ECHINODERMATA
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
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
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

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
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
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
Asteroidea WVS

- Well developed – used for...
  - Locomotion
  - Adhesion
  - Prey manipulation
  - Gas exchange
Asteroidea WVS

Lined by myoepithelium – ciliated and muscular

- **Madreropore** – 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 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

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

- **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

• 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

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

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

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

- tegmen
- anus
- mouth
- covering plates of grooves
- ambulacral groove
- pinnules
- arm bases
- mouth
- anal tube
- coelom
- intestine
- ossicles
- cirri
- pore of sperm discharge
- marsupium
- lappets
- tests
- spiny terminal pinnulars
- trifid group of podia
- saccule
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
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
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

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
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
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
Holothuroidian Anatomy

- 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!
Holothuroidian WVS

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

- 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

- 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 a 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!