

An introduction to the taxonomy of the Echinodermata

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Classification of the Phylum Echinodermata in the Animal Kingdom

How is animal classification achieved?

1. Body symmetry



Spherical

Any plane passing through the center divides a body in mirrored halves



Radial

More than two planes passing through the longitudinal axis can divide a body in mirrored halves

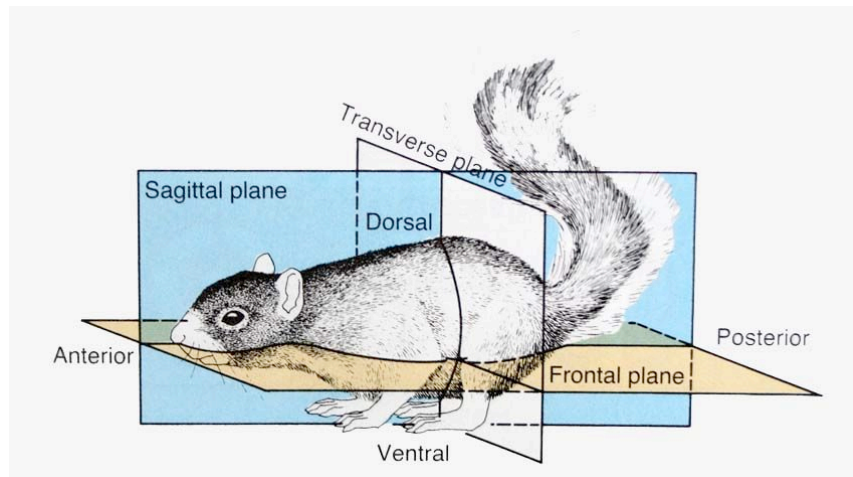


Bilateral

A sagittal plane divides into two mirrored halves (left and right)

Radiata and Bilateria

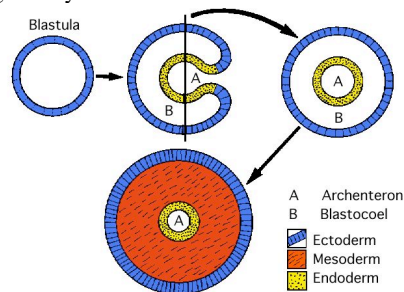
Terminology commonly utilized for bilaterally symmetrical animals



Classification of the Phylum Echinodermata in the Animal Kingdom

How is animal classification achieved?

1. Body symmetry (asymmetric, spherical, radial, bilateral)
2. Developmental pattern:
 - a. number of germ layers



Diploblastic and Triploblastic animals

Classification of the Phylum Echinodermata in the Animal Kingdom

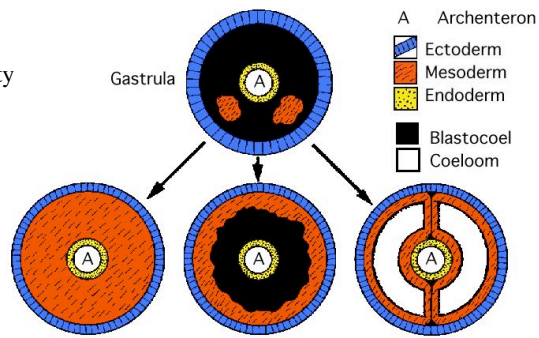
How is animal classification achieved?

1. Body symmetry (asymmetric, spherical, radial, bilateral)
2. Developmental pattern:
 - a. number of germ layers
 - b. presence of coelomic cavity

Possibility 1:
Mesoderm cells completely fill the blastocoel

Possibility 2:
Mesoderm cells only line the outer edge of the blastocoel

Possibility 3:
Space opens inside the mesoderm

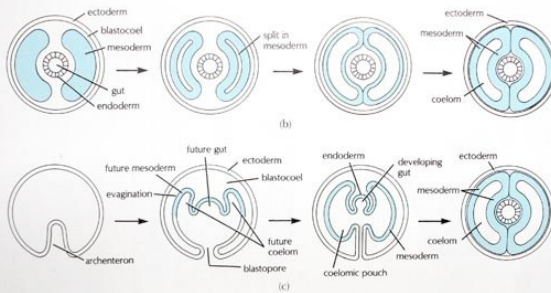


Acoelomates, pseudocoelomates and coelomates

Classification of the Phylum Echinodermata in the Animal Kingdom

How is animal classification achieved?

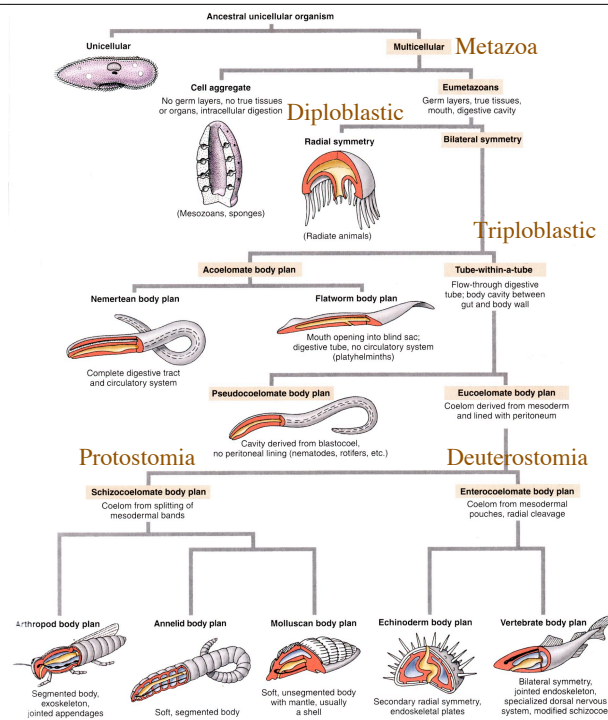
1. Body symmetry (asymmetric, spherical, radial, bilateral)
2. Developmental pattern:
 - a. number of germ layers
 - b. presence of coelomic cavity
 - c. mode of coelom formation



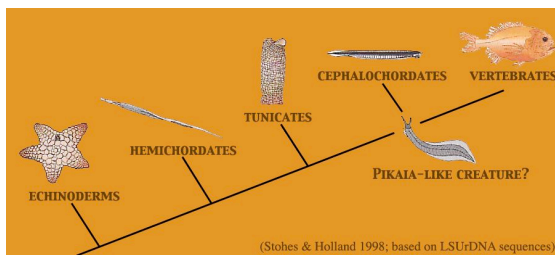
Possibility 1 - Schizocoely
Coelom formation by gradual enlargement of split in mesoderm

Possibility 2 - Enterocoely
Coelom formation through evagination of the archenteron

Where does that place Echinodermata in the Animal Kingdom?



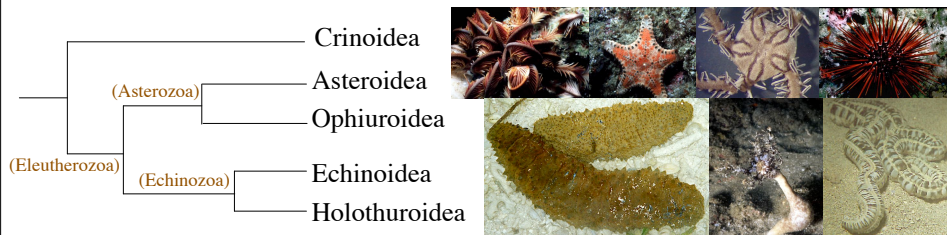
Where does that place Echinodermata in the Animal Kingdom?



Deuterostome lineage sister to hemichordates & chordates

- anus develops from blastoporus; mouth developing elsewhere
- enterocoelous coelomates
- radial, indeterminate cleavage
- endomesoderm, mesoderm derived from endoderm

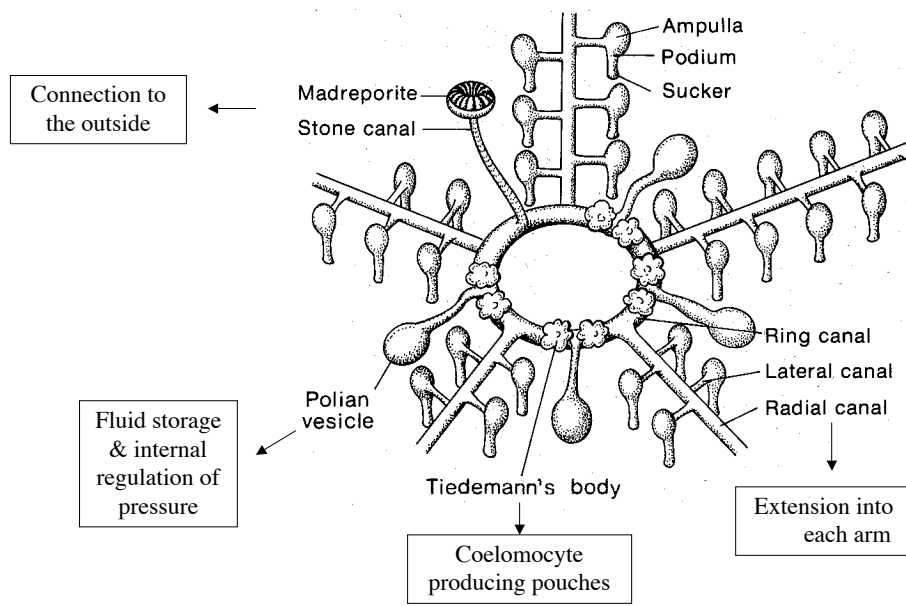
Five extant classes (after Janies 2001)



Characteristics of Phylum Echinodermata

- Latin *echinatus*, prickly & Greek *derma*, skin + *ata*, characterized by
- Highly diverse (some 6,500 extant species belonging to 5 classes: some 13,000 extinct species belonging to, at least, another 16 classes), **successful** (invaded all of the marine realm) & **ancient phylum** (at least since the Cambrian, 560 mya)
- Three defining unique characteristics:
 - a complex system of fluid-filled channels, the water-vascular system, derived from a coelomic compartment
 - secondary derived (bilateral larvae) pentamerous radial symmetry in adults
 - calcareous endoskeleton derived from mesodermal tissue
 - mutable connective tissue or catch tissue allowing for rapid and drastic alteration of its stiffness

The water-vascular system (here: Asteroidea)



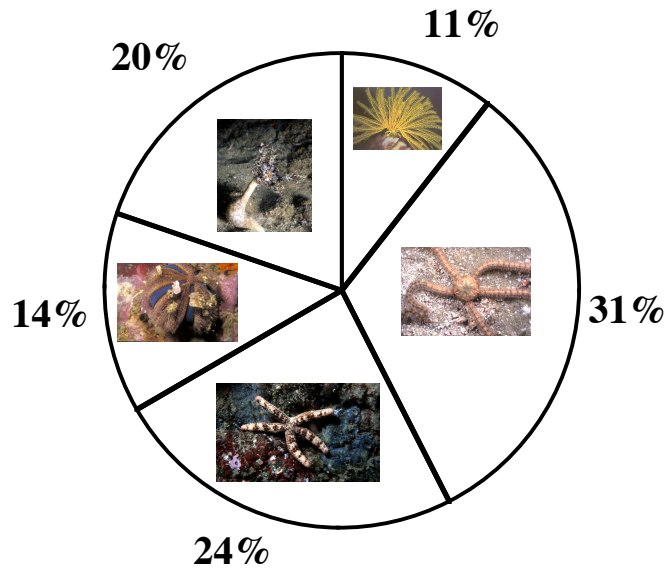
Mutable connective tissue



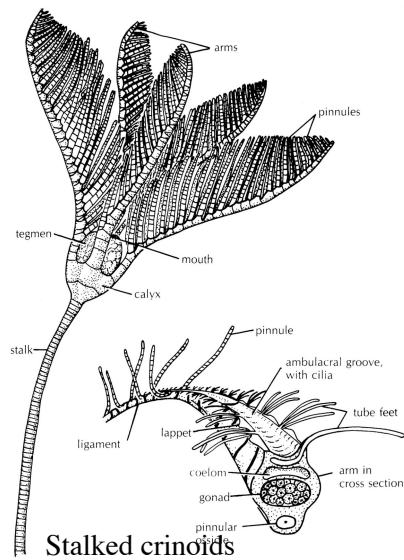
Other, non-unique characteristics of Phylum Echinodermata

- Body unsegmented with five (or more) radiating area, *ambulacra*, alternating with *interambulacra*;
- *No cephalization*; poorly developed nervous system; sensory system of tactile and chemoreceptors, podia, tentacles, photoreceptors and statocysts;
- Complete digestive system; anus absent in ophiuroids;
- Blood-vascular system (*hemal system*) much reduced, functionality remains poorly known (transport of nutrients from coelome to gonad?);
- Respiration by dermal branchiae, tube feet, respiratory trees (holothuroids) and bursae (ophiuroids);
- *Excretory organs absent*; although a cilia-driven nephridial system occurs in the larvae
- Mostly *dioceus* (few hermaphroditic); gonad multiple in most (single in holothuroids); *external fertilization*; development through free-swimming bilateral larval stages (some with direct development); subsequent metamorphosis
- Large *regeneration capacity*

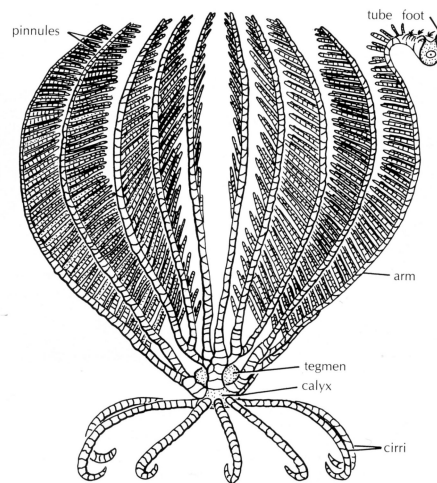
The five classes of extant echinoderms



Class Crinoidea - sea lilies & feather stars



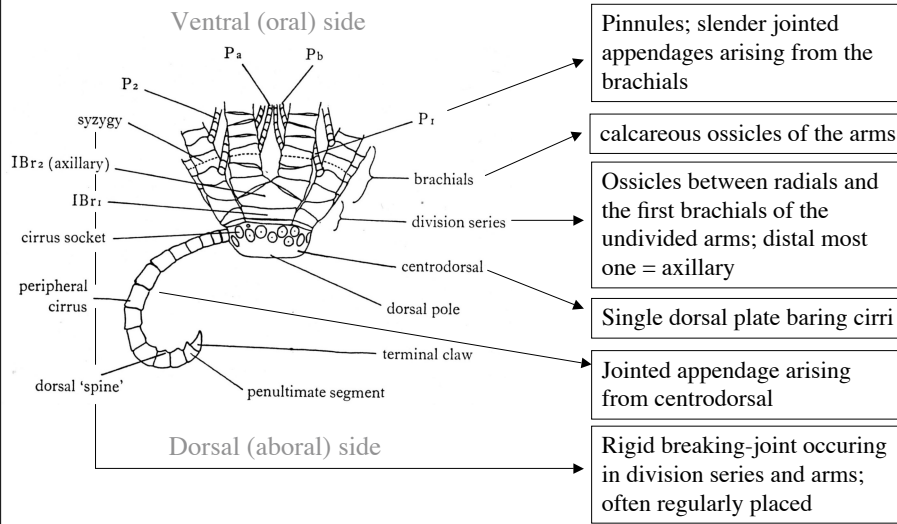
Stalked crinoids
(~100 species)



Non-stalked, motile comatulids
(~600 species)

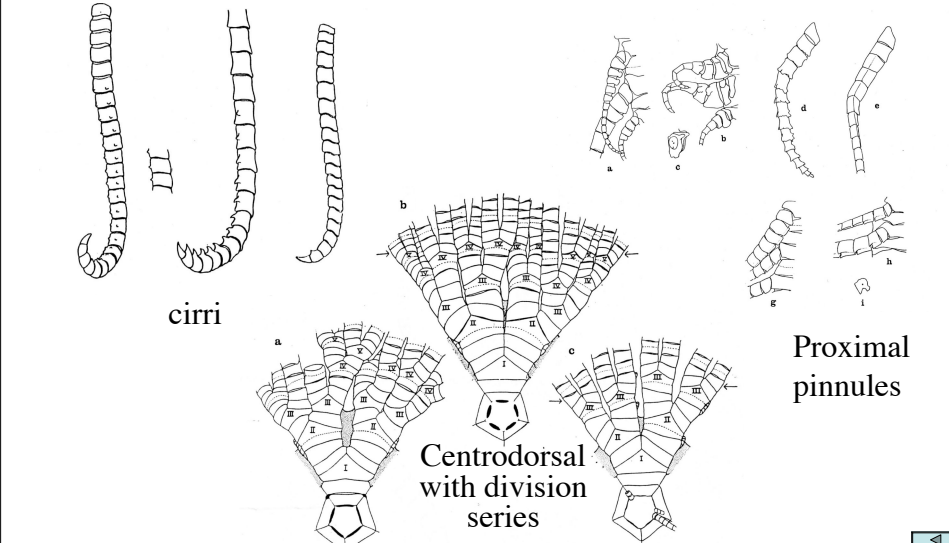
Basics to the taxonomy of the Crinoidea

Largely based upon skeletal elements

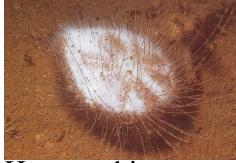


Basics to the taxonomy of the Crinoidea

Largely based upon skeletal elements, with their detail



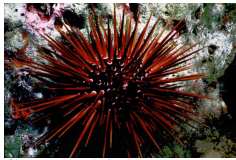
Class Echinoidea - sea & heart urchins, sand dollars



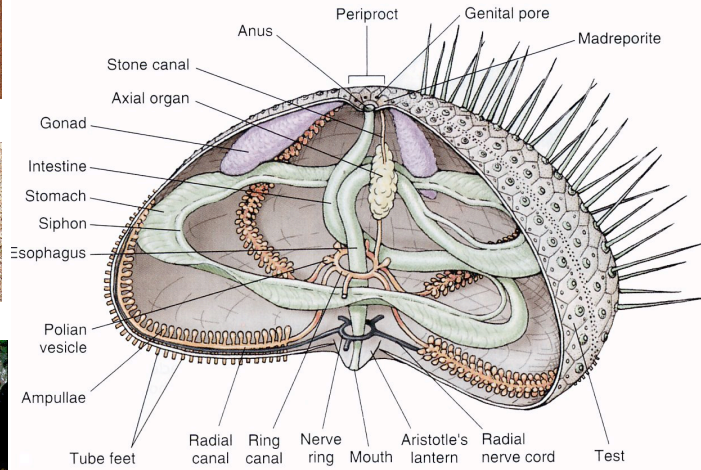
Heart urchins



Sand dollars

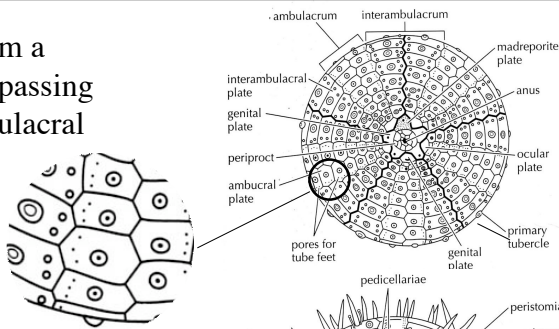


Sea urchins

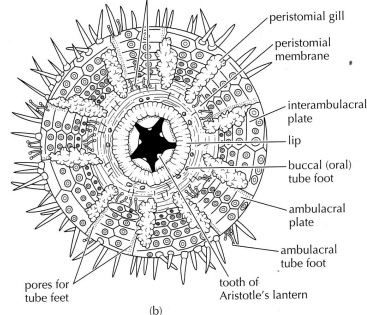
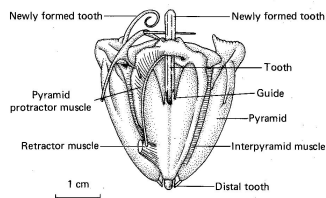


Defining characteristics of the Echinoidea

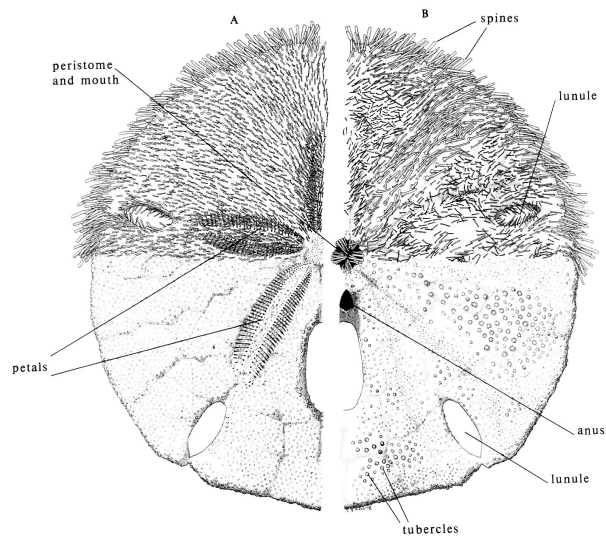
Ossicles joined to form a rigid test, with podia passing through pores in ambulacral plates



Aristotle's lantern for grazing



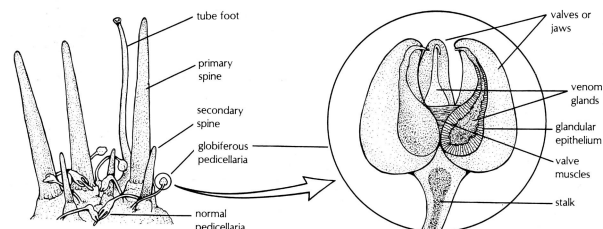
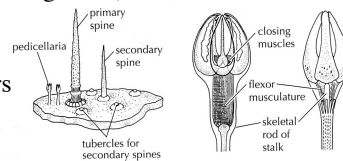
Defining characteristics of the Echinoidea



Basics to the taxonomy of the Echinoidea

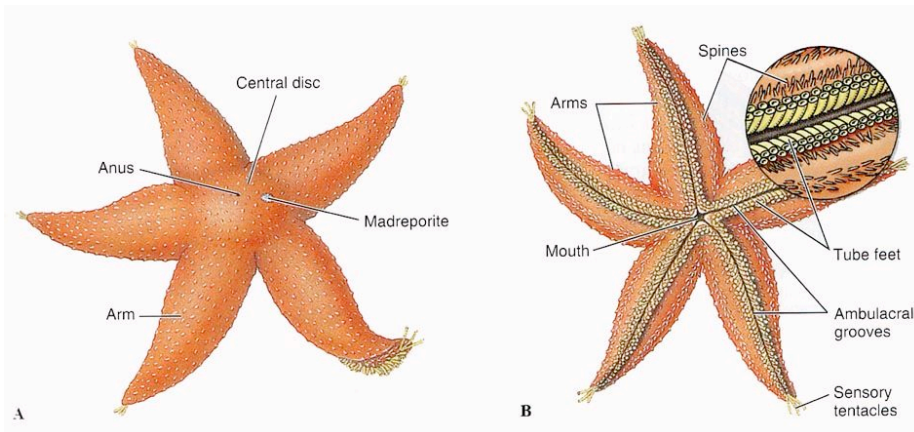
Largely based upon skeletal elements

- Form of test
- Position of anus (aboral for regularia, oral for regularia)
- Structure of apical system
- Arrangement of ambulacral plates, pore pairs
- Structure of spines, tubercles
- Structure of pedicellaria
- ...



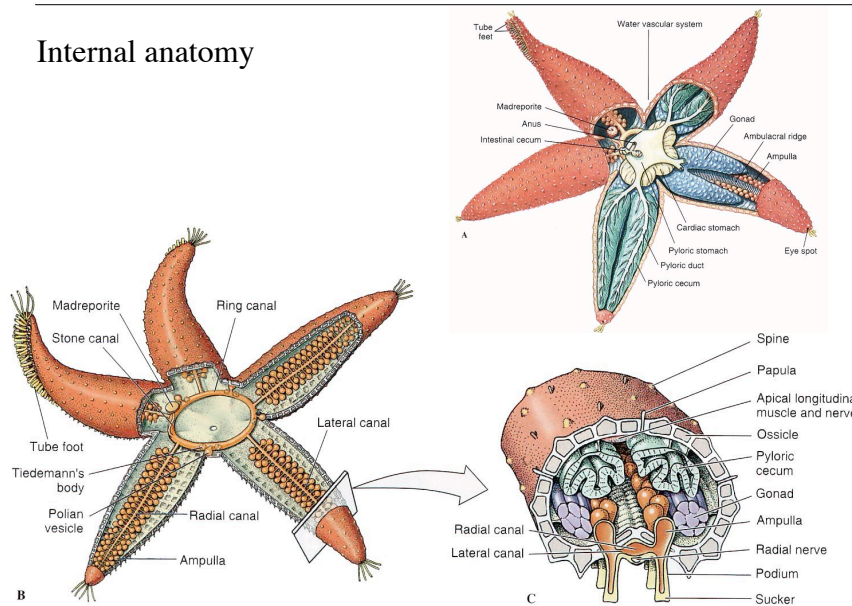
Class Asterozoidea - sea stars or starfish

External anatomy



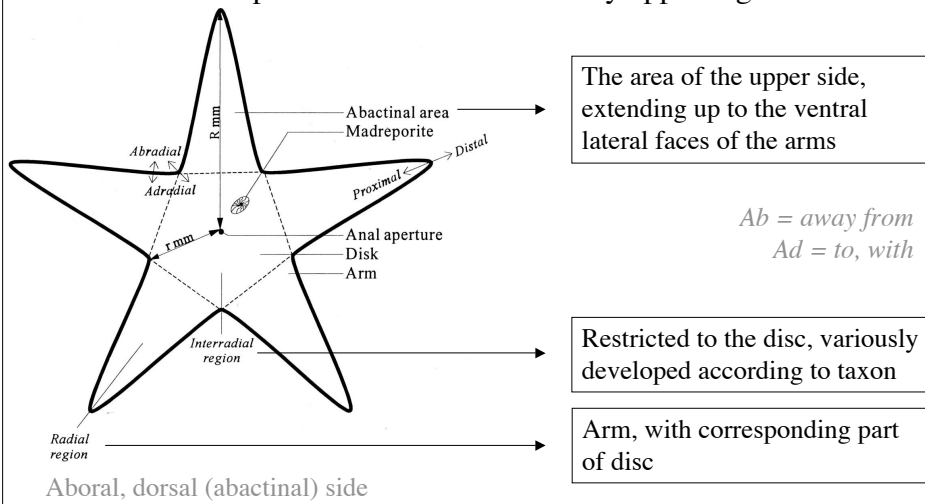
Class Asterozoidea - sea stars or starfish

Internal anatomy



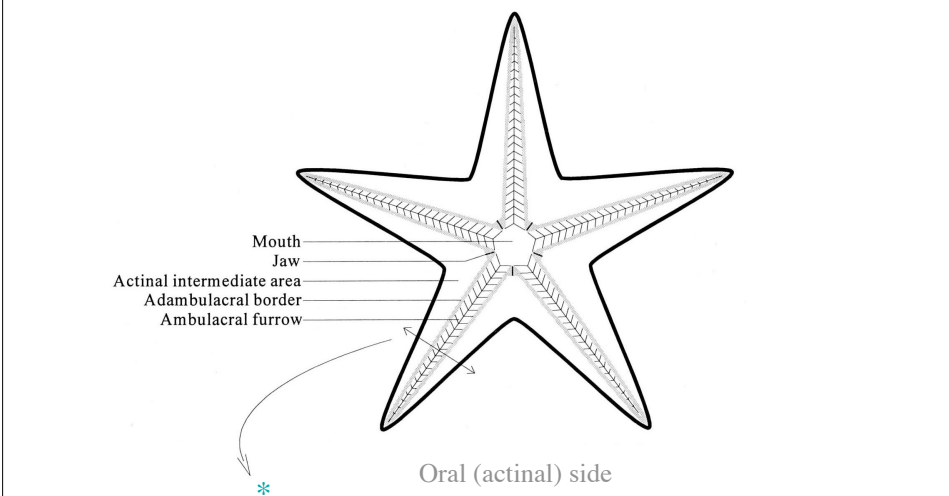
Basics to the taxonomy of the Asteroidea

Again mainly based on skeletal characteristics, mainly the architecture of plates and various secondary appendages

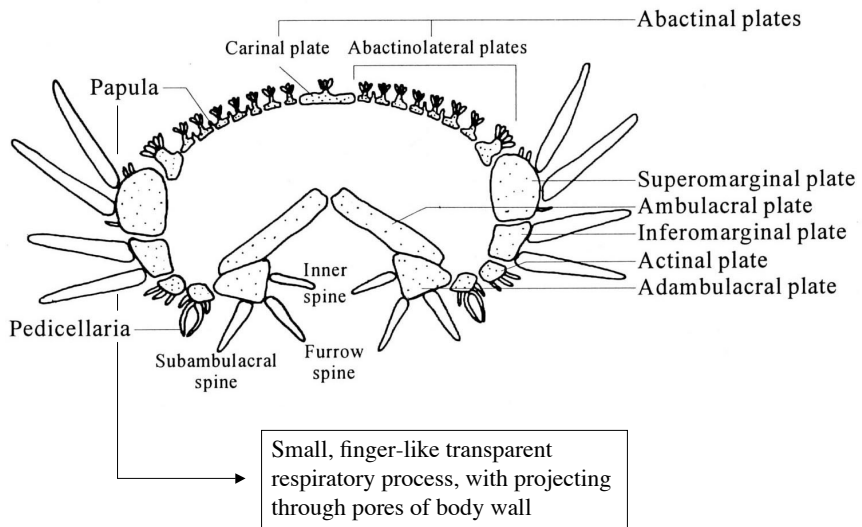


Basics to the taxonomy of the Asteroidea

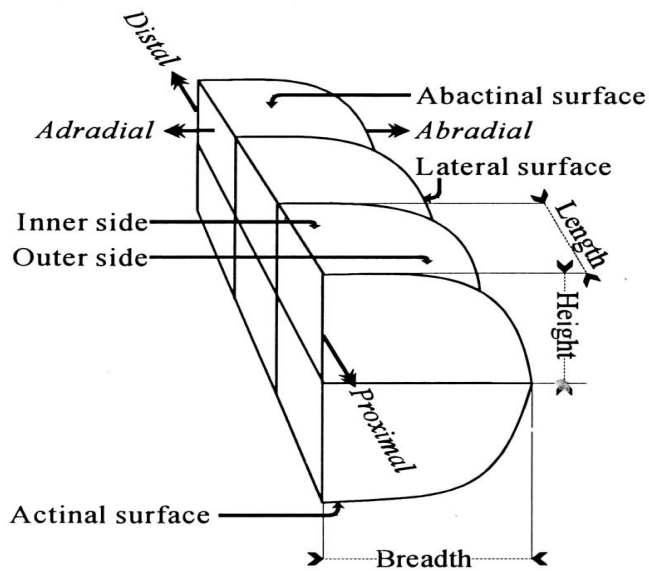
Again mainly based on skeletal characteristics, mainly the architecture of plates and various secondary appendages



Basics to the taxonomy of the Asteroidea



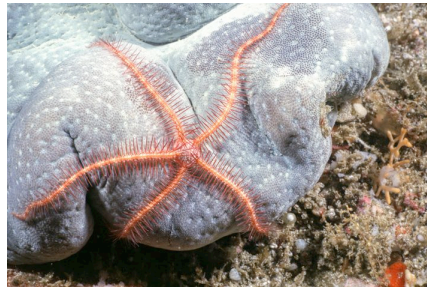
Basics to the taxonomy of the Asteroidea



Class Ophiuroidea - Brittle & feather stars

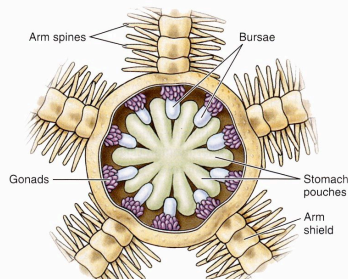
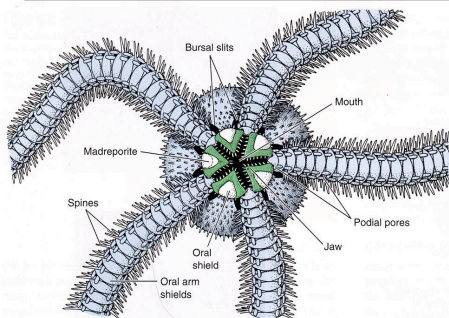


Euryalae - disc and arms covered with thick skin; arm spines scarce reduced, inserted ventrally



Ophiuræ - disc and arms covered with thick scales (sometimes concealed by a skin and granules); arm spines inserted laterally

Class Ophiuroidea - some general characteristics



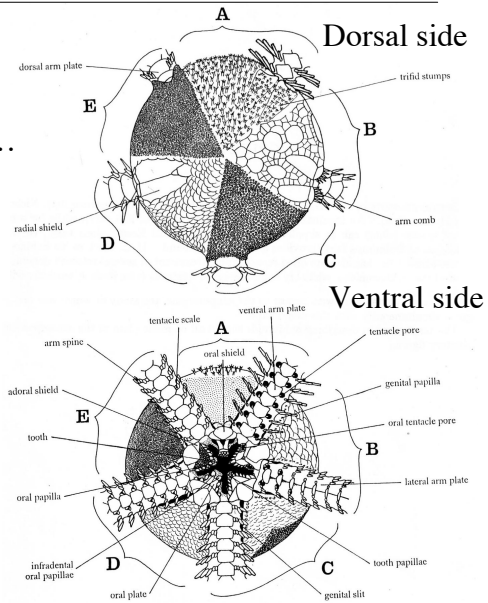
Some notable differences with Asteroidea

- No pedicellariae or papulae
- Ambulacral grooves closed
- Tube foot without suckers
- Madreporite on oral surface (on one of the oral shields)
- No ampullae
- No anus
- Visceral organs confined to the disc
- Respiration through bursae

Basics to the taxonomy of the Ophiuroidea

Largely based on skeletal elements: articulated ossicles (vertebrae), plates, spines, jaws,...

- A: Ophiotrichidae
- B: Ophiuridae
- C: Ophiocomidae
- D: Amphiuroidae
- E: Ophiodermatidae



Basics to the taxonomy of the Ophiuroidea

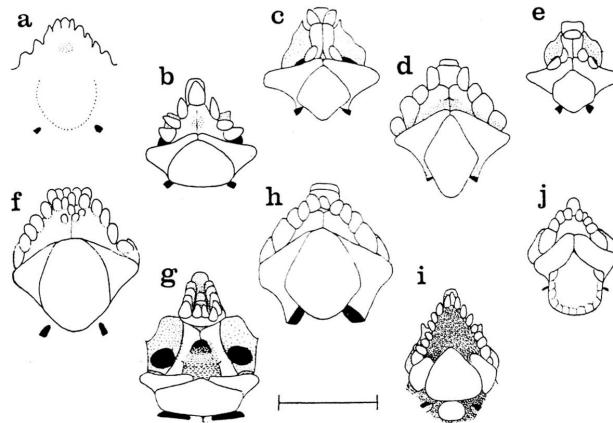
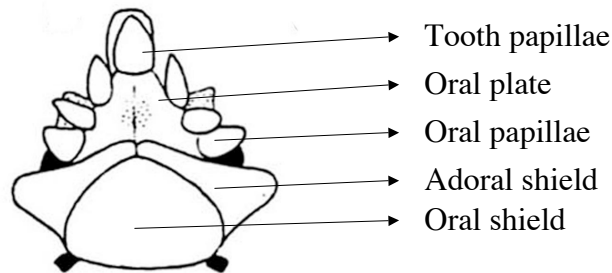


FIG. 22. Single jaws of: a. *Ophiomyxa australis*, b. *Ophiacantha discoidea*, c. *Amphiura septemspinos*, d. *Amphioplus (Lymanella) hastatus*, e. *Ophiactis savignyi*, f. *Ophiocoma pica*, g. *Ophiothrix savignyi*, h. *Ophionereis lineata*, holotype, i. *Ophiarachnella infernalis* and j. *Ophiolepis cincta*. In a, f, i and j the scale equals 2 mm., in b, e and g it equals 1 mm. and in c and d 0.7 mm.

Basics to the taxonomy of the Ophiuroidea



Basics to the taxonomy of the Ophiuroidea

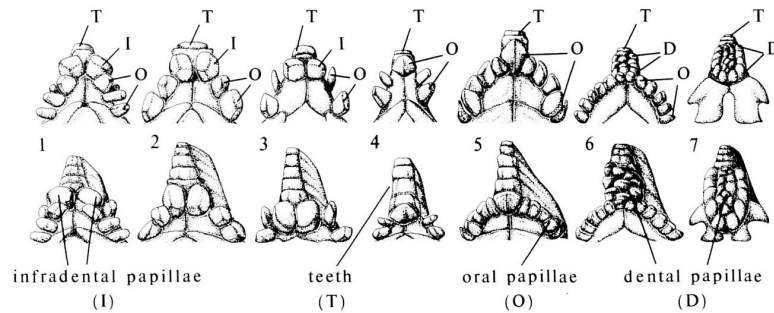
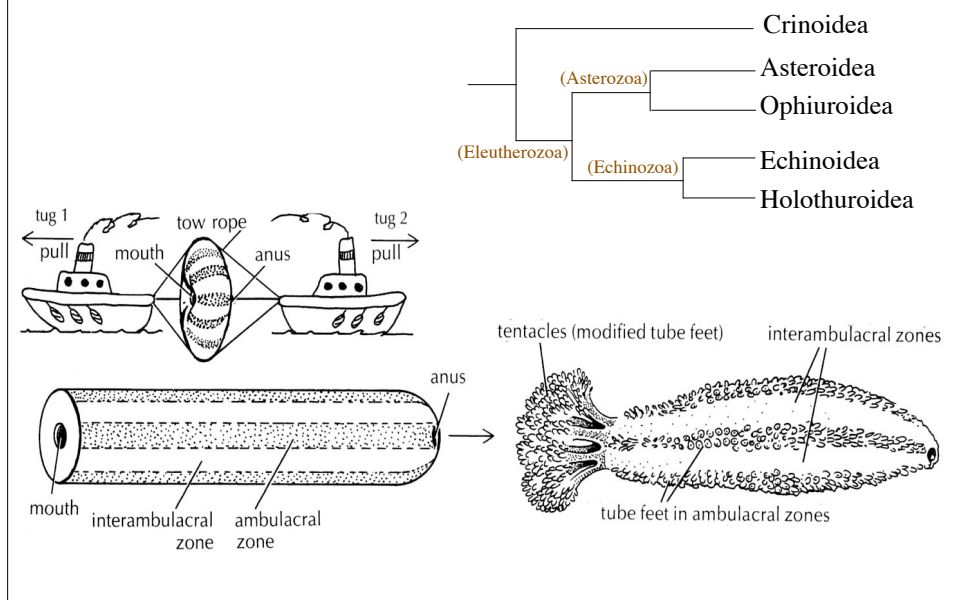


FIGURE 32. Brittle star jaw structures showing configurations of the dental papillae (D), infradental papillae (I), oral papillae (O), and teeth (T) that are characteristic of different families and genera. Upper row: ventral view of the jaw; lower row: the proximal edge of the jaw, showing the tooth row that projects into the mouth. (1) *Amphioplus thrombodes*, (2) *Ophiophragmus pulcher*, and (3) *Amphiura kinbergi* with paired infradental papillae at the apex of the jaw; (4) *Ophiactis savignyi* with two oral papillae on each side of the jaw, and (5) *Ophiolepis elegans* with several pairs of oral papillae; (6) *Ophiocoma echinata* with a cluster of dental papillae and a series of oral papillae, (7) *Ophiothrix suensonii* with a large cluster of dental papillae, oral papillae lacking. Illustration by R. Mooi.

Sister group of the Echinoidea

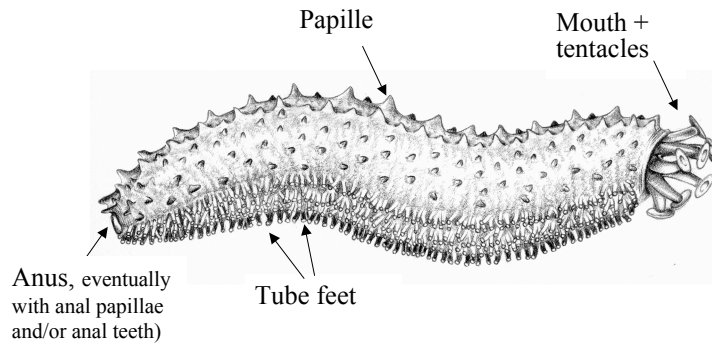


Holothuroidea - defining characteristics

- Worm-shaped body, greatly elongated along oral/aboral axis
- Presence of calcareous ring (attachment point for muscles operating the oral tentacles and for the anterior ends of other muscles that contract the body longitudinally)
- Cirlet of oral tentacles of various form (digitate, pinnate, peltate)
- Body ossicles reduced to microscopic size (sometimes completely absent) and embedded individual in different tissues
- Radial canals give rise to five primary tentacles => longitudinal canals
- Presence of respiratory trees: highly branched, muscular respiratory structures, extended from the cloaca into the coelomic cavity (cloacal breathing) (not in Apoda, some Elapsipoda)
- Presence of Cuvierian tubules (Holothuriidae only)

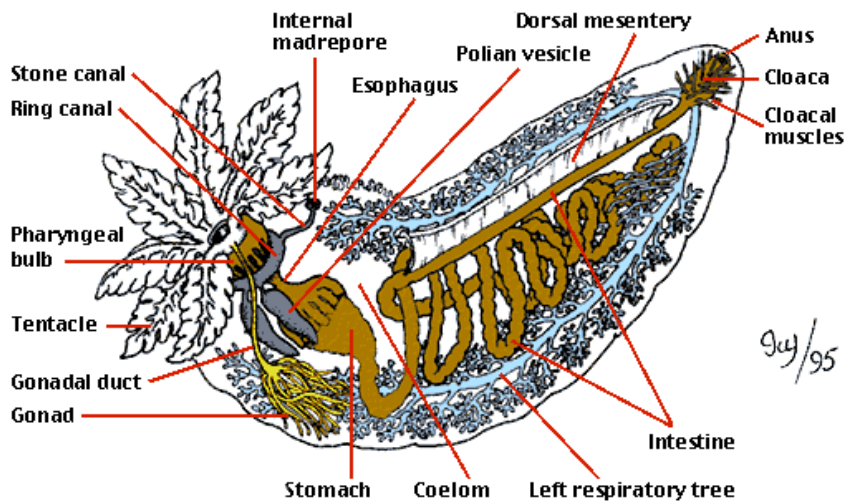
External anatomy

BIVIUM: the dorsal side, composed of two ambulacral (or radial) and three interambulacral (or interradial) regions



TRIVIUM: the ventral side, composed of three ambulacral and two interambulacral regions

Internal anatomy



Six extant orders

Apodida (269 species, 32 genera, 3 families)

Tentacles digitate, pinnate or, in some small species, simple. Respiratory trees absent. Tube feet completely absent. Calcareous ring without posterior projections. Body wall is very thin and often transparent. Found in both shallow and deep water.

Elasipodida (141 species, 24 genera, 3 families)

Tentacles shield-shaped and used in shovelling sediment. Respiratory trees present. Calcareous ring without posterior projections. With the exception of Deimatidae, body wall soft to gelatinous. All forms live in deep water.

Aspidochirotida (340 species, 35 genera, 3 families)

Tentacles shield-shaped. Respiratory trees present. Calcareous ring without posterior projections. Body wall generally soft and pliant. Most forms live in shallow water, though one family is restricted to the deep sea.

Molpadiida (95 species, 11 genera, 4 families)

Tentacles simple. Respiratory trees present. Calcareous ring without posterior projections. Body wall generally soft and pliant. Most forms live in shallow water, though one family is restricted to the deep sea.

Dendrochirotida (550 species, 90 genera, 7 families)

Tentacles highly branched and extended to filter material from the water column. Respiratory trees present. Some members with a calcareous ring composed of numerous small pieces or having long posterior extensions. Possess muscles for retracting oral introvert. Body wall may be hardened from enlarged plate-like ossicles. Live either attached to hard bottoms or burrow in soft sediment. Most species live in shallow water.

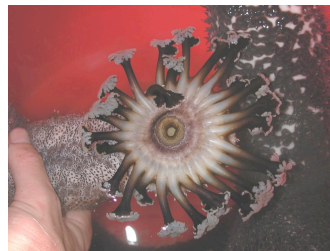
Dactylochirotida (about 35 species, 7 genera, 3 families)

Tentacles simple or with a few small digits. Respiratory trees present. Calcareous ring without posterior projections. Possess muscles for retracting oral introvert. All members have a rigid body encased in enlarged flattened ossicles. Body usually "U" shaped. All members live burrowed in soft sediment. Most live in deep water.

Dominant shallow-water groups



Dendrochirotida



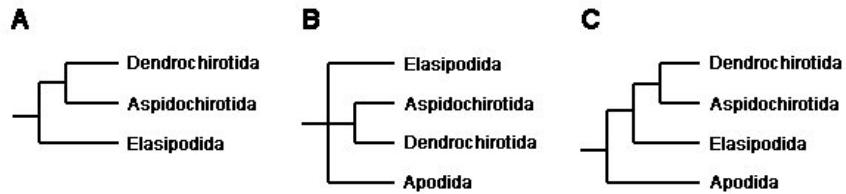
Aspidochirotida



Apodida



Systematics



Recent hypotheses about holothuroid relationships.

A. Tree based on complete 18S rDNA sequences (Littlewood et al., 1997).

B. Tree based on partial 28S rDNA sequences (Littlewood et al., 1997).

C. Interpretation of the 18S and 28S rDNA data favored by Smith (1997).

More information on Kerr & Kim, 2001(class); Kerr 2001 (Apoda); Samyn et al, 2005 (Holothuriidae, morphological); Kerr et al, 2005 (Holothuriidae, molecular).

Sea cucumber fisheries



Much more under <http://www.spc.int/coastfish/News/BDM/bdm.htm>

Interesting websites

<http://www.ucmp.berkeley.edu/echinodermata/echinodermata.html>

<http://www.tolweb.org/tree/phylogeny.html>

<http://www.calacademy.org/research/izg/echinodem/classify.html>

And further links on these sites



Thank you for your attention