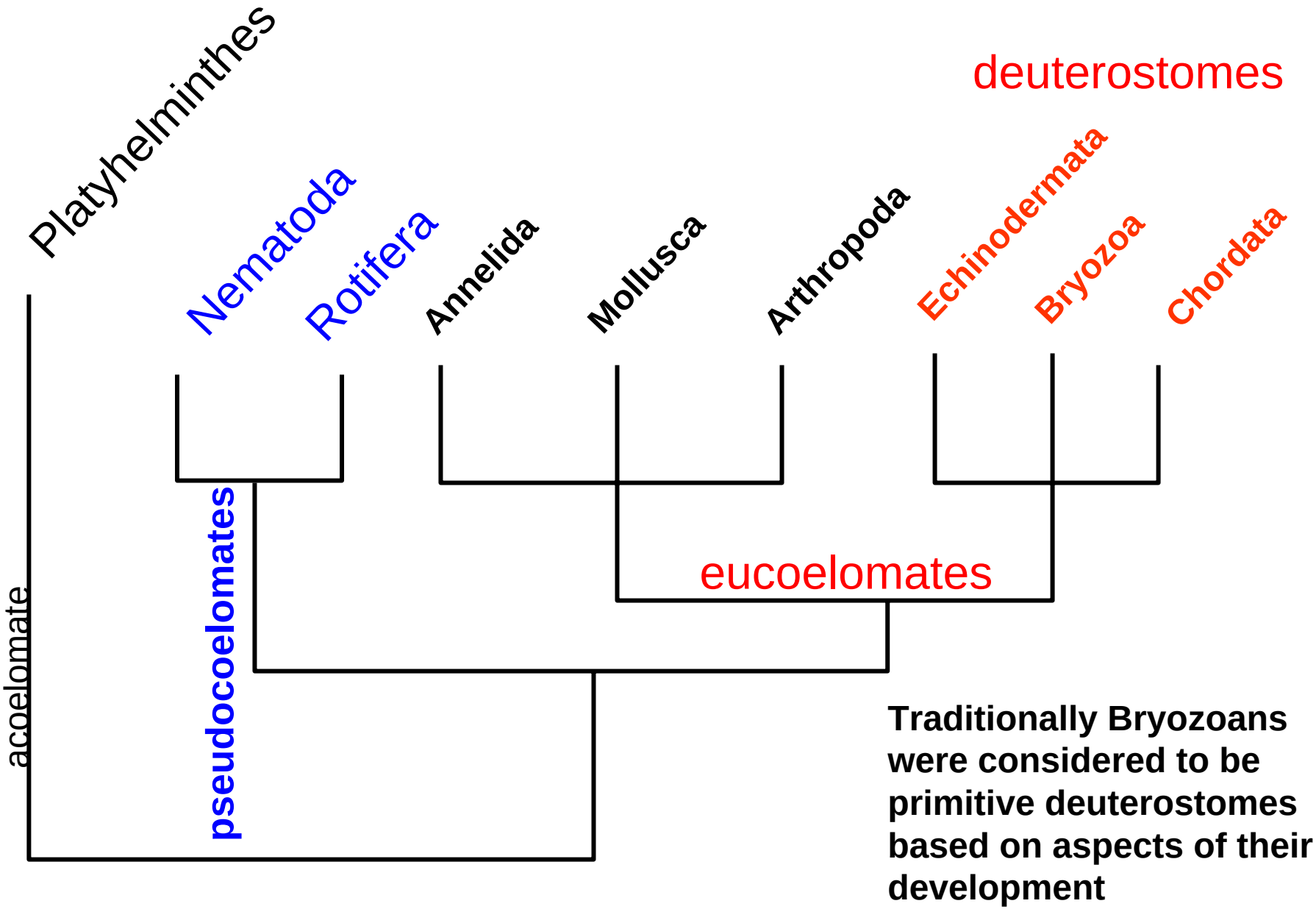
Bryozoa Characteristics

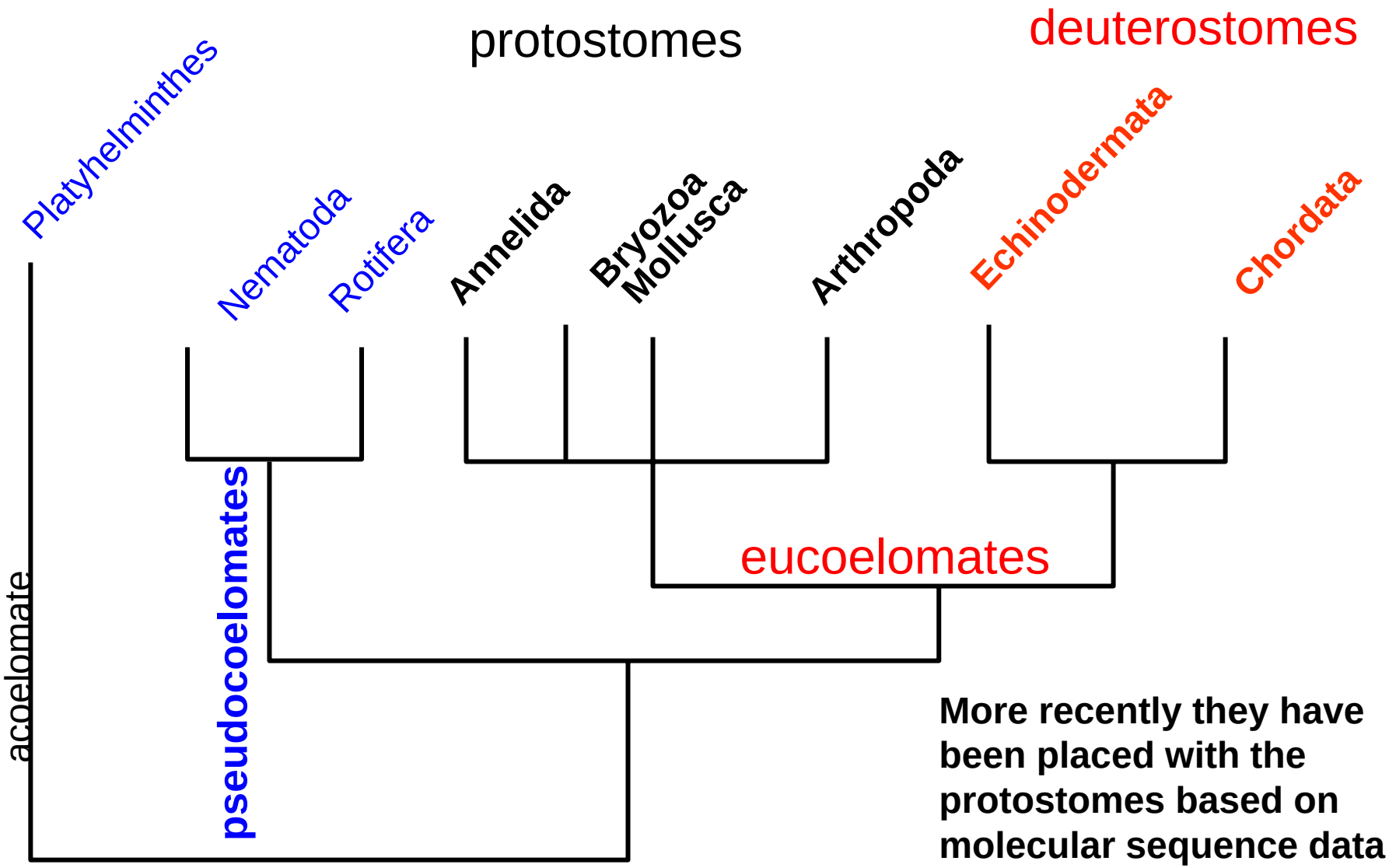
Colonial

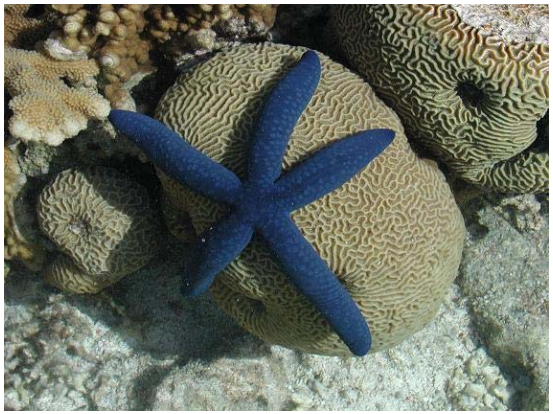
some Bryozoans are polymorphic and contain defensive zooids called avicularia

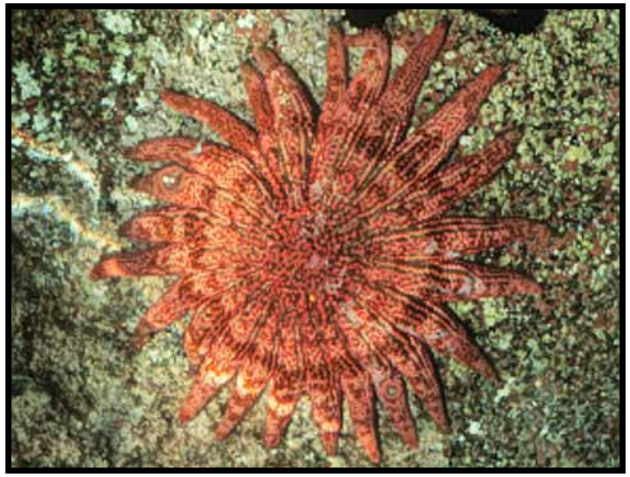


Used in defense and anti-fouling


Platyhelminthes
Nematoda
Rotifera
Annelida
Mollusca
Arthropoda
Echinodermata
Bryozoa
Chordata
deuterostomes
acoelomate
pseudocoelomates
eucoelomates
Traditionally Bryozoans were considered to be primitive deuterostomes based on aspects of their development

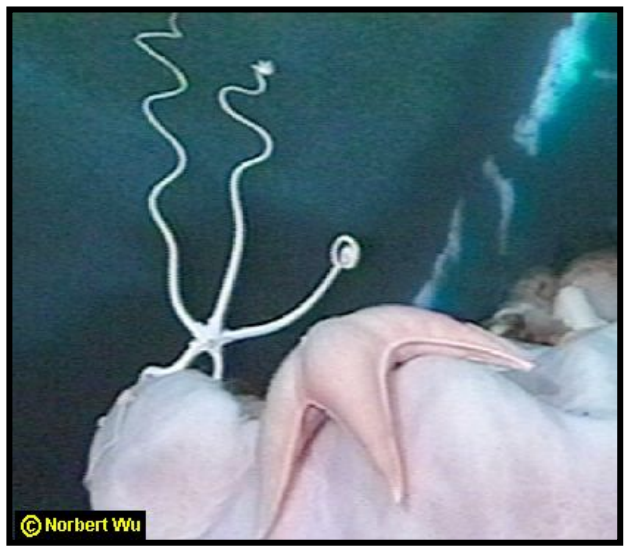

protostomes
deuterostomes
Platyhelminthes
Nematoda
Rotifera
Annelida
Bryozoa
Mollusca
Arthropoda
Echinodermata
Chordata
acoelomate
pseudocoelomates
eucoelomates
More recently they have been placed with the protostomes based on molecular sequence data





Phylum Echinodermata

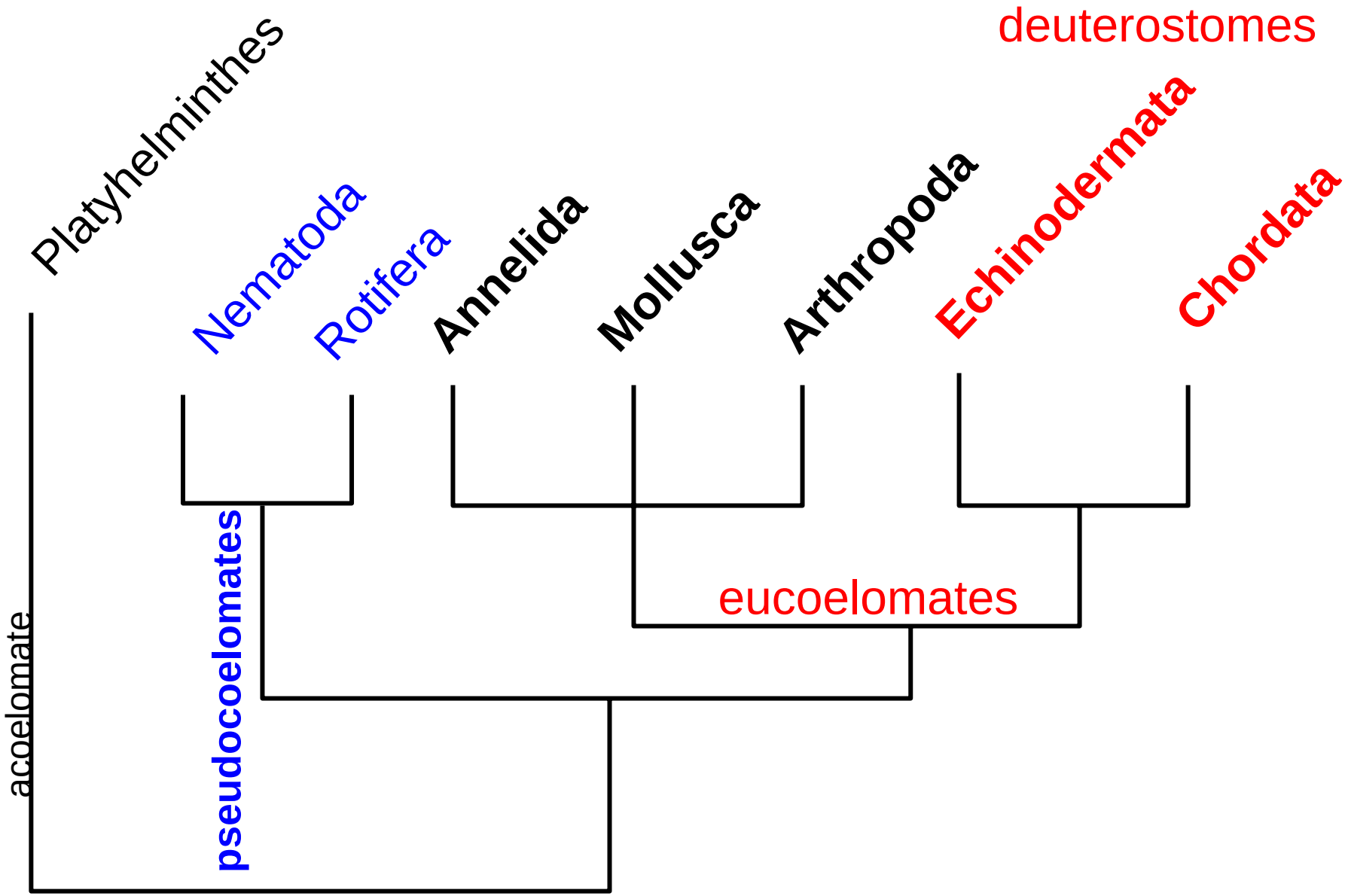
“spiny skinned” animals



Echinodermata Characteristics

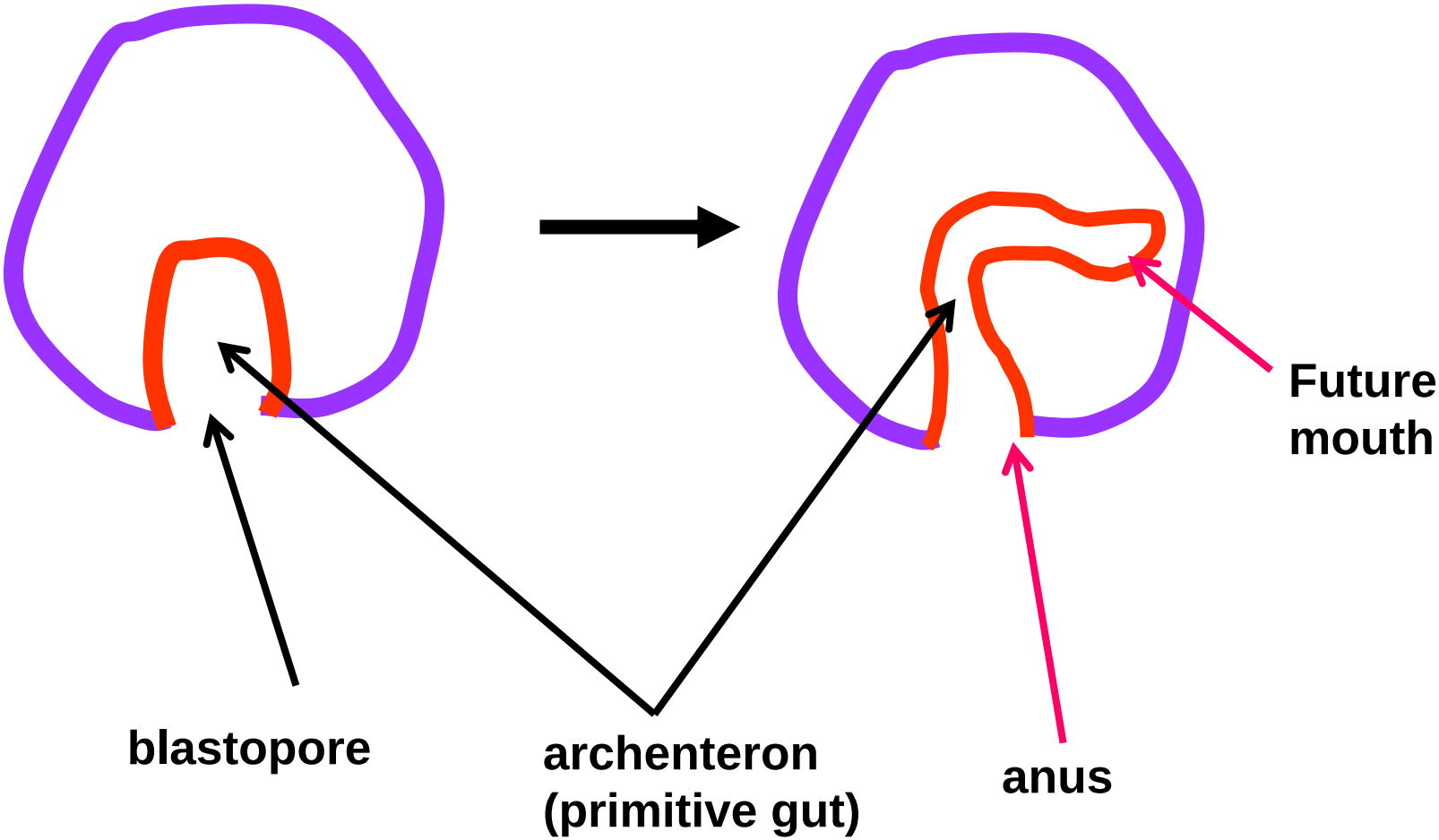
- Approximately 6000 species of Echinoderms

- All are marine and are benthic as adults


deuterostomes
Platyhelminthes
Nematoda
Rotifera
Annelida
Mollusca
Arthropoda
Echinodermata
Chordata
acoelomate
pseudocoelomates
eucoelomates

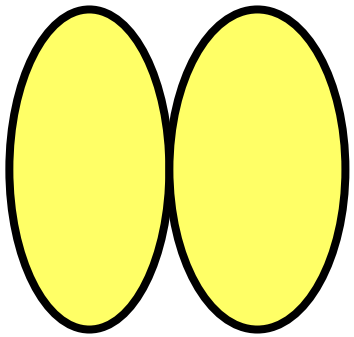
Deuterostome Mouth Formation

Blastopore becomes the anus and the mouth forms secondarily

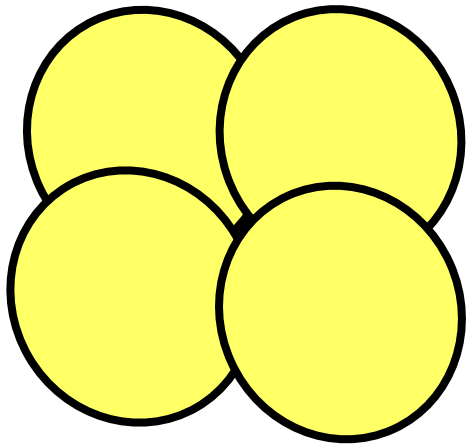


Deuterostome: Radial Cleavage

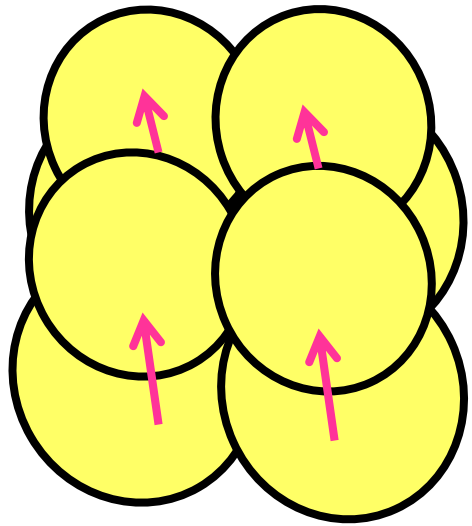
2 cells



4 cells

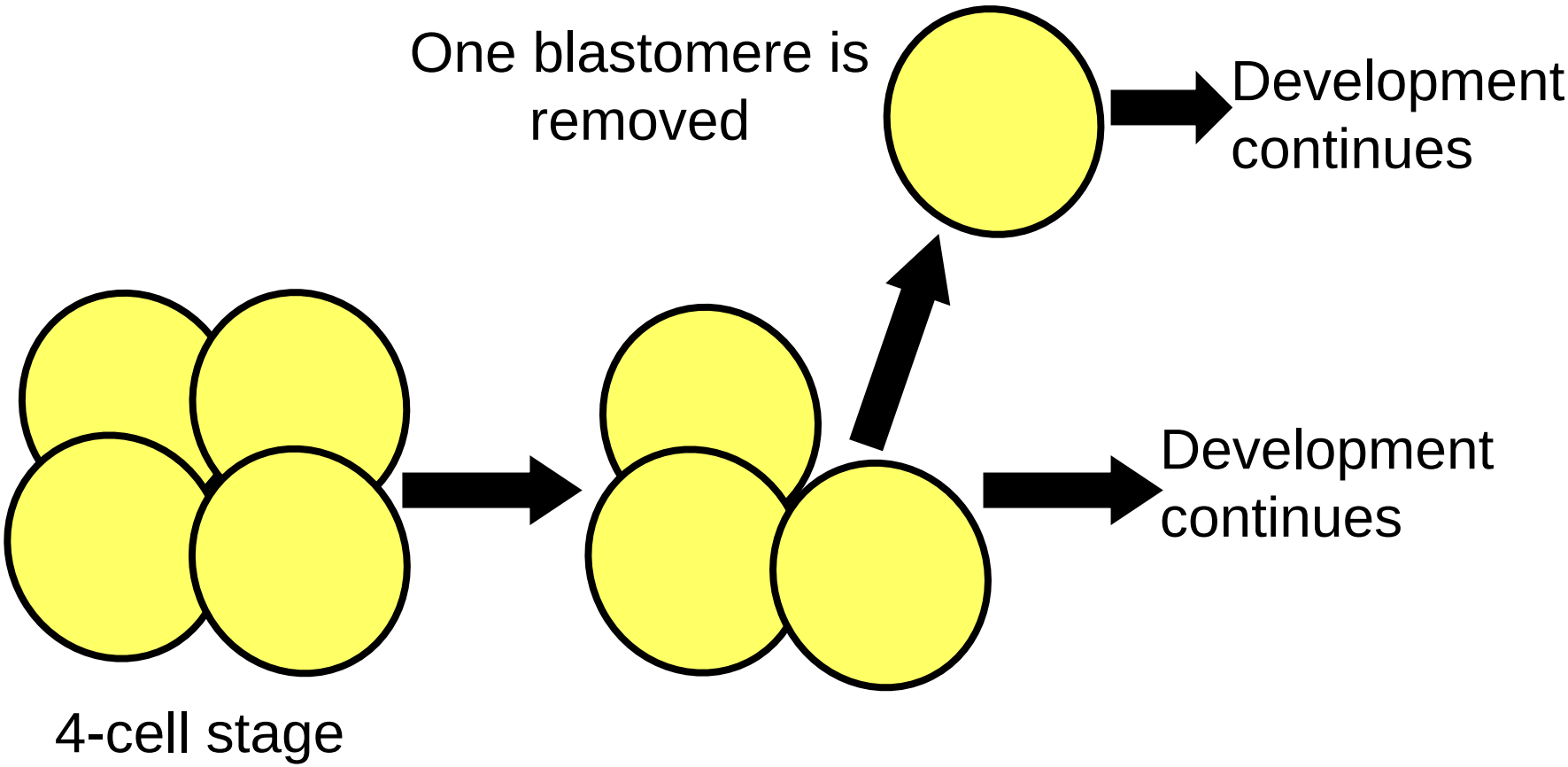


8 cells



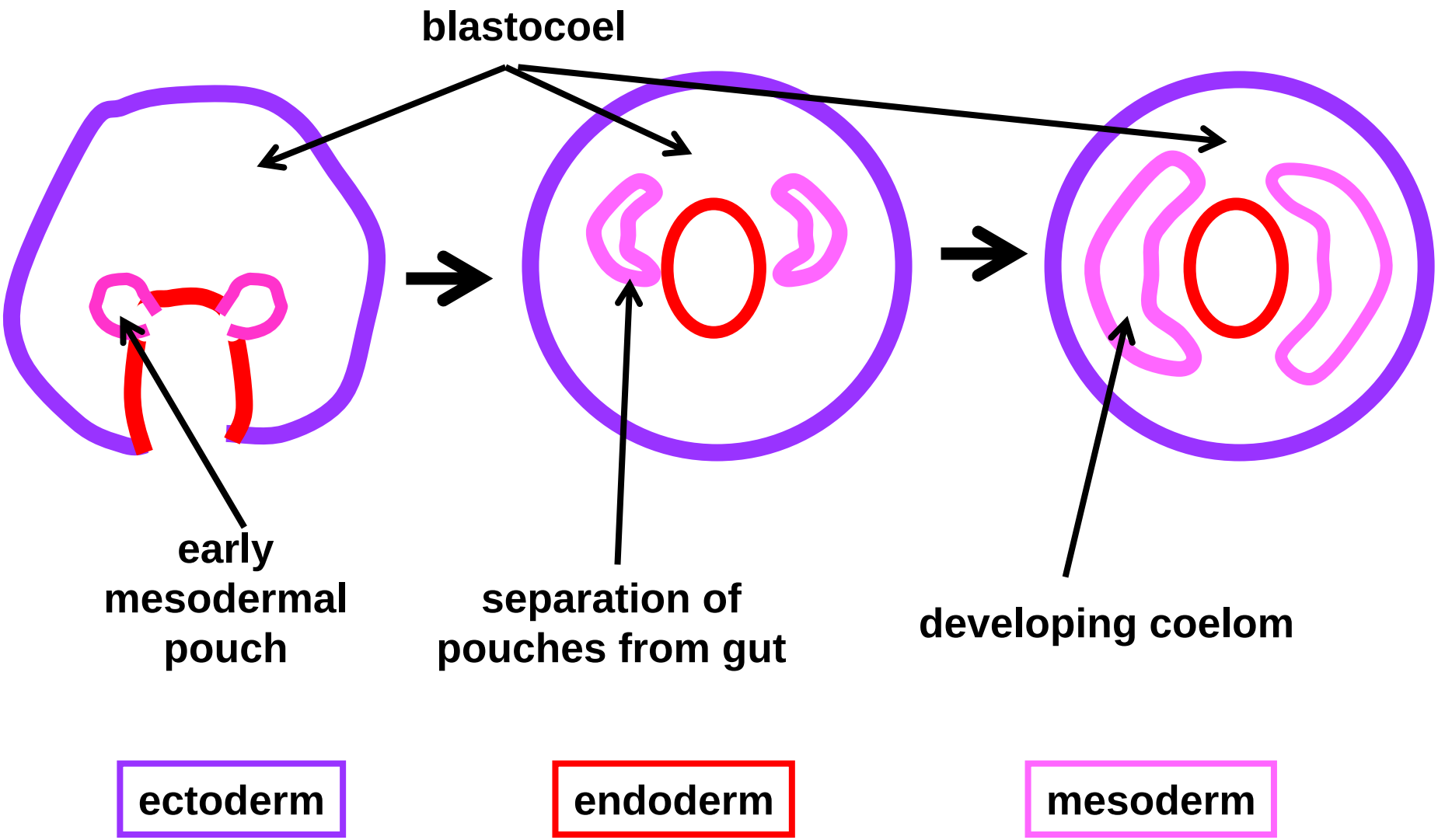
Blastomeres divide in a symmetrical fashion, producing layers of cells directly on top of one another

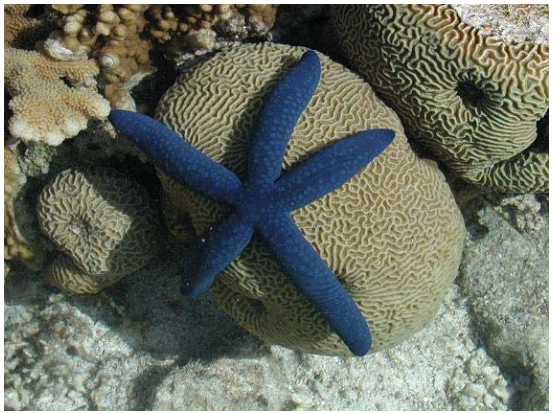
Deuterostome: Regulative Development

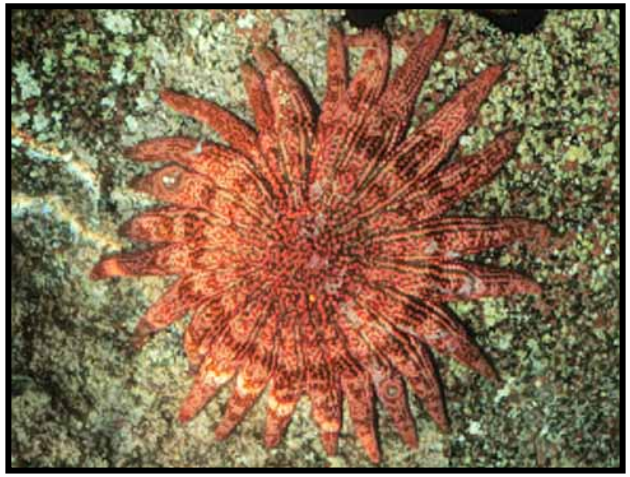


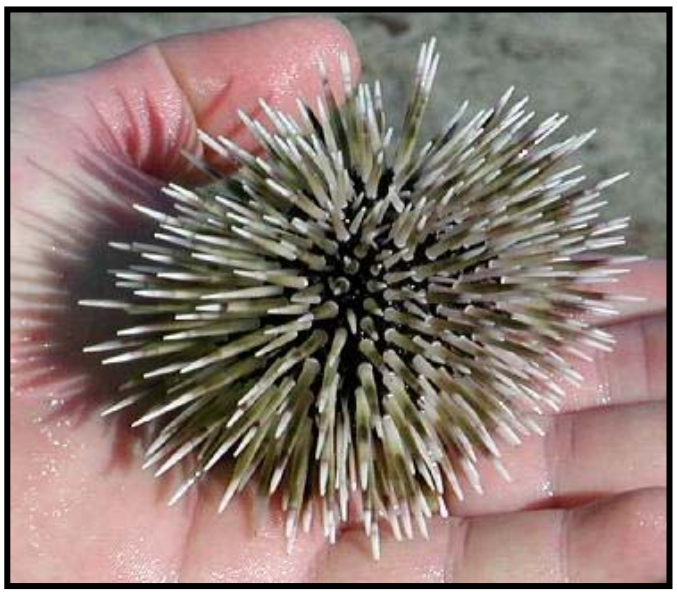
→ each blastomere is capable of regulating its development even when separated from the others

Deuterostome: Enterocoely





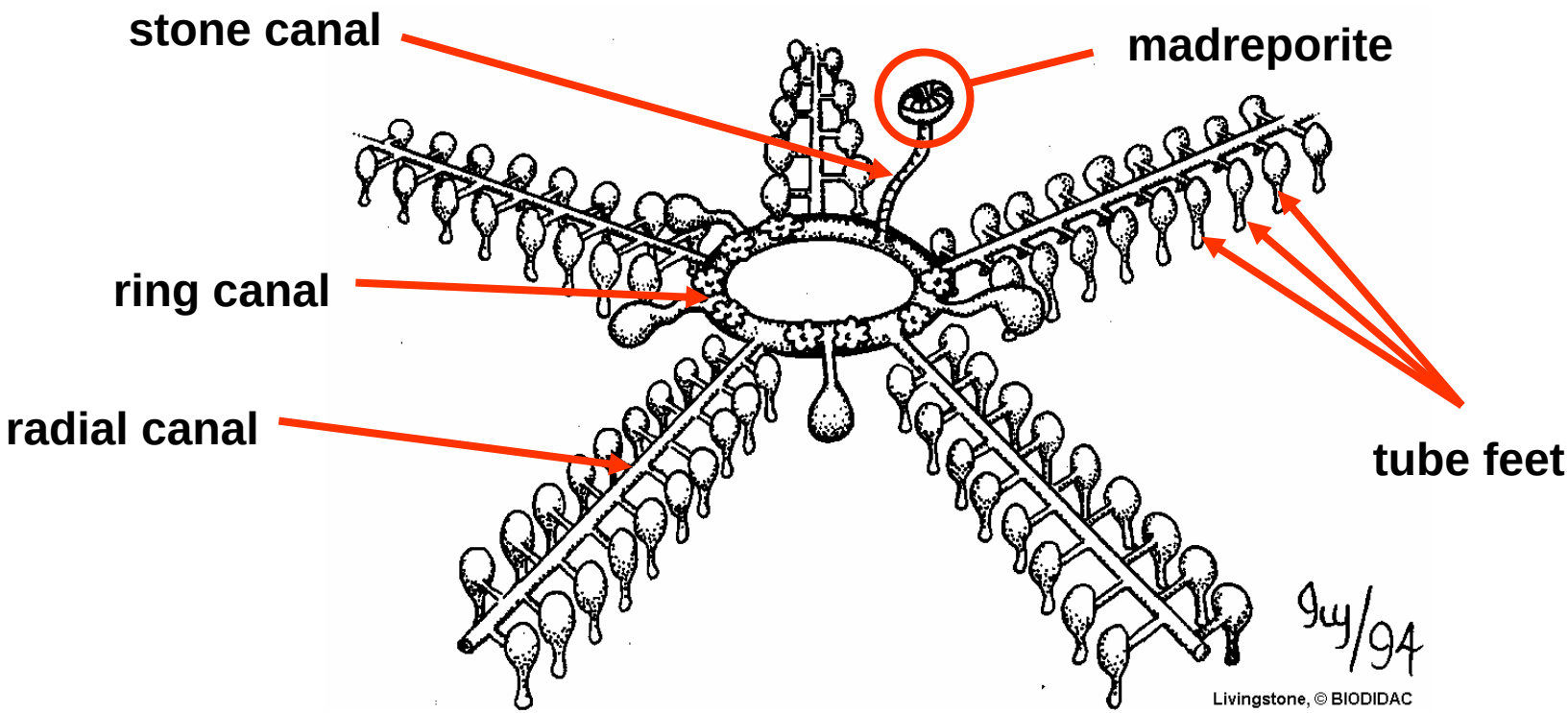




Echinodermata Characteristics

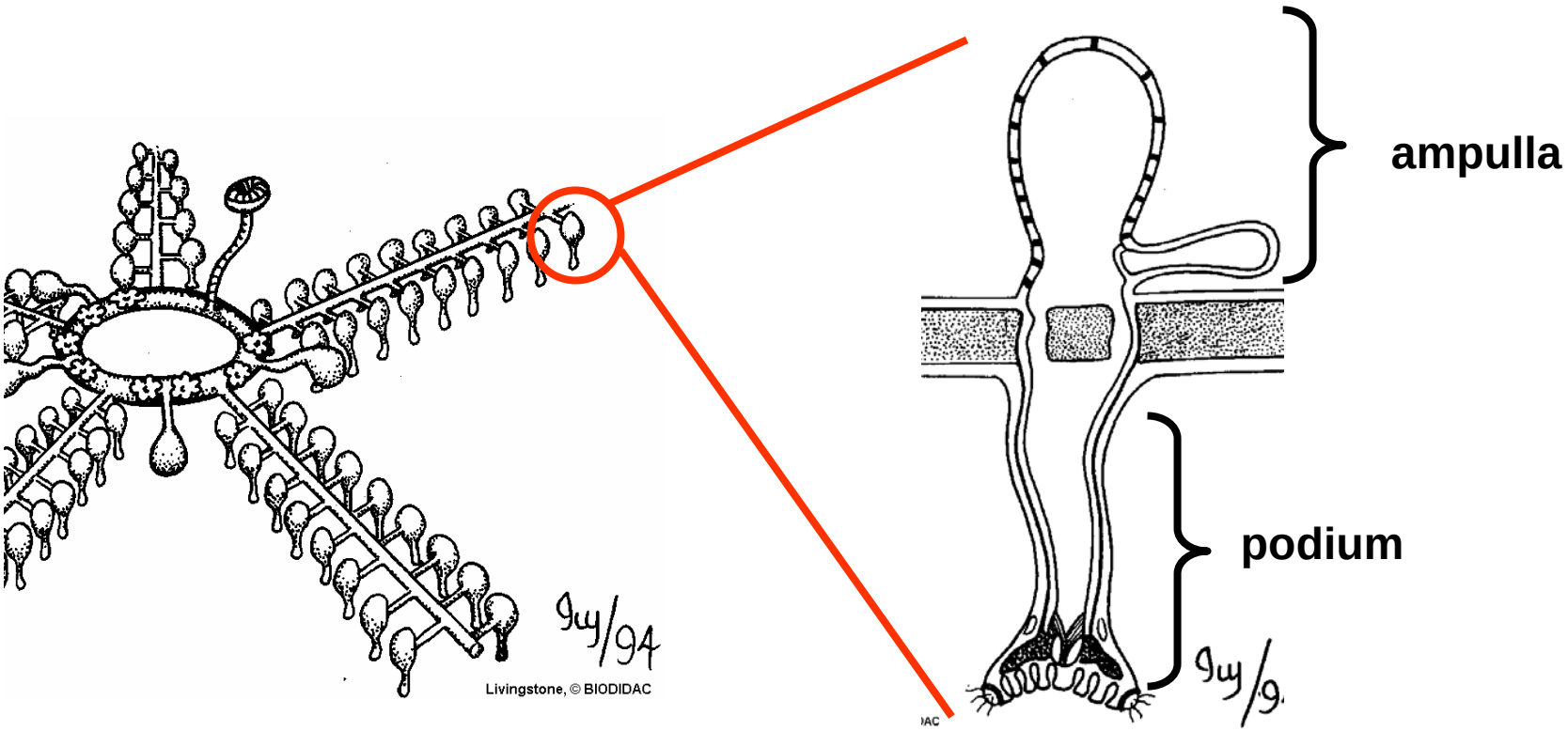
1. Water Vascular System

A system of coelomic canals that functions in:
circulation, gas exchange, excretion, and locomotion.

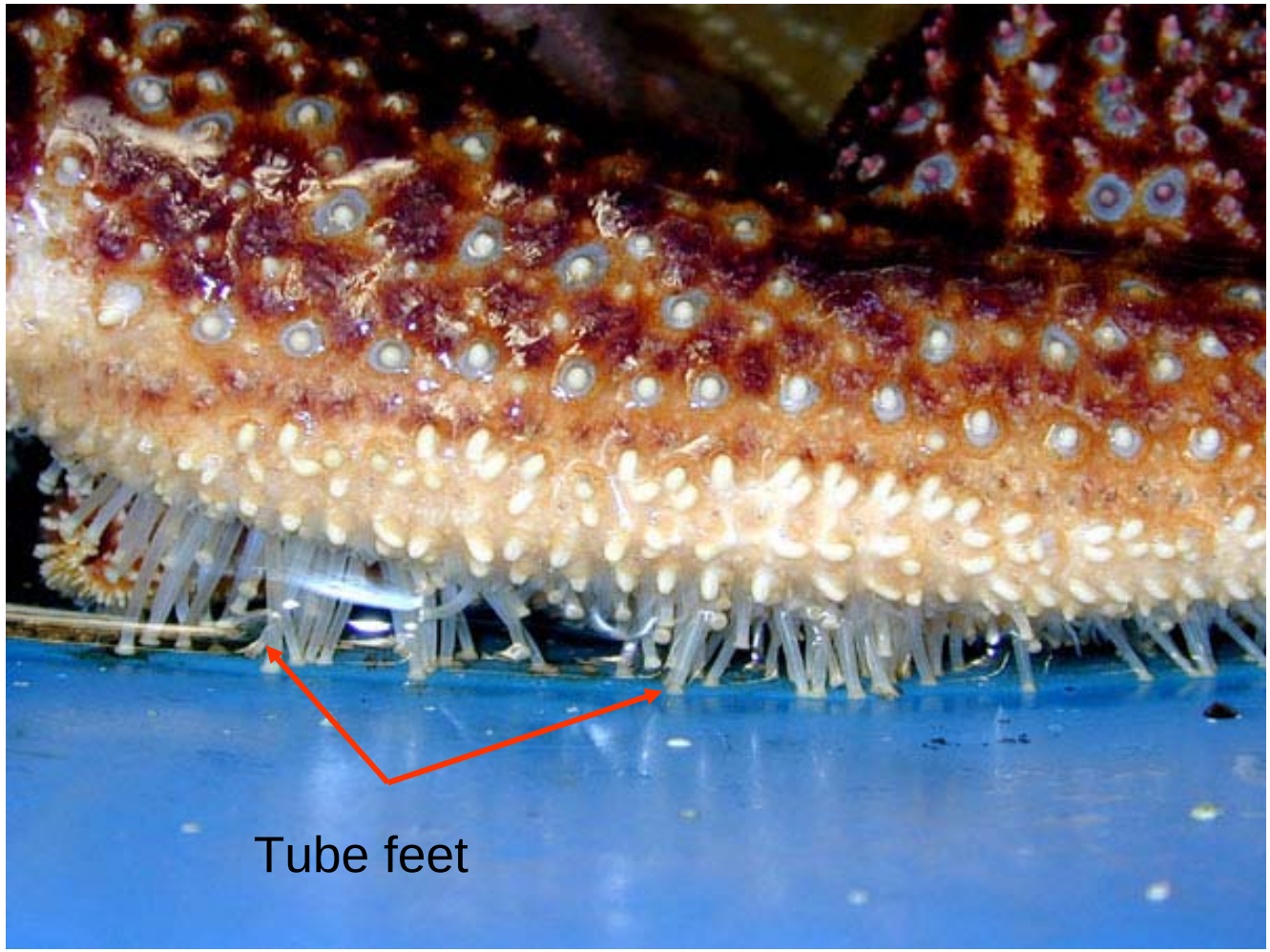


Echinodermata Characteristics

Water Vascular System



The structure of the tube foot

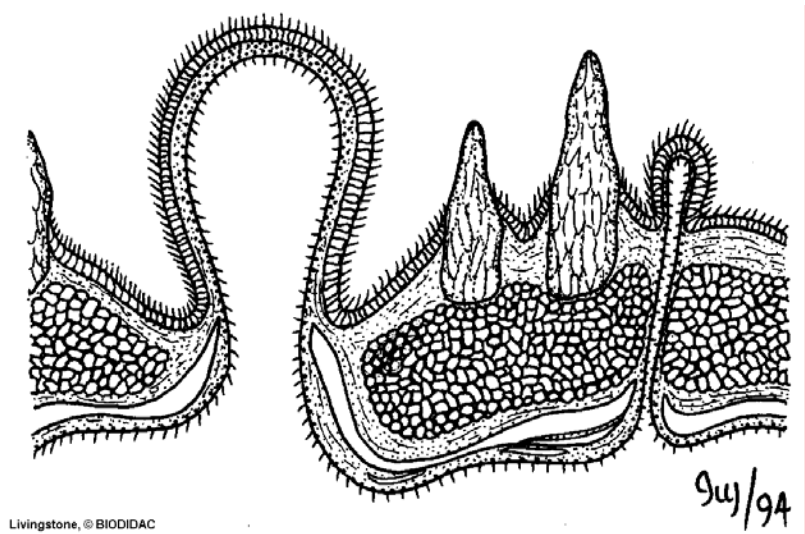

Tube feet

Echinodermata Characteristics

2. Dermal Endoskeleton

- All echinoderms have a dermal endoskeleton that is composed of calcareous ossicles and is covered by epidermis.
- The endoskeleton allows continuous growth and provides protection.

Fused to form a test
(e.g. sea urchins)

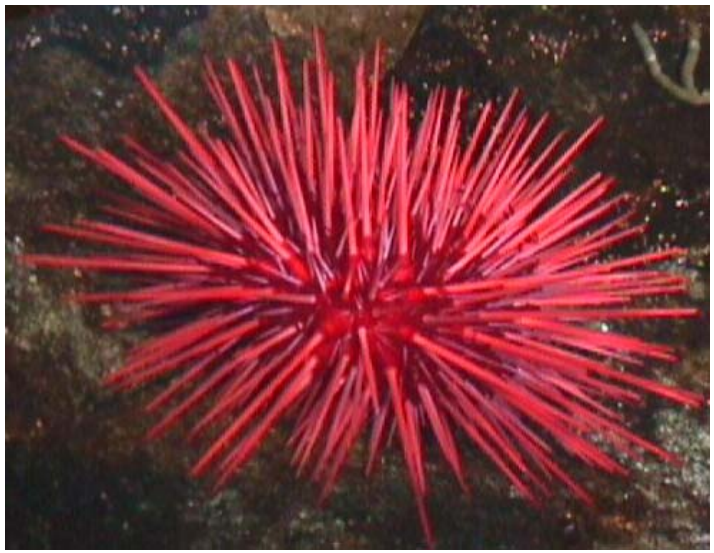


Articulating plates
(e.g. starfish)

Echinodermata Characteristics

Dermal Endoskeleton

- In many echinoderms the skeleton bears spines or bumps that are used for defense.



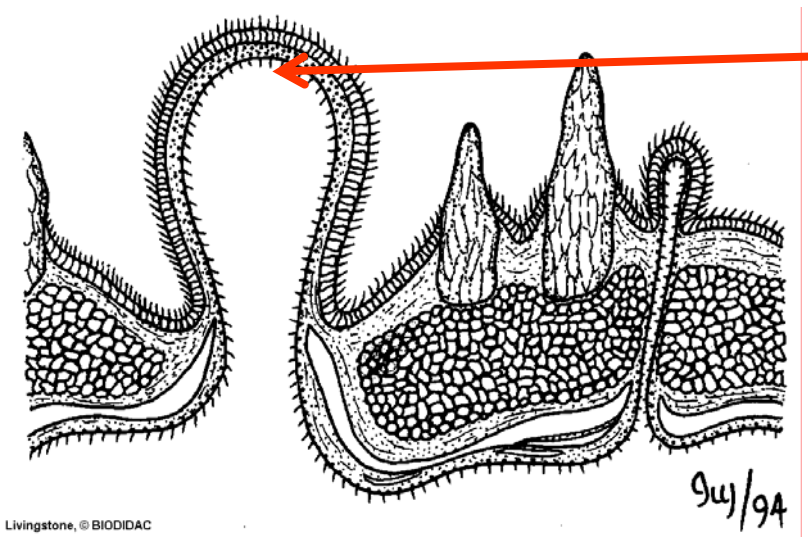
Sea urchin

Spines on crown of thorns starfish

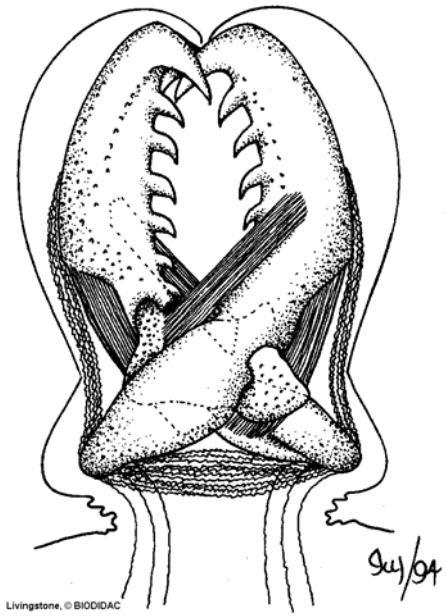
Echinodermata Characteristics

Dermal Endoskeleton

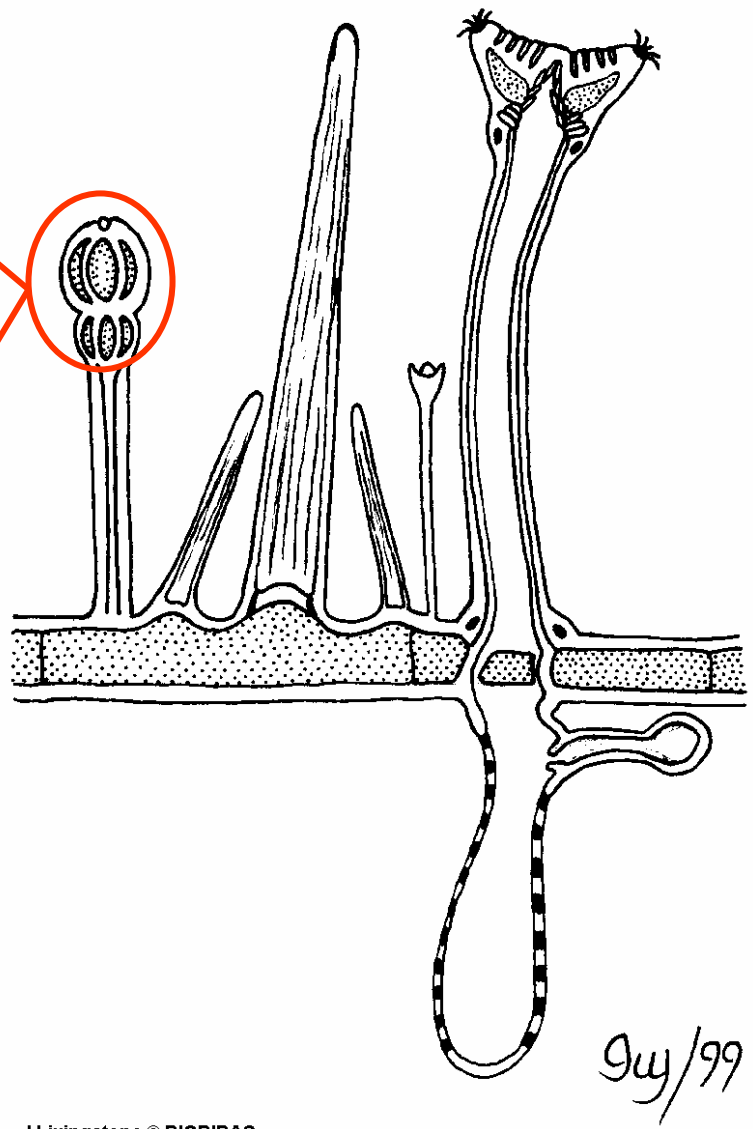
- The epidermis covering the endoskeleton contains many specialized structures:



Dermal branchiae (respiration): an extension of the coelomic cavity



Pedicellaria
(anti-fouling)



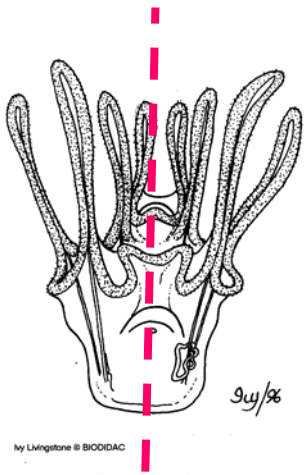
Echinodermata Characteristics

3. Mutable connective tissue: echinoderms can rapidly and reversibly change the stiffness of their connective tissue

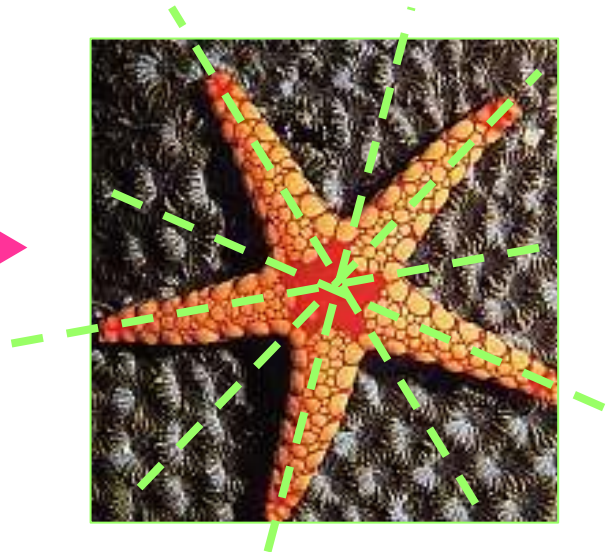
Echinodermata Characteristics

4. Secondary radial or biradial symmetry

• this bilaterally symmetrical larval form undergoes metamorphosis into an adult with radial pentamerous symmetry (with 5 or more radiating areas)



bilateral larval stage



radial pentamerous adult

Feeding and digestion

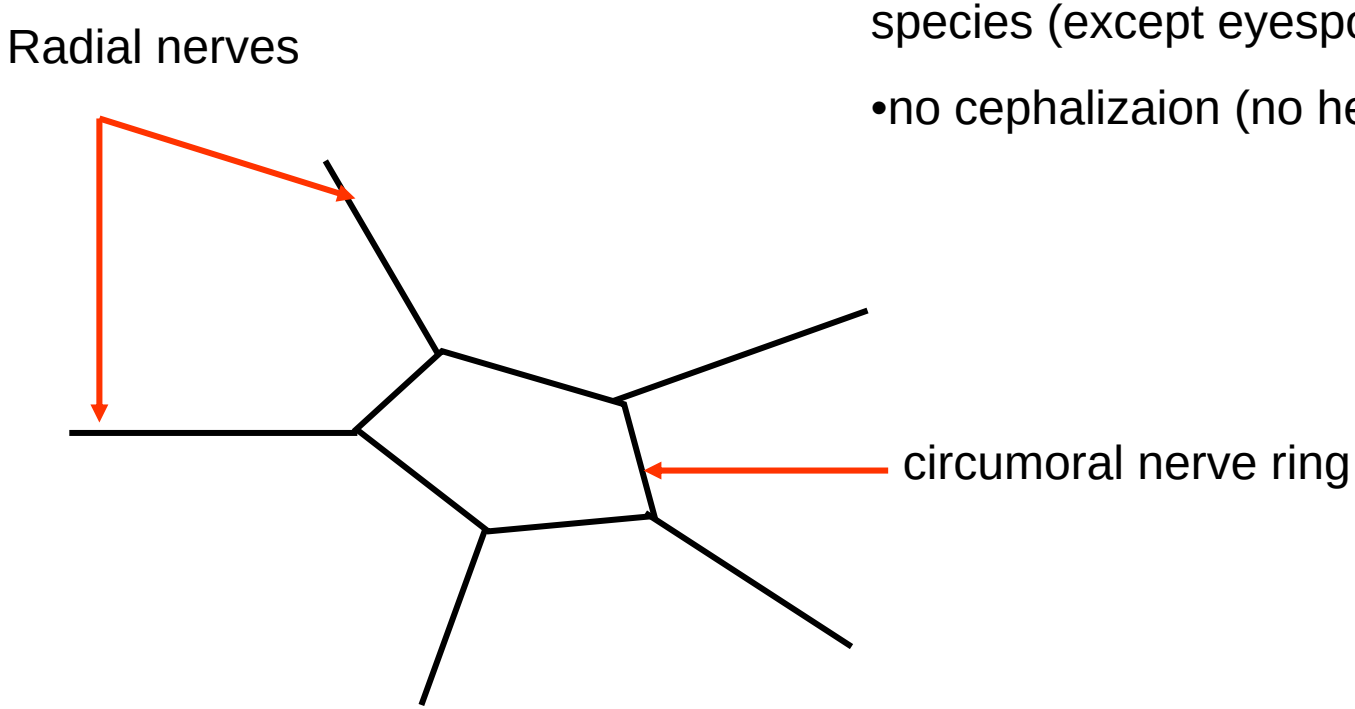
Grazers

Predators

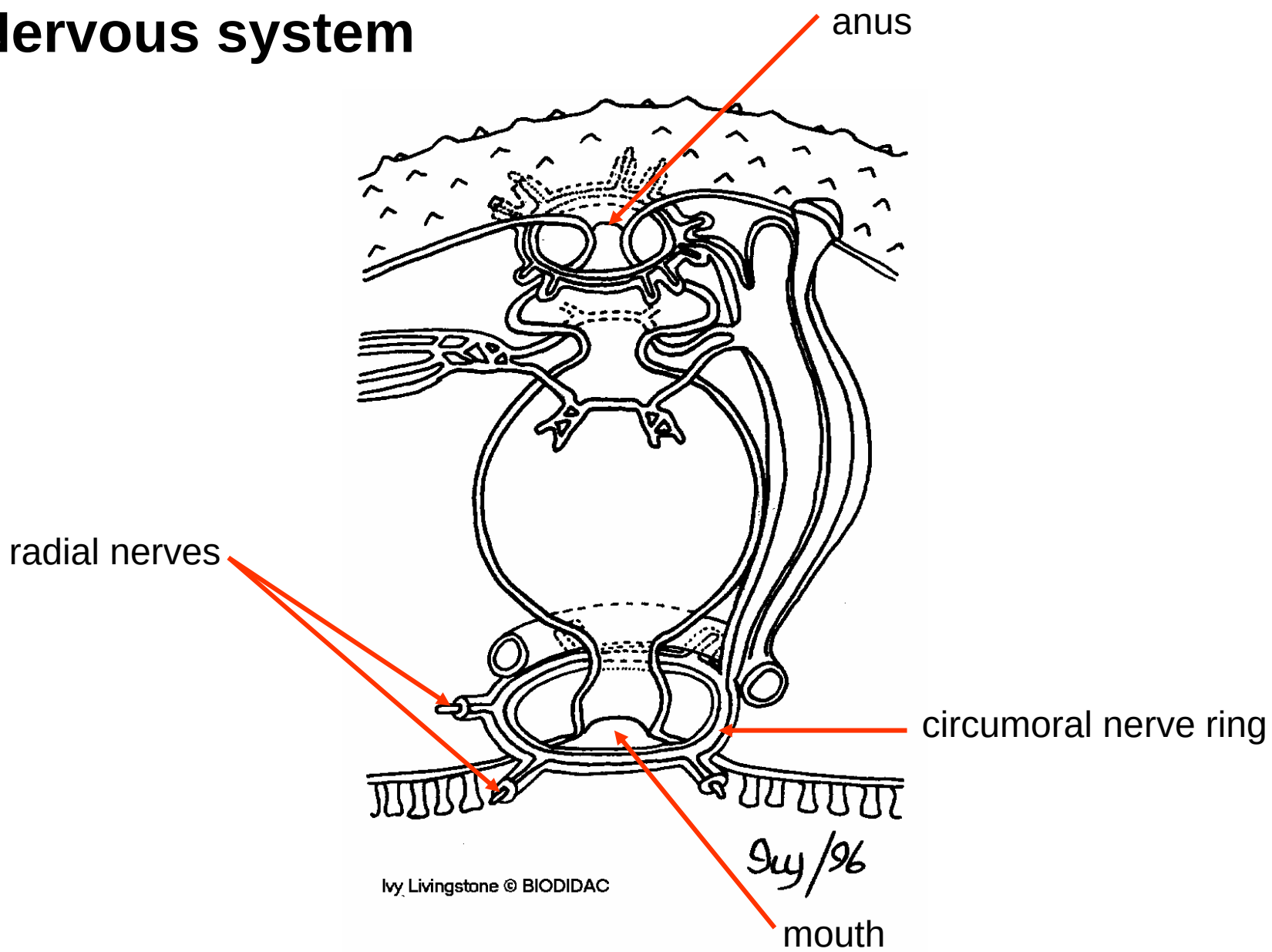
Most species have a complete digestive system.

Nervous system

- circumoral nerve ring
- radial nerves
- no sense organs in most species (except eyespots)
- no cephalizaion (no head)



Nervous system

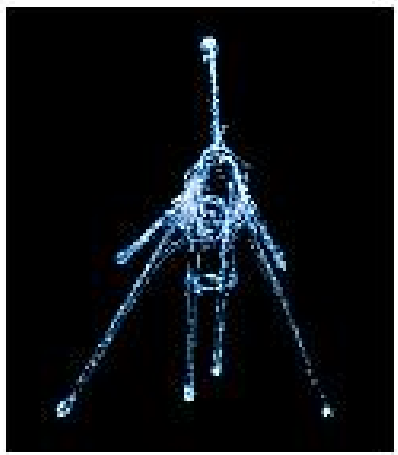


Echinodermata Characteristics

Reproduction

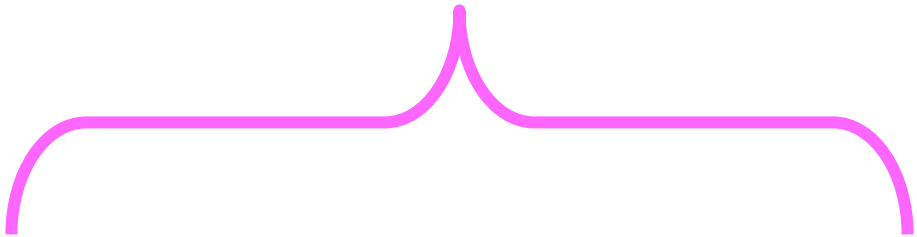
- usually dioecious
- usually external fertilization (eggs and sperm are shed into the water where fertilization occurs; broadcast spawning)
- indirect development with the presence of a free-swimming, bilateral larval stage (some have direct development)

spawning sea urchins



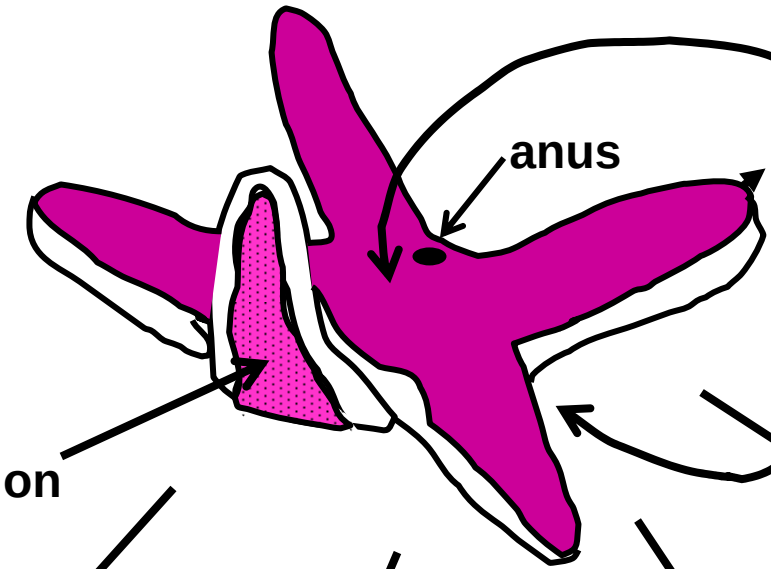
bilateral larval stage

Phylum Echinodermata



Class Asteroidea
Class Echinoidea
Class Ophiuroidea
Class Holothuroidea
Class Crinoidea

Echinoderm Radiation



Asteroidea

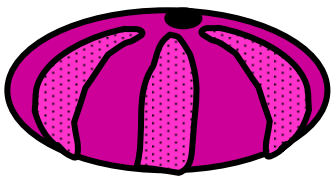
- arms

anus

aboral region

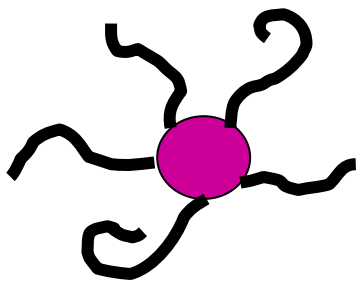
oral region

ambulacral region



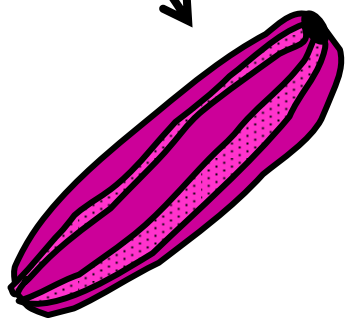
Echinodea

- fused ossicles



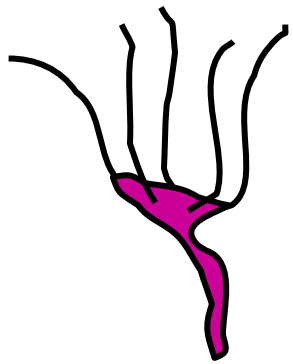
Ophiuroidea

- no ambulacral region
- no anus



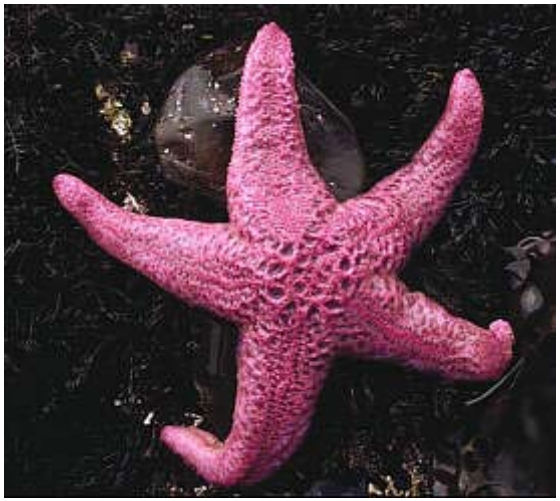
Holothuroidea

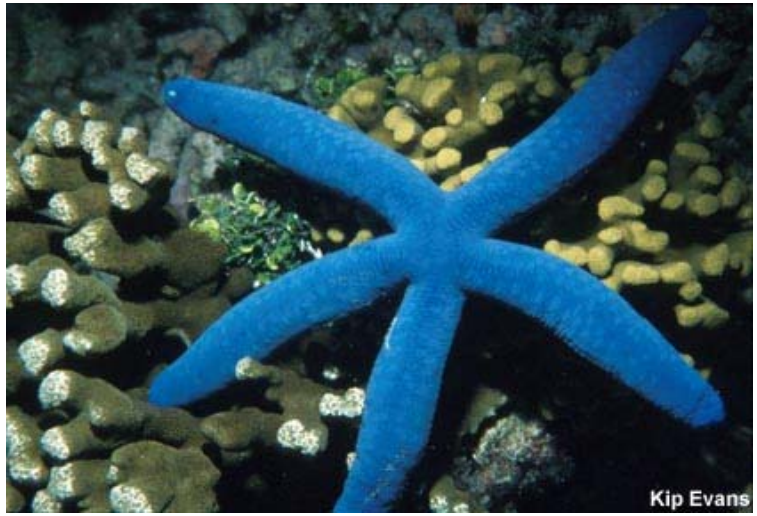
- secondarily bilateral



Crinoidea

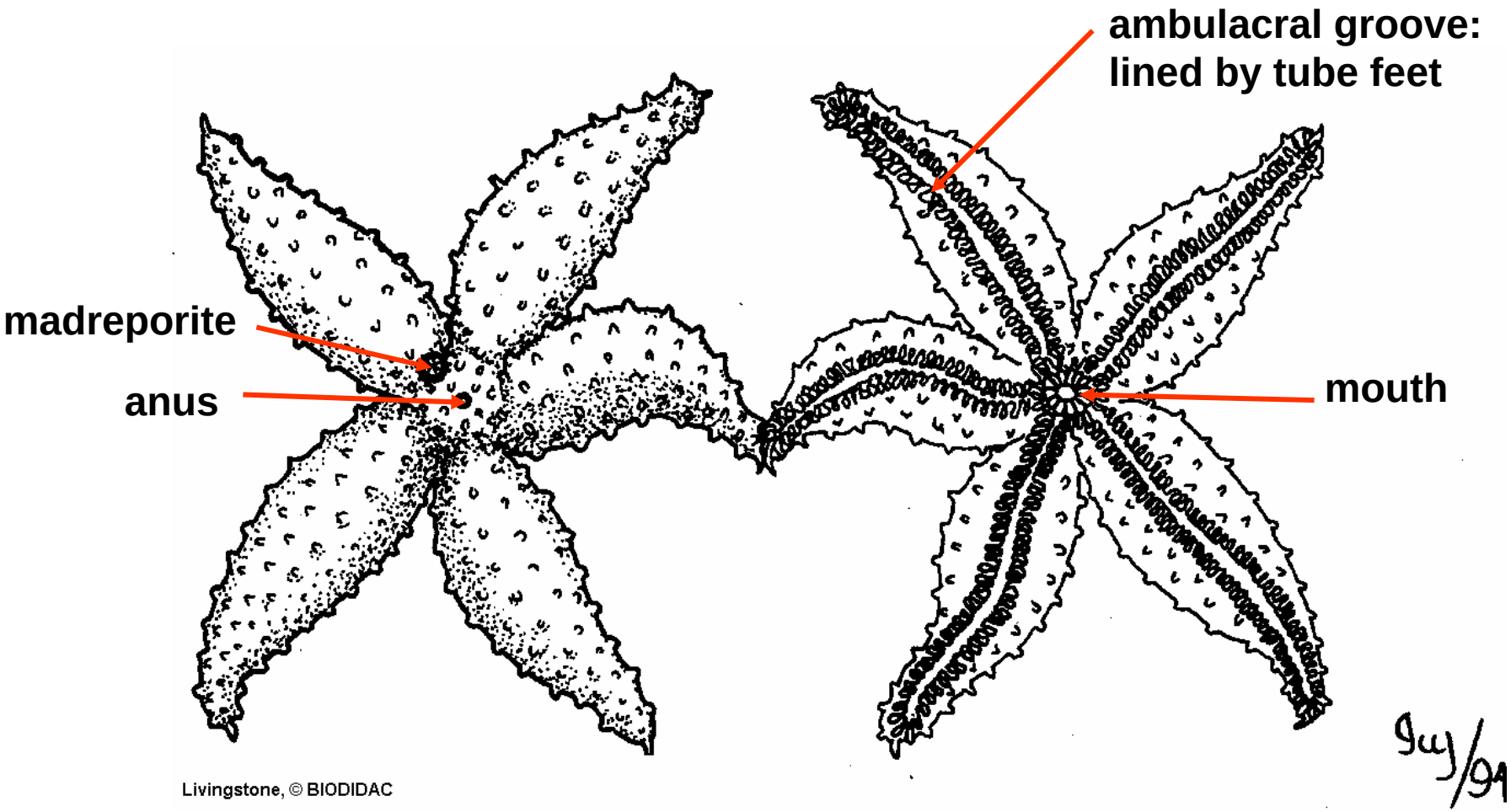
- on a stalk
- feathery arms

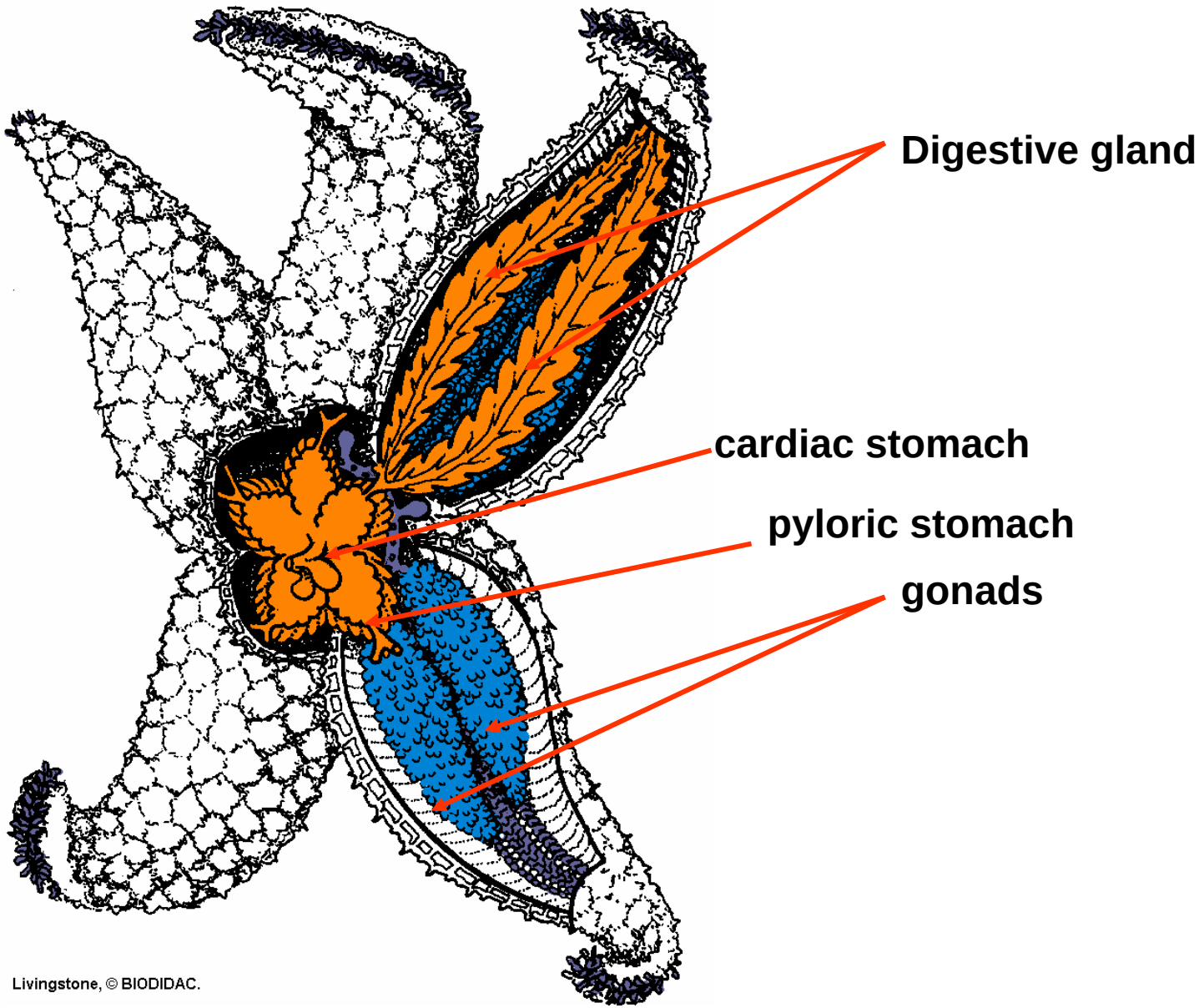


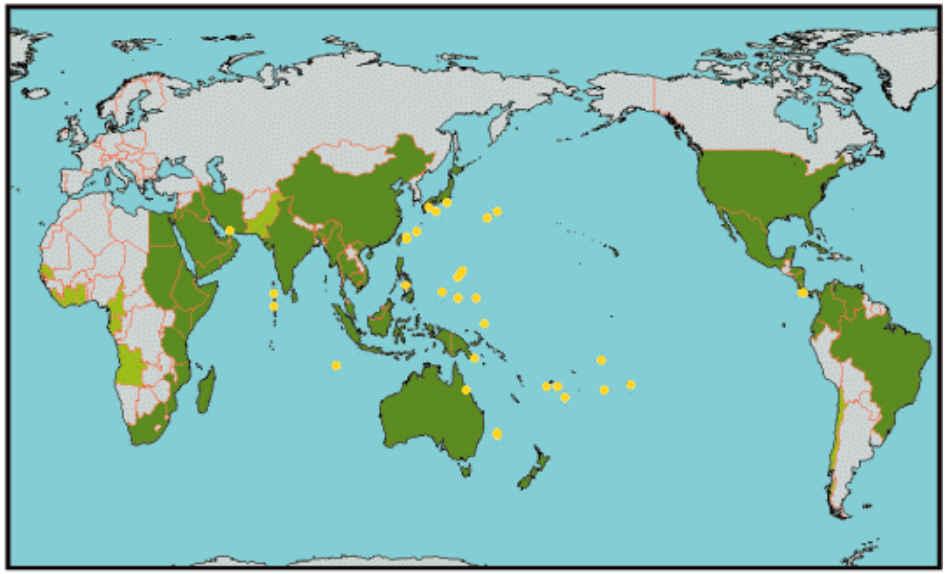


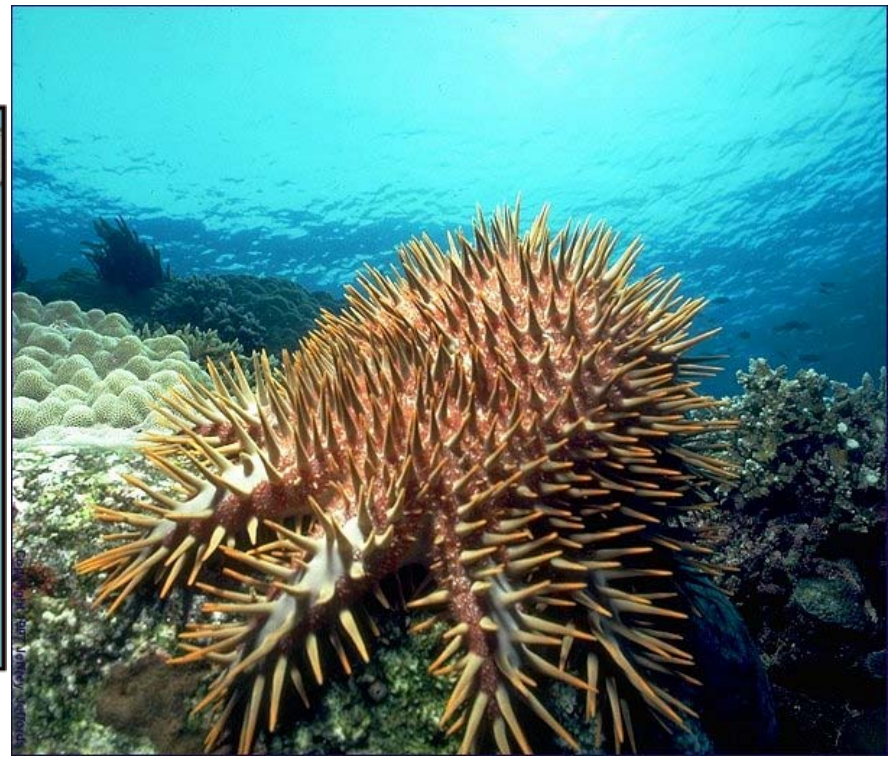
Class Asteroidea

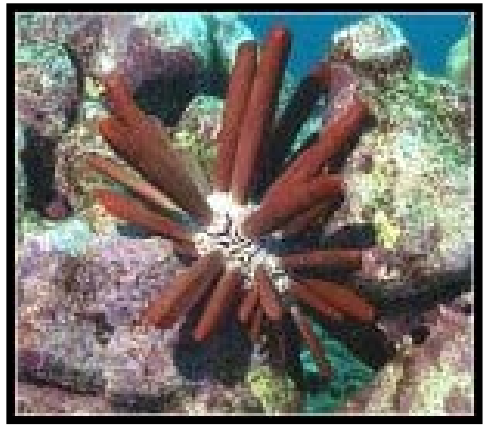
the “sea stars”


ambulacral groove:
lined by tube feet
madreporite
anus
mouth
Livingstone, © BIODIDAC
Aboral
Oral


Digestive gland
cardiac stomach
pyloric stomach
gonads
Livingstone, © BIODIDAC.

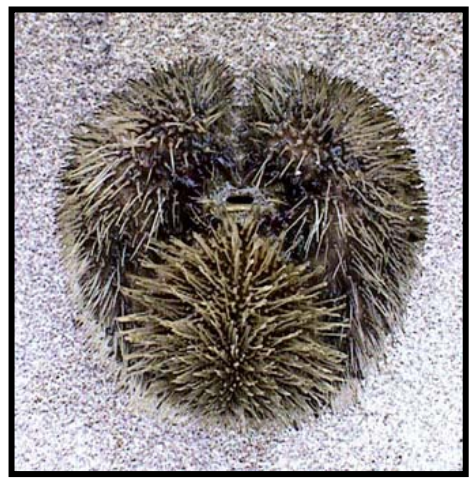






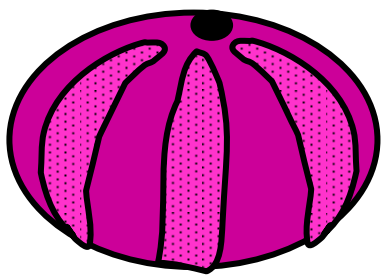
Class Echinoidea

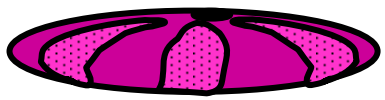
the“sea urchins”, “sand dollars”, “heart urchins”, “sea biscuits”…



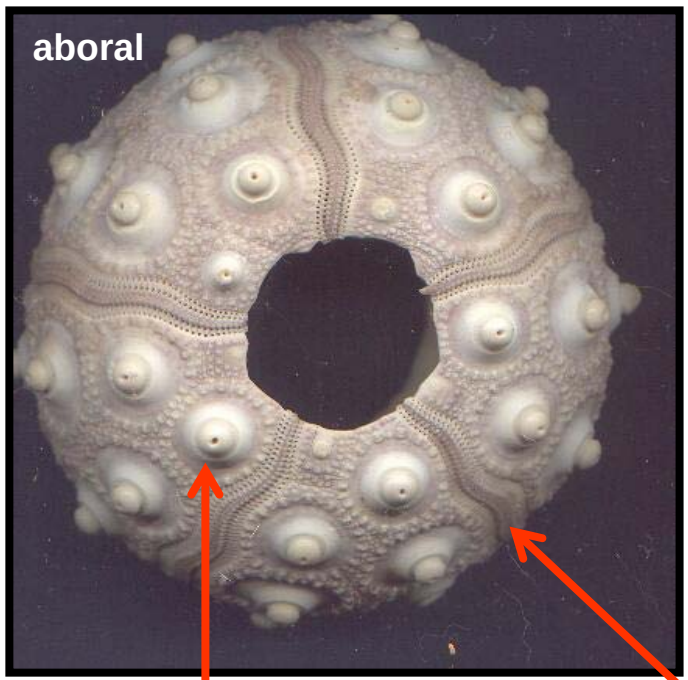
Class Echinoidea

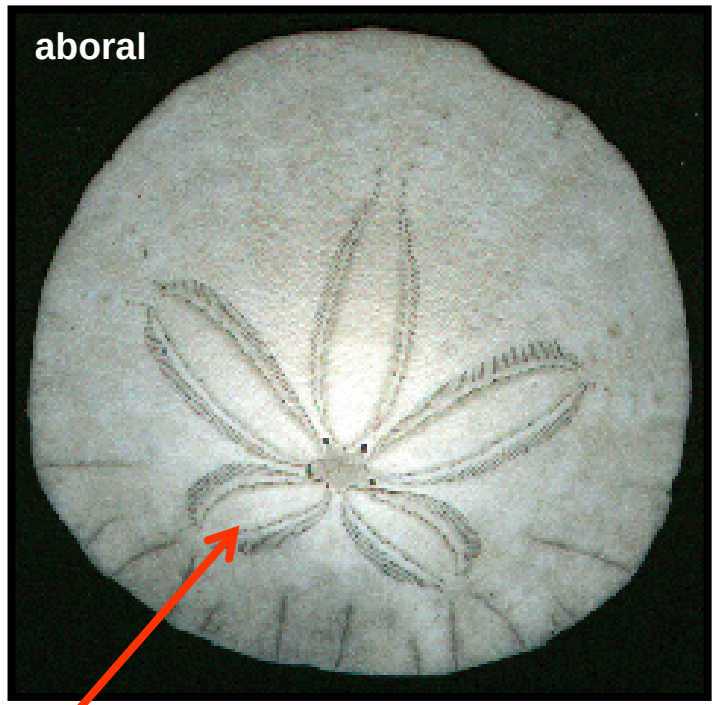
- globular or disc- shaped with no arms
- ossicle plates are fused to form a compact skeleton called a “test”
- ambulacral grooves closed
- movable spines with interspersed tube feet
- tube feet usually have suckers
- anus and madreporite aboral
- pedicellaria present
- Aristotle’s lantern





Class Echinoidea

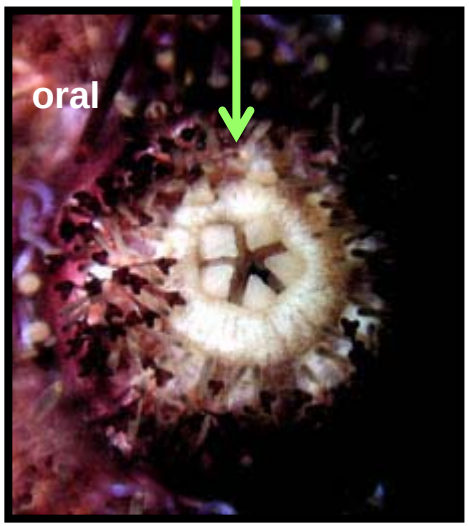


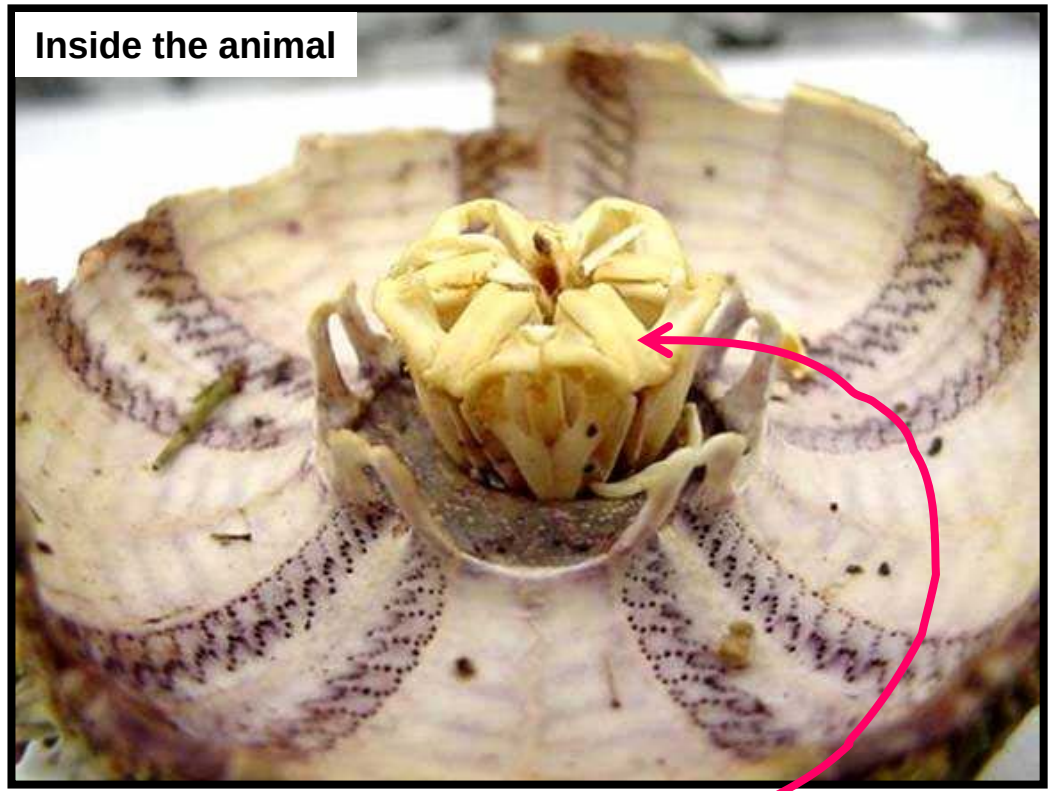


where the spines attach

ambulacral region

Class Echinoidea



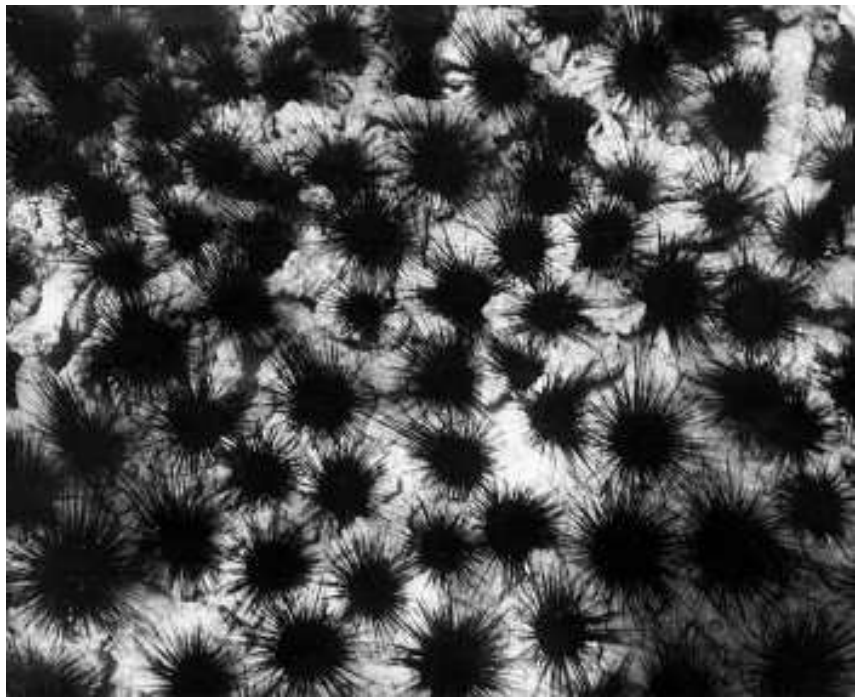


Aristotle's lantern

- complex chewing mechanism
- 5 teeth are attached

Sea Urchins are important grazers on reefs, in sea grass beds, and in Kelp forests

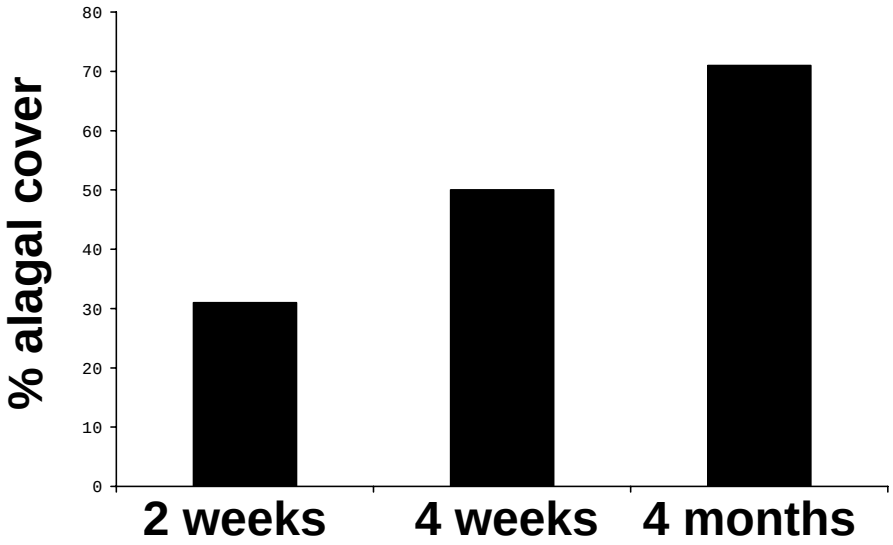
Without urchins (or with to many of them) these habitats become altered

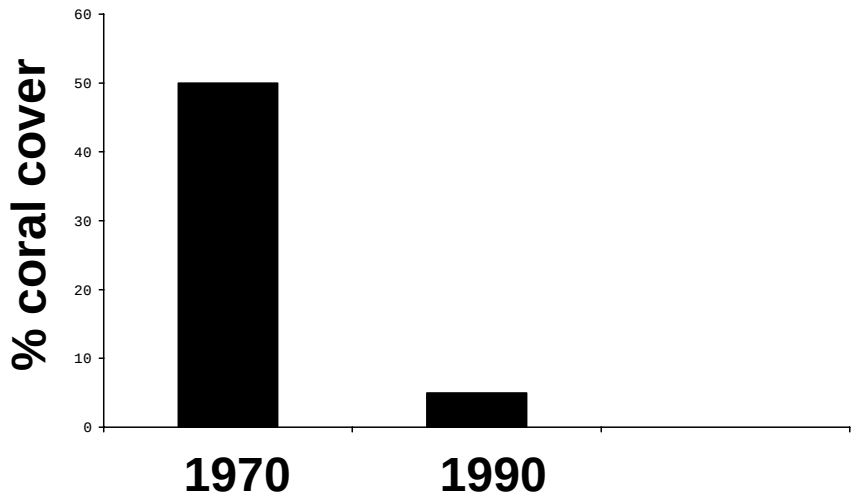


Prior to the early 1980s, the long spined urchin (*Diadema antillarum)* was very abundant

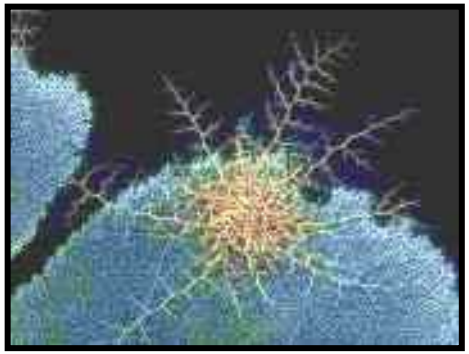
In 1983, a pathogen killed 99% of the *Diadema* in the Carribean

This led to an increase in algal abundance and a decrease in coral cover





↓ **Sea otter abundance** ↑ **Urchin abundance** ↓ **Kelp abundance**

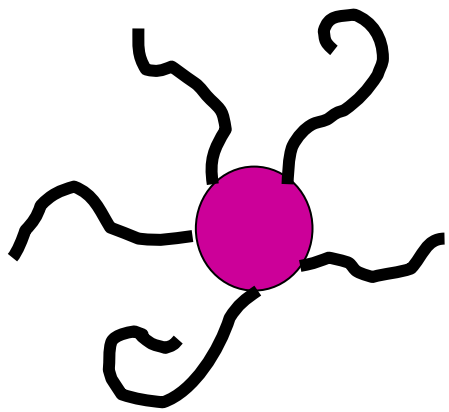


Class Ophiuroidea

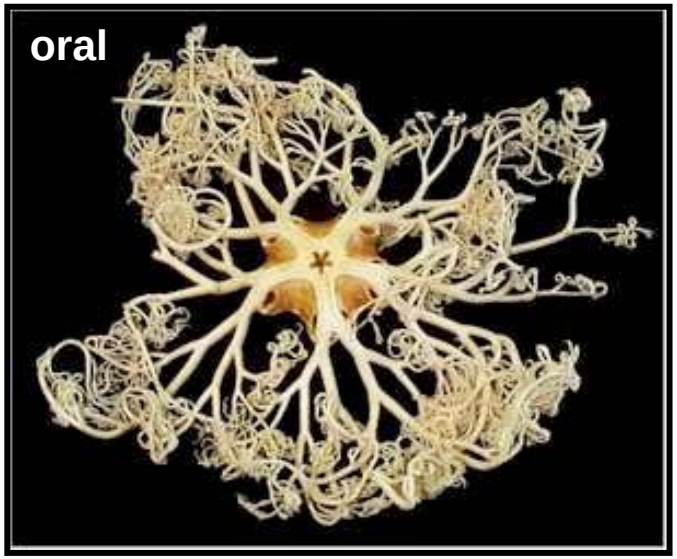
“brittle stars” and “basket stars”

Class Ophiuroidea

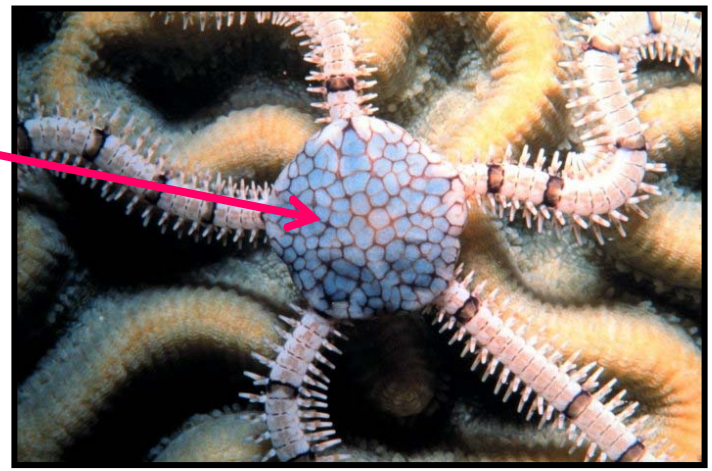
- star shaped with arms around an obvious central disc
- ambulacral grooves closed and covered by ossicles (no tube feet within them)
- tube feet without suckers and are not used for locomotion
- incomplete digestive system→ no anus
- pedicellaria absent



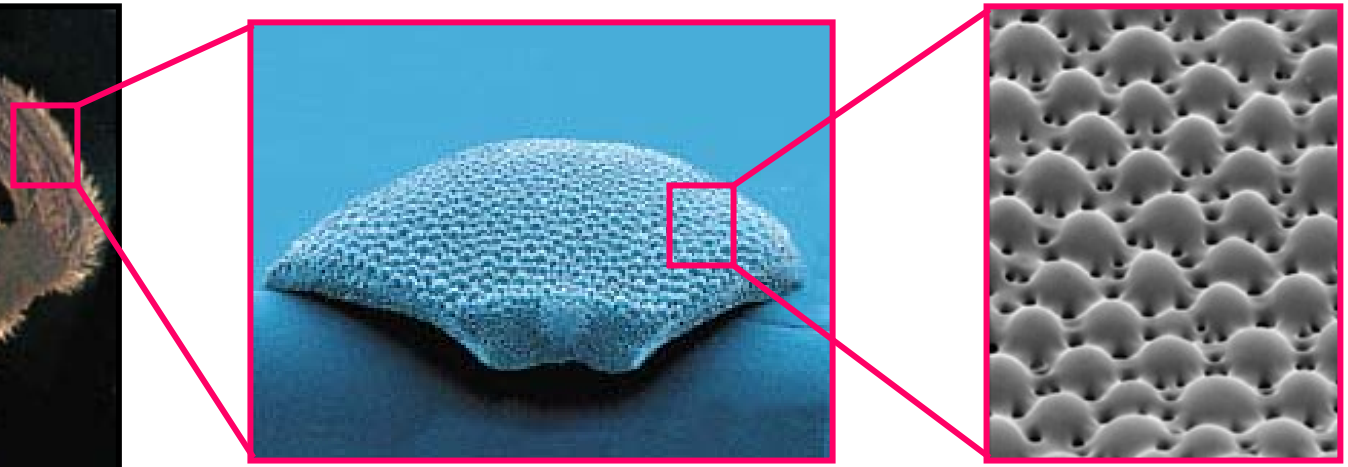
Class Ophiuroidea



Central disc



Class Ophiuroidea

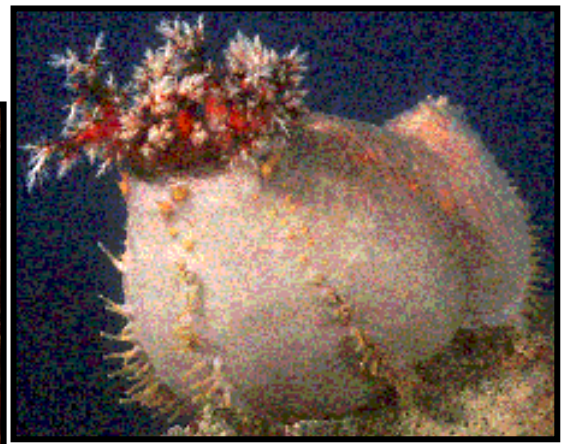


- Although they don't have any eyes, some brittle stars have photosensitive "lenses" all over their body.

- They can detect light/dark such as shadows and change color.

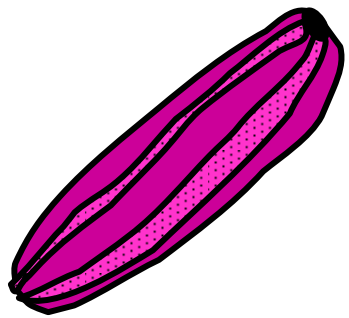
Class Holothuroidea

the “sea cucumbers”

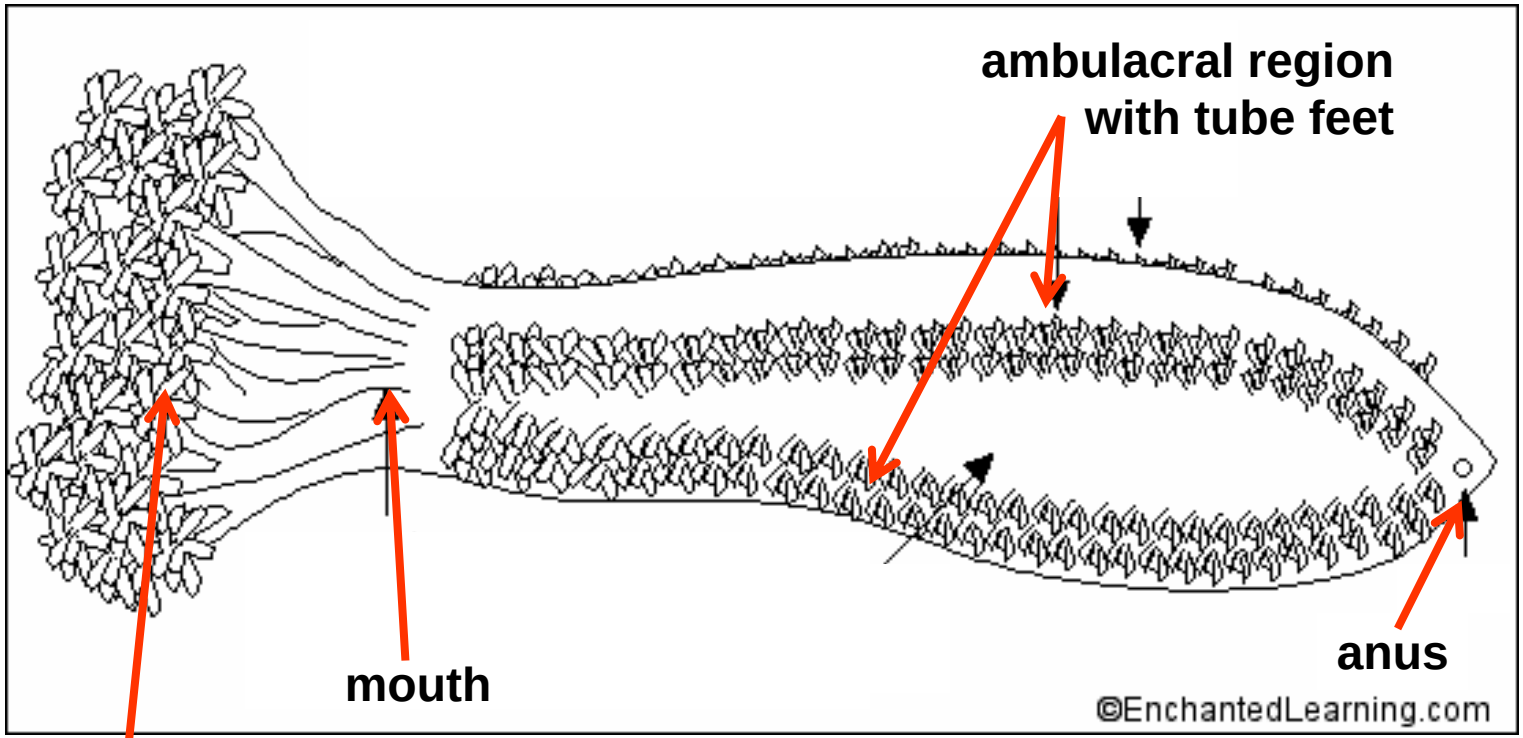


Class Holothuroidea

- cucumber-shaped with no arms
- secondarily bilateral
- ambulacral grooves closed
- microscopic ossicles are embedded in muscular body → soft body
- tube feet with suckers and some are modified around the mouth as feeding tentacles
- pedicellaria absent
- respiratory tree for gas exchange

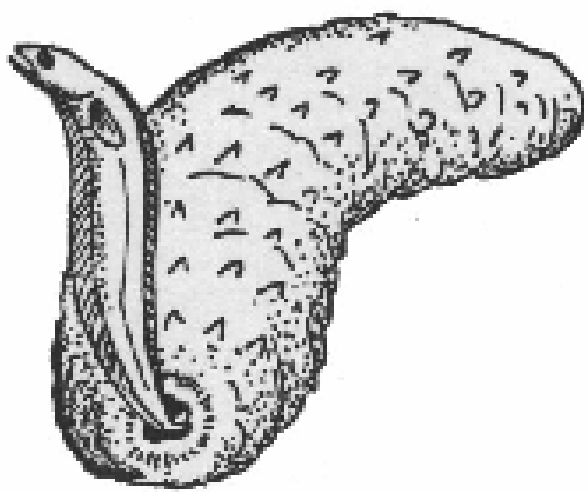


Class Holothuroidea



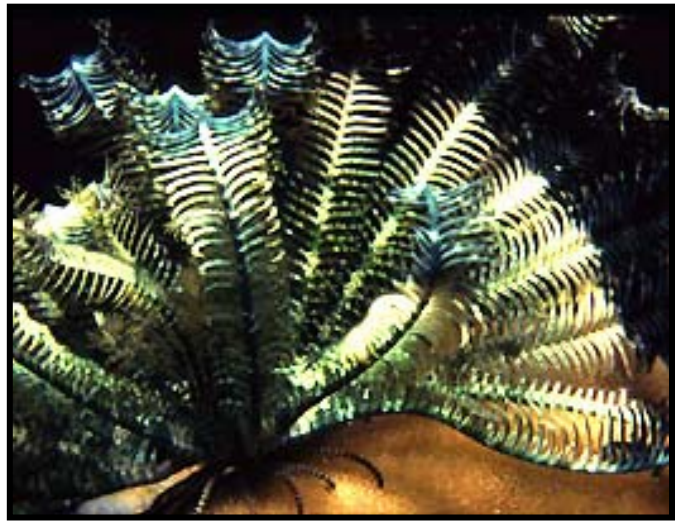
feeding tentacles
(modified tube feet)

Class Holothuroidea



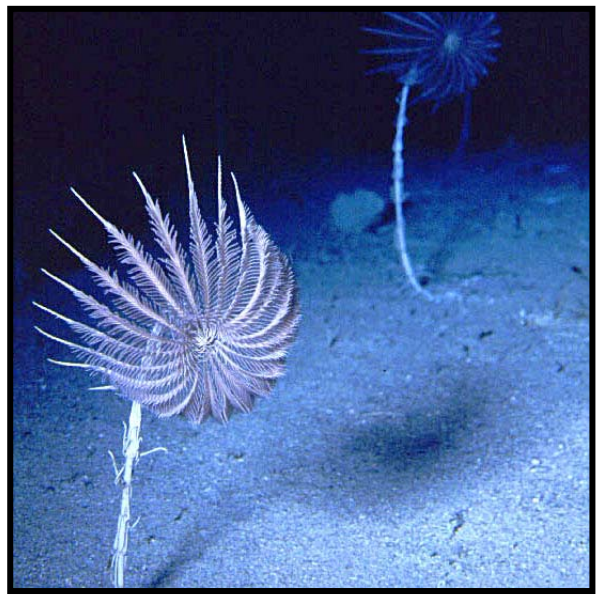
• Many cucumbers have a “pearlfish” living inside them.

• It is unknown whether the pearlfish is a parasite that feeds on the internal organs of the sea cucumber or whether it leaves the sea cucumber unharmed.



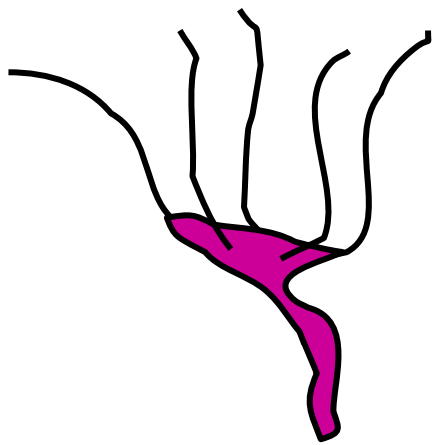
Class Crinoidea

the “sea lilies” and “feather stars”

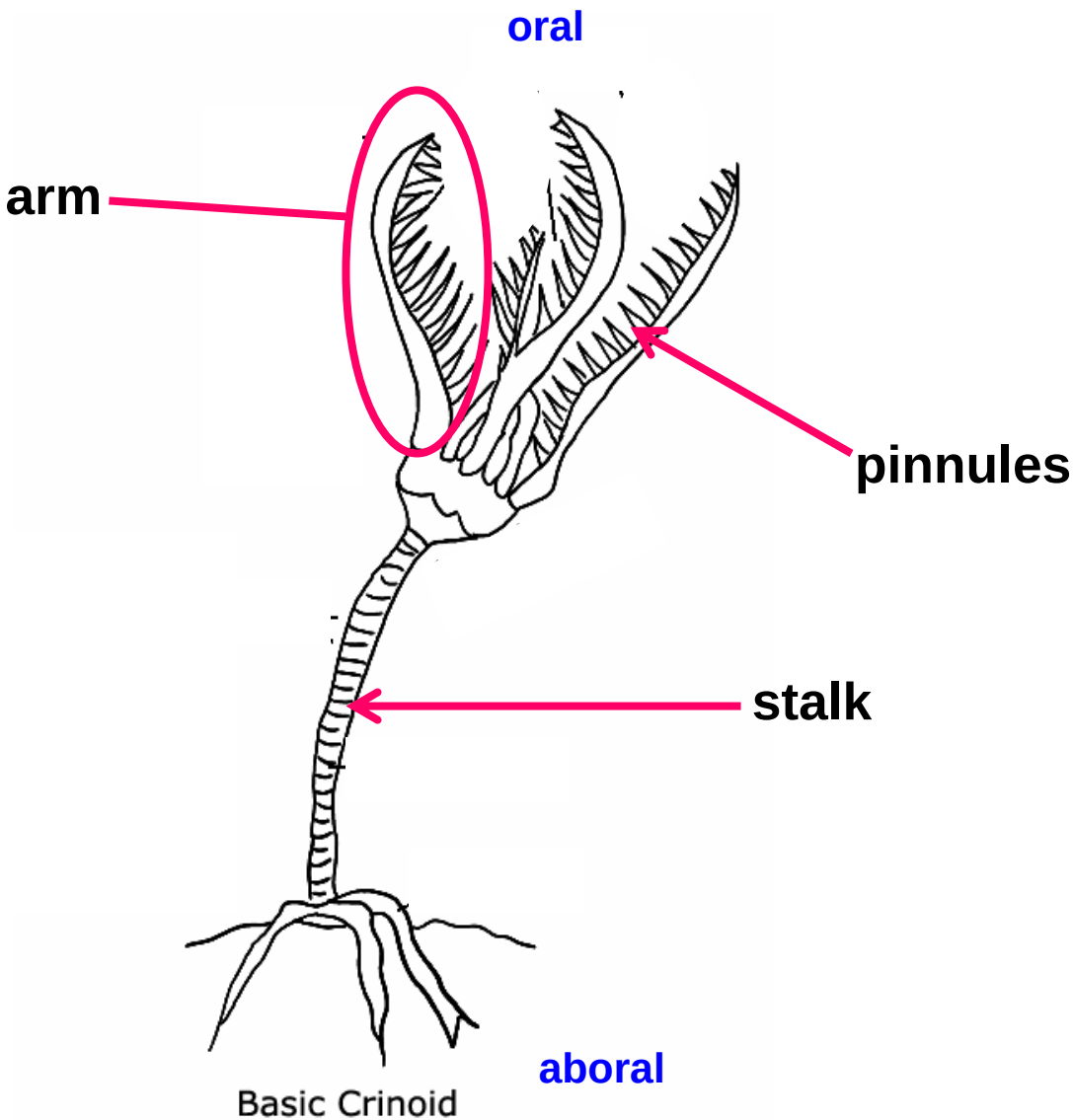


Class Crinoidea

- flower-shaped
- arms bearing pinnules
- stalked
- ciliated ambulacral grooves on oral surface with tentacle-like tube feet for food gathering
- body disc and stalk contain ossicles
- madreporite, spines, and pedicellaria absent



Class Crinoidea



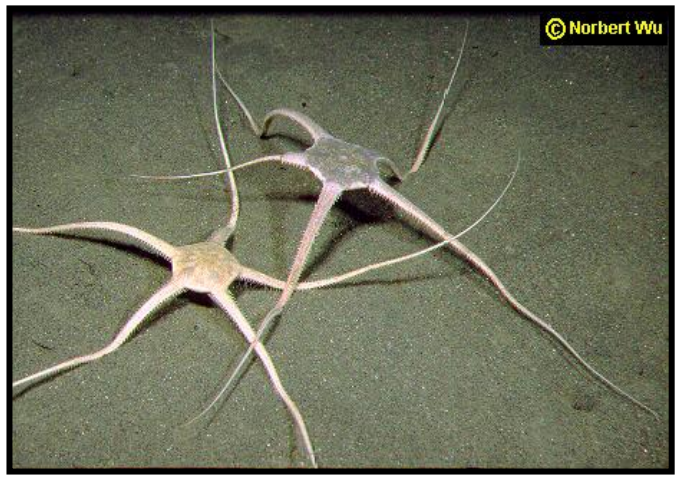
Regeneration

- **Most Echinoderms are capable of regenerating parts of their bodies when they are lost.**

Regeneration

- **Some sea stars and brittle stars use regeneration as a way to reproduce asexually.**

“comet” sea star



brittle star

Regeneration

- **Most sea cucumbers are able to expel their intestine out of their anus, and regenerate the lost structures.**
- **This is done in defense and during times of the year when food supply is low.**

Faculty research: Don Levitan

The evolution of gamete characteristics in broadcast spawning invertebrates

Male widowbird

Female widowbird

Bateman's Principle: since sperm are more numerous than eggs, male reproduction is limited by access to mates.

This principle has been very successful in explaining patterns of sexual selection and the evolution of sexual dimorphism.

Strongylocentrotus franciscanus

Does Bateman's principle apply to broadcast spawning species?

In relevance of Bateman's principle to broadcast spawners is probably related to population density.

sperm limitation ⟷ **sperm competition**

population density

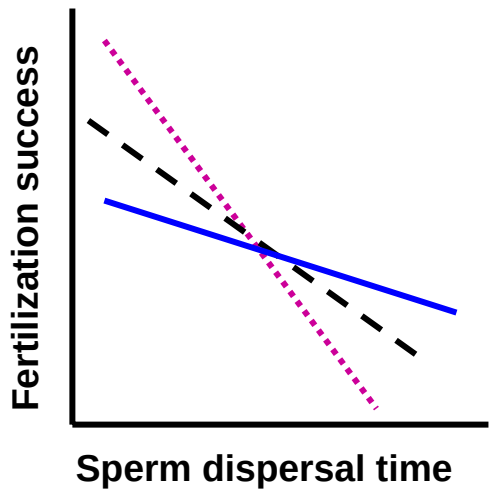
Dr. Levitan's research has examined the role of sperm limitation and sperm competition in the evolution of gamete traits three species of sea urchins.

1. ***Strongylocentrotus pupuratus***
2. ***S. franciscanus***
3. ***S. droebachiensis***

1. ***Strongylocentrotus pupuratus***
   Small eggs, fast/ short lived sperm

2. ***S. franciscanus***
   Intermediate eggs, intermediate sperm

3. ***S. droebachiensis***
   Large eggs, slow/ long lived sperm

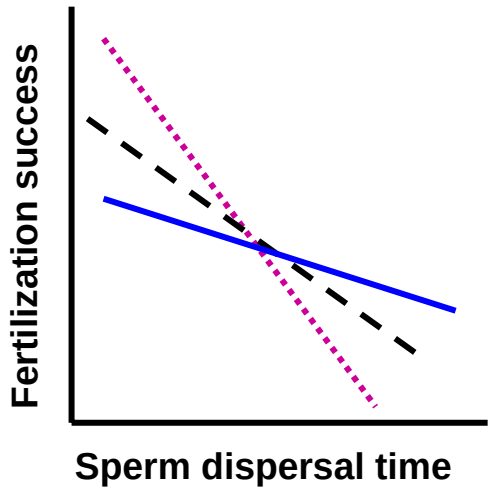


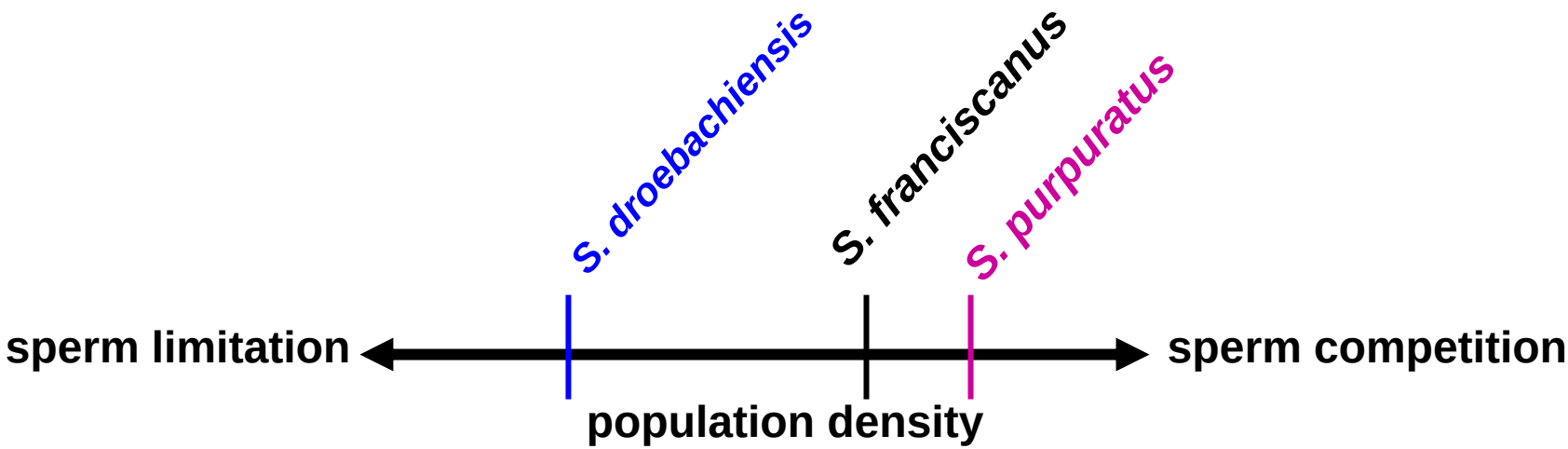
These differences are due to differences in egg size- larger eggs are better targets

1. ***Strongylocentrotus pupuratus***
   Small eggs, fast/ short lived sperm

2. ***S. franciscanus***
   Intermediate eggs, intermediate sperm

3. ***S. droebachiensis***
   Large eggs, slow/ long lived sperm





Male widowbird

Female widowbird

Bateman's Principle: since sperm are more numerous than eggs, male reproduction is limited by access to mates.

Dr. Levitan's research suggests that under conditions of sperm limitation, female traits (i.e. egg size) evolve to increase fertilization success.