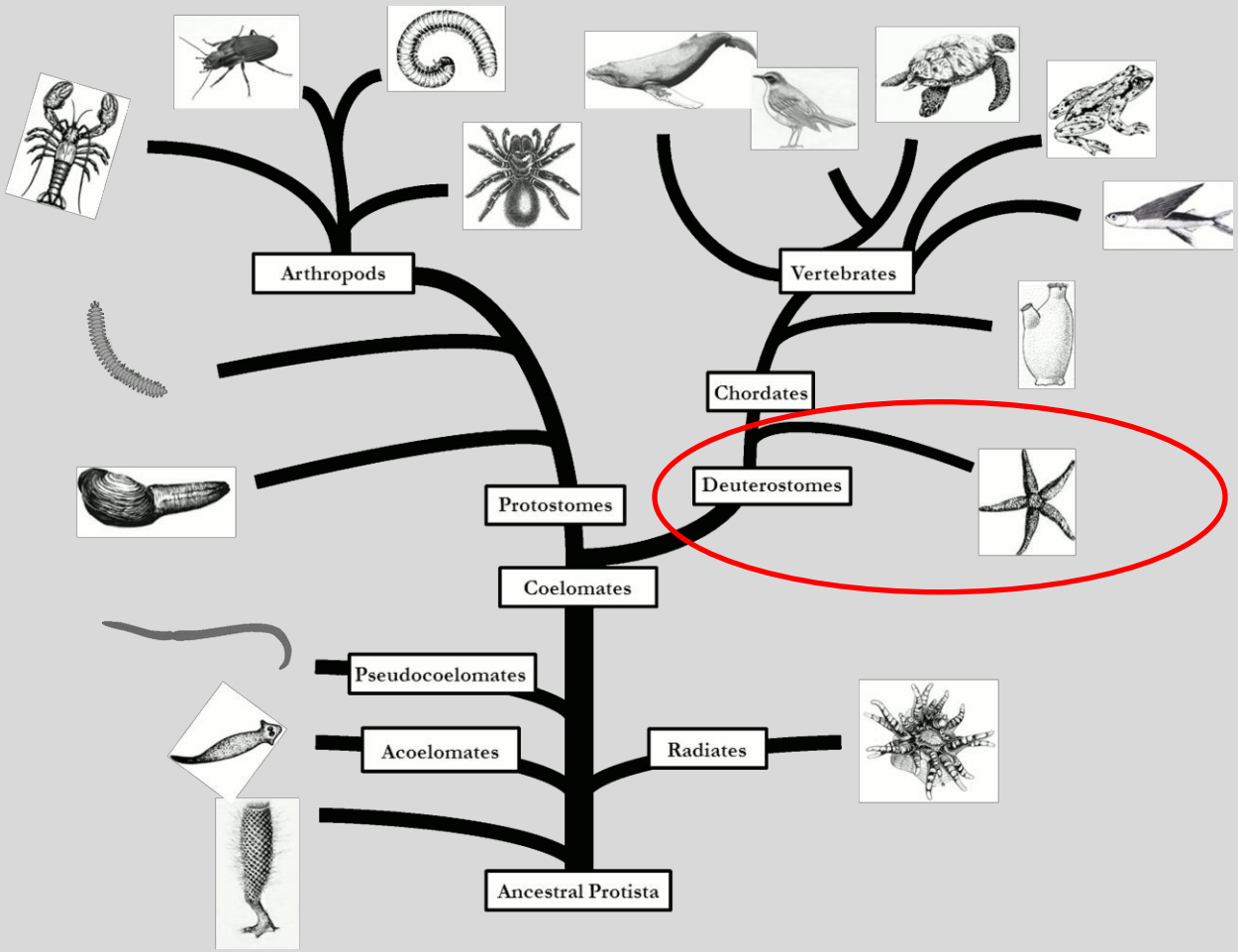
ECHINODERMATA

FISH 310

Where we are…


Arthropods
Vertebrates
Chordates
Deuterostomes
Protostomes
Coelomates
Pseudocoelomates
Acoelomates
Radiates
Ancestral Protista

Echinodermata Taxonomy

Subphylum Asterozoa

- Class Stelleroidea
  - Subclass Asteroidea – sea stars
  - Subclass Ophiuroidea – brittle & basket stars

Subphylum Crinozoa

- Class Crinoidea – sea lilies & feather stars

Subphylum Echinozoa

- Class Echinoidea – sea urchins & sand dollars
- Class Holothuroidea – sea cucumbers

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Class Echinoidea – sea urchins & sand dollars

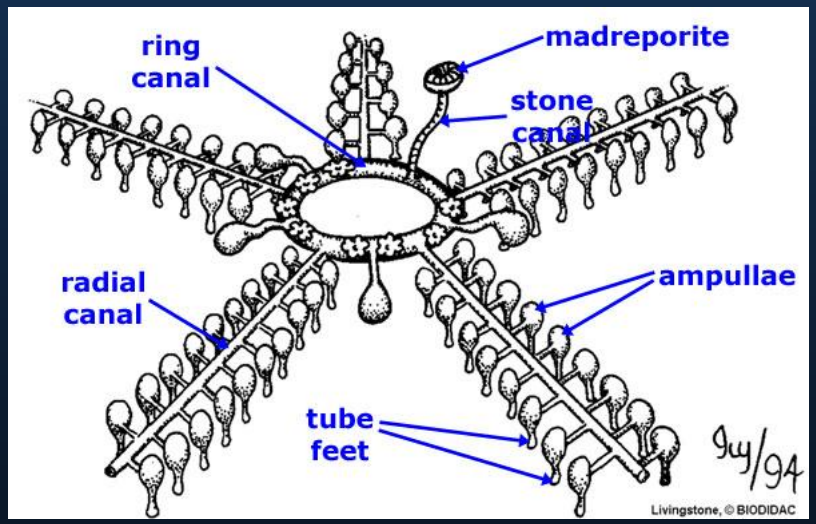
Class Holothuroidea – sea cucumbers

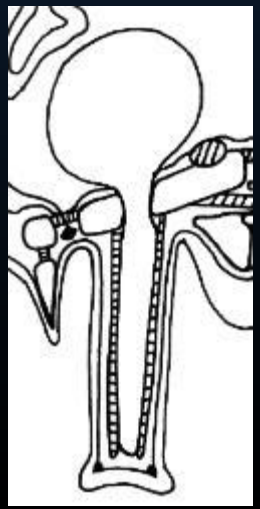
Mutable Connective Tissue (MCT)

- Reversibly vary rigidity of dermis
- Under nervous control
- Tissue matrix stiffened by Ca^{2+}

- Feeding
- Defense
- Autotomy
- Asexual reproduction

Water Vascular System (WVS)





- SUPER COOL!
- Echinoderm hydraulic system with diverse function
- Podia
  - Ambulacral Grooves/Zones
  - Locomotion, Gas exchange
  - Longitudinal muscles

Echinodermata Taxonomy

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Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

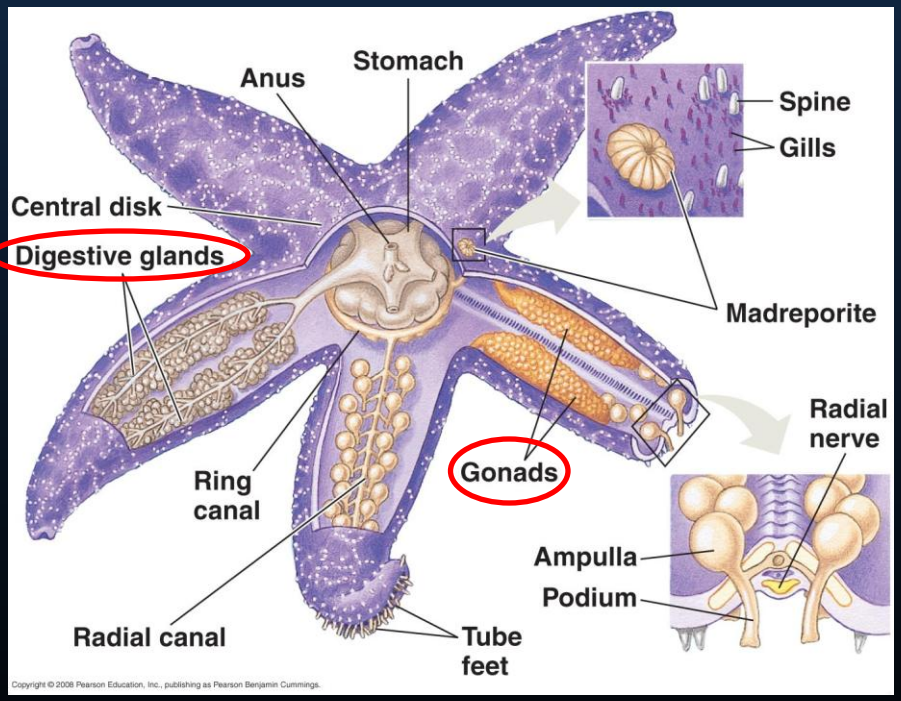
Subphylum Asterozoa: Class Stelleroidea

- Defining character:
  - Arms/Rays extend from a central disc
- Two subclasses
  - Subclass Asteroidea – sea stars
  - Subclass Ophiuroidea – brittle stars
- Recently grouped into one class based on fossil and molecular evidence

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

Subclass Asteroidea

- Seastars!
- ~1600 extant taxa
- **Defining character:**
  - **Gonads & digestive tract extend into each arm**



Asteroidea WVS

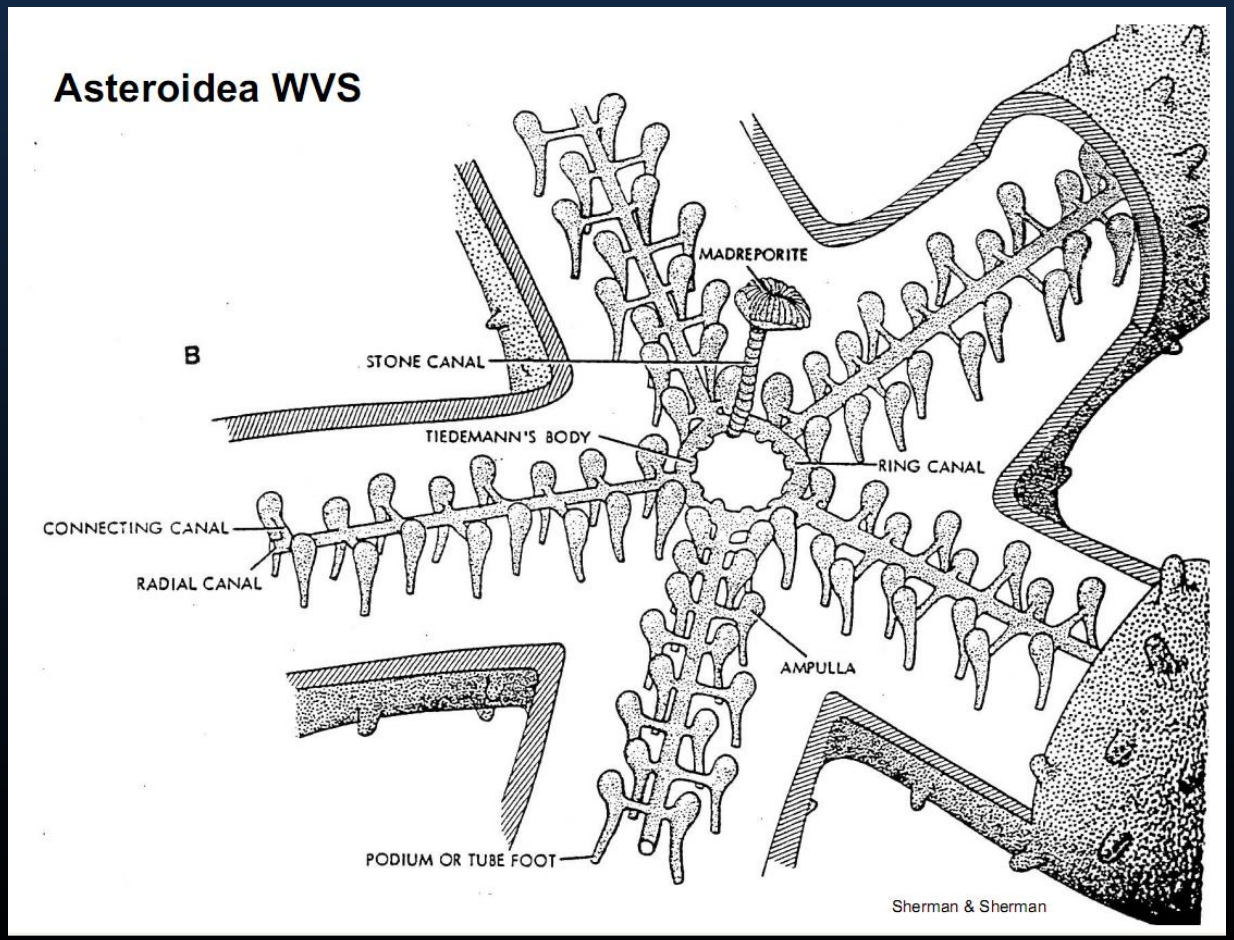
Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

- Well developed – used for…
  - Locomotion
  - Adhesion
  - Prey manipulation
  - Gas exchange

Asteroidea WVS

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

Lined by myoepithelium – ciliated and muscular



- Parts of the Asteroid WVS:
  - Madreporite – brings water into WVS
  - Stone canal – leads from madreporite to ring canal
  - Ring canal – cicumoral canal leads to radial canals
  - Polian vessicle & Tidemann's bodies – sacs attached to ring canal, maintain turgor
  - Radial canal – extend into rays and connect with ampullae
  - Ampullae – bulb shaped sacs that pump fluid into podia
  - Podia – tube feet

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

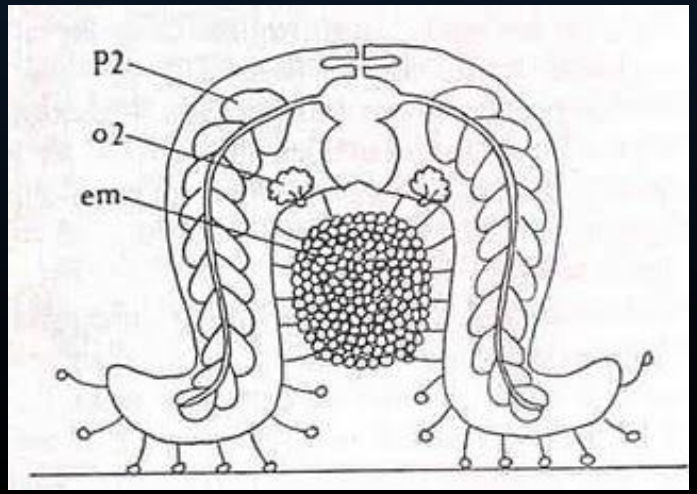
Asteroidea Reproduction

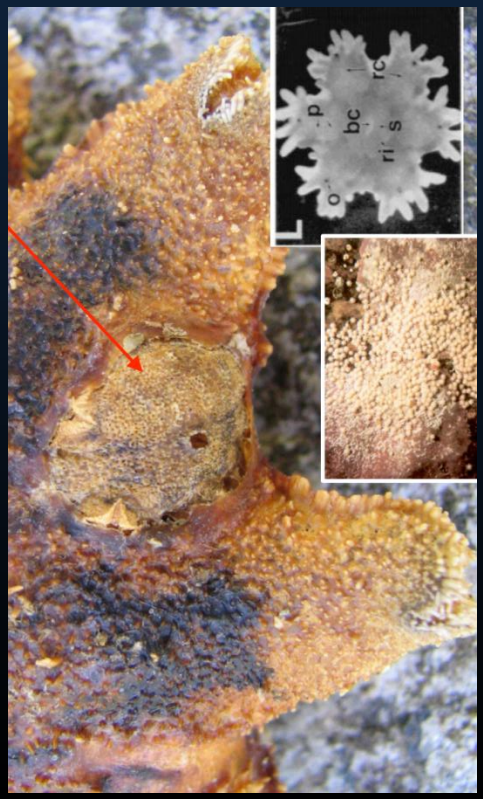
- Asexual
  - May autotomize limbs & regenerate
  - Usually must have portion of central disc

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

Asteroidea Reproduction

- Sexual
  - Most are dioecious
  - Generally have 10 gonads – 2 per arm
  - Most broadcast spawn seasonally
  - One female may shed 2.5 million eggs
  - Some cold water species are brooding direct developers





Asteroidea Feeding

- Wide variety of feeding styles:
  - External digestion by everting stomach
  - Ciliary-mucous feeding
  - Catch fish with pedicellaria
  - Dig through substrate for bivalves
  - May have general or specialized diet

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

Asteroidea Defense

- How might asteroids defend themselves?
  - Run away
  - Adhere to substrate
  - Venom
  - Camouflage
  - Pedicellaria
  - SLIME!!!

Echinodermata Taxonomy

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Subclass Asteroidea – sea stars 

Subclass Ophiuroidea – brittle & basket stars

Subphylum Crinozoa

Class Crinoidea – sea lilies & feather stars

Subphylum Echinozoa

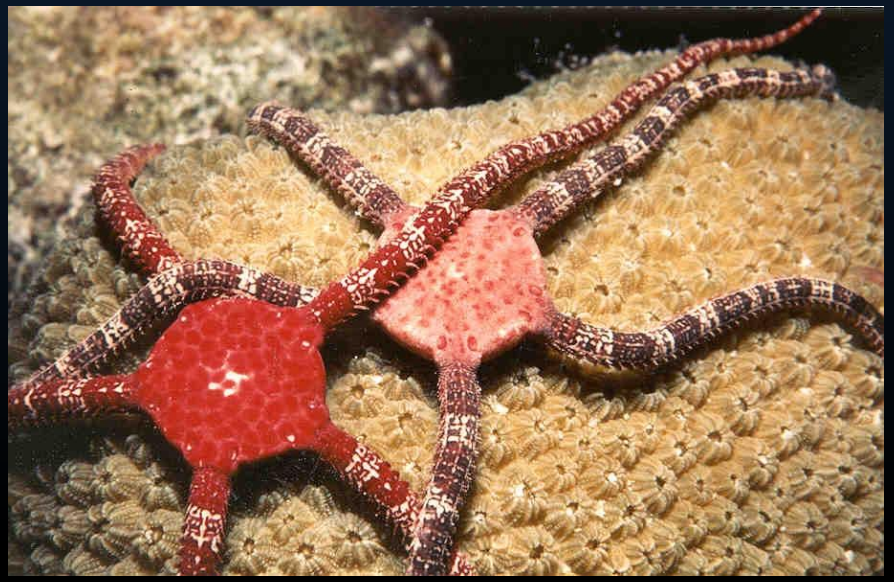
Class Echinoidea – sea urchins & sand dollars

Class Holothuroidea – sea cucumbers

Subclass Ophiuroidea

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

- Brittle & Basket Stars!
- ~2100 species
- Most 1-3cm diameter, some up to 1m armspan
- Wide variety of cryptic lifestyles
  - Symbioses (only symbiotic echinoderm)
- **Defining characters:**
  - **Ten bursae**
  - **Arms composed of jointed calcareous vertebrae**



Defining Characters

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

- Bursae – invaginations on the oral surface of the disc
  - Ten bursae usually present
  - Extend into coelomic cavity
  - Seawater circulated through bursae with cilia and muscular contraction
  - Gas exchange, possibly waste removal, some brood embryos in bursae
- Arms composed of calcareous vertebrae

Ophiuroid WVS

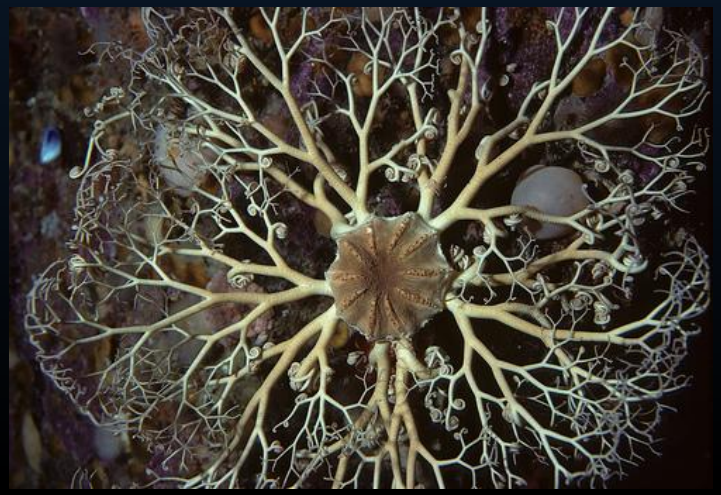
Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

- Similar to asteroid WVS except:
  - Madreporite is positioned orally
  - May possess multiple madreporites
  - Ampullae are absent
  - Contraction of radial canal moves podia

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

Ophiuroid locomotion

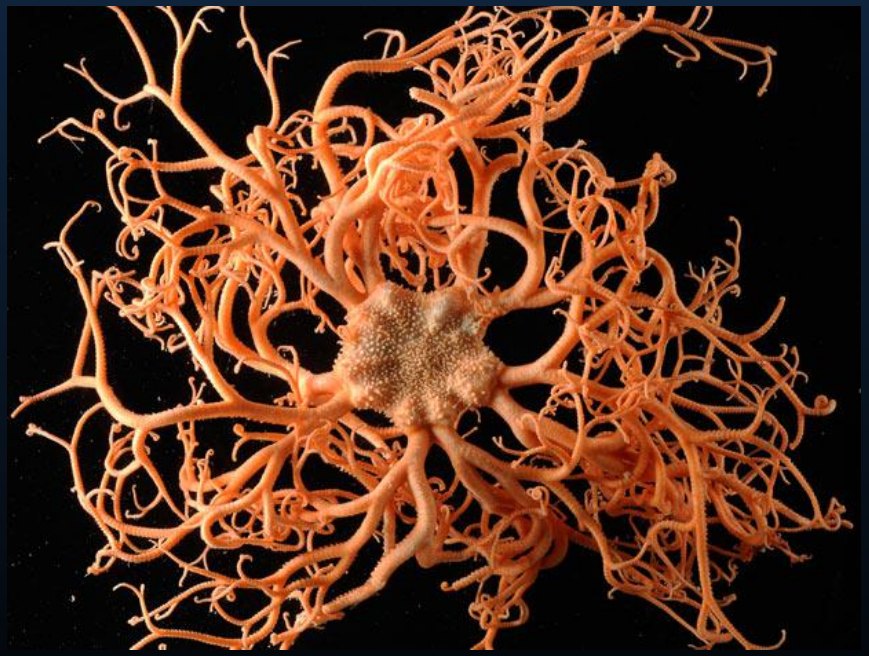
- Fast for echinoderms
- Tube feet rarely used to move, usually only for food manipulation and burrowing
- Brittle stars use long arms to move across the substrate
- Basket stars may brace themselves in position with their arms



Ophiuroid Feeding & Digestion

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

- Digestive system confined to central disc
- Ophiuroids lack an anus
- Many feeding strategies
  - Carnivores
  - Scavengers
  - Deposit feeders
  - Suspension feeders



Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

Carnivory

- *Ophioderma* lassos small crustaceans with arms and transfers prey to mouth
- If offered unlimited crustaceans in a lab setting, it will eat until the disc ruptures!

Ophiuroid reproduction

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

- Asexual
  - Clonal reproduction by fission of central disc into two pieces
  - Larvae may cast off an arm which regenerates an entire body

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

Ecology

- Globally distributed
- Common in Puget Sound
- Very large biomass in deep soft bottom habitats
  - *Ophiothrix fragilis* can reach densities of 2000/m^2

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- Class Crinoidea – sea lilies & feather stars

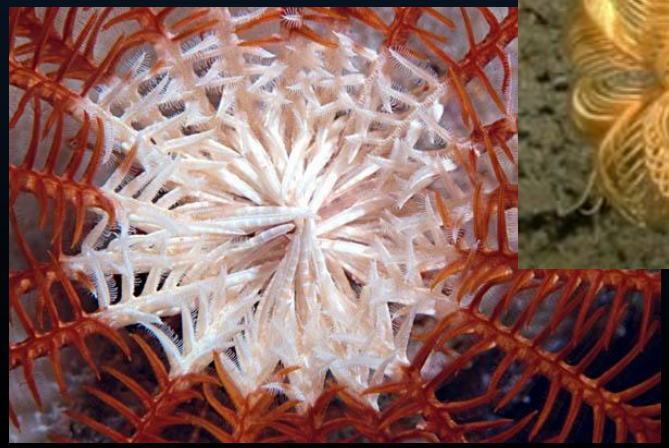
Subphylum Echinozoa

- Class Echinoidea – sea urchins & sand dollars
- Class Holothuroidea – sea cucumbers

Subphylum Crinozoa: Class Crinoidea

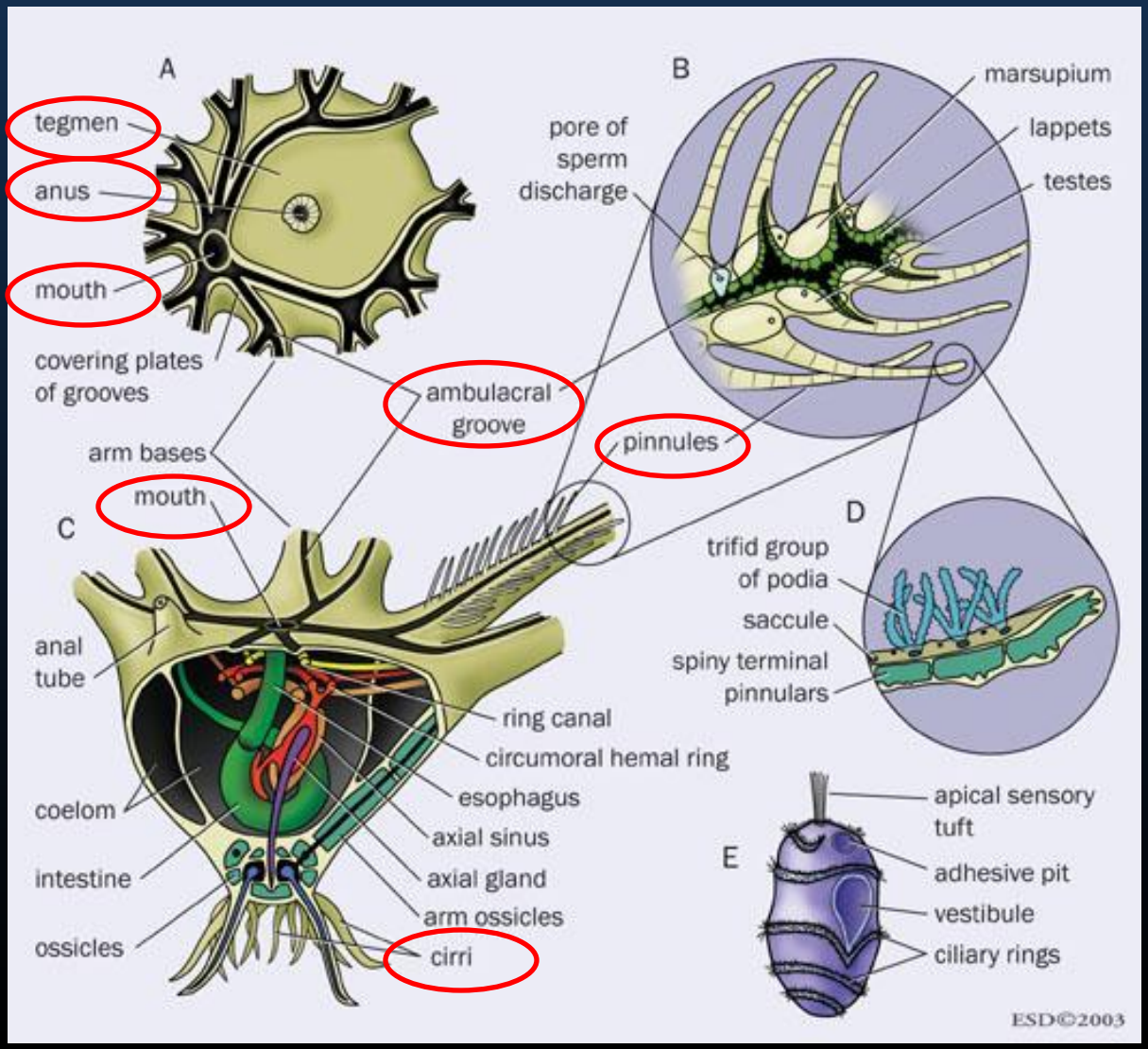
- Defining character:
  - Body held above substrate by stalk or grasping cirri
- 700 extant species
  - 100 sea lilies (4 orders)
  - 600 feather stars (1 order)
- Very ancient class
  - Some extinct species were over 65 feet tall!

Characteristics

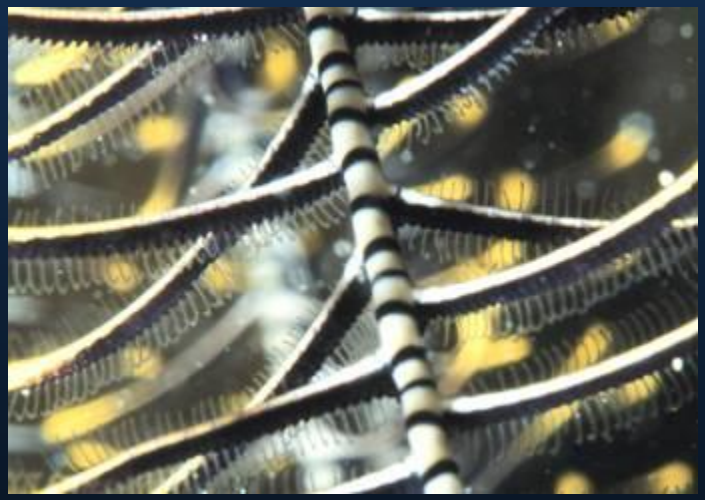


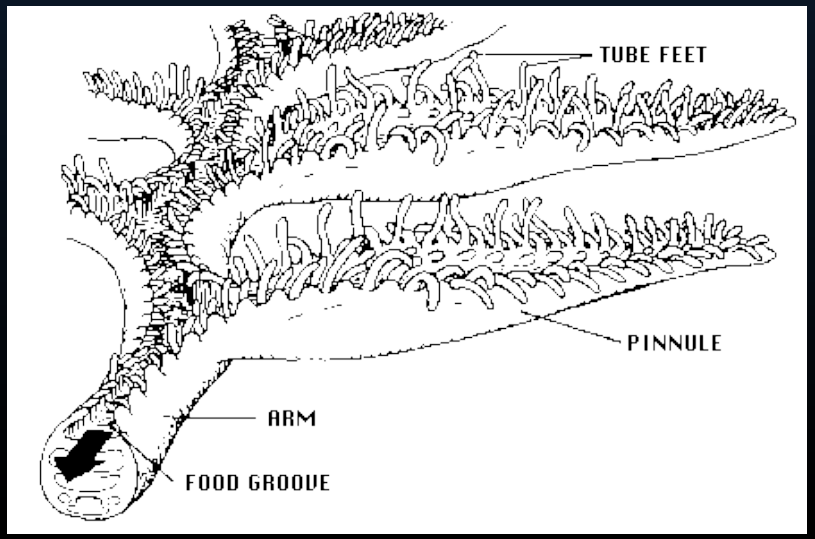
- Stalk or cirri
- (semi)sessile suspension feeders
- Oral surface up
- Food collected with tube feet
- Regeneration
- Often on coral reefs

Crinoidea Anatomy



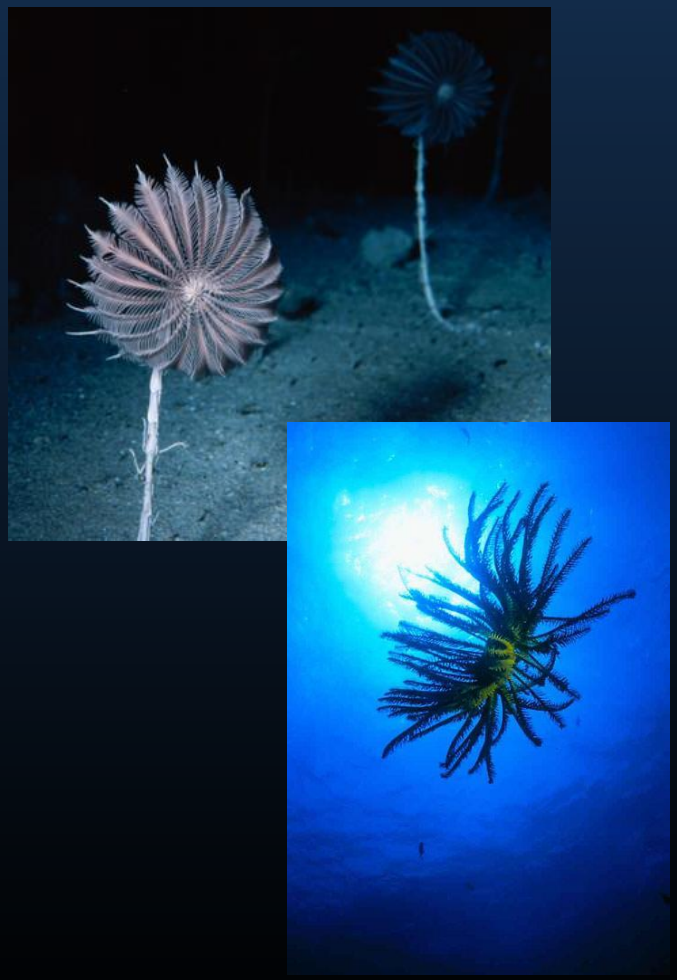
Crinoidea Feeding





- Passive suspension feeders
- Extend all appendages
- Podia secrete mucous
- Food caught & flicked into ambulacral groove

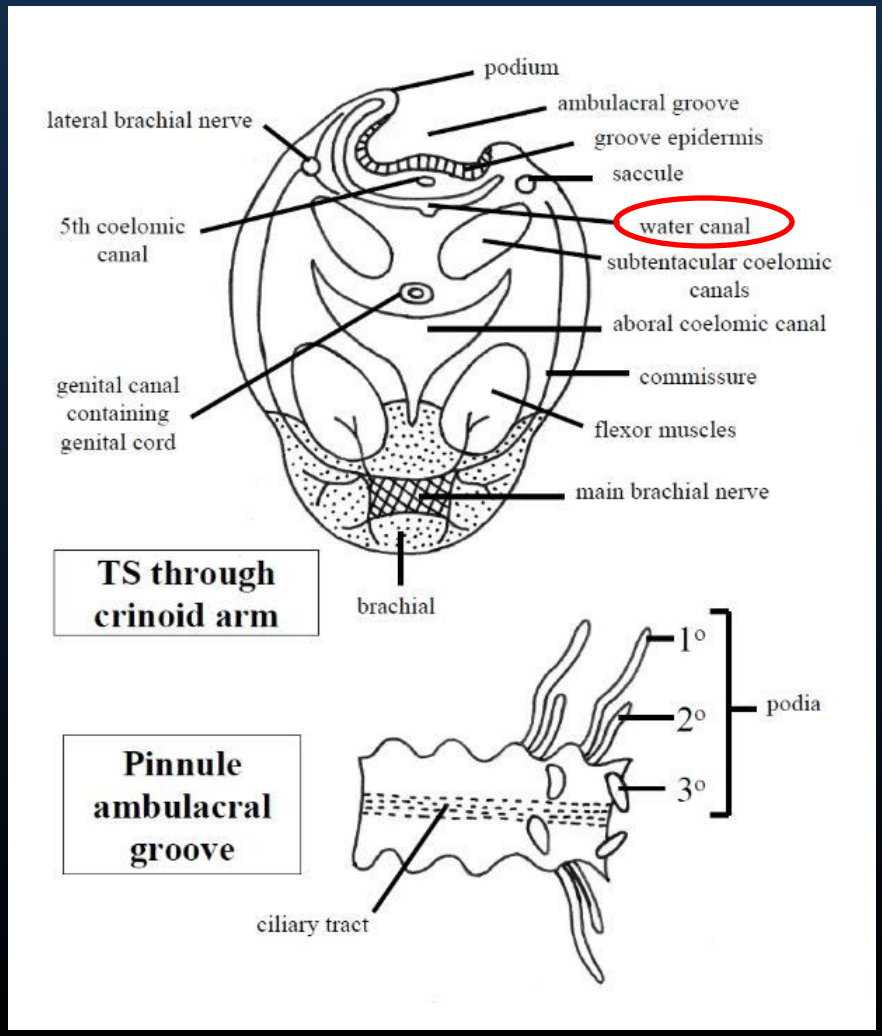
Crinoidea Locomotion



- Sea lilies
  - Stalk contains no musculature
  - MCT orients body
- Feather stars
  - Cirri cling to substrate
  - Crawl – terminal hooks on arms
  - Swim

Crinoidea WVS

- Similar to seastar except…
  - No madreporite
  - Ring canal has numerous stone canals opening into coelem
  - WVS connected to environment though ciliated tubes that penetrate tegem
  - Ampullae absent



Crinoidea Reproduction

- No asexual reproduction
- Dioecious
- Gonads in pinnules
- Spawn by rupturing pinnule walls
- Some brood, viviparous

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- Class Echinoidea – sea urchins & sand dollars
- Class Holothuroidea – sea cucumbers

Echinozoa
Echinoidea
Holothuroidea

Subphylum Echinozoa:

- 'Defining character':
  - Lack arms
- Two classes
  - Class Echinoidea – sea urchins, heart urchins, sand dollars
  - Class Holothuroidea – sea cucumbers

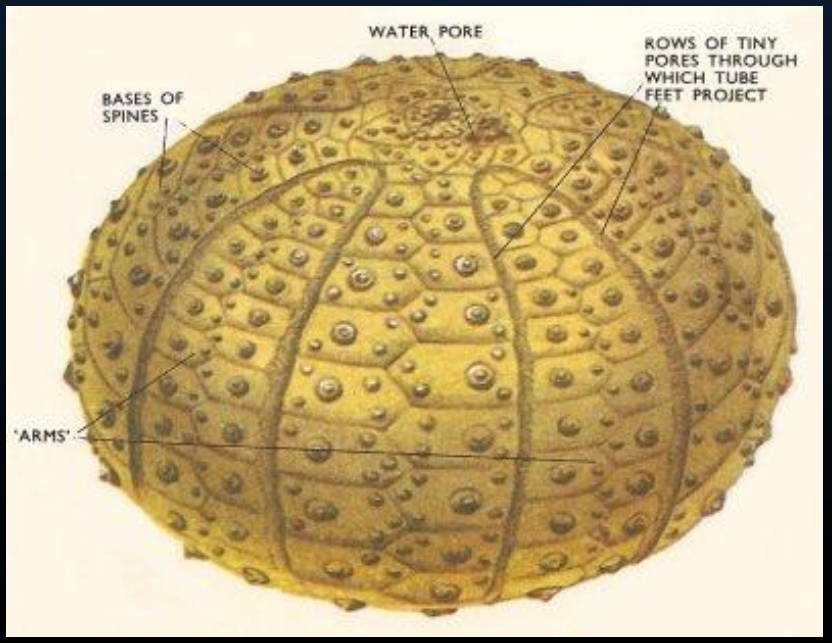
Class Echinoidea

- Sea urchins, heart urchins & sand dollars!
- ~1000 extant species
- Body is spherical or flattened to a disc
- 6-40+cm in diameter

- **Defining characters:**
  - **Ossicles form a rigid test**
  - **Podia pass through ambulacral plates**
  - **Have complex mouthparts called an Aristotle's Lantern**

Echinoid Anatomy

- Ossicles form plates that fit together as an inflexible test
- Grow through addition of calcareous material to edged of existing ossicle & formation of new ossicles
- Podia pass through pores in the ambulacral zone
- <u>Interambulacral zone</u> is devoid of tube feet, spines are prominent
  - 5 ambulacral plates, 5 interambulacral zones
  - Podia have well developed suction cups at ends



Echinoid Anatomy

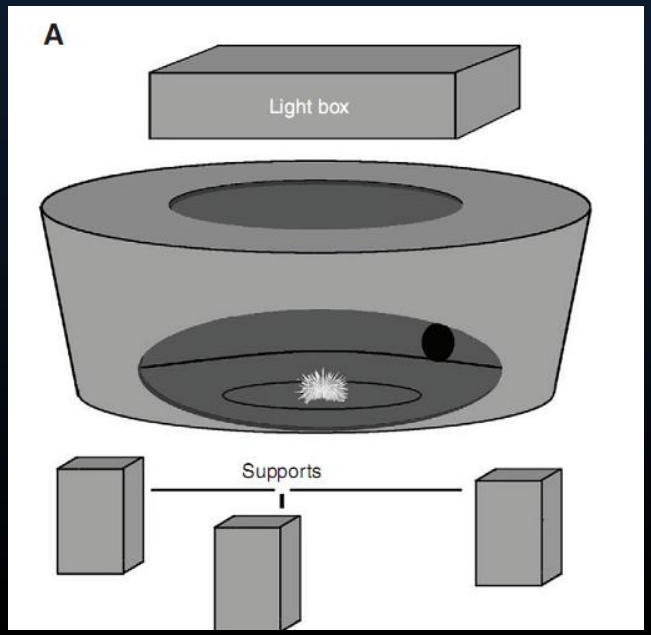
- Aristotle's Lantern
  - Highly developed mouthparts
  - Ossicles & muscles
    - 5 primary ossicles, up to 35
  - Mouth is surrounded by the peristomial membrane & 5 large buccal podia
  - Some may have gill outfoldings around mouth
  - Teeth can protrude from the mouth

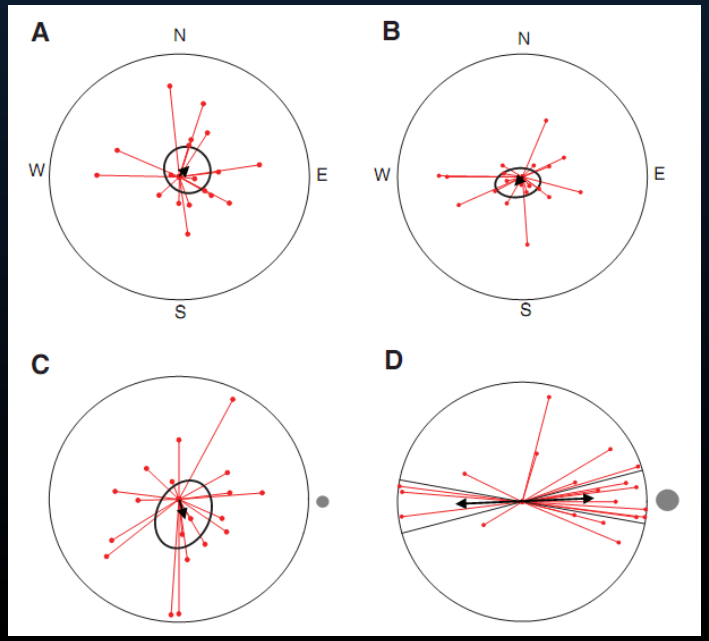
Can Urchins See?

Echinozoa
Echinoidea
Holothuroidea

- Urchins placed in arena with different sized dark circles
- Movement of urchin recorded
- Urchins moved toward/away from larger 10 degree target

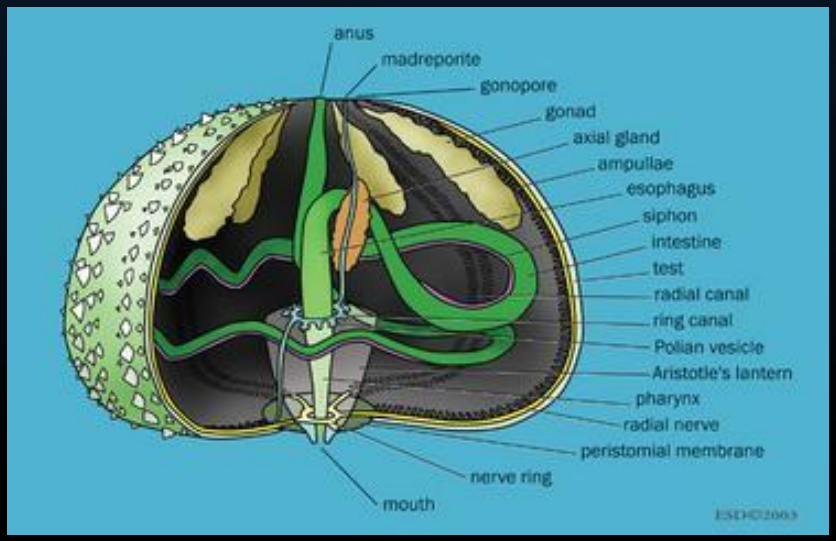
- Have photosensitive test
- Whole body may act like a compound eye





Yerramilli & Johnsen, 2010

Echinoid Feeding & Digestion



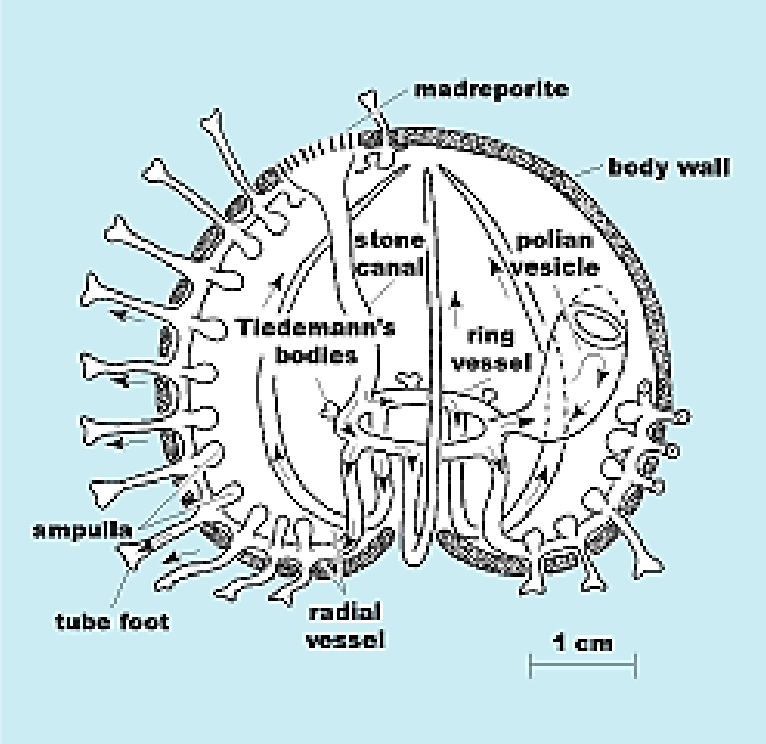
- Most sand dollars are suspension & deposit feeders
- Most urchins are algal grazers
  - Many also eat invertebrates and sediment
- No true stomach
- Anus located aborally

Locomotion

- Urchins
  - Spines & podia used
  - Spines can scrape into rock
  - Urchins hold spines low in high flow
- Sand dollars
  - Use spines instead of tube feet
  - Adapted to soft substrate

Echinoid WVS

- Essentially the same as asteroids!

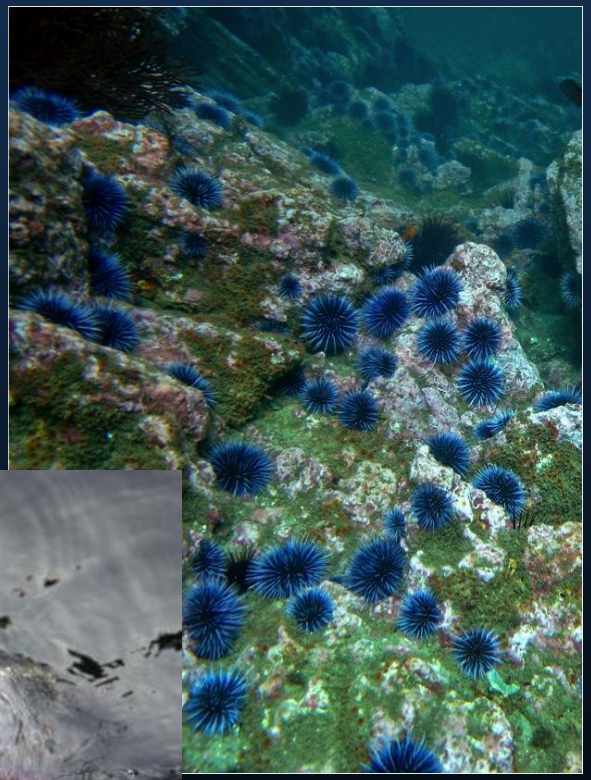


Reproduction

- All dioecious
- Generally 5 gonads
- Gonad empties aborally through gonoduct to gonopore
- Mostly broadcast spawners, some brood

Urchin Ecology

- Urchin barrens
  - Herds of urchins
  - Consume entire kelp forests
  - Reduce diversity of their habitat
  - Often controlled by otters



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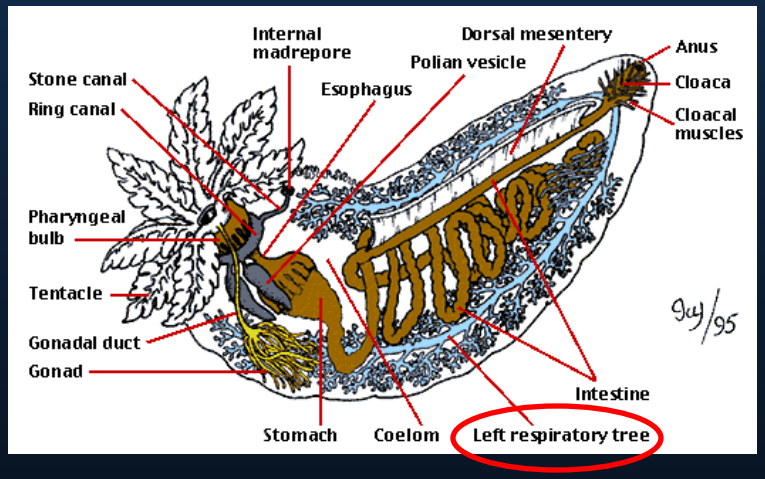
Echinozoa
Echinoidea
Holothuroidea

Subphylum Holothuroidia:

- Defining Characteristics
  - Vermiform body
  - Small ossicles embedded in body wall
  - **Respiratory trees**
- ~1200 species

Respiratory Trees

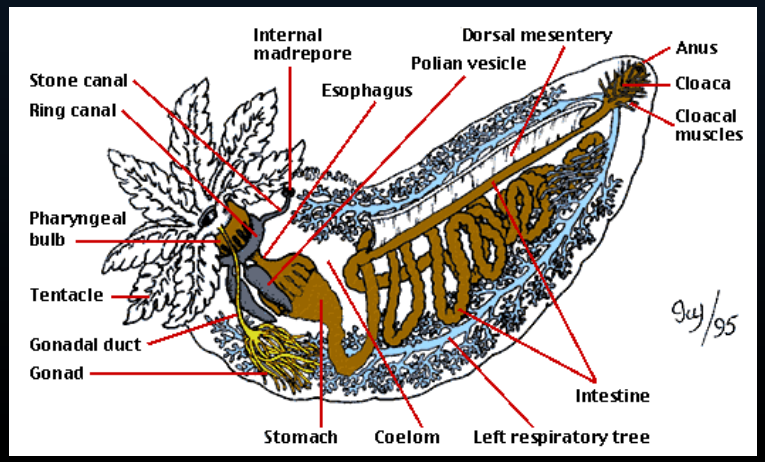


- Specialized respiratory structures
- Paired inside body cavity
- Cloaca pumps water across trees
- Some fish live symbiotically inside cucumber
- Enters through cloaca

Holothuroidian Anatomy

Echinozoa
Echinoidea
Holothuroidea

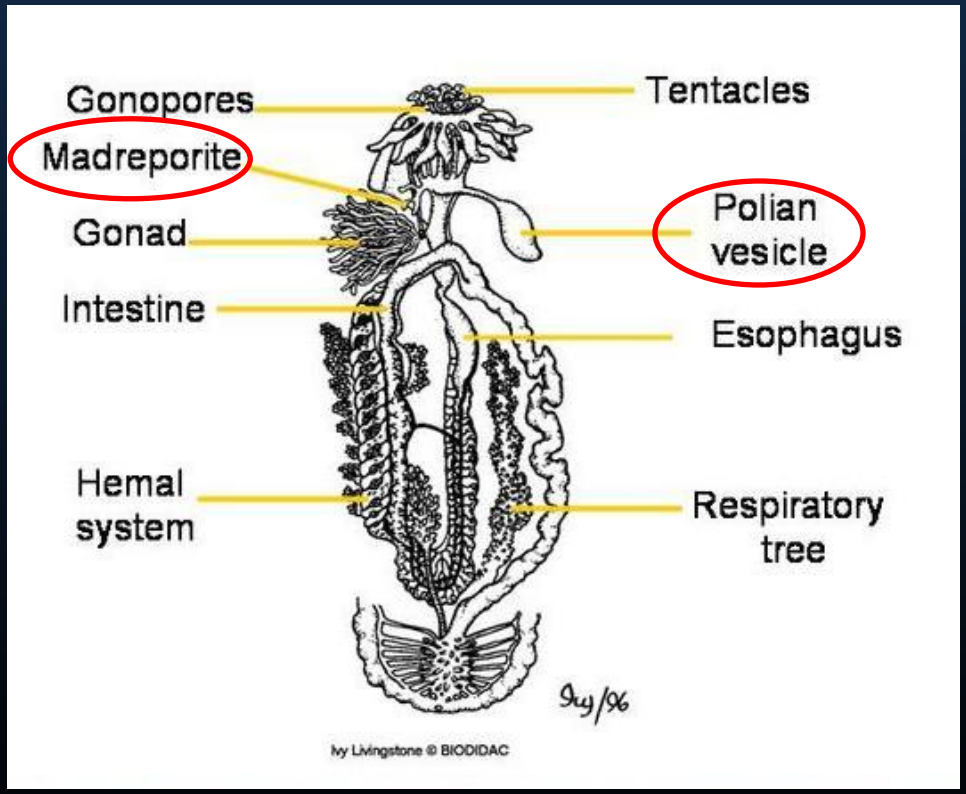
- Most have layers of circular & longitudinal muscles in body
- Podia confined to ambulacral strips
- Mouth surrounded by feeding tentacles
- Cloaca on aboral end used for respiration and waste elimination
- Many body forms!



Echinozoa
Echinoidea
Holothuroidea

Holothuroidian WVS

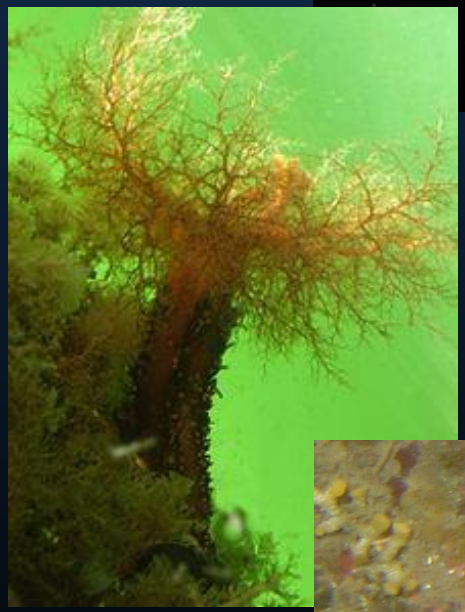
- Similar to other echinoderms
- Ring canal supported by calcareous ring
- Madreporite suspended inside coelem
- Often have large Polian vessicles



Locomotion

Echinozoa
Echinoidea
Holothuroidea

- Generally slow, many sessile
- Pelagic species swim
  - Webbed papillae that form fins
- Burrowing
  - Peristalsis
- Crawl
  - Tube feet
- Drag themselves
  - Buccal podia



Holothuroidian Defense

- Bright coloration
- Fill with water – turgid
- Cuverian tubules
  - Sticky and/or toxic
- True evisceration

Holothuroidian Reproduction

Echinozoa
Echinoidea
Holothuroidea

- Only have one gonad – unique in echinodermata
- Most dioecious
- Mid dorsal gonopore opens between two buccal podia
- Most free spawn, some brood

Holothuroidian Ecology

- Holothuroids comprise large portion of deep sea biomass
- Filter feeders remove particulates from water
- Cucumbers may pass up to 130 kg of substrate through their digestive system per year!