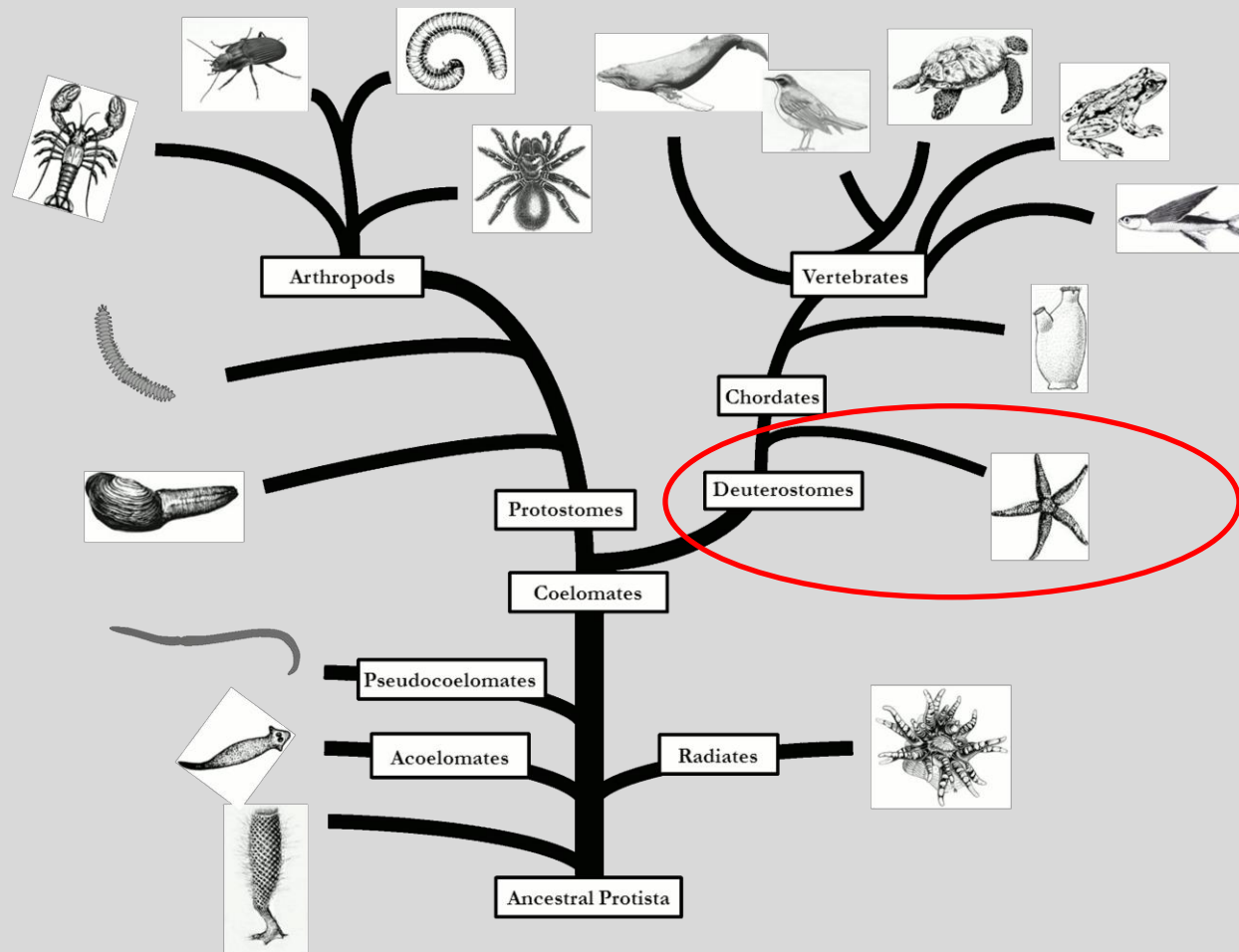


ECHINODERMATA

FISH 310



Where we are...



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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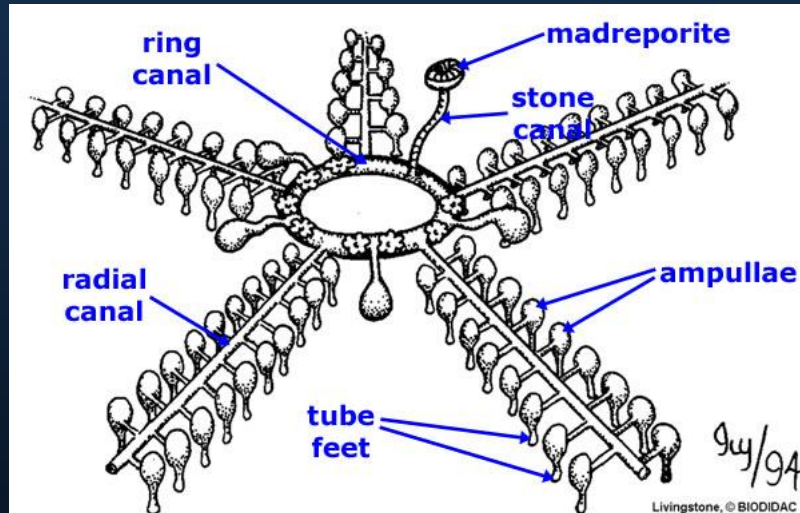
Class Echinoidea – sea urchins & sand dollars

Class Holothuroidea – sea cucumbers

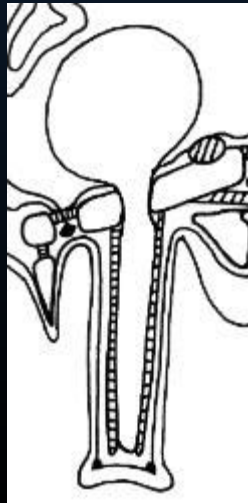
Mutable Connective Tissue (MCT)

- 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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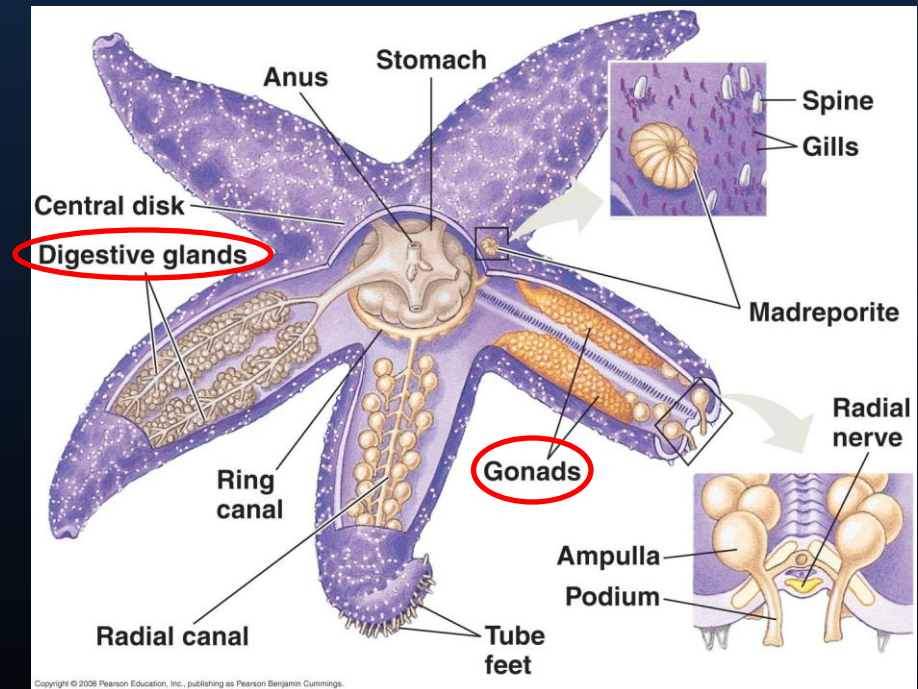
Subphylum Asterozoa: Class Stelleroidea

- 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



Subclass Asteroidea

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



Asterozoa

Asterozoa

Stellerozoa

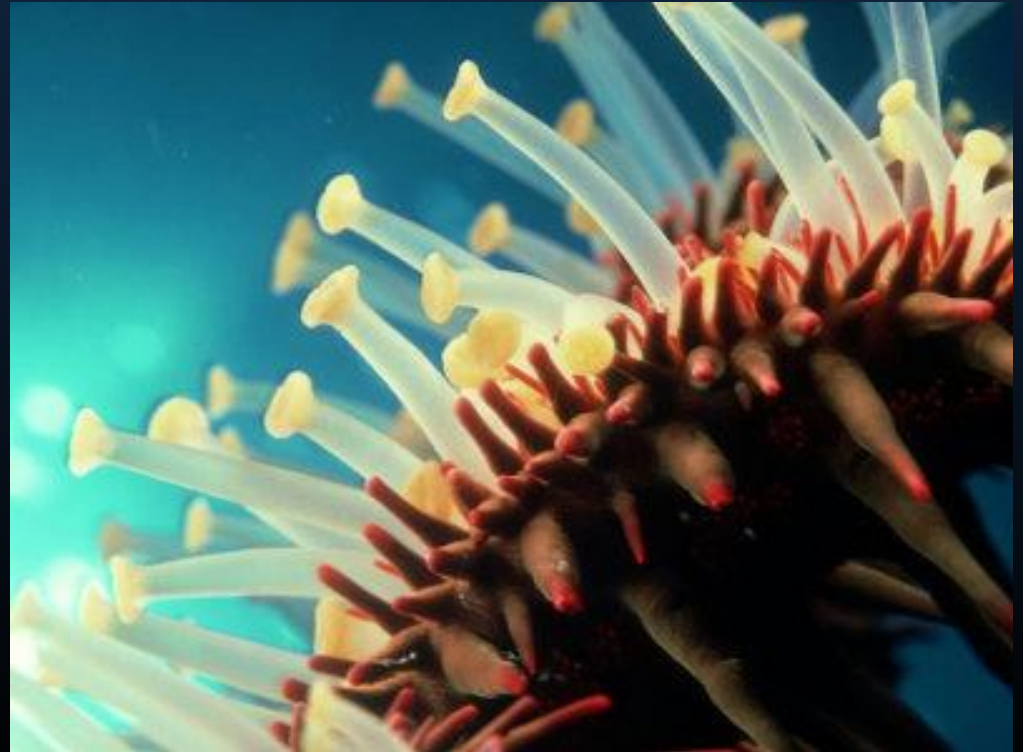
Asterozoa

Ophiurozoa

Asterozoa
Stellerozoa
Asterozoa
Ophiurozoa

- Well developed – used for...

- Locomotion
- Adhesion
- Prey manipulation
- Gas exchange



Asteroidea WVS

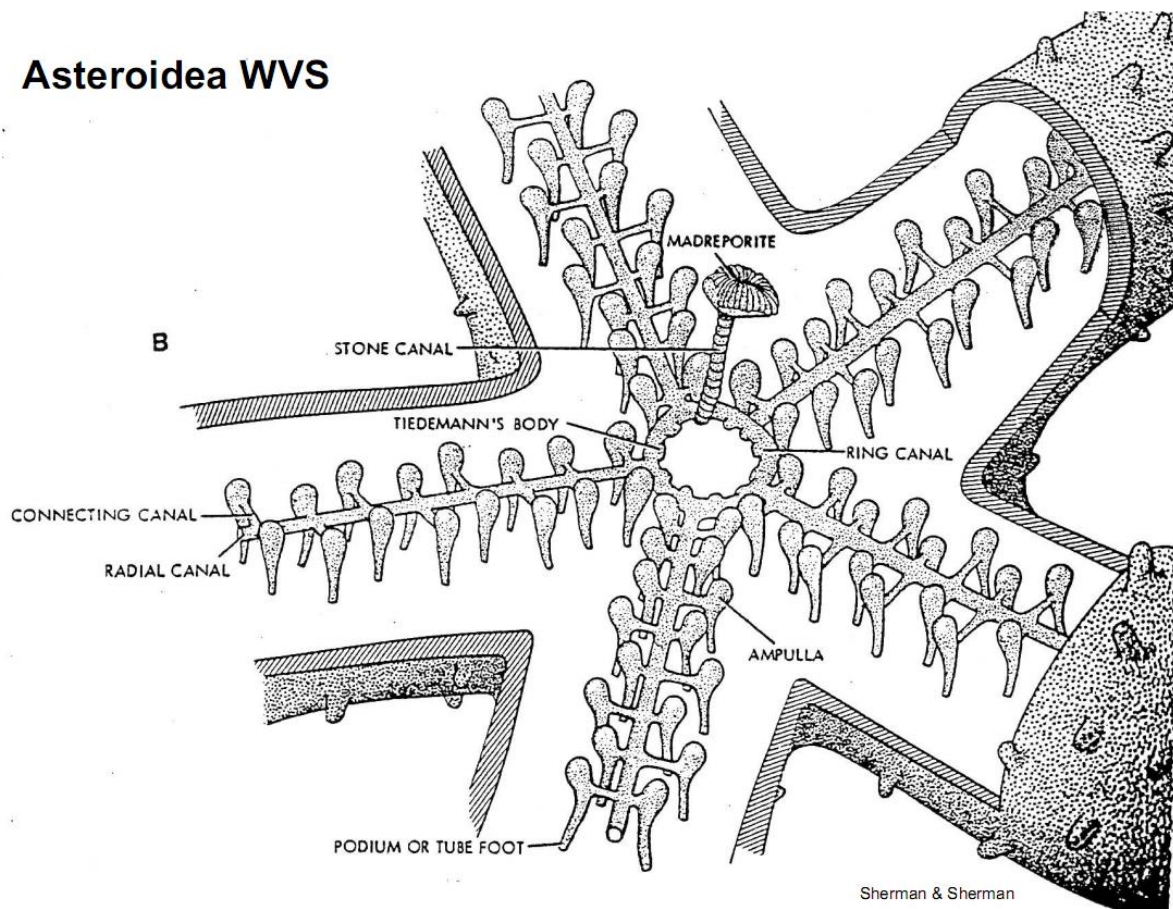
Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

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 – circumoral canal leads to radial canals
- Polian vesicle & 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

Asteroidea WVS



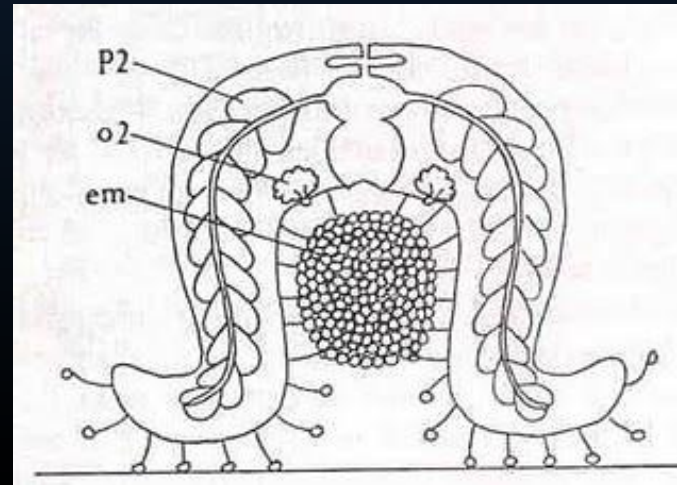
Asteroidea Reproduction

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



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



Asteroidea Defense

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

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



Echinodermata Taxonomy

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Subclass Ophiuroidea – brittle & basket stars

Subphylum Crinozoa

Class Crinoidea – sea lilies & feather stars

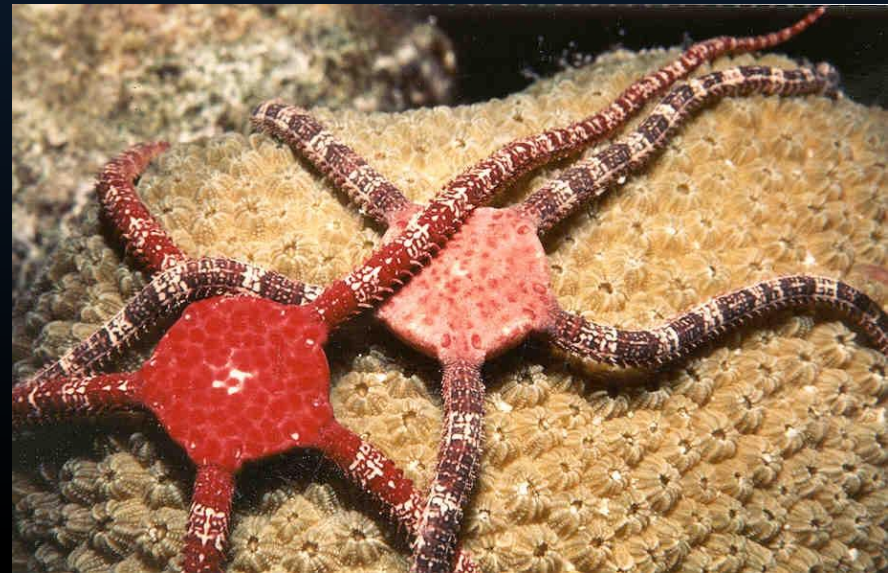
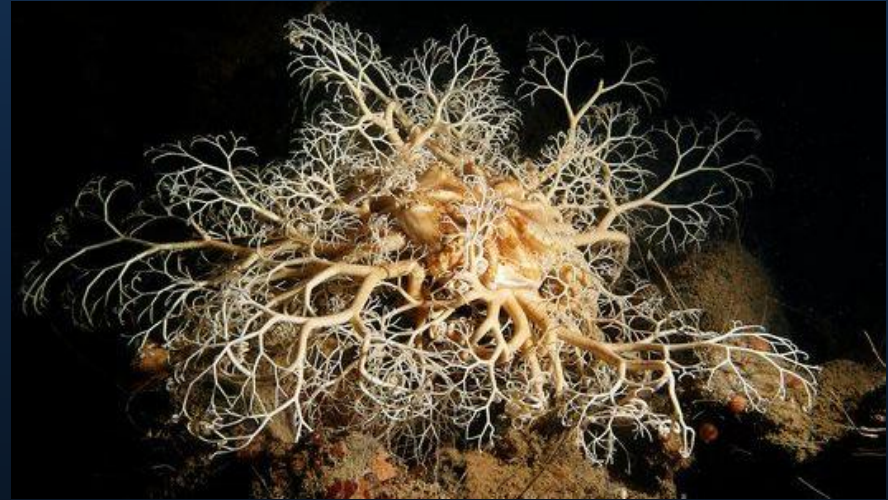
Subphylum Echinozoa

Class Echinoidea – sea urchins & sand dollars

Class Holothuroidea – sea cucumbers

Subclass Ophiuroidea

- 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

Ophiuroid locomotion

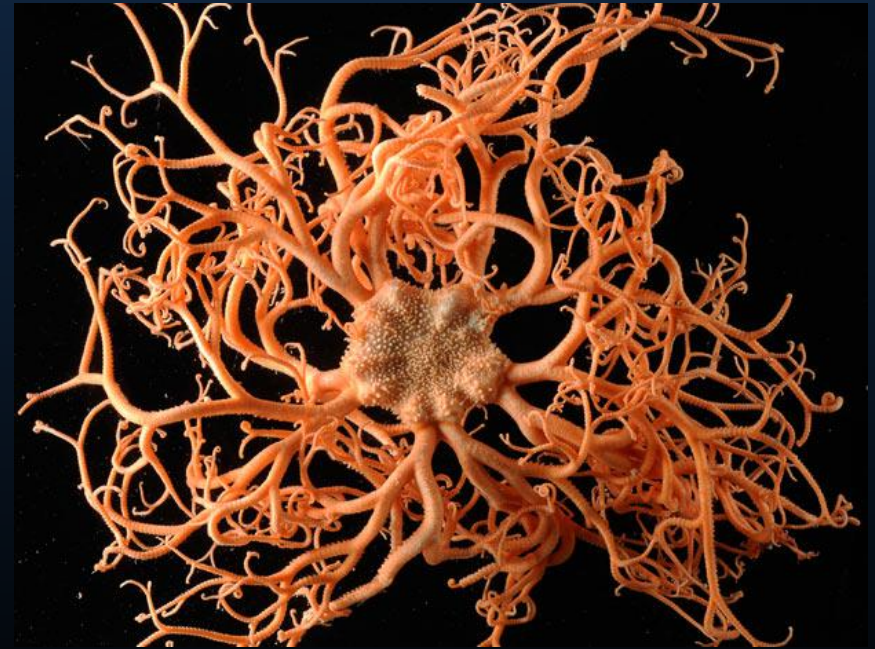
- Fast for echinoderms
- Tube feet rarely used to move, usually only for food manipulation and burrowing
- Brittle stars use long arms to move across the substrate
- Basket stars may brace themselves in position with their arms



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



Carnivory

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

- *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

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



Ecology

Asterozoa
Stelleroidea
Asteroidea
Ophiuroidea

- Globally distributed
- Common in Puget Sound
- Very large biomass in deep soft bottom habitats
 - *Ophiothrix fragilis* can reach densities of 2000/m²



Echinodermata Taxonomy

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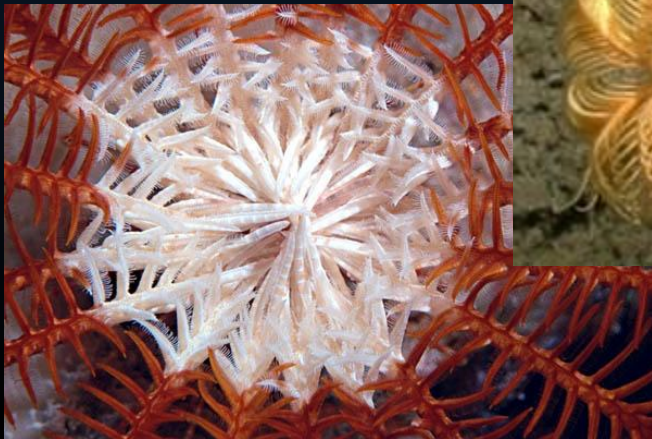
Class Holothuroidea – sea cucumbers

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!

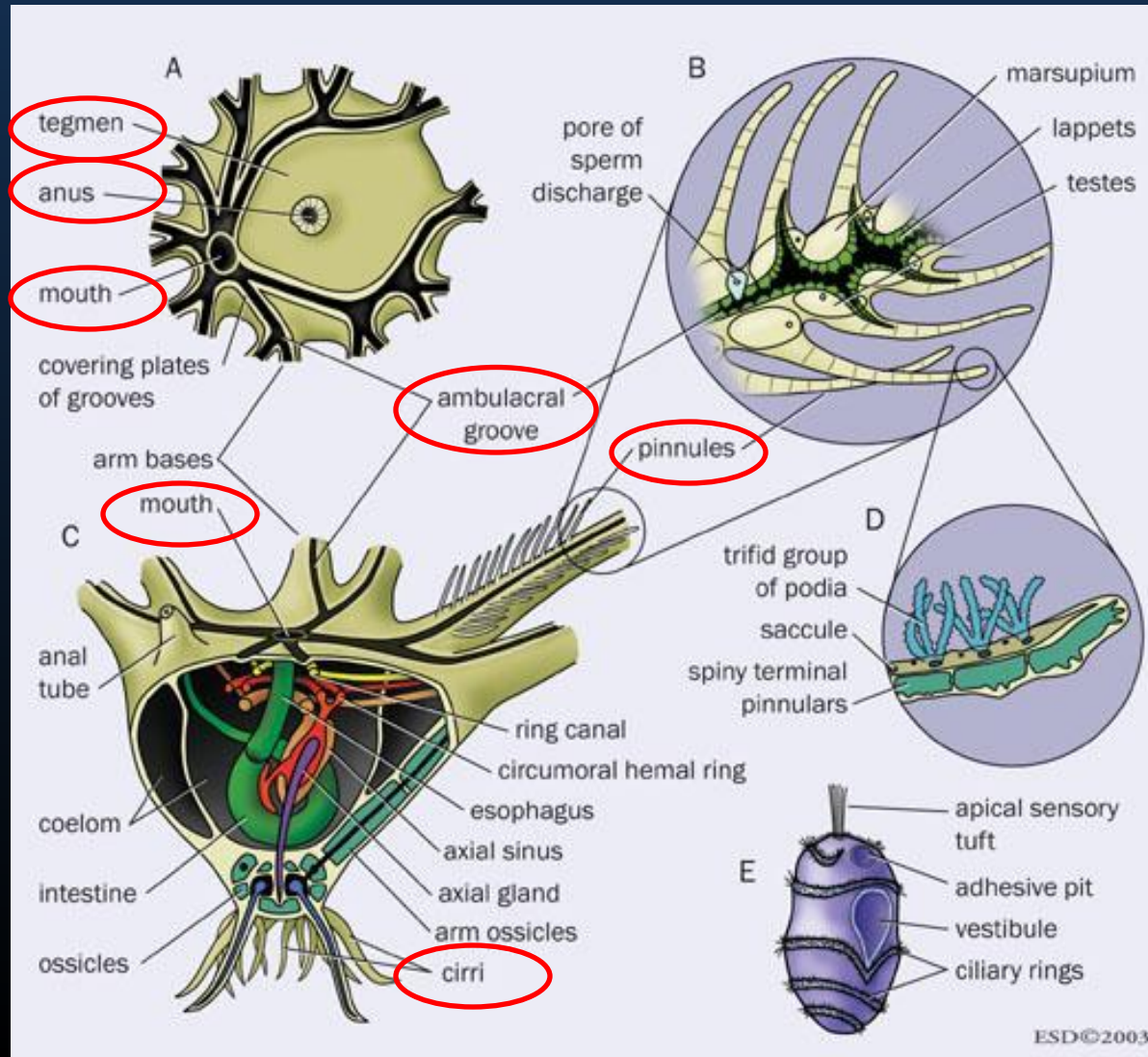


Characteristics

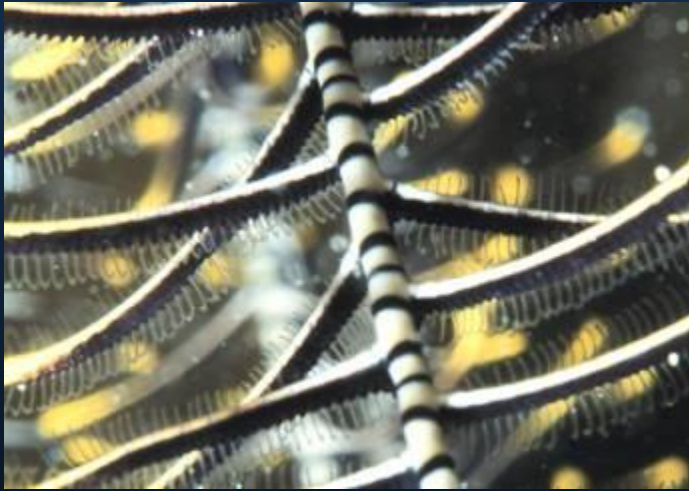


- Stalk or cirri
- (semi)sessile suspension feeders
- Oral surface up
- Food collected with tube feet
- Regeneration
- Often on coral reefs

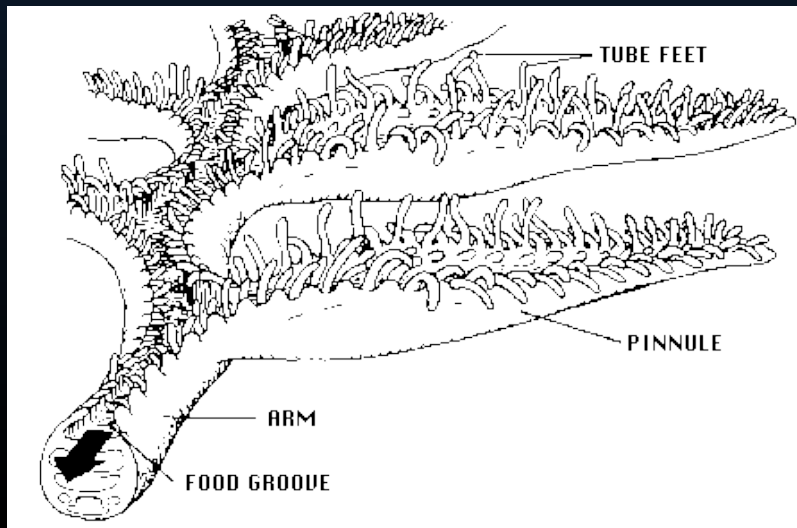
Crinoidea Anatomy



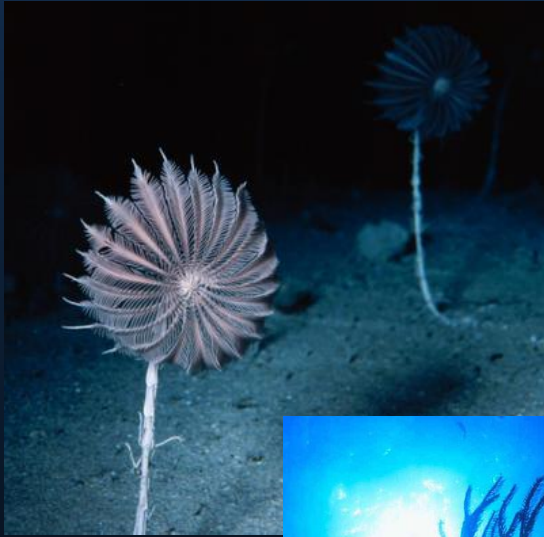
Crinoidea Feeding



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



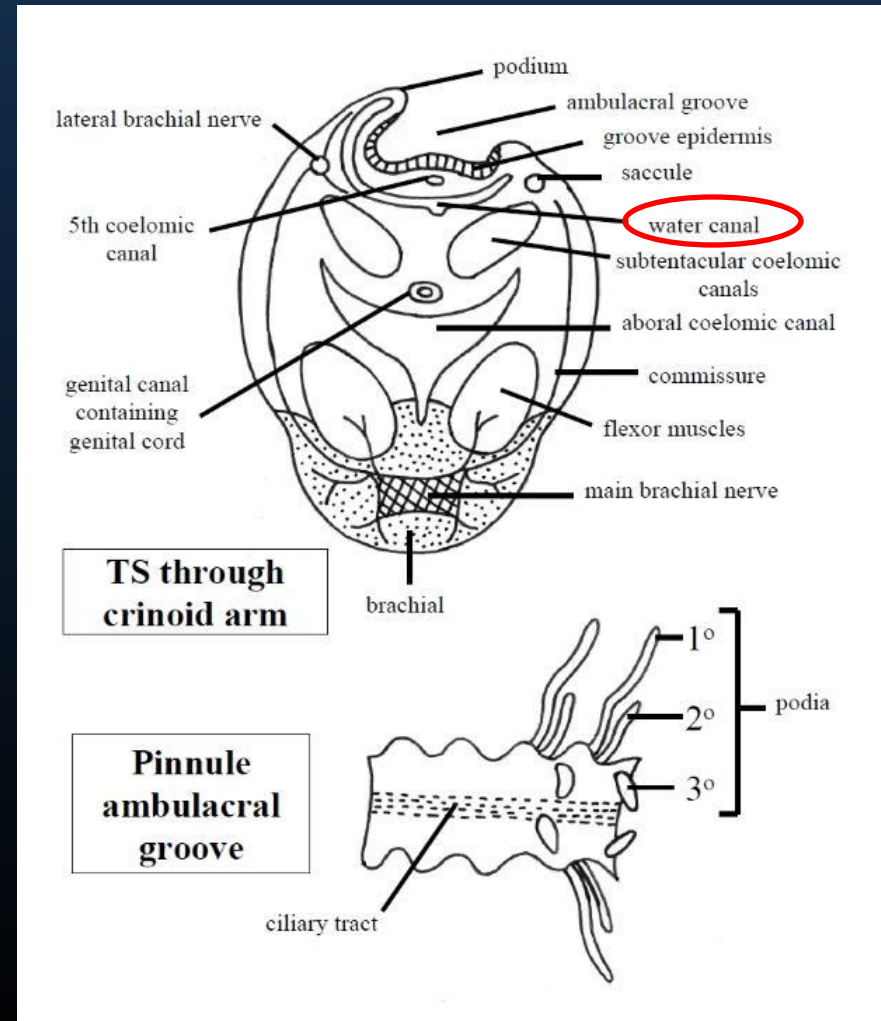
Crinoidea Locomotion



- 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 through 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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Subphylum Echinozoa

Class Echinoidea – sea urchins & sand dollars

Class Holothuroidea – sea cucumbers

Subphylum Echinozoa:

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



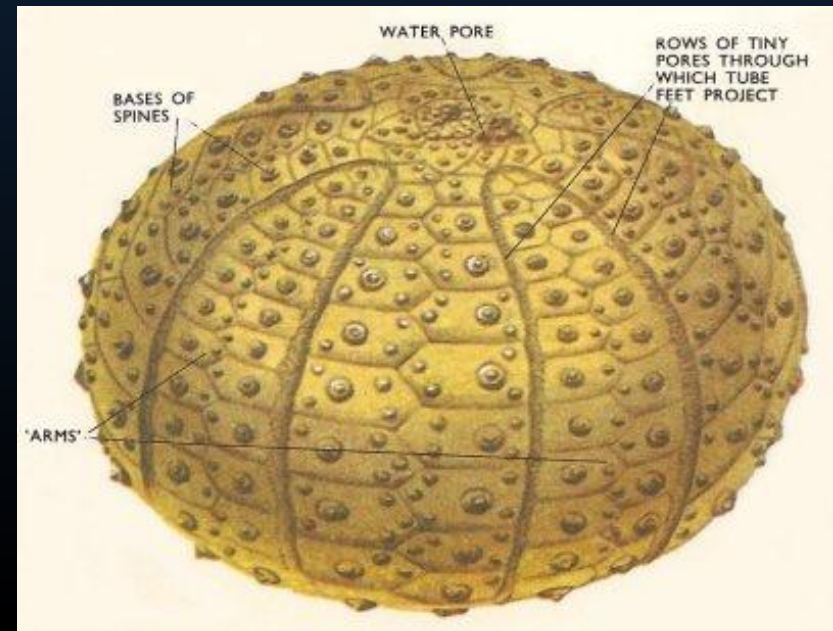
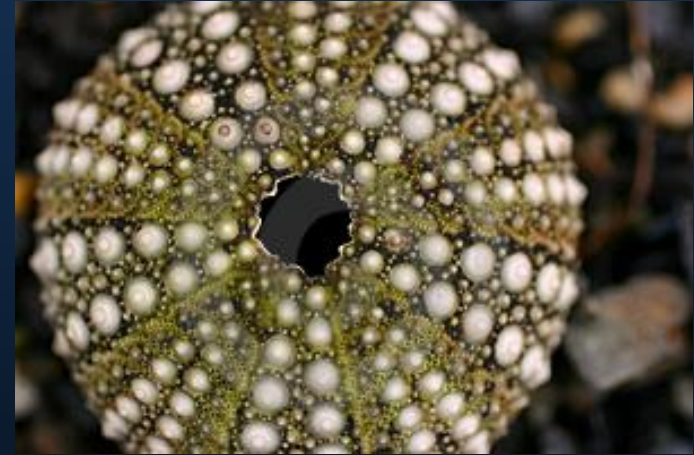
Class Echinoidea



- 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
- Interambulacral zone is devoid of tube feet, spines are prominent
 - 5 ambulacral plates, 5 interambulacral zones
 - Podia have well developed suction cups at ends



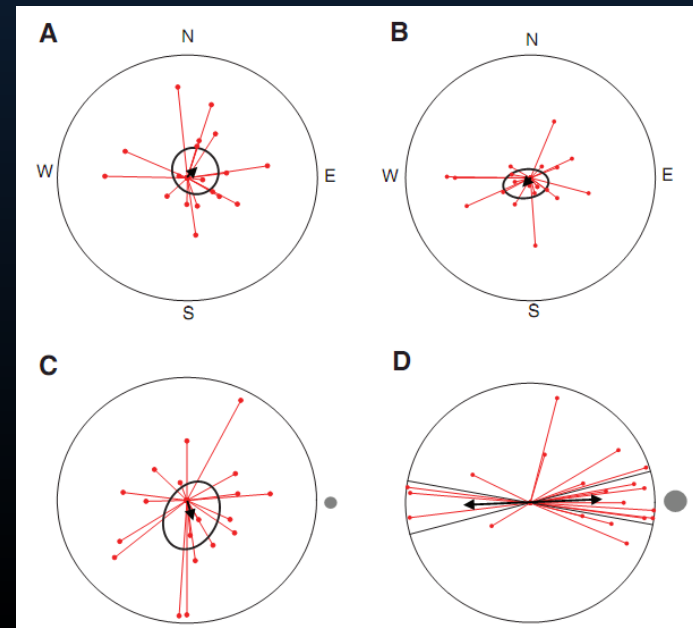
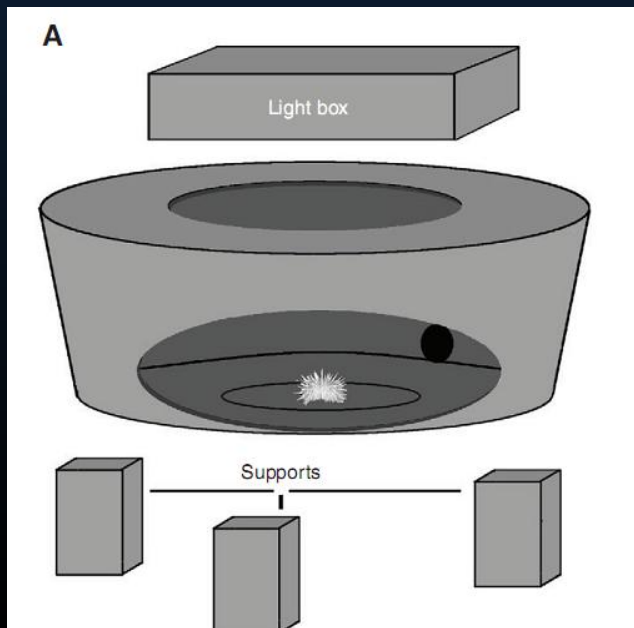
Echinoid Anatomy

- 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?

- 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

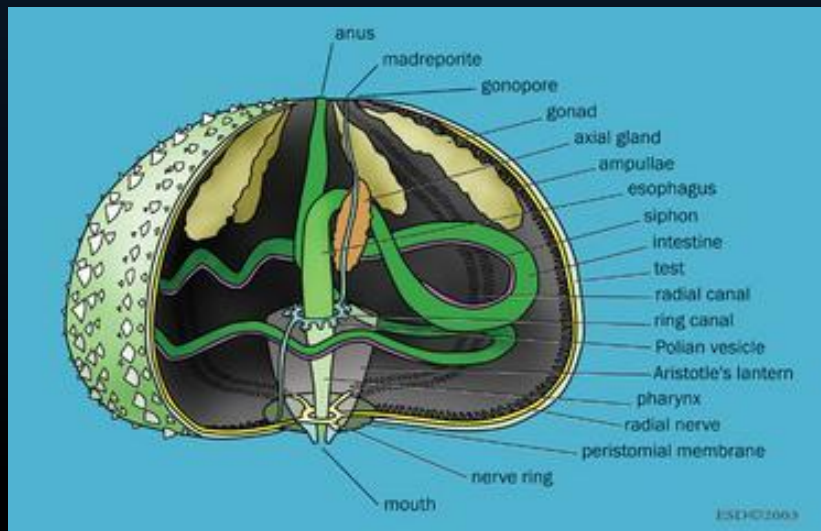


Echinoid Feeding & Digestion

Echinozoa
Echinoidea
Holothuroidea

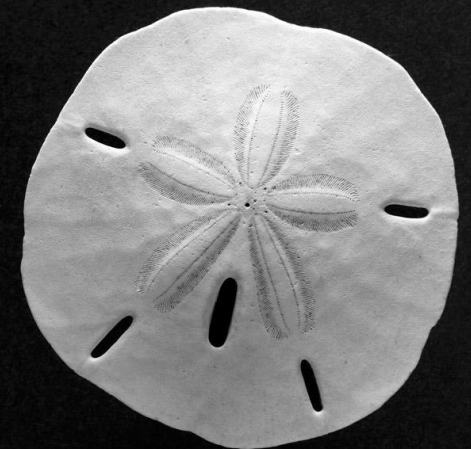


- Most sand dollars are suspension & deposit feeders
- Most urchins are algal grazers
 - Many also eat invertebrates and sediment
- No true stomach
- Anus located aborally



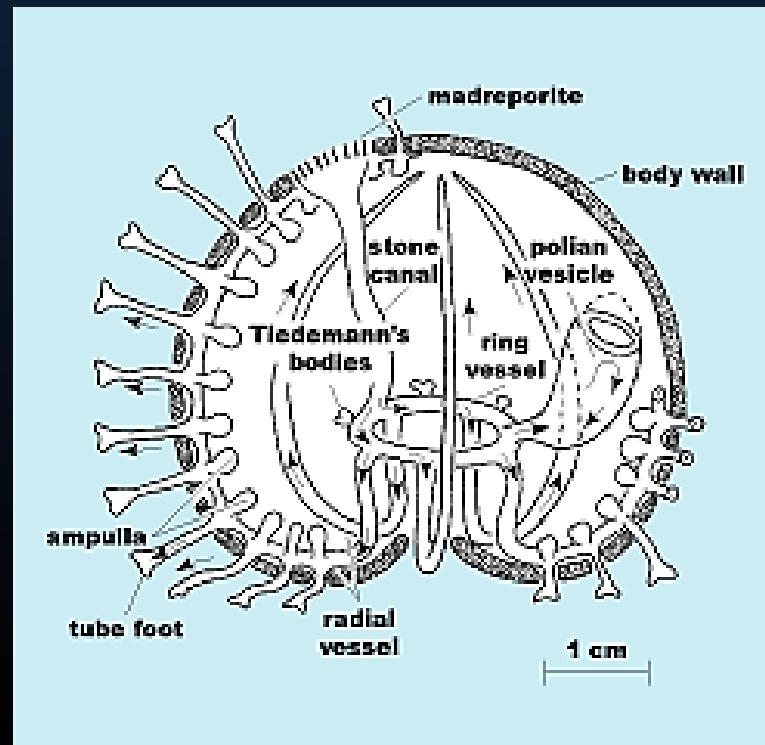
Locomotion

- 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!



Echinozoa

Echinoidea

Holothuroidea

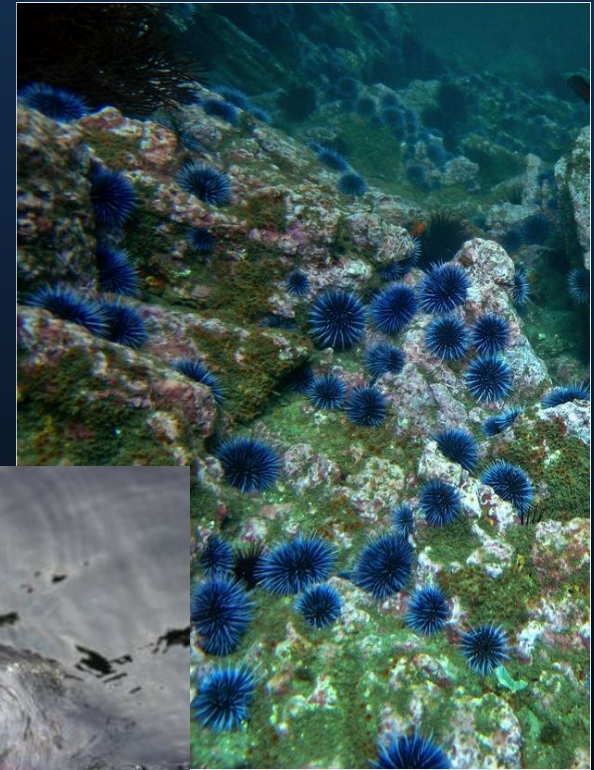
Reproduction



- 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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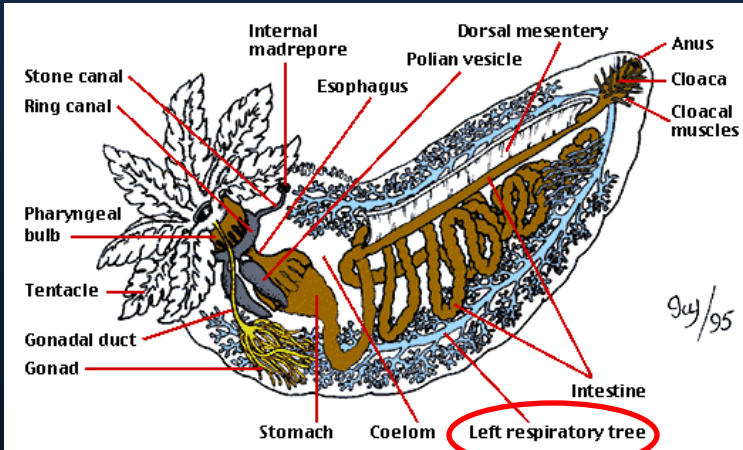
Class Holothuroidea – sea cucumbers

Subphylum Holothuroidea:

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



Respiratory Trees



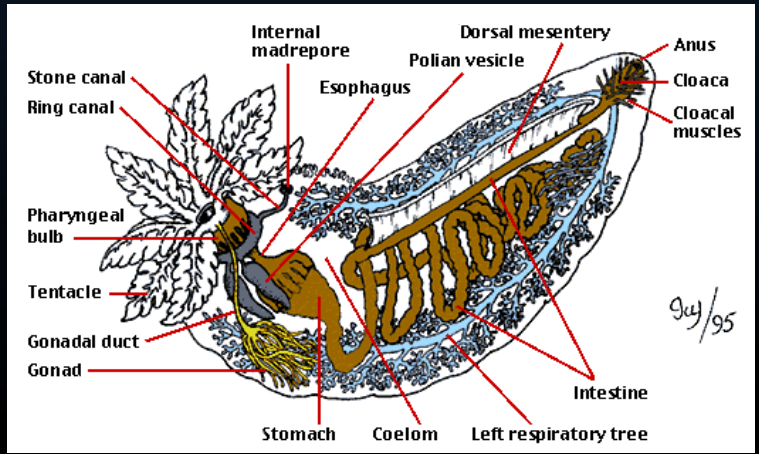
- Specialized respiratory structures
- Paired inside body cavity
- Cloaca pumps water across trees
- Some fish live symbiotically inside cucumber
- Enters through cloaca



Holothuroid anatomy

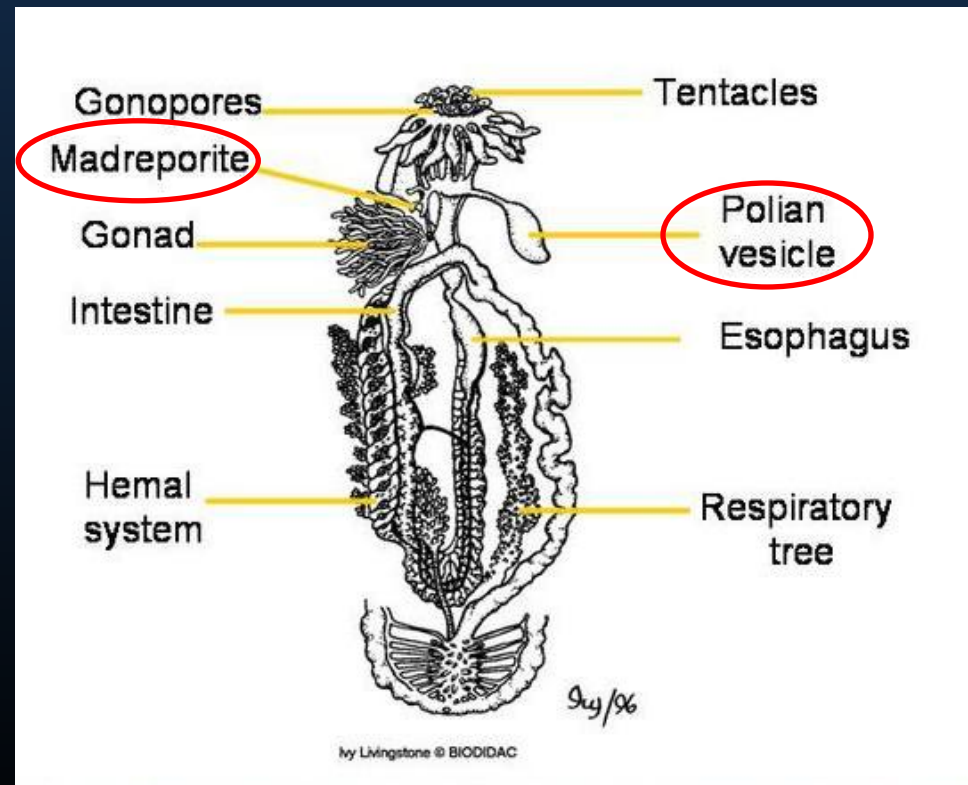
Echinozoa
Echinoidea
Holothuroidea

- 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!



Holothuroidial WVS

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



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

Holothuroid 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!

