Deuterostome Animals
Echinoderms and Chordates
Deuterostome Roots

• We deuterostomes develop butt-first, and we’re proud of it..

• But not many other clades of animals develop this way...
Ancestral protist

- No true tissues
  - Radial symmetry
    - Tissues
      - Bilateral symmetry
        - Protostomes
          - Flatworms
            - Molluscs
              - Cnidarians
                - Sponges
        - Bilateral symmetry
          - Deuterostomes
            - Roundworms
              - Arthropods
                - Echinoderms
                  - Chordates

Figure 17.5
Two major kinds of Coelomates:

- **Protostome** – mouth develops from blastopore.
  Rotifers, Flatworms, Annelids, Molluscs, Arthropods

- **Deuterostome** – anus forms from blastopore.
  Echinoderms, Chordates
Cleavage

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

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

becomes the mouth

Protostomes

Annelida
Mollusca
Onychophora
Arthropoda

becomes the anus

Deuterostomes

Echinodermata
Chordata
Deuterostome Evolution

Based mainly on 18S RNA, Cameron et al. 2000 PNAS 97(9): 4469-4474
Deuterostome Phyla

- **Echinodermata** (sea stars, urchins, crinoids)
- **Hemichordata** (acorn worms, pterobranchs, extinct graptolites)
- **Urochordata** (tunicates, salps)
- **Chordata** (cephalochordates, vertebrates)
Phylum Echinodermata

Sea stars, sea urchins, sea cucumbers, sand dollars

Marine animals with:

- Spiny “skin”
- Water vascular system
- Tube feet
- Endoskeleton plates
- Radial symmetry as adults
- Bilateral symmetry as larvae
Class Asteroidea (Sea Stars)

- Mainly carnivorous – evert stomach to carry out digestion.
- Locomotion mainly by tube feet - arms move only slowly
- Arms are short and thick, with coelomic extensions containing digestive glands and gonads

Sea stars in time lapse
https://www.youtube.com/watch?v=CYN0J3HCihI

Star Fish Eating Clam
https://www.youtube.com/watch?v=4dkieg7F37c

sea-stars eating mussels
https://www.youtube.com/watch?v=2DFXGafpGkQ
- Stomach
- Digestive gland
- Ampulla
- Gonad
- Anus
- Tube feet
- Spine
- Dermal gill
- Pedicellariae
Echinoderm water vascular system
A seastar (*Asterias*) opening a bivalve
Starfish facts: 11 facts about Sea Stars  
https://www.youtube.com/watch?v=l8as-z-EShc

Sea Star Time-lapse: Eating Mussel  
https://vimeo.com/45154593

Zombie Starfish - Nature's Weirdest Events: Series 4  
https://www.youtube.com/watch?v=KrfcgIOmBYw
Class Ophiuroidea - Brittle stars

- central disc containing the organ systems
- arms longer, more slender than sea stars
- use arms for locomotion, capable of rapid movement by muscle action
- tube feet lack suckers
- No anus.
- Deposit, detritus, and suspension feeders
Class Echinoidea (sea urchins, et al.)

- Globular or flattened, 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)
Class Holothuroidea - Sea Cucumbers

- Elongated flexible bodies, propelled by 3 to 5 rows of tube feet
- Circle of modified tube feet surrounds mouth
- Gut has branches for respiration

Sea Cucumber
https://www.youtube.com/watch?v=vsLBOkYLLLel

Sea Cucumber Fights with Guts
https://www.youtube.com/watch?v=wXf_YodWw40

Sea Cucumber expelling its intestines
https://www.youtube.com/watch?v=aCxKFc3XtJs

Seaview Science Video: Sea Cucumbers
https://www.youtube.com/watch?v=MVNrbyU-Vck
Class Holothuroidea - Sea Cucumbers
Class Holothuroidea
sea cucumbers
Class Holothuroidea - Sea Cucumbers

• Tube feet around mouth form feeding tentacles, gather food and transfer to mouth.

• Gut has branches for respiration, and Cuvierian threads expelled for defense
Class Crinoidea - Sea lilies, feather stars

- Feather stars (unstalked) and sea lilies (stalked, attached).
- Globular body (calyx) partially encased in skeletal plates
- Exaggerated, branched arms used for suspension feeding
- Oral surface turned upward
- Greatest diversity in Paleozoic
Crinoids

- Flexible arms
- Calyx (cup)
- Bead-like columnals
- Column (stem)
- Holdfast
Ancestral protist

No true tissues

Radial symmetry

Tissues

Bilateral symmetry

Protostomes

Sponges

Cnidarians

Molluscs

Flatworms

Annelids

Roundworms

Arthropods

Echinoderms

Chordates

Deuterostomes
Phylum Chordata

- ~45,000 species, 97% of them are vertebrates
  - Subphylum Urochordata
  - Subphylum Cephalochordata
  - Subphylum Vertebrata
Deuterostome Evolution

Based mainly on 18S RNA

Cameron et al. 2000 PNAS  97(9): 4469-4474,
The invertebrate chordates

The chordates include all of the vertebrates (fish, amphibians, reptiles, mammals and birds), but also two non-vertebrate subphyla:

- the Urochordata
- the Cephalochordata

never develop a vertebral column
Characteristics of the Chordata

• bilaterally symmetrical
• triploblastic
• have a well developed coelom
• have a complete digestive system
Characteristics of the Chordata

- Notochord
- Dorsal, tubular nerve cord
- Pharyngeal pouches or gill slits
- Post anal tail (extends beyond anus)

Not all of these characteristics are apparent in adult organisms and may appear only in the embryonic or larval stages.
Chordate Body Plan

- Brain
- Dorsal, tubular nerve cord
- Notochord
- Postanal tail
- Mouth
- Pharynx (gill) slits
- Heart
- Intestine
- Anus
- Muscular segments
Notochord

- **Notochord**: the notochord is a flexible, rodlike structure. It extends the length of the body and is an anchor point for muscles.

- The notochord bends without shortening so it permits the animal to undulate.
Notochord

• In nonvertebrates and the jawless vertebrates the notochord is present throughout life.

• However, in the jawed vertebrates it is replaced by the vertebral column; the remnants of the notochord being found in the intervertebral disks.
Chordates

– Chordates consists of three groups of invertebrates:
  • Tunicates, or sea squirts, also lack a cranium
  • Lancelets are bladelike animals without a cranium.
  • Hagfishes are eel-like forms that have a cranium.
– All other chordates are vertebrates.
Hagfish
Tunicates
Subphylum Urochordata

- Marine animals with tough tunics
- Suspension-feeders
- Adult is sessile and feeds via pharyngeal slits
- Larvae are free swimming
  - dorsal tubular nervous system
  - notochord and
  - gill slits
Sea squirts (Class Asciidiacea, Tunicates)
- Adults are marine, sessile, filter feeding organisms that live either solitarily or in colonies.

*Ciona intestinalis* (a solitary sea squirt)
Tunicate larvae (tadpole)

Free-swimming,
- dorsal tubular nervous system
- notochord and
gill slits

Searches for a place to settle and then attaches and metamorphoses into an adult
Salps

- Barrel-shaped, planktonic tunicates, drift through the open ocean
- Moves by contracting, thus pumping water through its gelatinous body

Giant Pyrosome and Salps - pelagic sea squirts
https://www.youtube.com/watch?v=5EQGA_4BZ5s

Sea Salps
https://www.youtube.com/watch?v=-Jooz4gz264
Garstang’s hypothesis of chordate larval evolution

- In the 1920’s it was proposed that the vertebrates were derived from an ancestral ascidian that retained its characteristics into adulthood (the process by which juvenile characteristics are retained into adulthood is referred to as paedomorphosis).
Garstang’s hypothesis of chordate larval evolution
Garstang’s hypothesis of chordate larval evolution

• Garstang’s hypothesis is supported by embryological evidence, but more recently molecular analyses have suggested that sessile ascidians are a derived form and that the free-living Cephalochordates are more likely to be the closest relatives of the chordates.
Subphylum Cephalochordata - Lancelets

- Invertebrates most similar to vertebrates
- Small segmented fishlike animals that inhabit sandy sediments of coastal waters.
- Lack a distinct head and have no cranium
- Burrowing filter-feeders
- 29 species
Subphylum Cephalochordata: the lancelet

Amphioxus (Branchiostoma)
Subphylum Cephalochordata: the lancelet

Amphioxus *(Branchiostoma)*
Amphioxus

- Amphioxus is a filter feeder.
- Water enters the mouth and then is moved by beating cilia through the pharyngeal slits, where food is trapped in mucus. Cilia then move the food to the gut.
Amphioxus

- Amphioxus is considered to be the closest living relative of the vertebrates
- Shares several characteristics with vertebrates that Urochordates do not possess.
  - Segmented blocks of striated muscle
  - Dorsal and ventral aortas
  - Branchial (gill) arches (blood vessels running over the gills)
Pikaia

- Paleozoic fossil, 505 MYA
- Rod running along its back resembled a backbone-like structure.
- Markings on the sides typical shape of chordate muscle bundles
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End