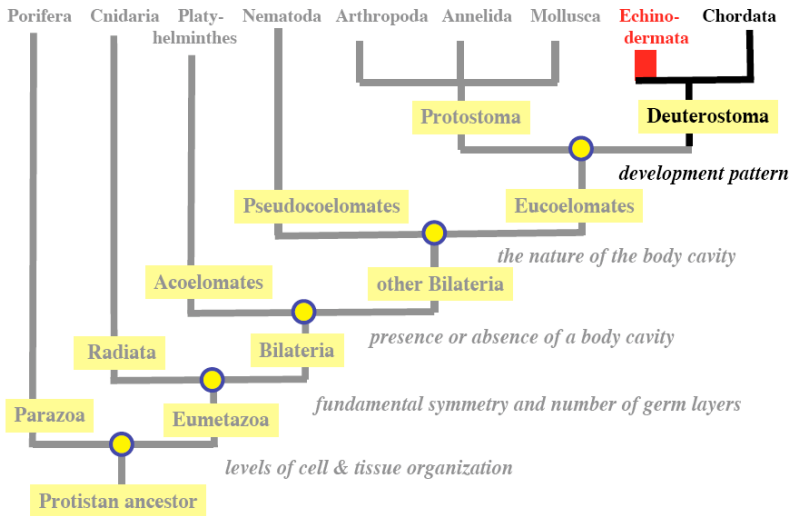


## The deuterostomes: Echinoderms and Chordates



## The deuterostomes: Echinoderms and Chordates

ECHINODERMS: phylum Echinodermata ("spiny skin")

About 7,000 species, all marine substrate dwellers (larvae planktonic). Adults are usually sedentary or slow-moving.

Unique features (besides deuterostomate development) are:

- **Internal (dermal) skeleton** (endoskeleton) made of ossicles of  $\text{CaCO}_3$ . In some species these are movable (spines that can be pointed).
- **Pentaradial symmetry** (in most forms). After coelom formation the larva goes through a bilaterally symmetric stage which develops asymmetrically.
- **Internal water vascular system**, derived from coelom. Used in locomotion and other functions. Connects to **podia** (short 'tentacles' or arms, often with grasping ends) – also called **tube feet** – that extend from animal.

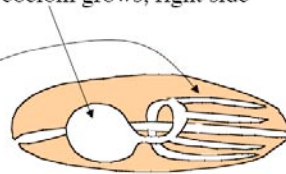
## The deuterostomes: Echinoderms and Chordates

ECHINODERMS: phylum Echinodermata ("spiny skin")

Larval development is very complicated.

After coelom formation via enterocoely, larva is bilaterally symmetrical, but then develops asymmetrically:

- at early metamorphosis, left side of coelom grows, right side degenerates
- subsequently, coelom forms 5 branches that guide growth pattern to produce adult symmetry
- further growth and metamorphosis yields an adult form that show **secondary radial symmetry** based on five body 'sectors': **pentaradial** symmetry

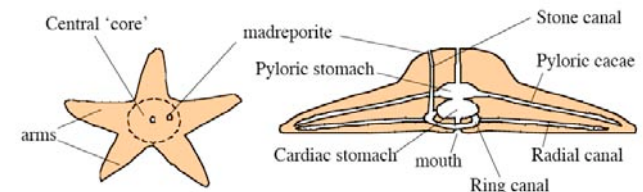


## The deuterostomes: Echinoderms and Chordates

ECHINODERMS: phylum Echinodermata ("spiny skin")

There are 5 classes of echinoderms; we consider 3:

Class **ASTEROIDEA** (sea stars) [class **Ophiuroidea**, brittle stars, is similar; class **Crinoidea** resemble sea stars but have more 'feathery' arms and may be sessile with stalks (sea lilies) or mobile (feather stars)]



Radial and ring canals, stone canal: **water vascular system**, opening to outside is madreporite

Cardiac & pyloric stomachs, pyloric caecae: processing food, distributing nutrients

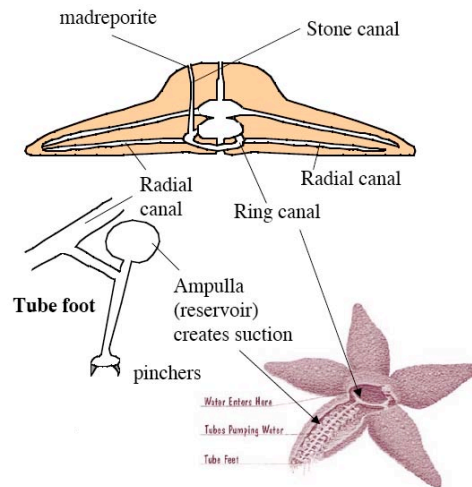
## The deuterostomes: Echinoderms and Chordates

ECHINODERMS: phylum Echinodermata ("spiny skin")

- Simple nerve net (arranged **pentaradially**) and some central coordination of movement.

- Tube feet**, connected to radial canals; individually controlled. Each tube foot contains muscles and nerves; some have pinchers and others act by suction (ampullae help create it). Animal has hundreds of tube feet.

- Seastars are predators or scavengers; feed by everting stomach onto prey and secreting digestive enzymes. Can be "top predators" on molluscs and crustaceans.

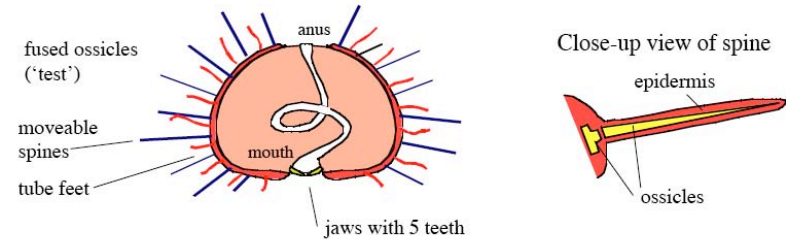


## The deuterostomes: Echinoderms and Chordates

ECHINODERMS: phylum Echinodermata ("spiny skin")

**Class ECHINOIDEA (sea urchins and sand dollars)**

- pentaradial symmetry but lacks arms
- tube feet in 5 rows and there are 5 teeth
- ball-shaped (sea urchins) or flattened disks (sand dollars)



## The deuterostomes: Echinoderms and Chordates

ECHINODERMS: phylum Echinodermata ("spiny skin")

**Class ECHINOIDEA (sea urchins and sand dollars)**

Sea urchins are grazing animals (mainly on plant matter) with a complex jaw structure.



Sand dollars are suspension filter feeders; look like flattened sea urchin without spines.



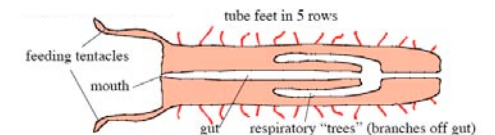
## The deuterostomes: Echinoderms and Chordates

ECHINODERMS: phylum Echinodermata ("spiny skin")

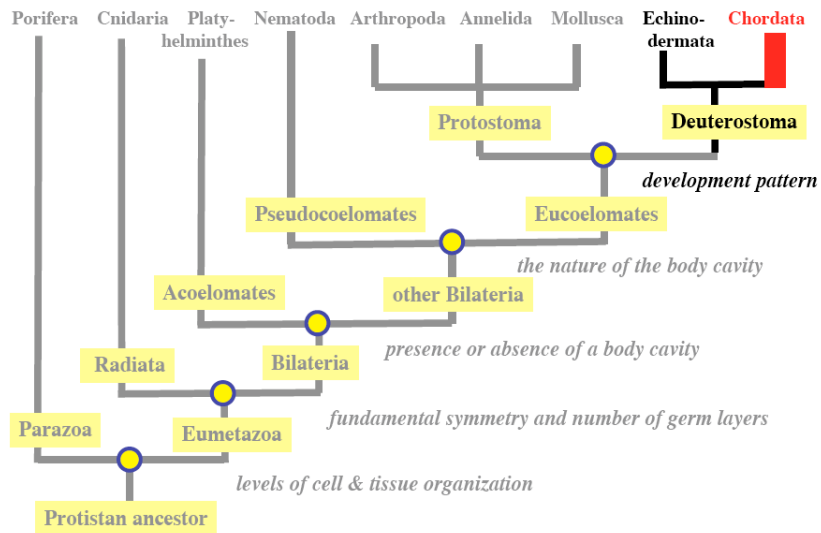
**Class HOLOTHUROIDEA (sea cucumbers)**

- pentaradial symmetry and the water vascular system (5 rows of tube feet)
- Some of the tube feet around the mouth are modified into large feeding tentacles
- lack spines and much of the dermal ossicles
- elongate

Sea cucumbers live in burrows or crawl around on the sea bottom; feed on debris in sand or mud



## The deuterostomes: Chordates

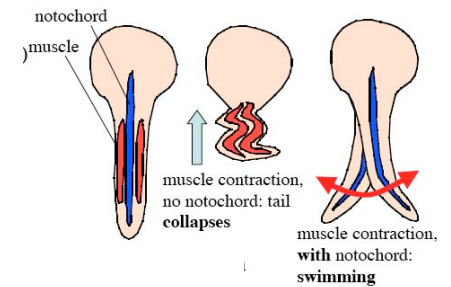


## CHORDATES: phylum Chordata

About 70,000 species, highly variable in body form, in nearly all habitats. All have typical deuterostome development (indeterminate radial cleavage, coelom forms by enterocoely) and these diagnostic characters:

- **notochord**: longitudinal flexible rod extending rearwards from “head”; **viscoelastic** support element

- **dorsal hollow nerve cord** (nerve cords **ventral** in protostomes)
- **pharyngeal slits** (gill slits) openings in the pharynx (“throat”)
- **post-anal tail**, usually muscular
- often some evidence of **segmentation** (but not in all classes)



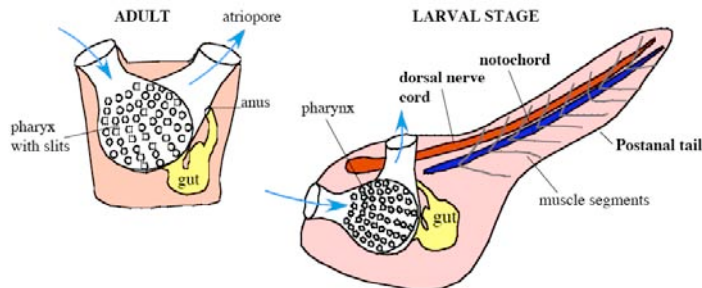
In some groups, some or all of these characters only appear in development or in larval stages – not in adults.

Three major subphyla: **Urochordata**, **Cephalochordata**, **Vertebrata**

## CHORDATES: phylum Chordata

**Urochordata** (tunicates; sea squirts)

Adult tunicates are sessile filter feeders that don't much resemble “typical” chordates, although they do have the pharyngeal slits:



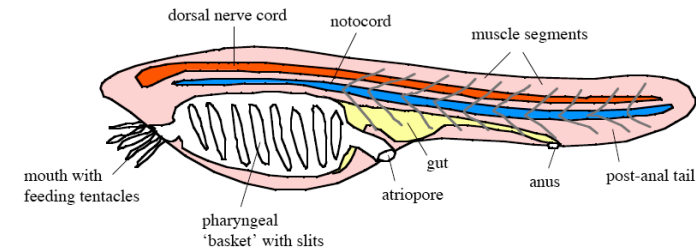
However, larval stage (mobile) show **all typical chordate characters**.

- Recent data suggest only a few genes may be responsible for the loss of the tail during metamorphosis

## CHORDATES: phylum Chordata

**Cephalochordata** (lancelets—including the very famous *Branchiostoma*, formerly known as “Amphioxus”)

- show all the typical chordate characters throughout life
- extremely similar to larval tunicates.



Lancelets are small (a few cm long) and live buried in sand with the head and mouth exposed. Water is pumped through the pharyngeal basket, filtering out food particles. Animals can swim (or dig) by lateral contractions of the tail.

## CHORDATES: phylum Chordata

**Vertebrata** (vertebrates; about 40,000 species)

Vertebrates probably evolved from Urochordates or a similar ancestral group. Vertebrates have the basic chordate body plan, with a few important modifications:

- pharyngeal slits reduced or absent in adult, in most forms
- **segmented vertebral column**, for support; most groups also show evidence of segmentation in muscle groups
- in most classes, **paired appendages** (usually 2 pairs)
- **skull** at front, more cephalization
- **Neural crest** forms with dorsal nerve cord from neural tube during development, eventually becomes skull parts, etc.

Several classes; evolution started with aquatic forms

## CHORDATES: phylum Chordata

**Vertebrata** (vertebrates; about 40,000 species)

Extremely diverse in form, function, ecology, etc.

- aquatic, terrestrial, burrowing, aerial forms
- elaborate appendages (fins, legs, wings) or none (snakes)

But great underlying similarities in development, biochemistry, and genetics:

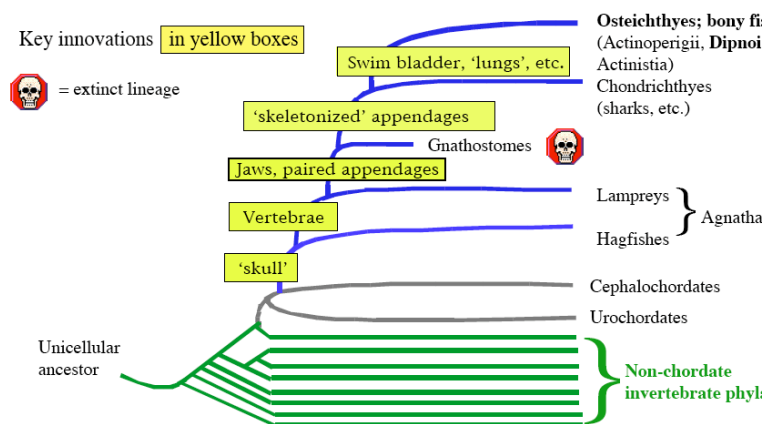
- All vertebrates have about the same number of genes (~20,000 to 25,000)
- Most of these genes are found in all vertebrates, but have somewhat different sequences and functions in the different vertebrate groups.

• Examples: chicken – human DNA sequence is about 75% identical; the puffer fish genome is about 72% identical with the genomes of chickens and humans; rodent and human genomes are about 88% identical.

## CHORDATES: phylum Chordata

**Vertebrata** (vertebrates; about 40,000 species)

Approximate phylogenetic history of aquatic vertebrate evolution:



## CHORDATES: phylum Chordata

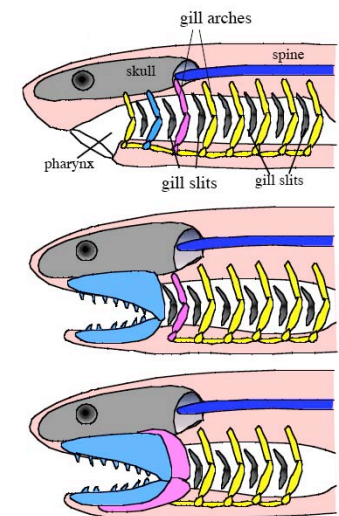
Evolution of the jaw from ancestral gill structures:

**Agnathans:** no body jaws; feed by sucking up dead flesh (hagfish) or rasping skin and feeding on blood or juices (lampreys).

Hinged bony jaws (first seen in the extinct **Placoderm** fishes) powered by strong muscles were a major advance: allowed animals to consume large prey.

Jaws evolved from the body supports of the anterior gill arches (derived from **pharyngeal slits**). Some skull bones and the bones of the inner ear are also derived evolutionarily from gill arches.

Trend is for loss or modification of arches and gill slits to simpler form.



# CHORDATES: phylum Chordata

Approximate phylogenetic history of **terrestrial vertebrate** evolution, with key features for life on land

**Birds, mammals** (and **dinosaurs**, which may be different enough from reptiles to merit separate classification) represent refinements of metabolism, locomotion, and reproduction from reptile ancestors.

