TAKSONOMI HEWAN

CHAPTER 8:
ECHINODERMATA

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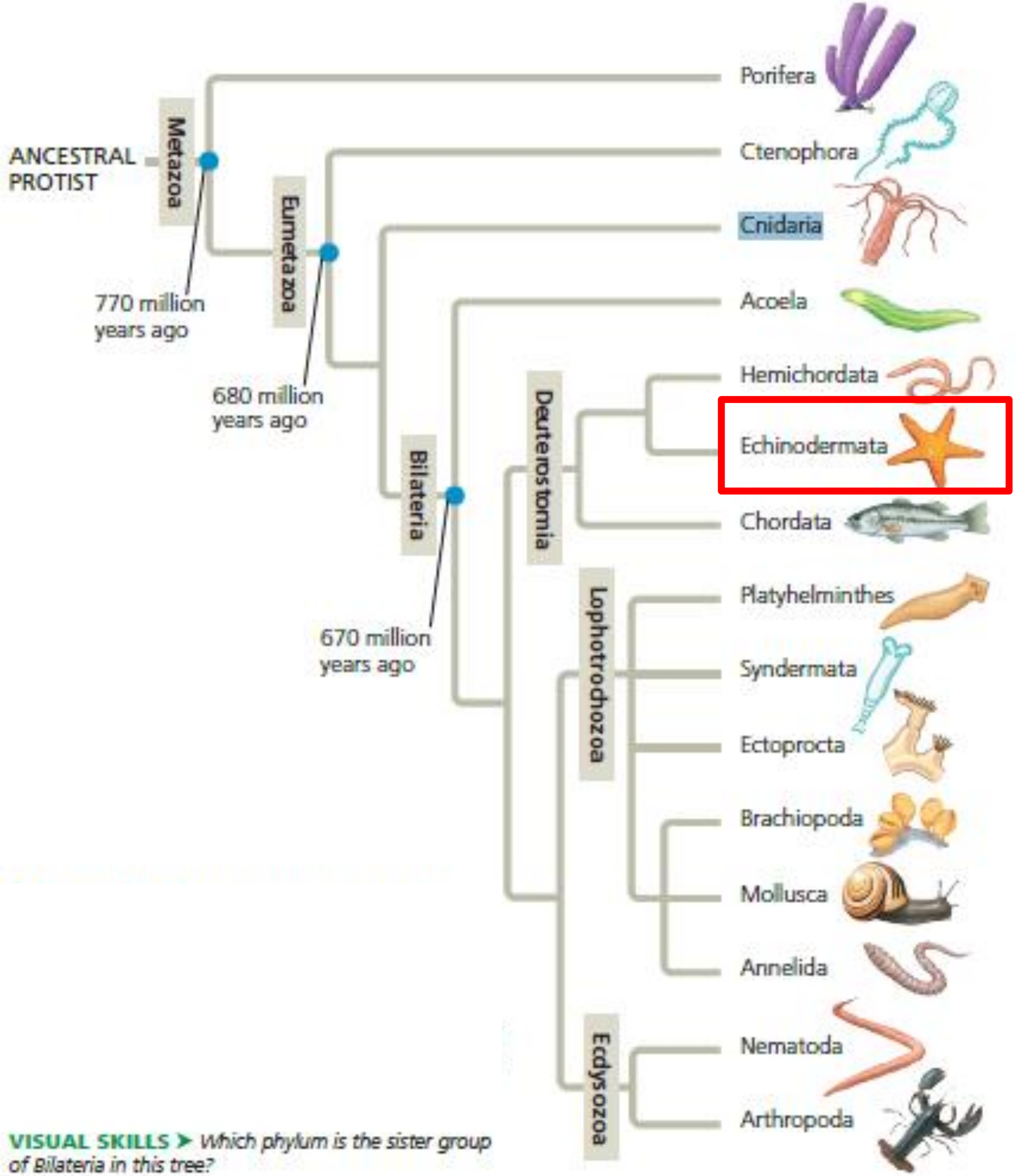
IAIN Jember


TO-DOLIST



VISUAL SKILLS ➤ *Which phylum is the sister group of Bilateria in this tree?*

DEUTEROSTOMIA

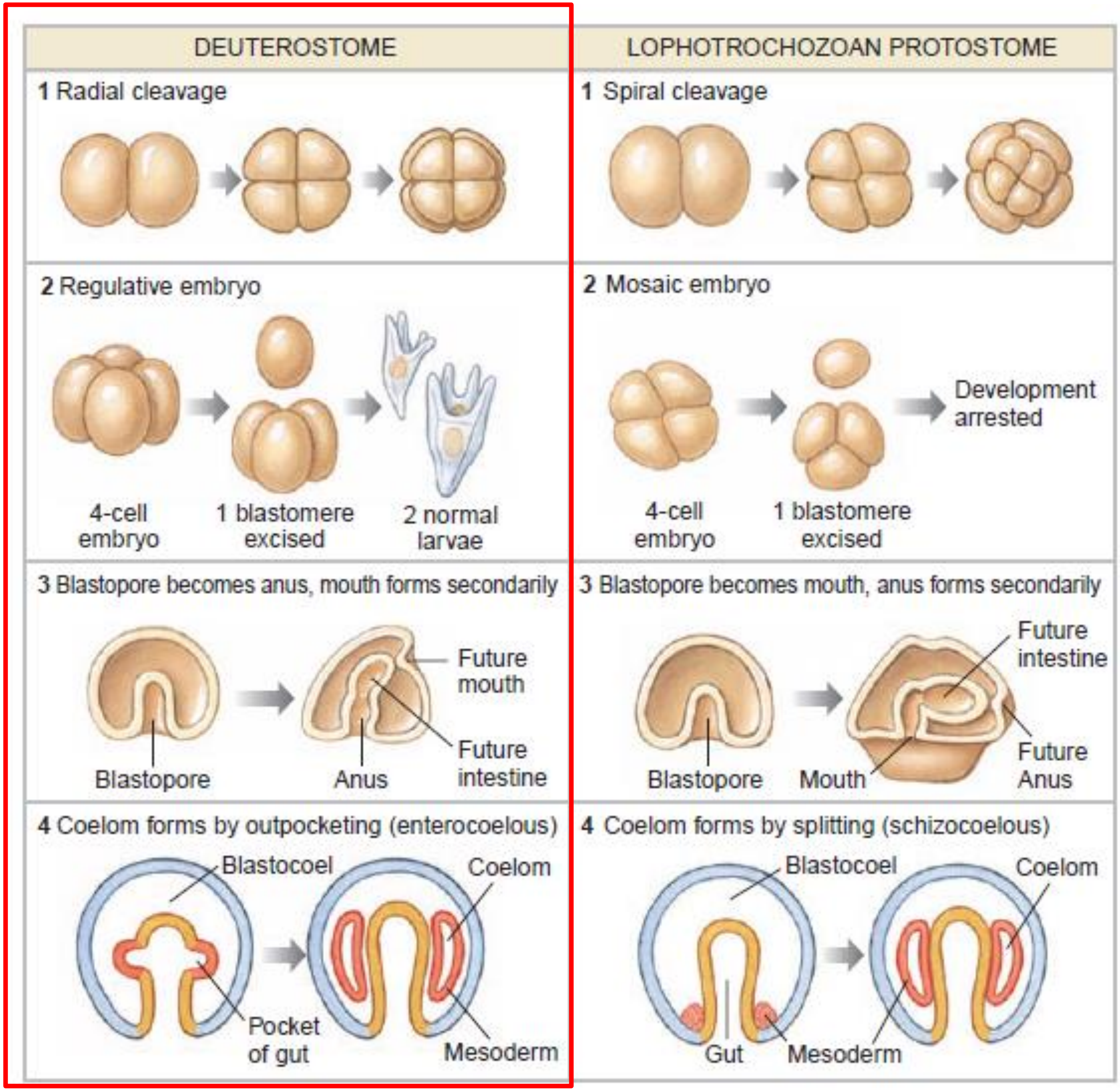
Echinodermata (7,000 species)

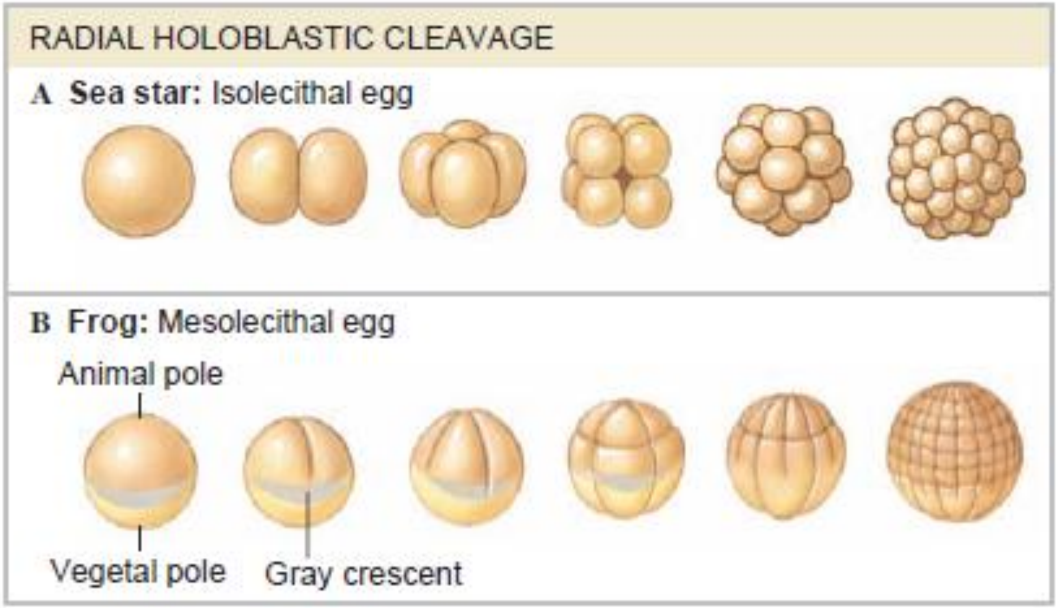
A sea urchin

Termasuk **sand dollar, bintang laut, landak laut/ bulu babi**, hidup di laut, masuk dalam klade Deuterostome. **Simetri Bilateral pd tahap larva**. **Simetri Radial/Biradial pd thap Dewasa** Bergerak & makan menggunakan network dr kanal internal utk memompa air ke daerah tubuh lainnya

Classical deuterostome developmental features are **radial regulative cleavage**; formation of the **mouth from a second opening (deuterostomy)**; and coelom formation by enterocoely. **All deuterostomes are coelomate**.

DEUTEROSTOMIA





Echinodermata

Chordata

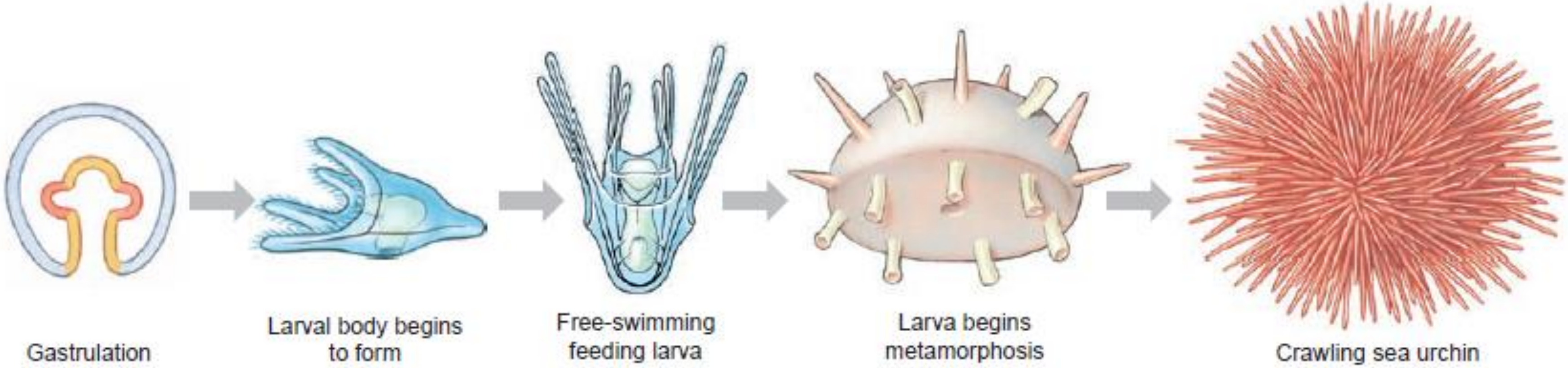


Figure 8.8

Indirect development in a sea urchin. After gastrulation, a free-swimming larva develops; it feeds and grows in ocean surface waters. The larva will metamorphose into a tiny bottom-dwelling sea urchin; the urchin feeds and grows, reaching sexual maturity in this body form.

PHYLUM ECHINODERMATA

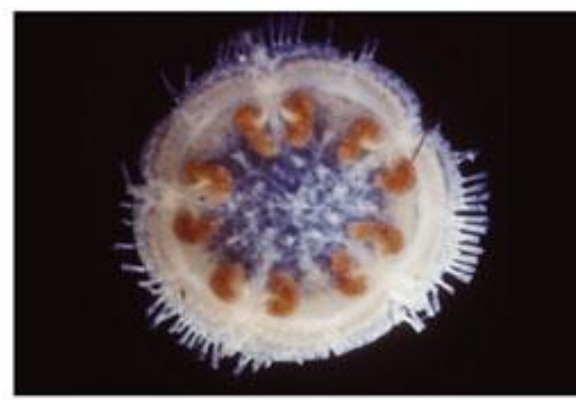
(a) A sea star (class Asteroidea)

(b) A brittle star (class Ophiuroidea)

(c) A sea urchin (class Echinoidea)

(d) A feather star (class Crinoidea)

(e) A sea cucumber (class Holothuroidea)



(f) A sea daisy (class Concentricycloidea)

General Characteristics

- Unique **water-vascular system of coelomic** origin extends from body surface as series of tentacle-like projections **(podia,** or **tube feet)** protracted by increase of fluid pressure within them
- Opening to exterior **(madreporite** or **hydropore)** usually present
- Living in marine habitats
- Free-living taxa
- **Body unsegmented** (nonmetameric) with **pentaradial symmetry**; body rounded, cylindrical, or star-shaped, with five or more radiating areas, or ambulacra, alternating with interambulacral areas; no head
- **Triploblastic body**

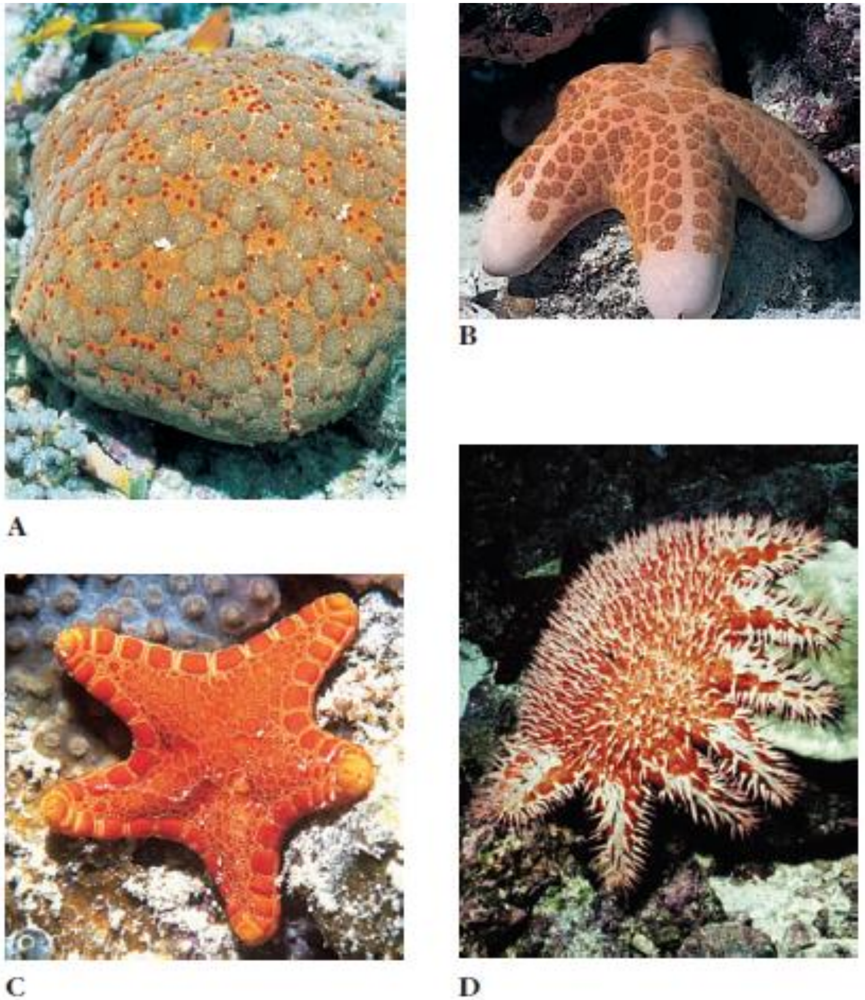


Figure 22.4
Some sea stars (class Asteroidea) from the Pacific. **A,** Pincushion star, *Culcita navaeguineae*, preys on coral polyps and also eats other small organisms and detritus. **B,** *Choriaster granulatus* scavenges dead animals on shallow Pacific reefs. **C,** *Tosia queenslandensis* from the Great Barrier Reef System browses encrusting organisms. **D,** Crown-of-thorns star, *Acanthaster planci*, is a major coral predator

General Characteristics

- As adults they show **secondary radial symmetry** – **pentaradial** (5 parts).
  - Perhaps an adaptation for sessile living in early echinoderms.
    - Crinoids

- Today's echinoderms are mostly **motile**.
  Many are still radial.
  Some have again become superficially bilateral (skeletal & organ systems still pentaradial).
  Sea cucumbers.
  A few sea urchins.

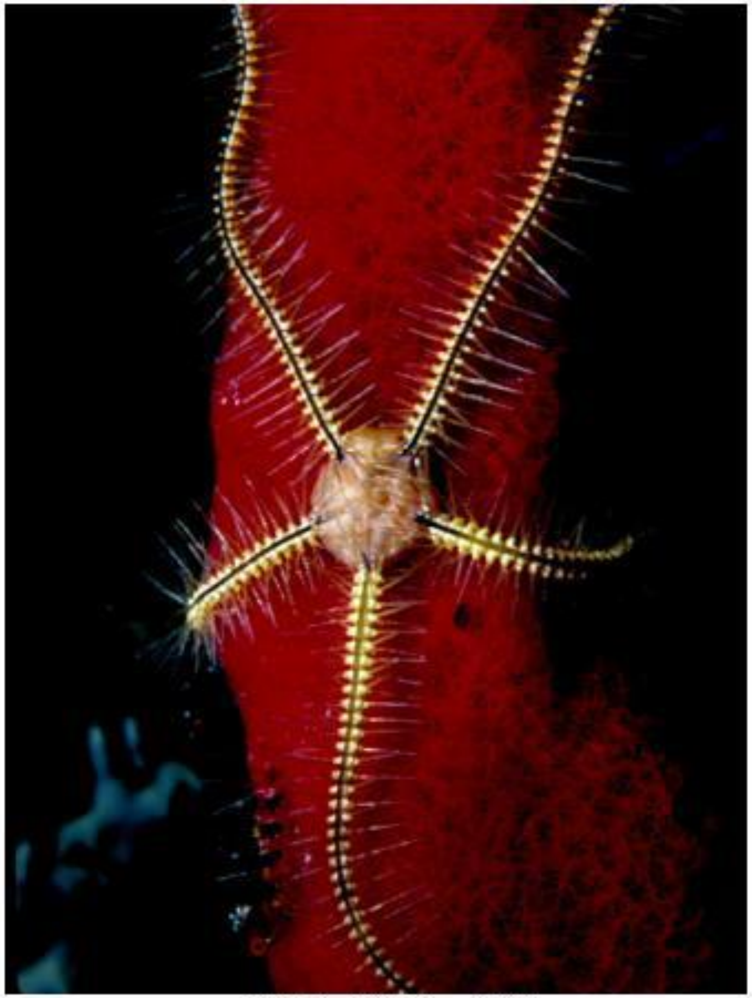
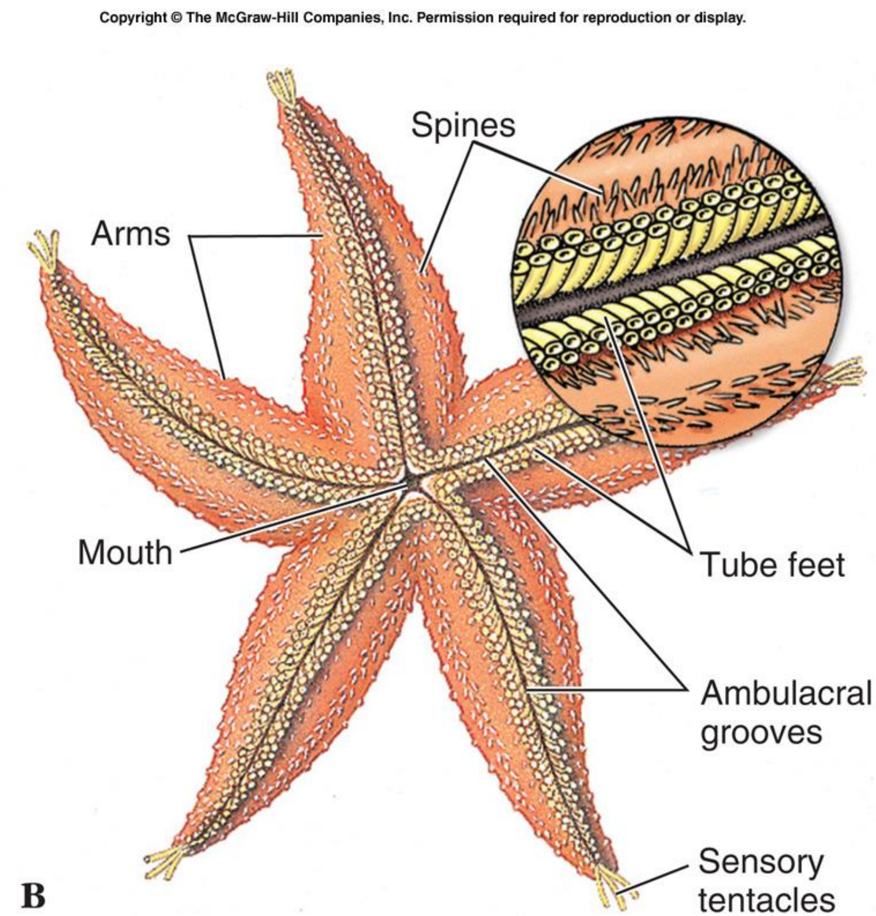


Photo Copyright © Diane R. Nelson

General Characteristics

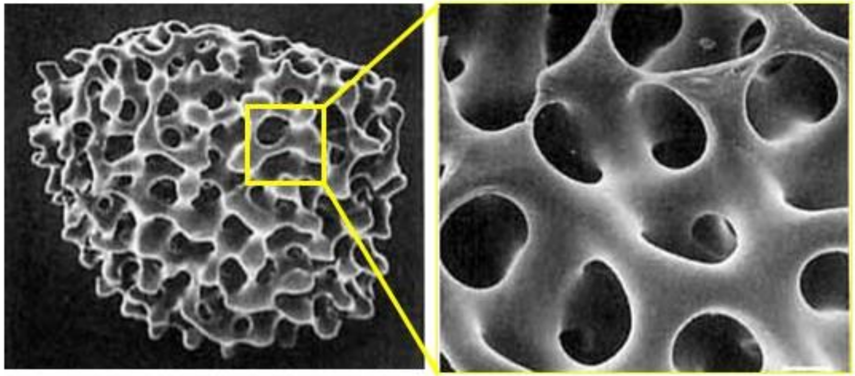
- Canals of the water vascular system lead to the **tube feet**.
  - Tube feet may have suckers, allowing the echinoderm to move while remaining firmly attached to the substrate – important in areas with lots of wave action.



General Characteristics

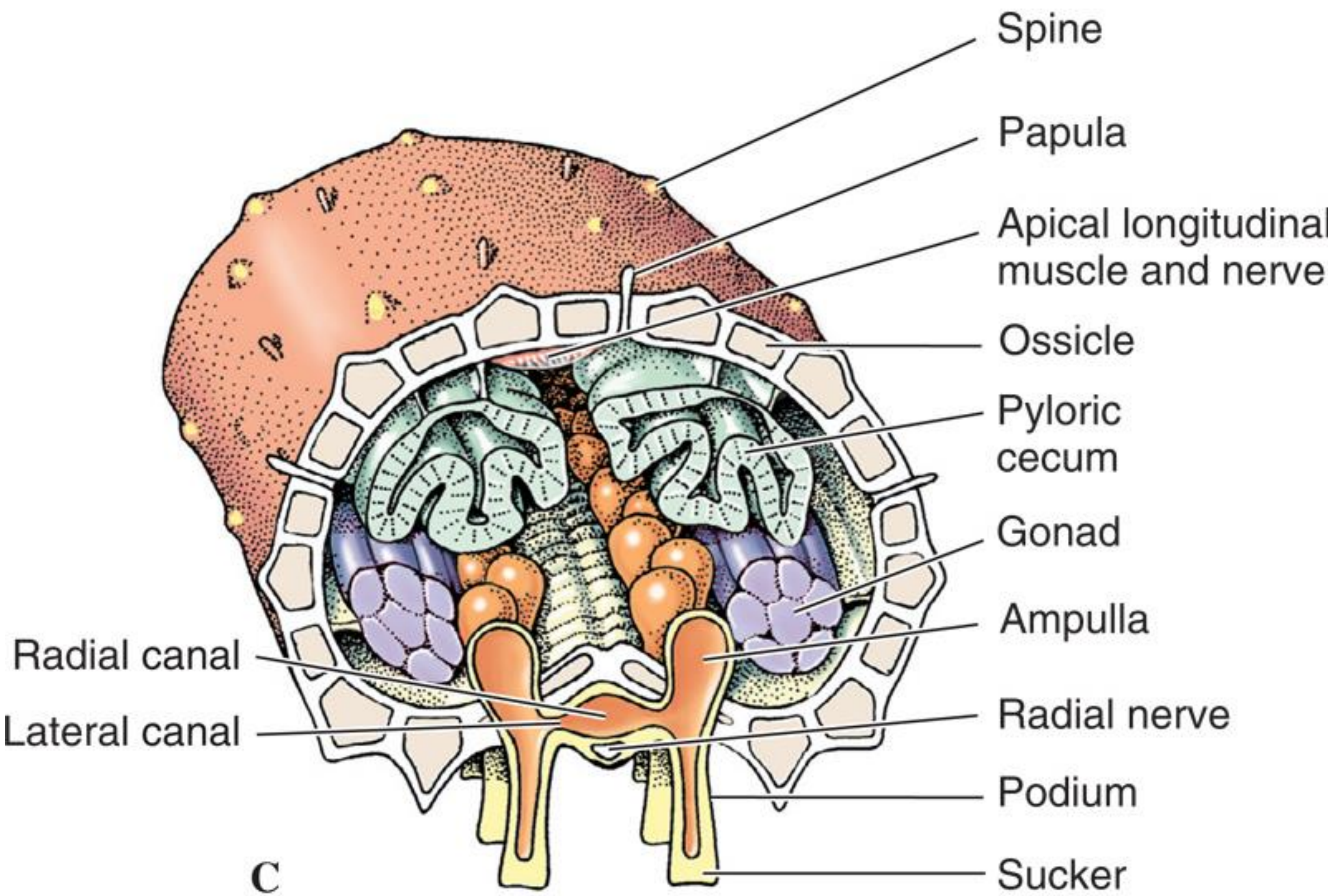
- Coelom extensive, forming perivisceral cavity and cavity of water-vascular system; **coelom of enterocoelous type**; coelomic fluid with **amebocytes**
- Endoskeleton of dermal **calcareous ossicles with spines** or of **calcareous spicules** in dermis; covered by epidermis (ciliated in most); **pedicellariae** (in some)
- **Ossicles**: small calcareous elements embedded in the dermis of the body wall of echinoderms. They form part of the endoskeleton and provide rigidity and protection
- A **pedicellaria** (plural: **pedicellariae**) is a small wrench- or claw-shaped appendage with movable jaws, called valves, commonly found on echinoderms (phylum Echinodermata), particularly in **sea stars** (class Asteroidea) and **sea** urchins (class Echinoidea).
- Digestive system usually complete; axial or coiled; **anus absent in ophiuroids**

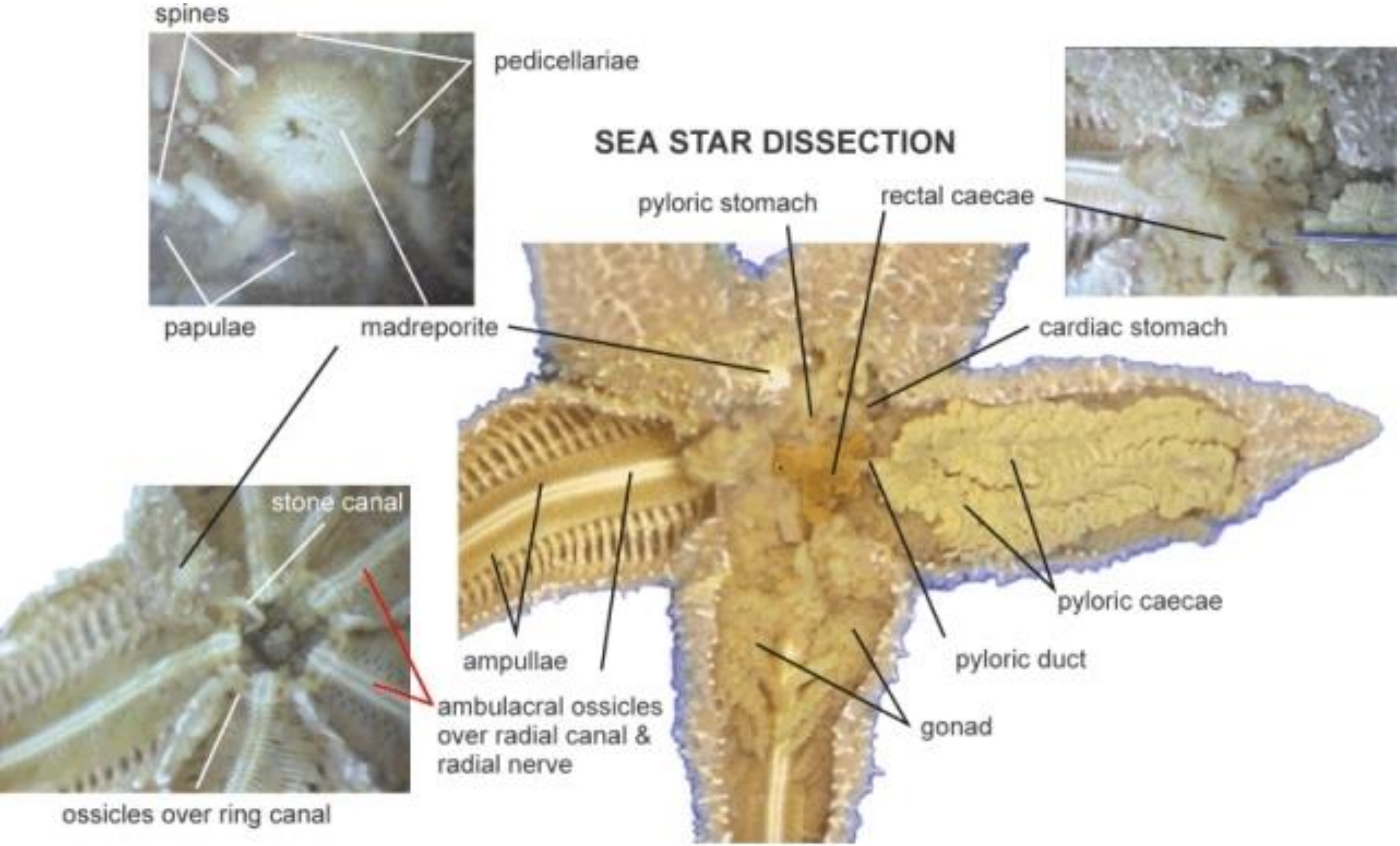
- skeleton is composed of **ossicles**, porous chunks of calcium carbonate filled with living tissue



Ossicles fuse together in sea urchins to form protective inner shell and spines

- Echinoderms have an **endoskeleton** of **calcareous ossicles** often with spines.
  - Endoskeleton is covered by an epidermis.
  - Some have a very substantial endoskeleton (sea urchins), others have only a few scattered dermal ossicles (some sea cucumbers).


Spine
Papula
Apical longitudinal muscle and nerve
Ossicle
Pyloric cecum
Gonad
Ampulla
Radial canal
Lateral canal
Radial nerve
Podium
Sucker
C


SEA STAR DISSECTION
spines
pedicellariae
papulae
madreporite
pyloric stomach
rectal caecae
cardiac stomach
stone canal
pyloric caecae
ampullae
pyloric duct
ambulacral ossicles
over radial canal &
radial nerve
gonad
ossicles over ring canal

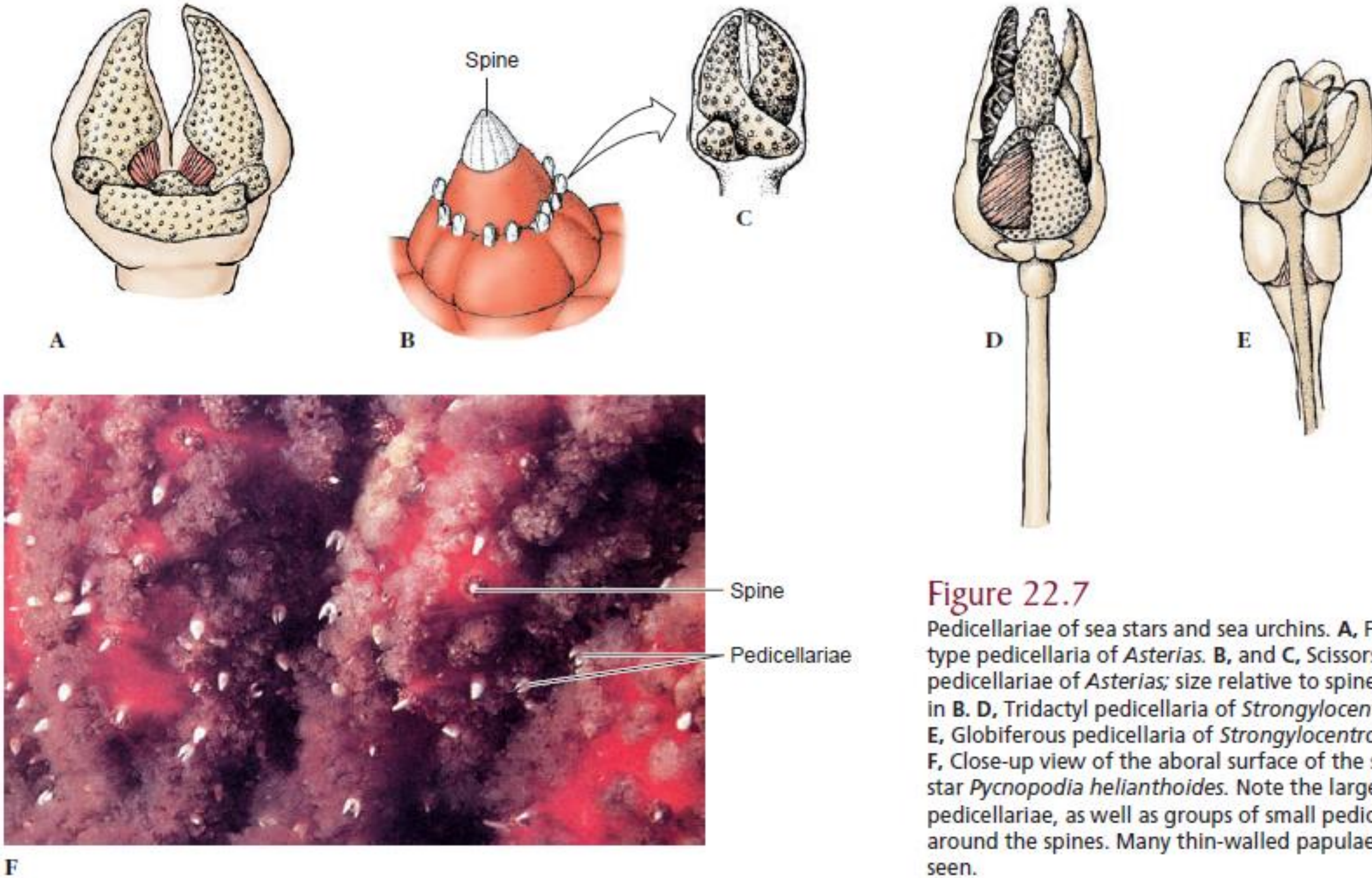
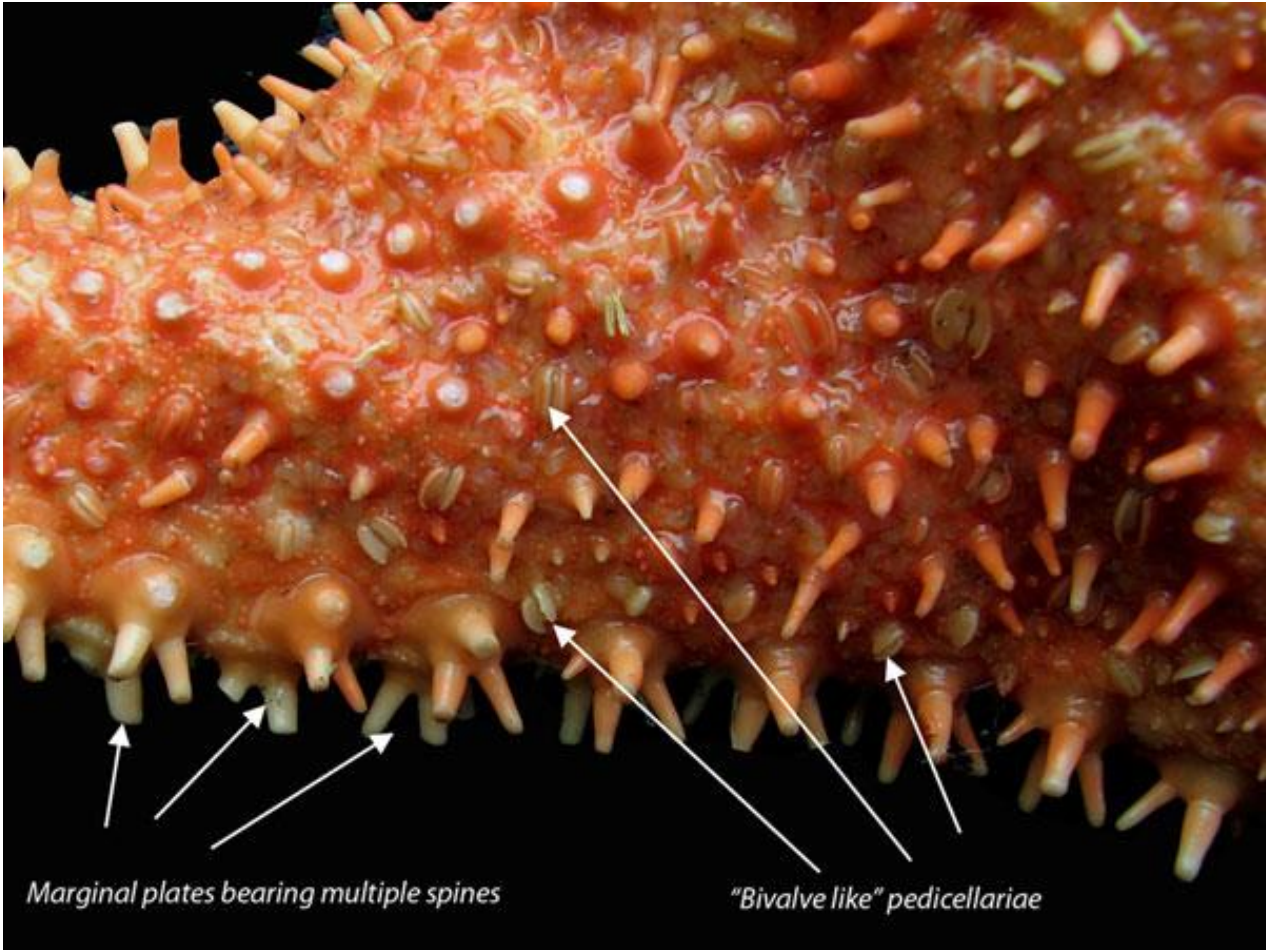
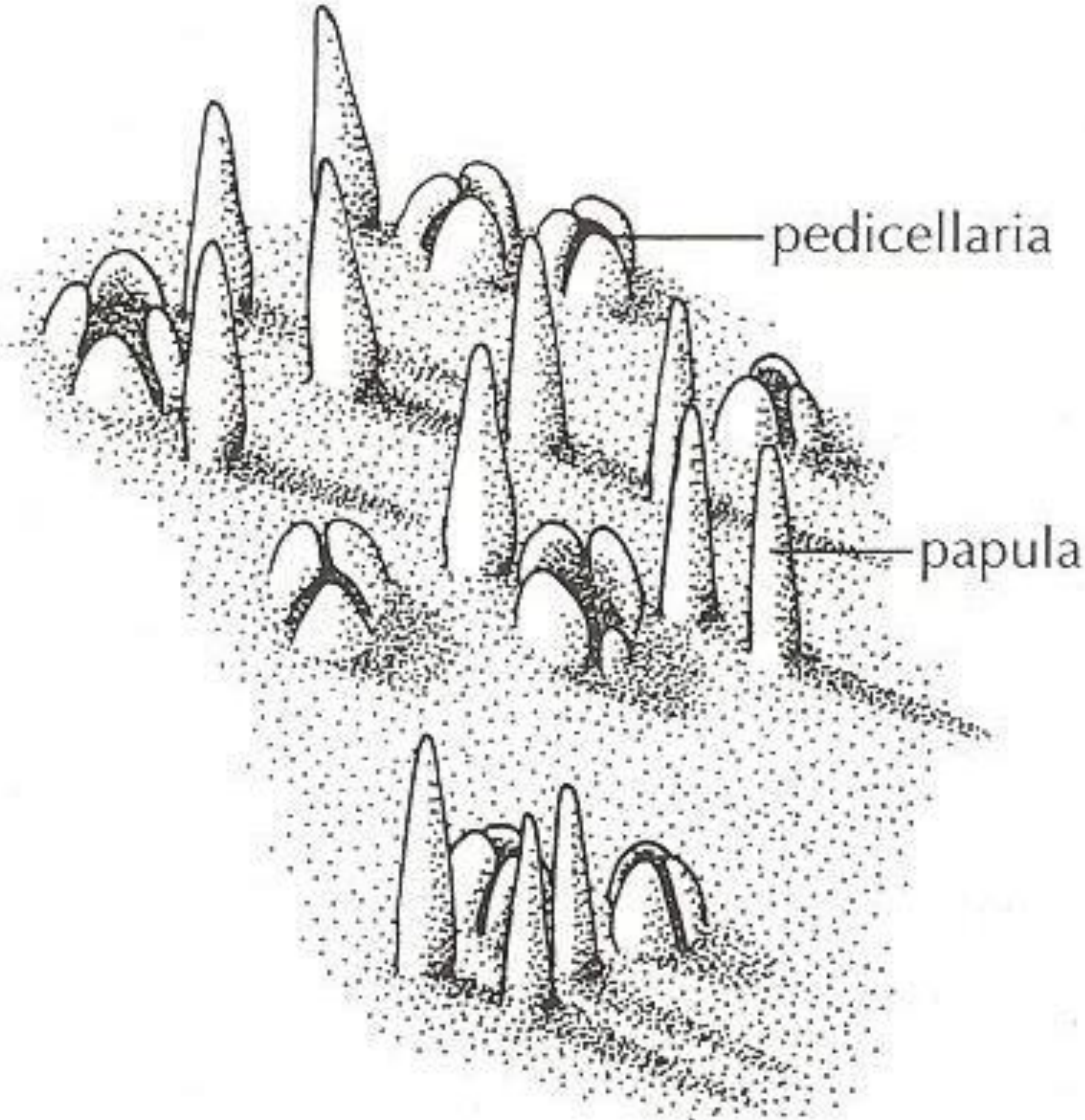


Figure 22.7

Pedicellariae of sea stars and sea urchins. **A,** Forceps-type pedicellaria of *Asterias.* **B,** and **C,** Scissors-type pedicellariae of *Asterias;* size relative to spine is shown in **B. D,** Tridactyl pedicellaria of *Strongylocentrotus.* **E,** Globiferous pedicellaria of *Strongylocentrotus.* **F,** Close-up view of the aboral surface of the sea star *Pycnopodia helianthoides.* Note the large pedicellariae, as well as groups of small pedicellariae around the spines. Many thin-walled papulae can be seen.

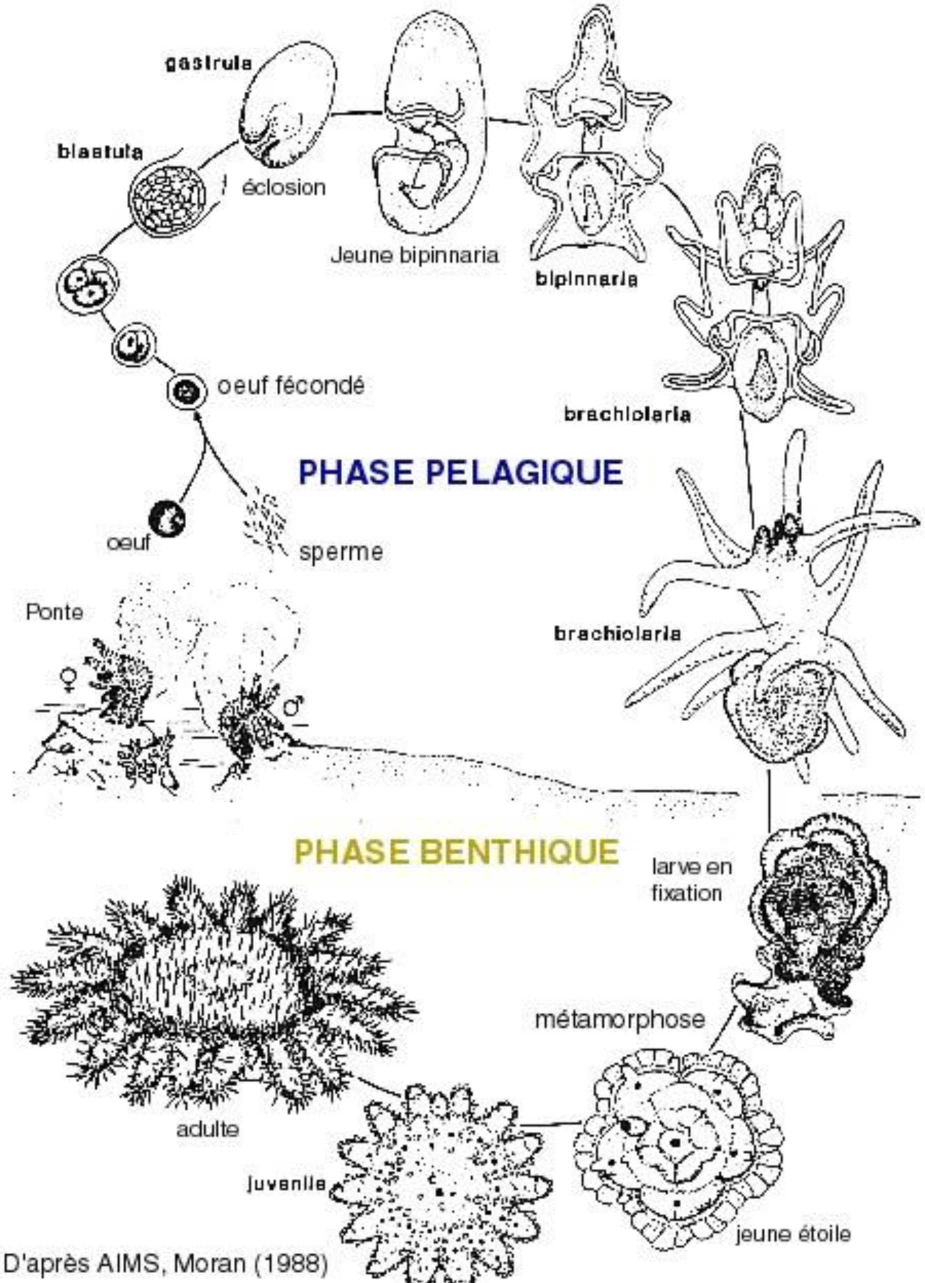

Marginal plates bearing multiple spines
“Bivalve like” pedicellariae



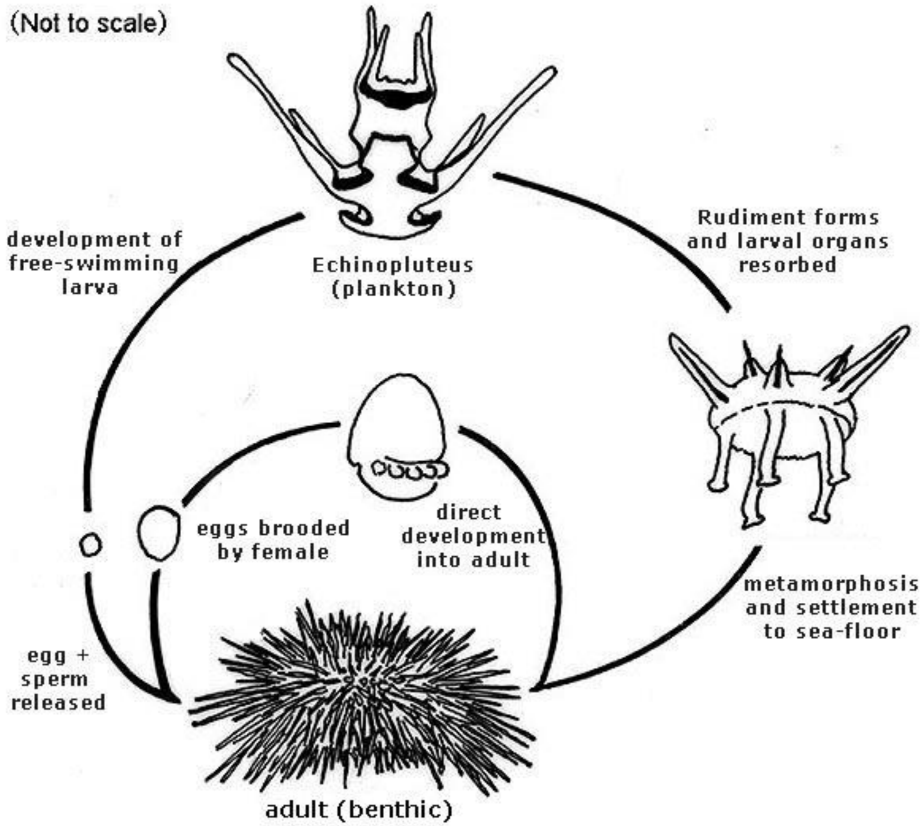
Aboral surface.

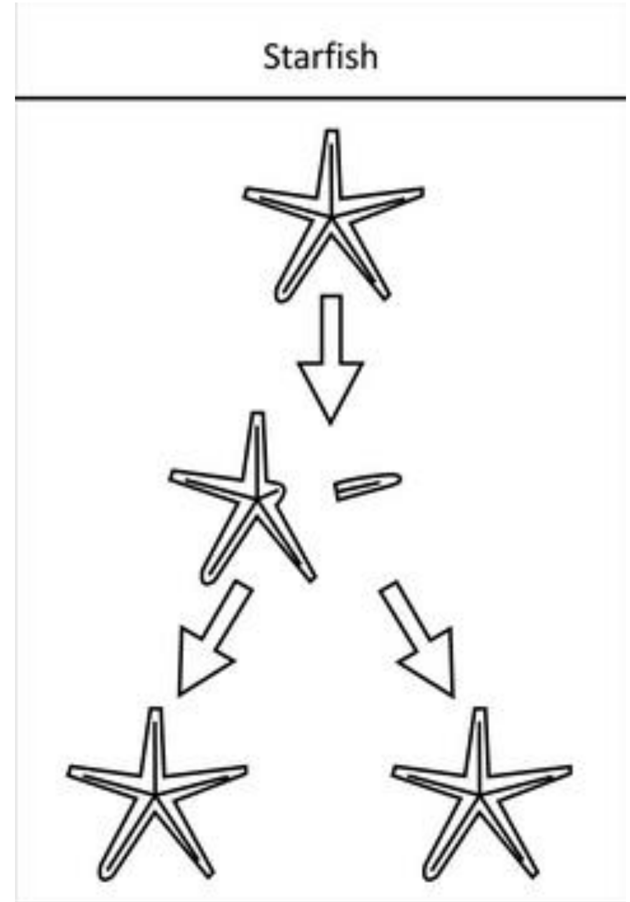
General Characteristics

- Autotomy and regeneration of lost parts conspicuous; **asexual reproduction** by **fragmentation in some**
- **Sexes separate** (except a few hermaphroditic) with large gonads, single in holothuroids but multiple in most; simple ducts, **with no elaborate copulatory apparatus** or secondary sexual structures; fertilization usually **external**



D'après AIMS, Moran (1988)


(Not to scale)
Echinopluteus (plankton)
development of free-swimming larva
Rudiment forms and larval organs resorbed
eggs brooded by female
direct development into adult
metamorphosis and settlement to sea-floor
egg + sperm released
adult (benthic)


Starfish

General Characteristics

- Eggs (which may be brooded or laid as benthic egg masses) hatch into **bilateral**, **free-swimming larvae**.
- The type of larva is specific to each echinoderm class.

- Echinoderms are bilaterally symmetrical as larvae.
  - This means their ancestors were bilaterally symmetrical.

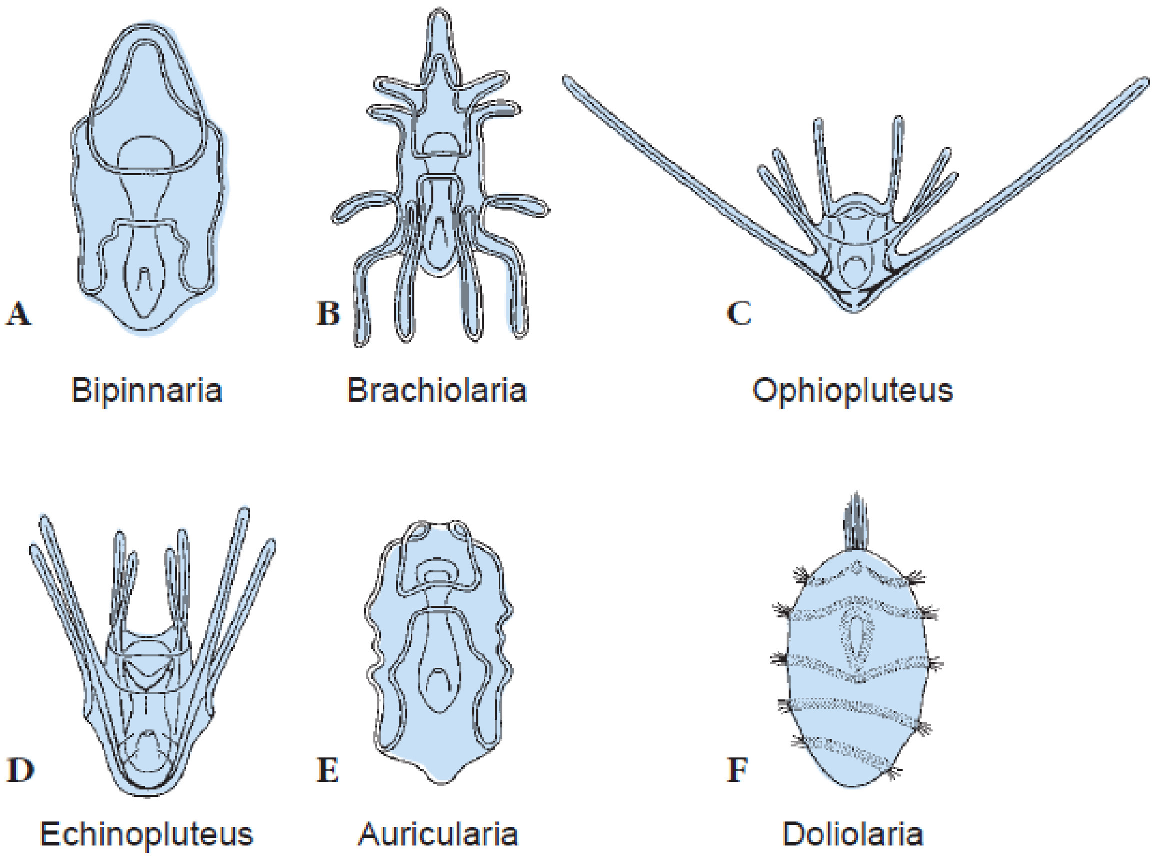


Figure 22.12

Larvae of echinoderms. **A,** Bipinnaria of asteroids. **B,** Brachiolaria of asteroids. **C,** Ophiopluteus of ophiuroids. **D,** Echinopluteus of echinoids. **E,** Auricularia of holothuroids. **F,** Doliolaria of crinoids.

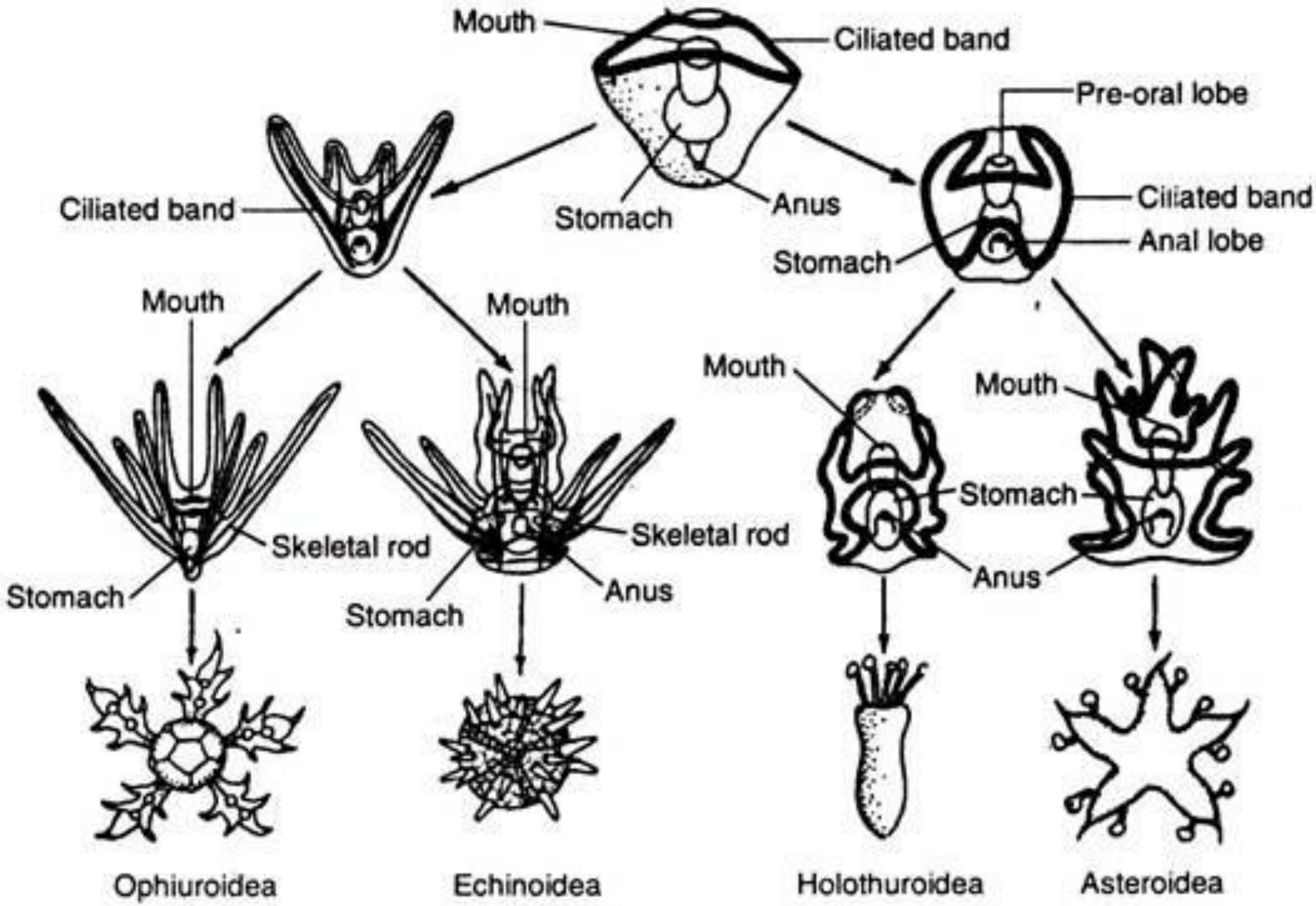
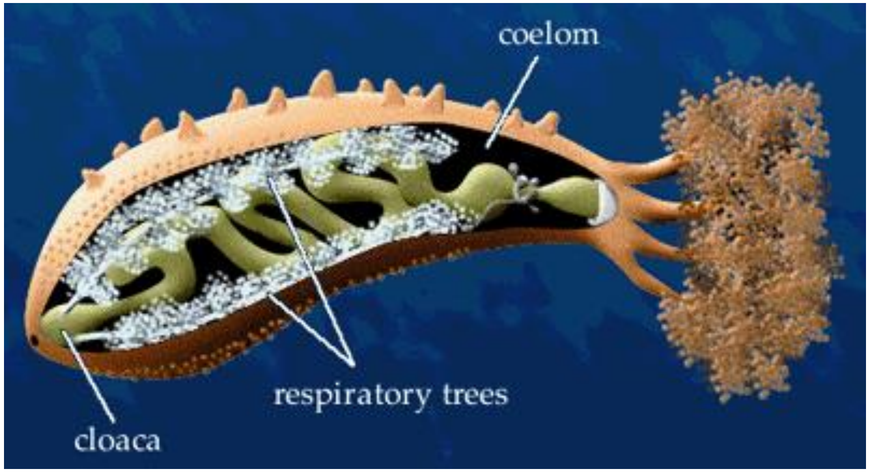
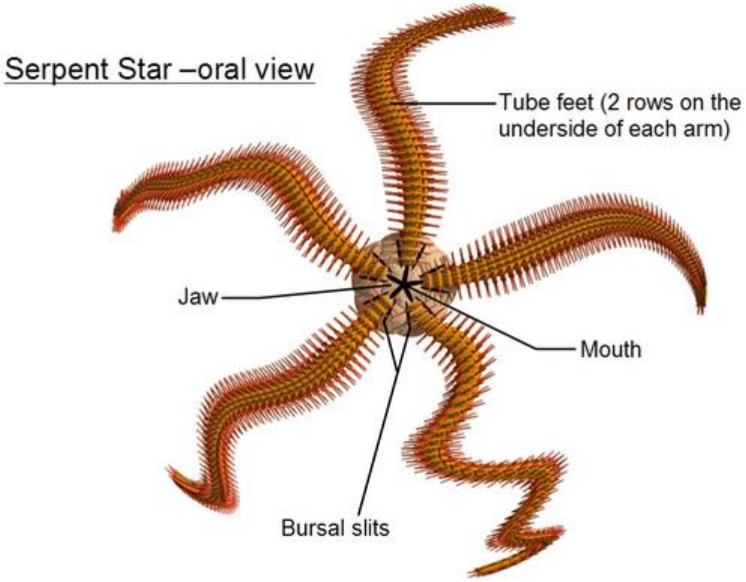


Fig. 21.33: Showing the development of radially symmetrical adult echinoderms from the bilaterally symmetrical larva (after Parker and Haswell).
Note that (i) the Ophiuroidea and Echinoidea are closely related and (ii) Holothuroidea and Asteroidea are closely related.

- **Excretory organs absent** Respiration by **papulae, tube feet, respiratory tree** (holothuroids), and **bursae (ophiuroids)**
- Blood-vascular system **(hemal system) much reduced,** playing little if any role in circulation, and surrounded by extensions of coelom **(perihemal sinuses);** main circulation of body fluids (coelomic fluids) by peritoneal cilia





- Nervous system with circumoral ring and radial nerves; usually two or three systems of networks located at different levels in the body, varying in degree of development according to group
- **No brain;** few specialized sensory organs; sensory system of tactile and chemoreceptors, podia, terminal tentacles, photoreceptors, and statocysts

PLOS | ONE

CORRECTION

Correction: A Higher Level Classification of All Living Organisms

Michael A. Ruggiero, Dennis P. Gordon, Thomas M. Orrell, Nicolas Bailly, Thierry Bourgoin, Richard C. Brusca, Thomas Cavalier-Smith, Michael D. Guiry, Paul M. Kirk

Citation: Ruggiero MA, Gordon DP, Orrell TM, Bailly N, Bourgoin T, Brusca RC, et al. (2015) Correction: A Higher Level Classification of All Living Organisms. PLoS ONE 10(6): e0130114. doi:10.1371/journal.pone.0130114

Published: June 11, 2015

Rank
Superkingdom
Kingdom
Subkingdom
Infrakingdom
Superphylum
Phylum
Subphylum
Infraphylum
Superclass
Class
Subclass
Infraclass
Superorder
Order

Main ranks are in bold type; unnamed taxa are not counted.

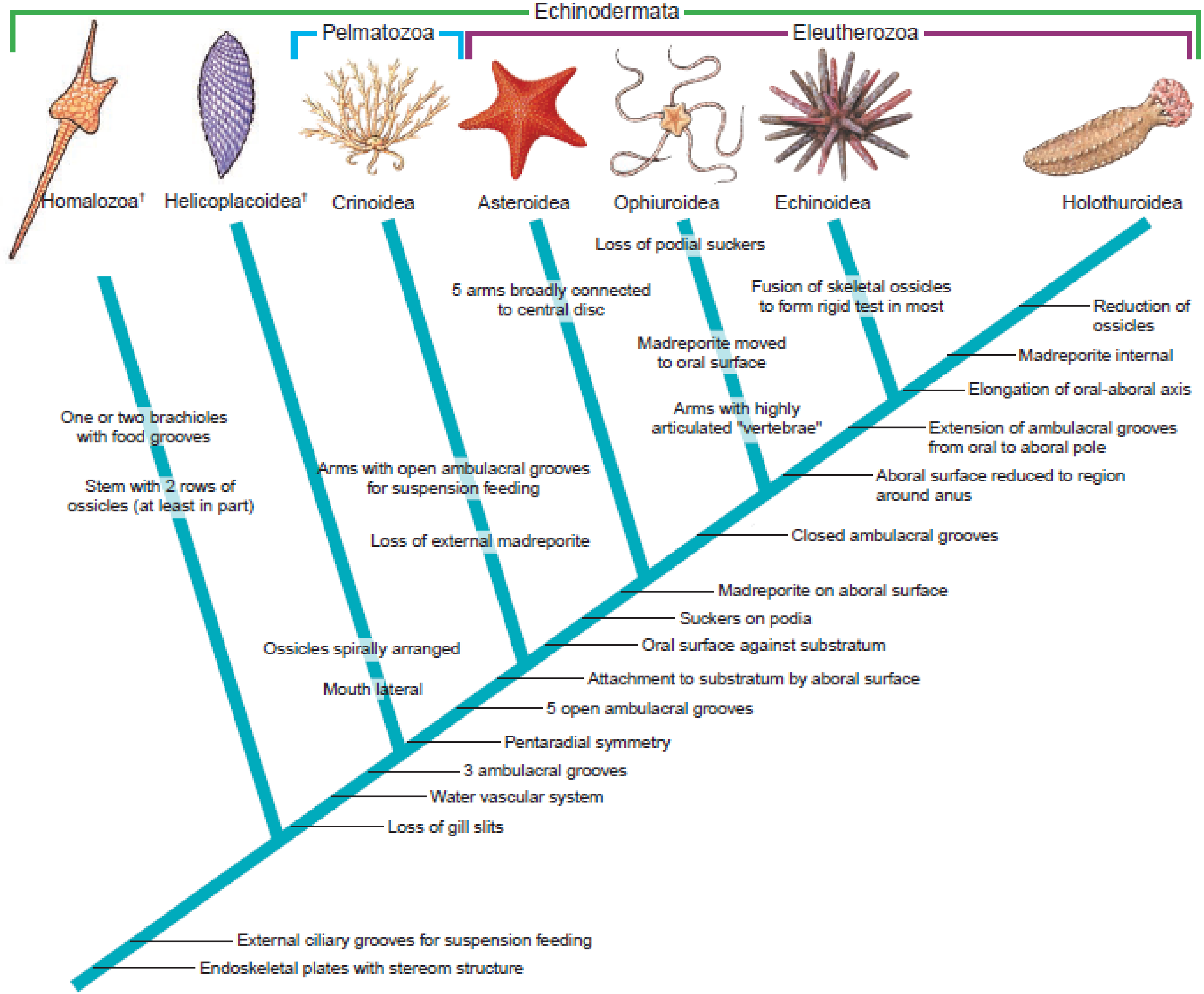
doi:10.1371/journal.pone.0130114.t001

KLASIFIKASI ECHINODERMATA

Phylum Echinodermata			
	Subphylum Asterozoa		
		Class Asteroidea	
			Order Brisingida
			Order Forcipulatida
			Order Notomyotida
			Order Paxillosida
			Order Peripoda
			Order Spinulosida
			Order Valvatida
			Order Velatida
		Class Ophiuroidea	
			Order Euryalida
			Order Ophiurida

	Subphylum Crinozoa		
		Class Crinoidea	
			Order Comatulida
			Order Cyrtocrinida
			Order Hyocrinida
			Order Isocrinida

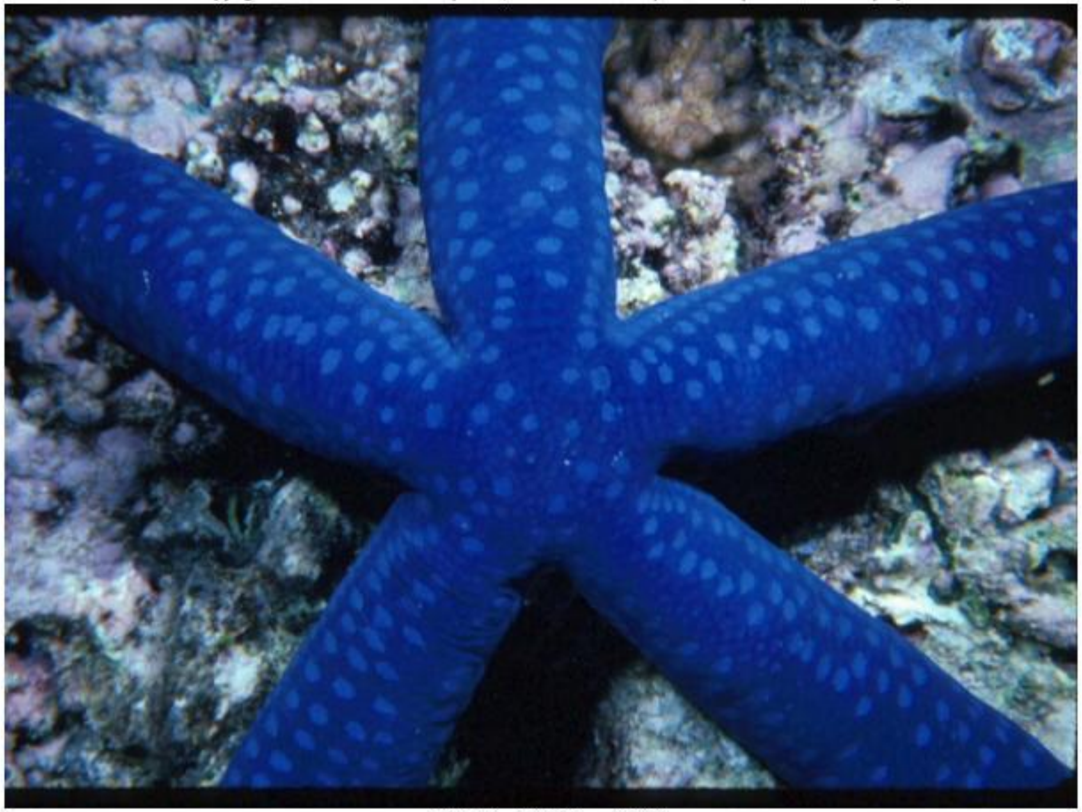
- Subphylum Echinozoa
  - Class Echinoidea
    - Subclass Cidaroidea
      - Order Cidaroida
    - Subclass Euechinoidea
      - Infraclass N.N.
        - Order Echinothurioida
      - Infraclass Acroechinoidea
        - Order Aspidodiadematoida
        - Order Diadematoida
        - Order Micropygoida
        - Order Pedinoida
      - Infraclass Carinacea
        - Order Arbacioida
        - Order Camarodonta
        - Order Salenioida
        - Order Stomopneustoida
      - Infraclass Irregularia
        - Order Cassiduloida
        - Order Clypeasteroida
        - Order Echinolampadoida
        - Order Holasteroida
        - Order Spatangoida
  - Class Holothuroidea
    - Order N.N. (*Thyone*)
    - Order Apodida
    - Order Aspidochirotida
    - Order Dendrochirotida
    - Order Elasipodida
    - Order Molpadida



†Extinct groups.

Class Asteroidea

- Sea stars have arms (rays) arranged around a central disc.
- The body is flattened, flexible, and covered with a ciliated, pigmented epidermis.



Class Asteroidea

- The mouth is on the underside of the sea star.
- **Ambulacral grooves** stretch out from the mouth along each ray.
  - Tube feet border each groove

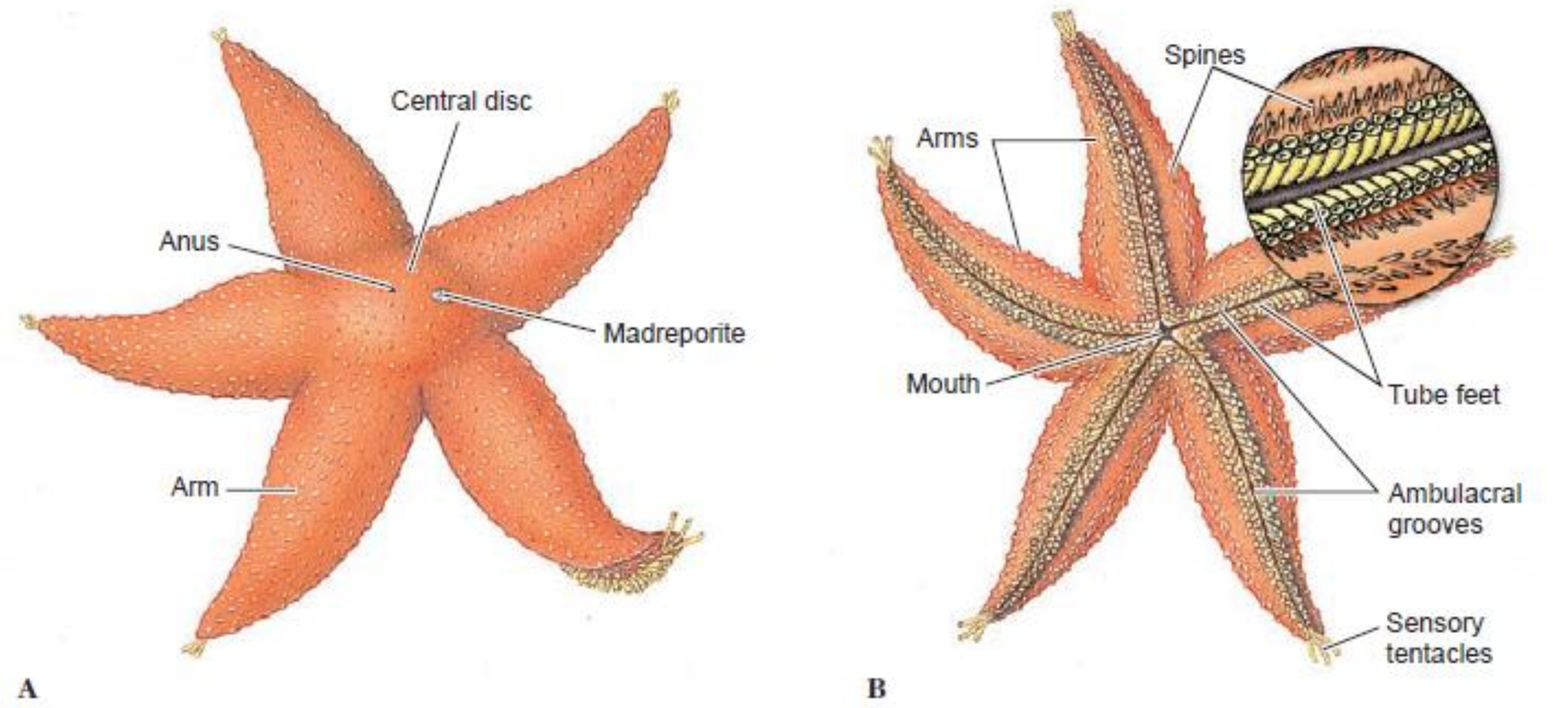
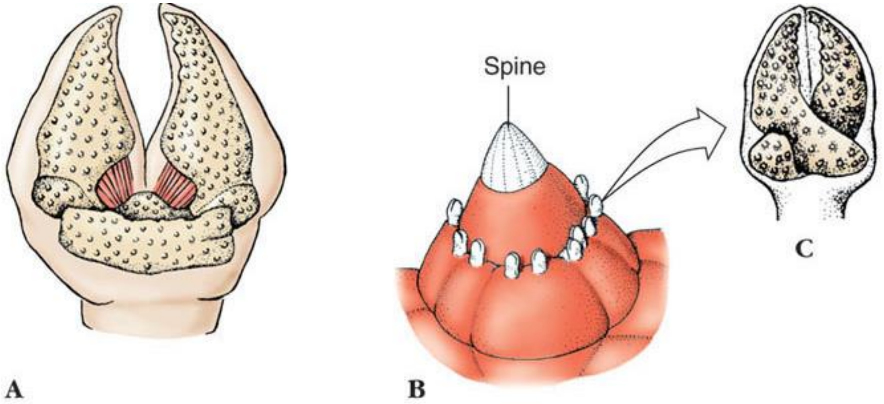
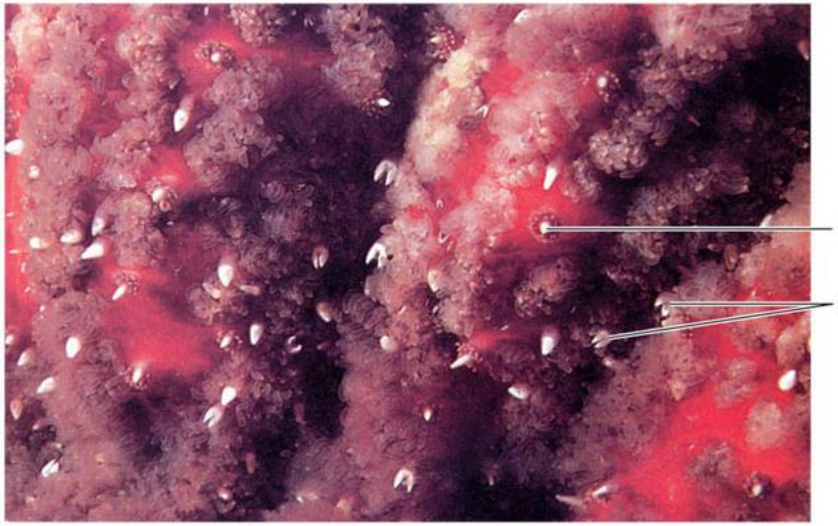


Figure 22.5
External anatomy of asteroid. **A,** Aboral view. **B,** Oral view.

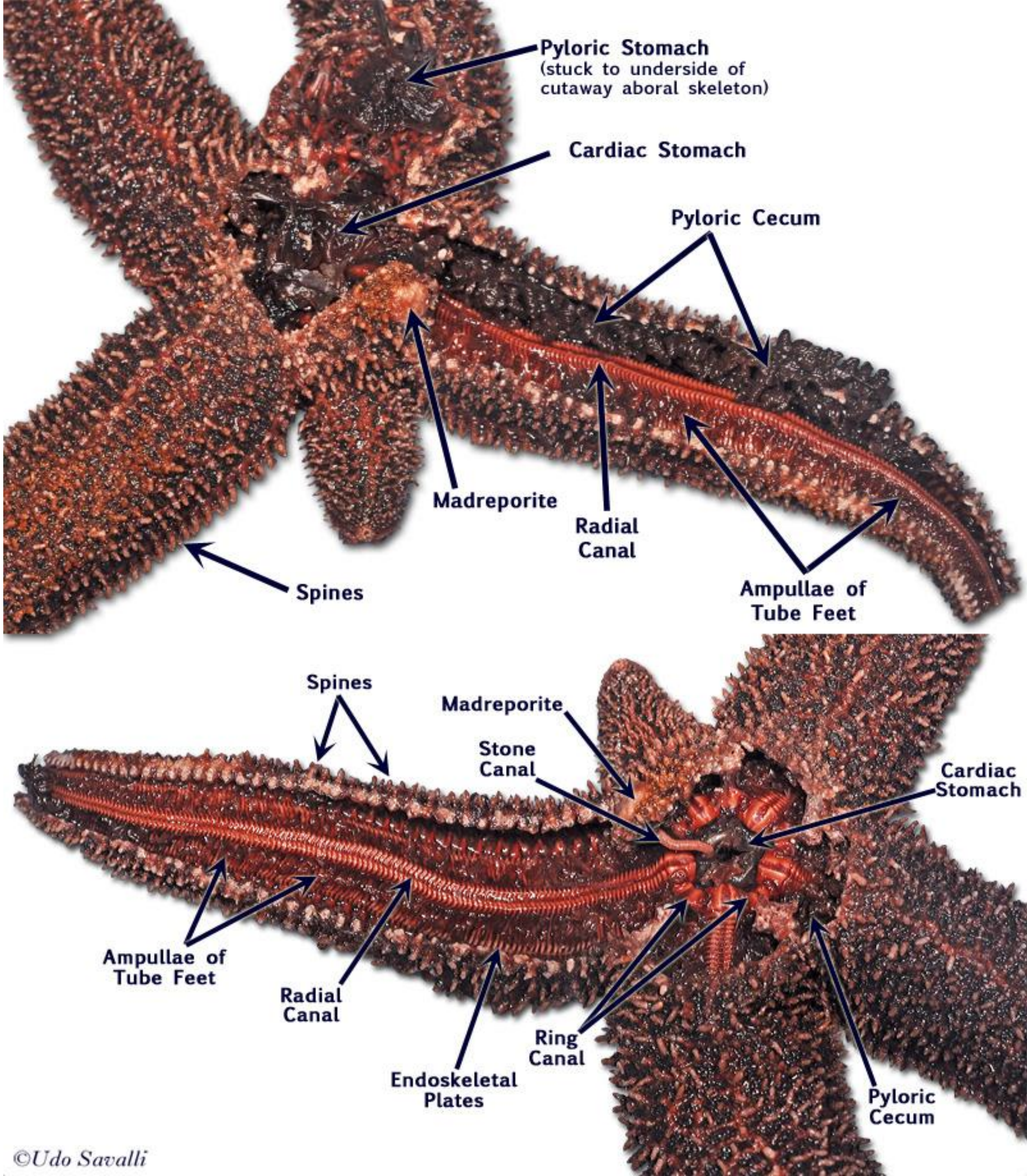
Class Asteroidea

- The **aboral surface** is often rough and spiny.
- Around the base of each spine there are pincerlike **pedicellariae** that keep the surface free of debris and sometimes help with food capture.





- The upper part of the stomach connects to a pair of **digestive glands** (pyloric ceca/ cecum) in each arm.



Class Asteroidea - Feeding

- Most sea stars are **carnivorous**; feeding on molluscs, crustaceans, polychaetes, echinoderms, other inverts & sometimes small fish.

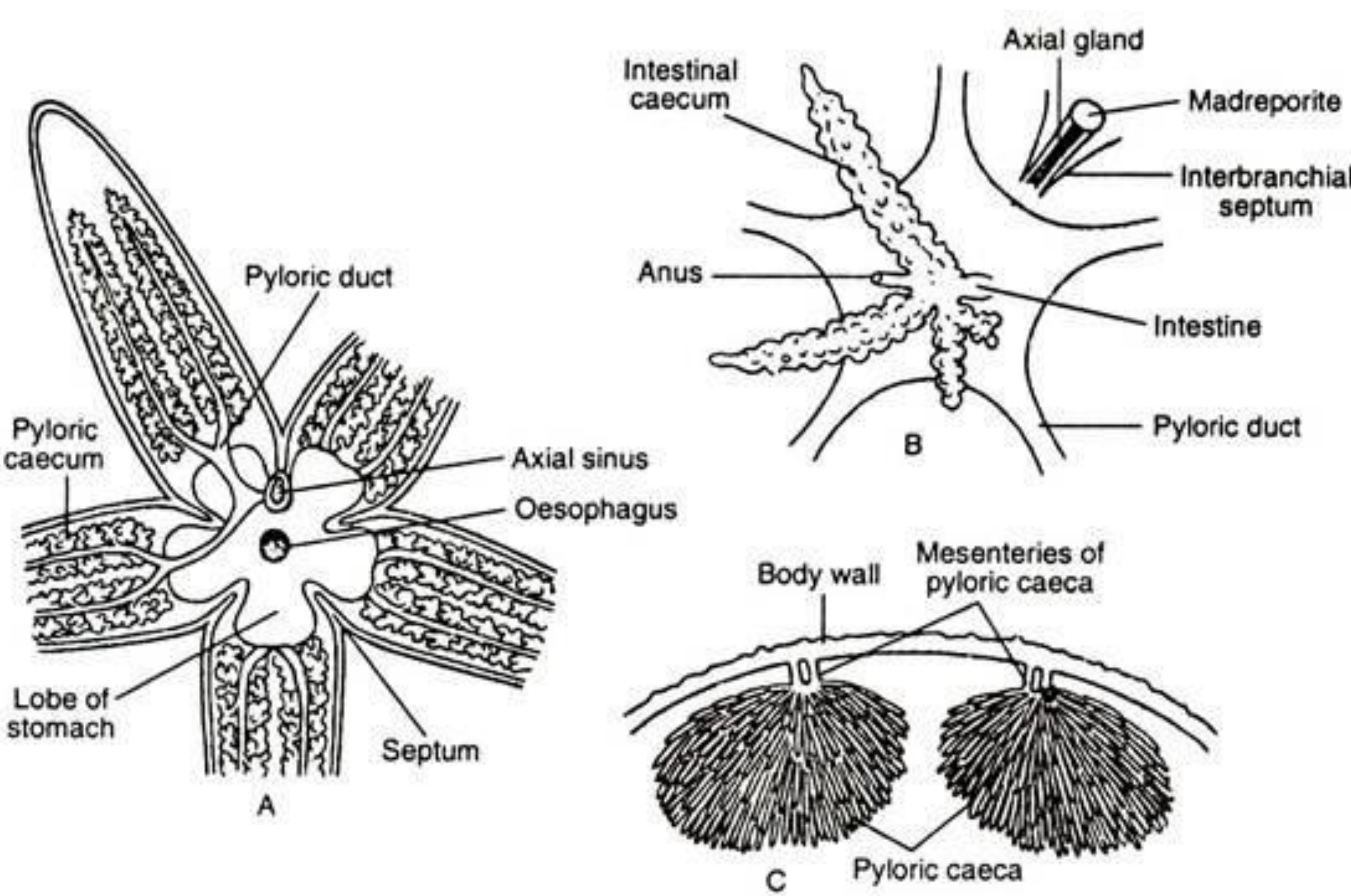
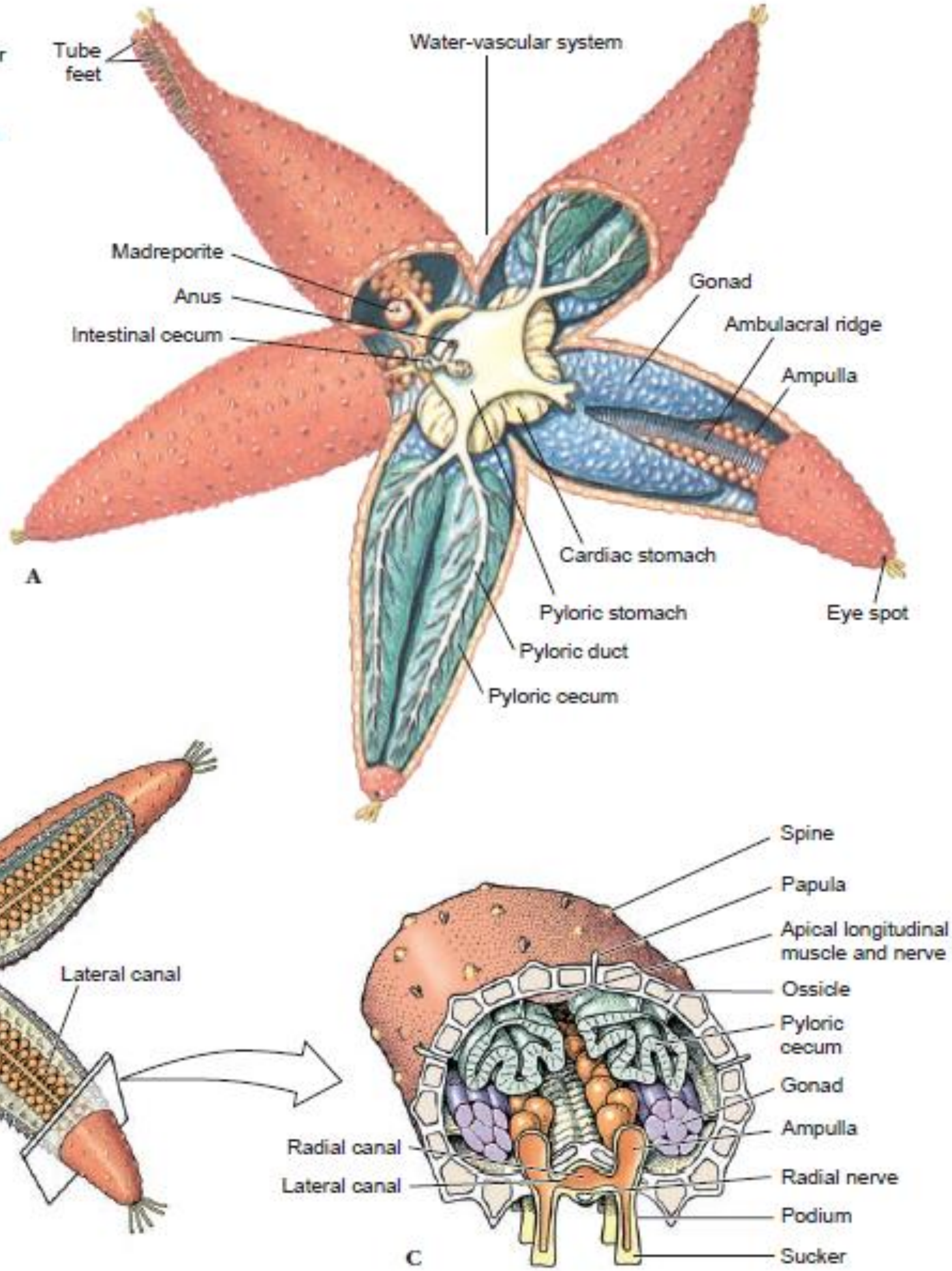


Fig. 21.6: A. Aboral view of the digestive tract of *Asterias*. B. Pyloric stomach and intestinal caeca of *Asterias* (enlarged view). C. Attachment of pyloric caeca with the aboral wall of arm of *Asterias*.

Figure 22.6

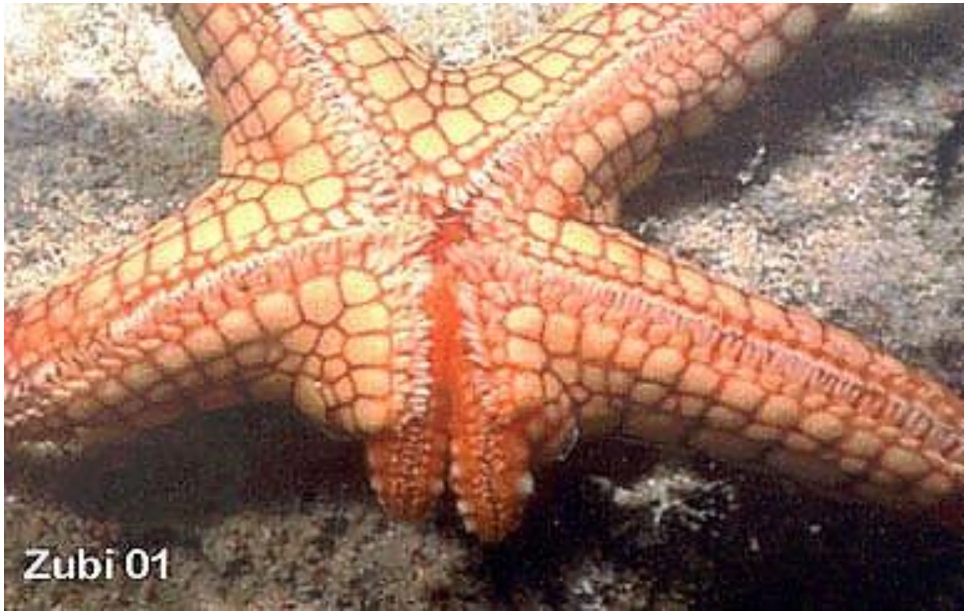
A, Internal anatomy of a sea star. **B,** Water-vascular system. Podia penetrate between ossicles. (Polian vesicles are not present in *Asterias*.) **C,** Cross section of arm at level of gonads, illustrating open ambulacral grooves.



Class Asteroidea – Reproduction

- Most sea stars have separate sexes with a pair of gonads in each ray.
- Fertilization is external.

- Echinoderms can regenerate lost parts.
- Sea stars can readily replace an arm if it is lost.
- This may take several months
- They can also cast off an injured arm.



Class Asteroidea – Reproduction

- Some species can even regenerate an entire individual from a broken off arm.
  - Usually, a small piece of the central disc must be included.
  - *Linckia* can regenerate a whole new individual from a broken arm with no central disc attached.

Class Asteroidea – Reproduction

- **Metamorphosis** involves a reorganization into a radial juvenile.
  - Left/right becomes oral/aboral.

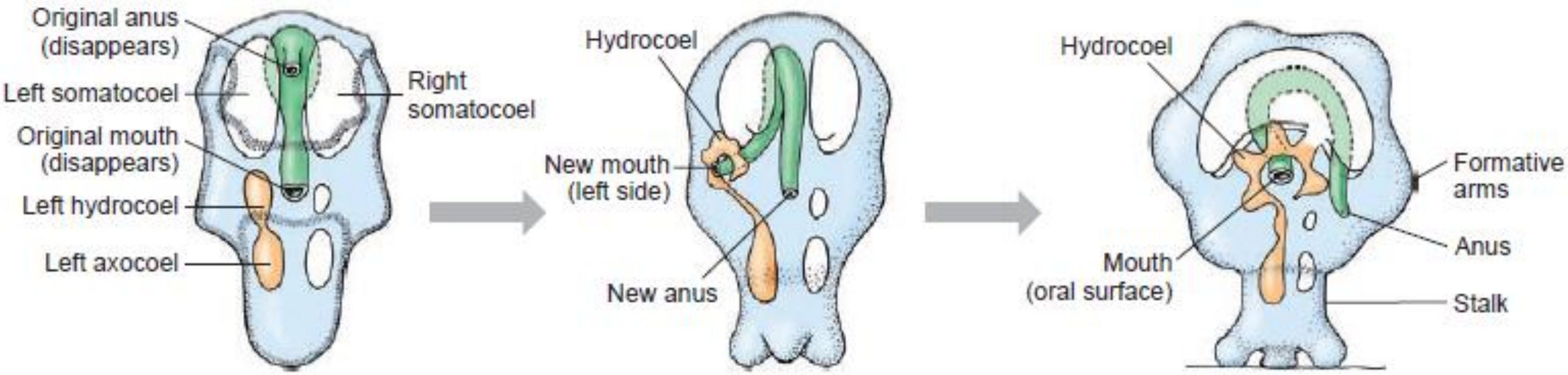


Figure 22.11
Asteroid metamorphosis. The left somatocoel becomes the oral coelom, and the right somatocoel becomes the aboral coelom. The left hydrocoel becomes the water-vascular system and the left axocoel the stone canal and perihemal channels. The right axocoel and hydrocoel are lost.

Class Ophiuroidea

- No **pedicillariae** or **skin gills**.
- **Madreporite** is on the oral surface.
- **Tube feet** have no suckers, their primary function is to aid in feeding.
- Brittle stars move using their arms rather than tube feet.

Figure 22.14

A, Brittle star, *Ophiura lutkeni* (class Ophiuroidea). Brittle stars do not use their tube feet for locomotion but can move rapidly (for an echinoderm) by means of their arms. **B,** Basket star, *Astrophyton muricatum* (class Ophiuroidea). Basket stars extend their many-branched arms to filter-feed, usually at night. They show a strongly negative phototropic response.

A

B

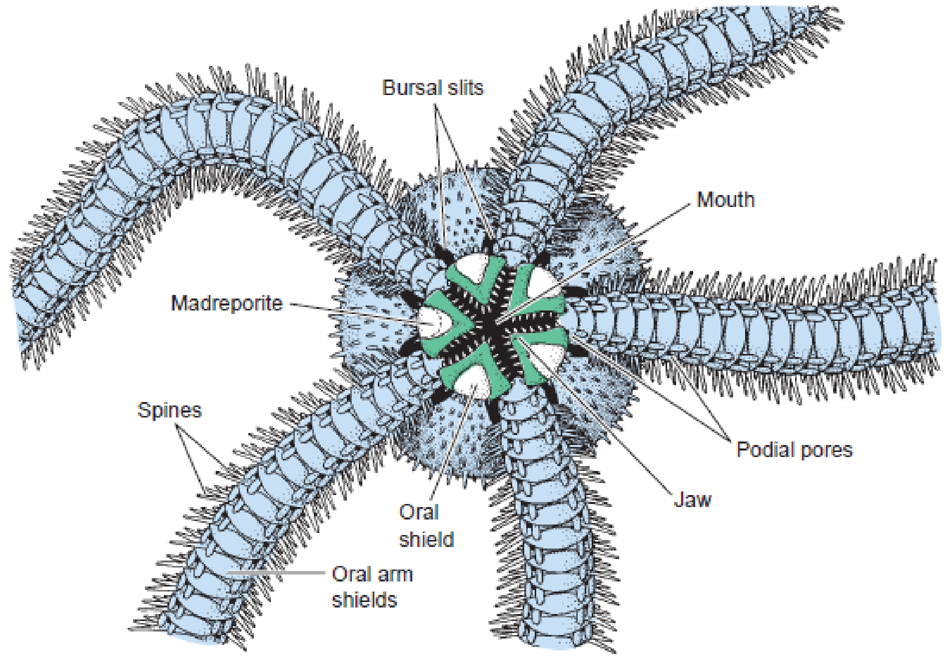


Figure 22.15
Oral view of spiny brittle star, *Ophiothrix.*

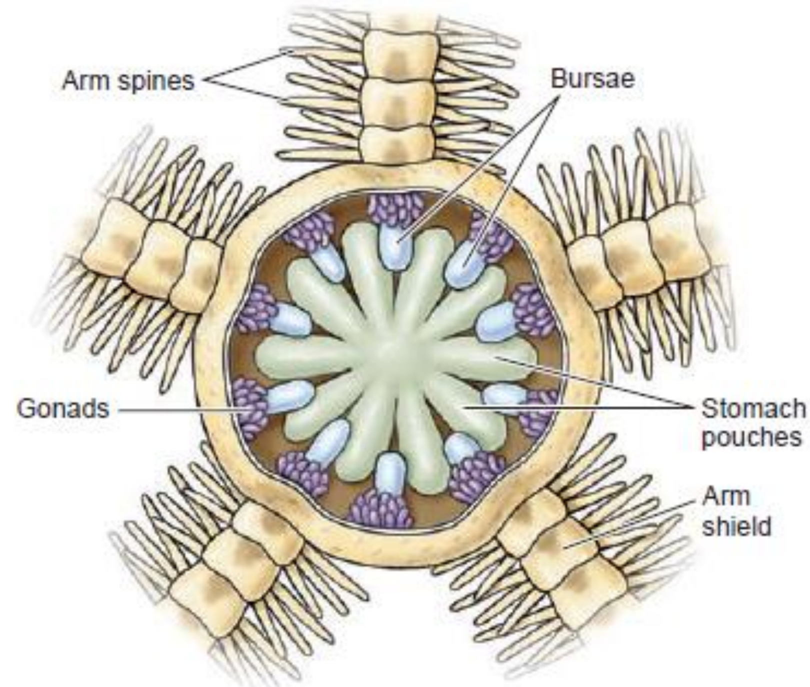


Figure 22.16
Ophiuroid with aboral disc wall cut away to show principal internal structures. Bursae are fluid-filled sacs in which water constantly circulates for respiration. They also serve as brood chambers. Only bases of arms are shown.

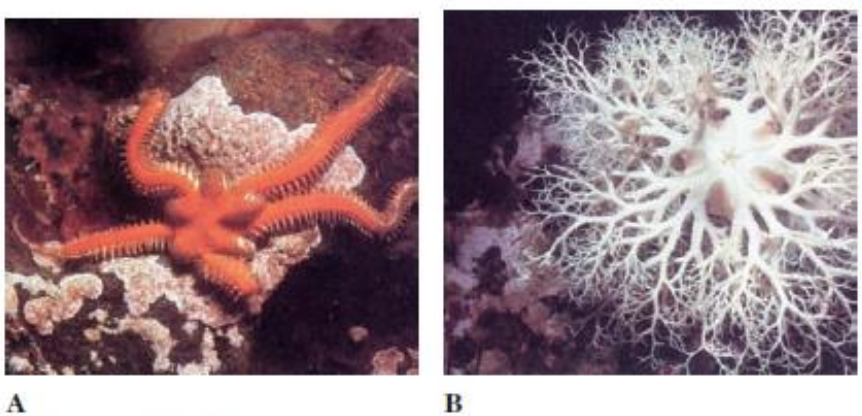


Figure 22.17
A, This brittle star, *Ophiopholis aculeata,* has its bursae swollen with eggs, which it is ready to expel. The arms have been broken and are regenerating. **B,** Oral view of a basket star, *Gorgonocephalus eucnemis,* showing pentaradial symmetry.

Class Echinoidea

Class Echinoidea includes sea urchins and sand dollars.

The **endoskeleton** is well developed in echinoids. **Dermal ossicles** have become close-fitting plates that form the **test**.

Class Echinoidea

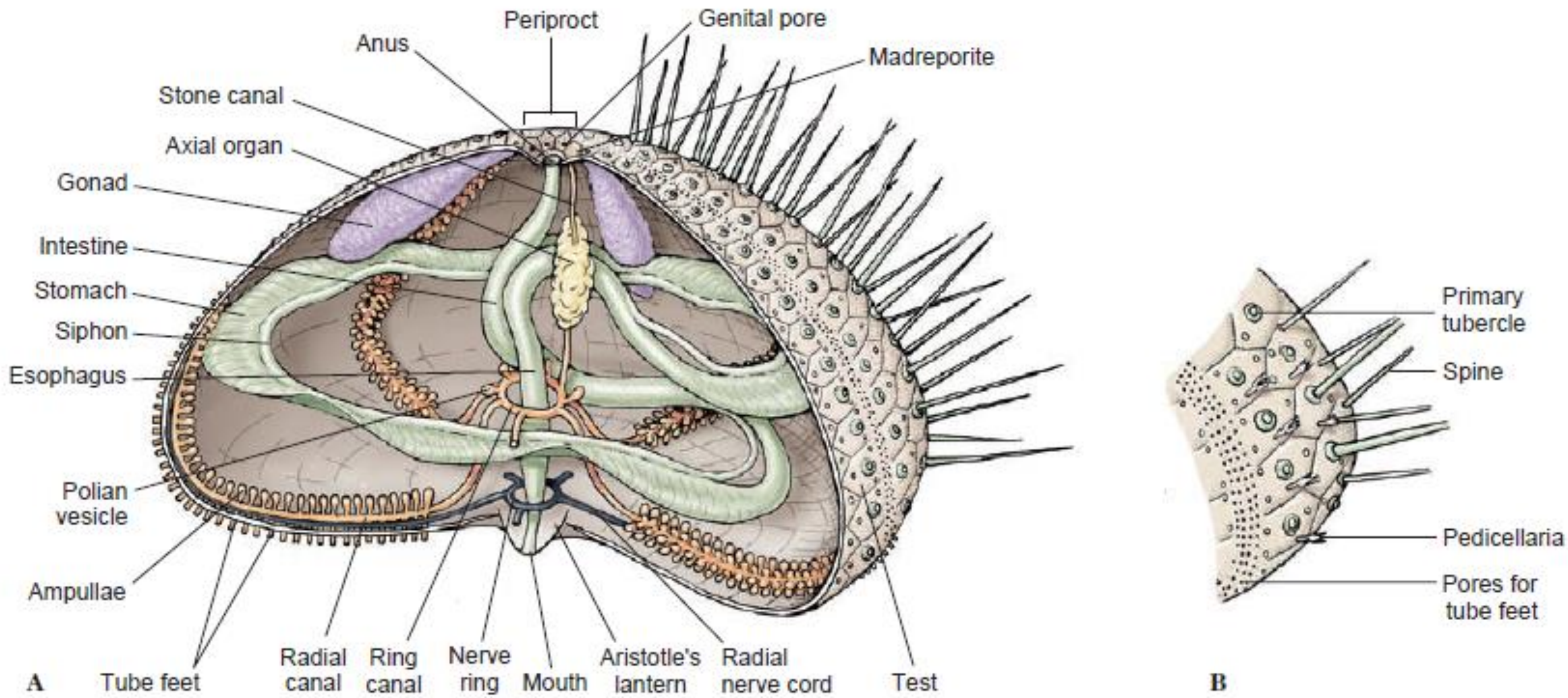


Figure 22.22
A, Internal structure of a sea urchin; water-vascular system in tan. **B,** Detail of portion of endoskeleton.

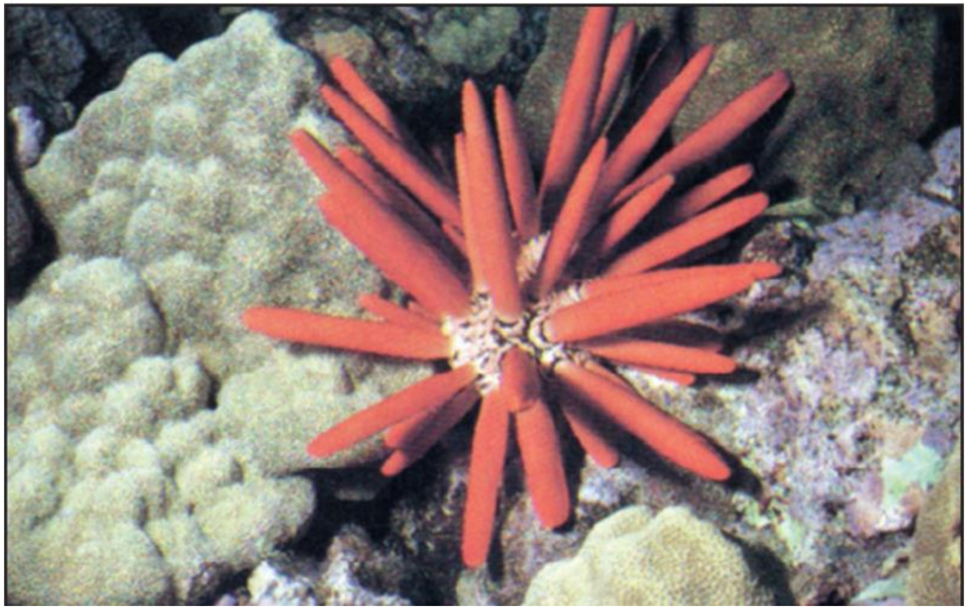
Class Echinoidea

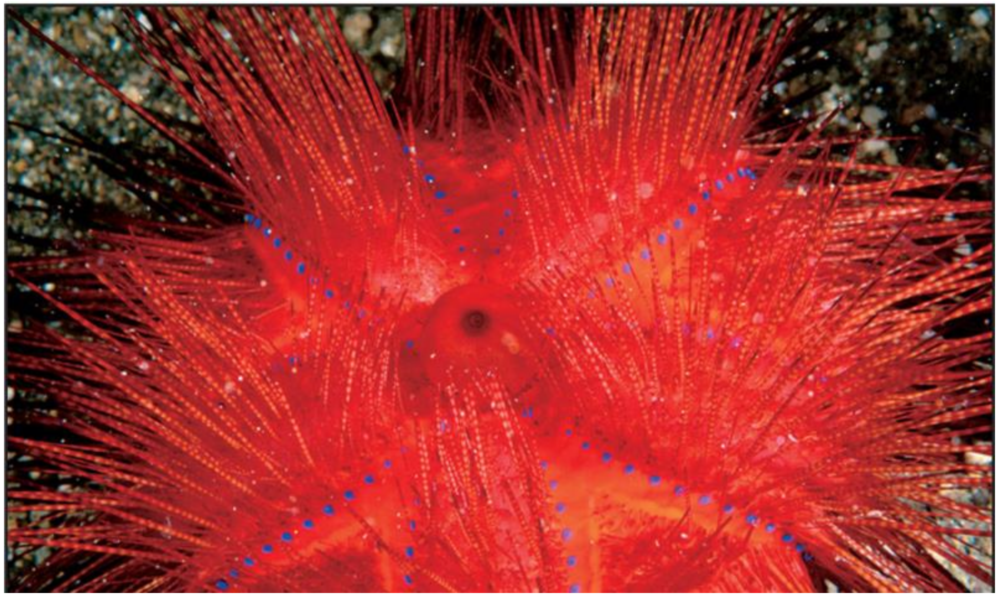
- Echinoids lack arms, but still show the **pentamerous plan** in the five ambulacral areas with pores in the **test** for the tube feet.

Class Echinoidea

Most echinoids are "**regular**" having a hemispherical shape, radial symmetry, and medium to long spines.

Regular urchins move using their tube feet with some help from spines.





Class Echinoidea

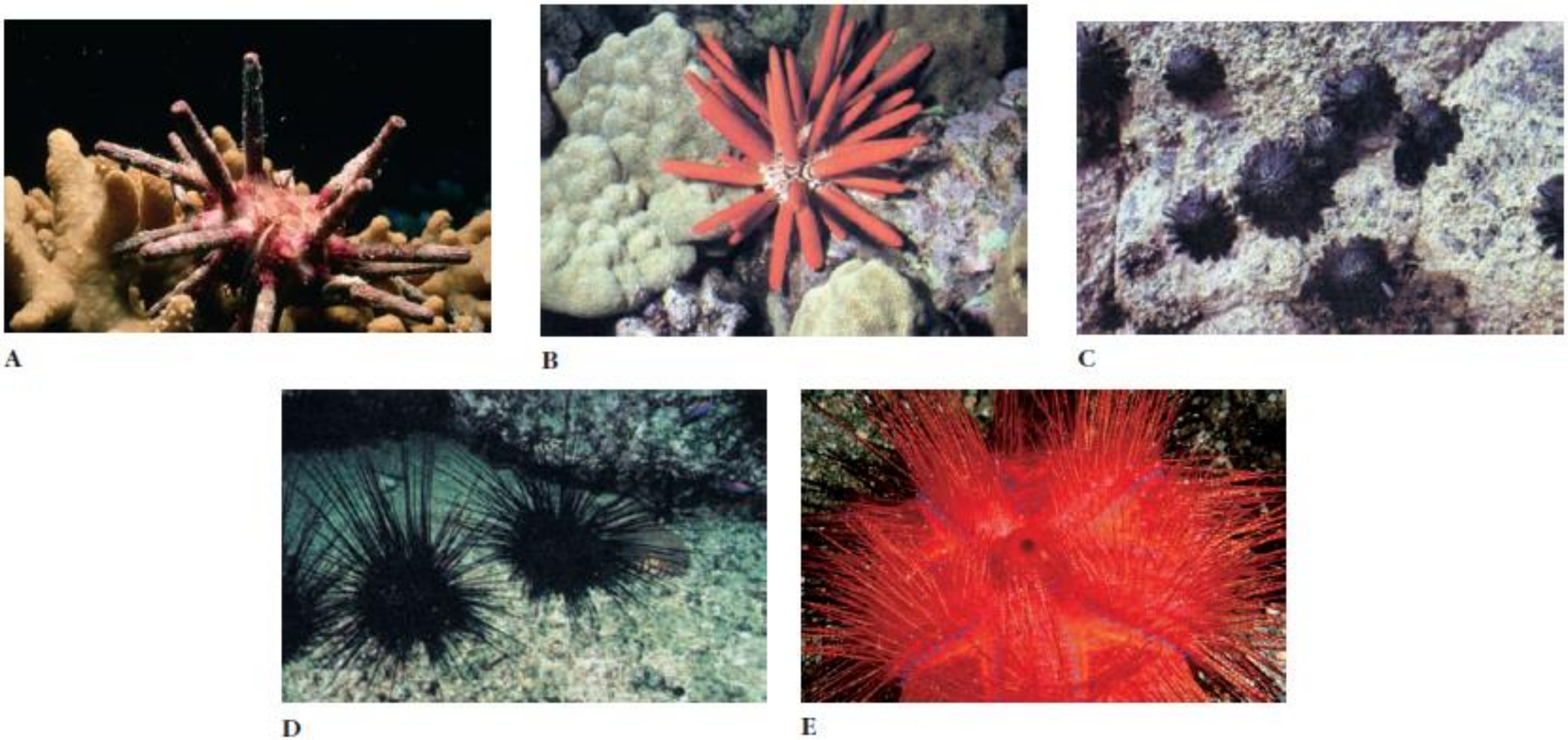


Figure 22.18

Diversity among regular sea urchins (class Echinoidea). **A,** Ten-lined pencil urchin, *Eucidaris metularia* in the Red Sea. Members of this order have many ancestral characters and have survived since the Paleozoic era. They may be closest in resemblance to the common ancestor of all other extant echinoids. **B,** Slate-pencil urchin, *Heterocentrotus mammilatus*. The large, triangular spines of this urchin were formerly used for writing on slates. **C,** Aboral spines of the intertidal urchin, *Colobocentrotus atratus*, are flattened and mushroom shaped, while the marginal spines are wedge shaped, giving the animal a streamlined form to withstand pounding surf. **D,** *Diadema antillarum* is a common species in the West Indies and Florida. **E,** *Astropyga magnifica* is one of the most spectacularly colored sea urchins, with bright-blue spots along its interambulacral areas.

- "**Irregular**" echinoids include the sand dollars and heart urchins that include some species that have become bilateral.
- Spines are usually short and are used in locomotion.

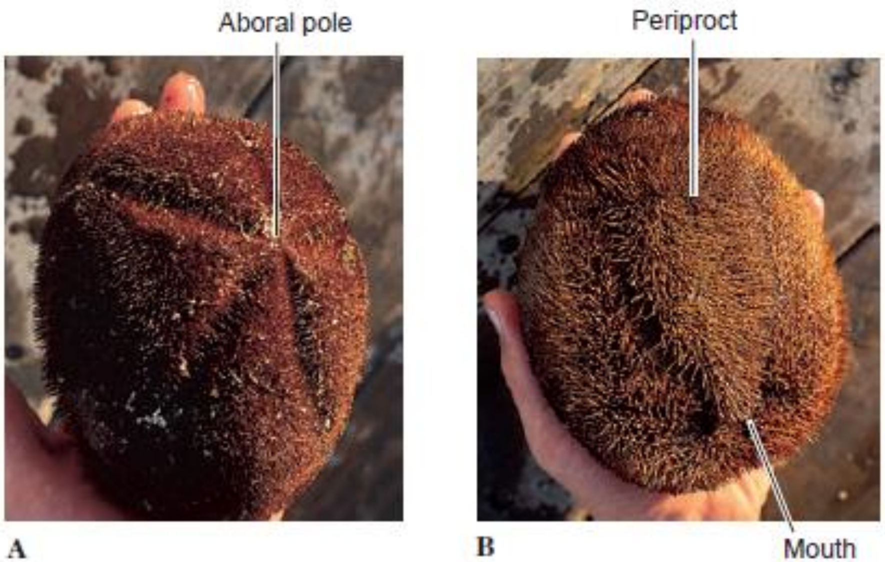


Figure 22.21

An irregular echinoid, *Meoma,* one of the largest heart urchins (test up to 18 cm). *Meoma* occurs in the West Indies and from the Gulf of California to the Galápagos Islands. **A,** Aboral view. Anterior ambulacral area is not modified as a petaloid in heart urchins, although it is in sand dollars. **B,** Oral view. Note curved mouth at anterior end and periproct at posterior end.

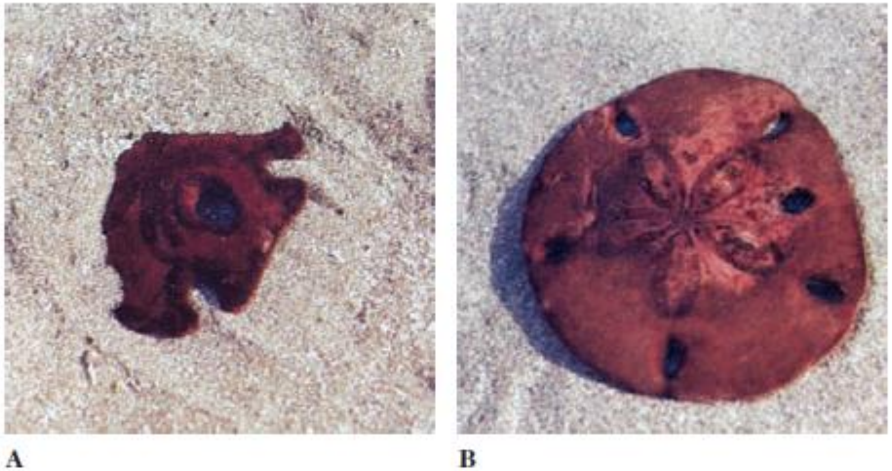


Figure 22.20

Two sand dollar species. **A,** *Encope grandis* as normally found burrowing near the surface on a sandy bottom. **B,** Removed from the sand. The short spines and petaloids on the aboral surface of this *Encope micropora* are easily seen.

- Some urchins have very reduced tests, and bright coloration.
- The **pedicellariae** in these species contain painful toxins.
- Echinoids live in all seas from the intertidal to the deep sea.
- Urchins usually prefer rocky substrate, while sand dollars and **heart urchins like to burrow into sandy substrate**

- Echinoids have a complex chewing mechanism called **Aristotle's lantern**.
  - Teeth are attached here.
- Sea urchins are usually omnivorous feeding mostly on algae.

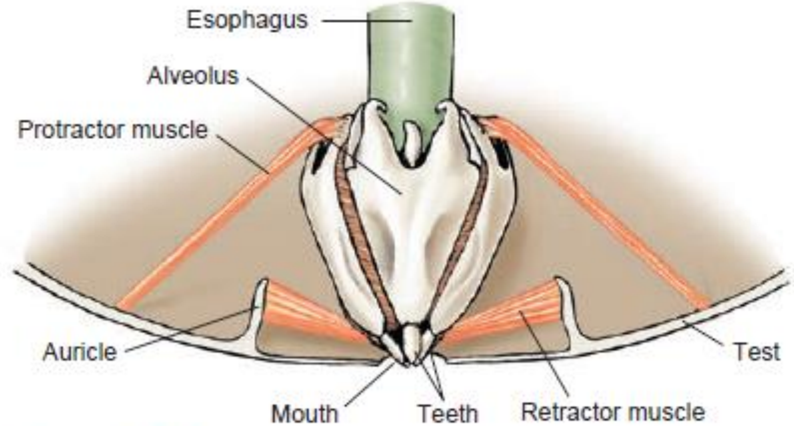


Figure 22.23
Aristotle's lantern, a complex mechanism used by sea urchins for masticating their food. Five pairs of retractor muscles draw the lantern and teeth up into the test; five pairs of protractors push the lantern down and expose the teeth. Other muscles produce a variety of movements. Only major skeletal parts and muscles are shown in this diagram.

- Sand dollars use their short spines to move sand & its organic contents to the sides, the food particles drop between the spines, and ciliated tracts on the oral side carry the particles to the mouth.

Class Holothuroidea

- **Sea cucumbers (Class Holothuroidea)** are elongated along the oral/aboral axis.
- Bilateral
- **Ossicles** are greatly reduced in most species.
- The body wall is usually leathery with tiny ossicles embedded in it, but can be very thin.

A B C

Figure 22.24

Sea cucumbers (class Holothuroidea). **A,** Common along the Pacific coast of North America, *Parastichopus californicus* grows to 50 cm in length. Its tube feet on the dorsal side are reduced to papillae and warts. **B,** In sharp contrast to most sea cucumbers, the surface ossicles of *Psolus chitonoides* are developed into a platelike armor. The ventral surface is a flat, soft, creeping sole, and the mouth (surrounded by tentacles) and anus are turned dorsally. **C,** Tube feet are found in all ambulacral areas of *Cucumaria miniata* but are better developed on its ventral side, shown here.

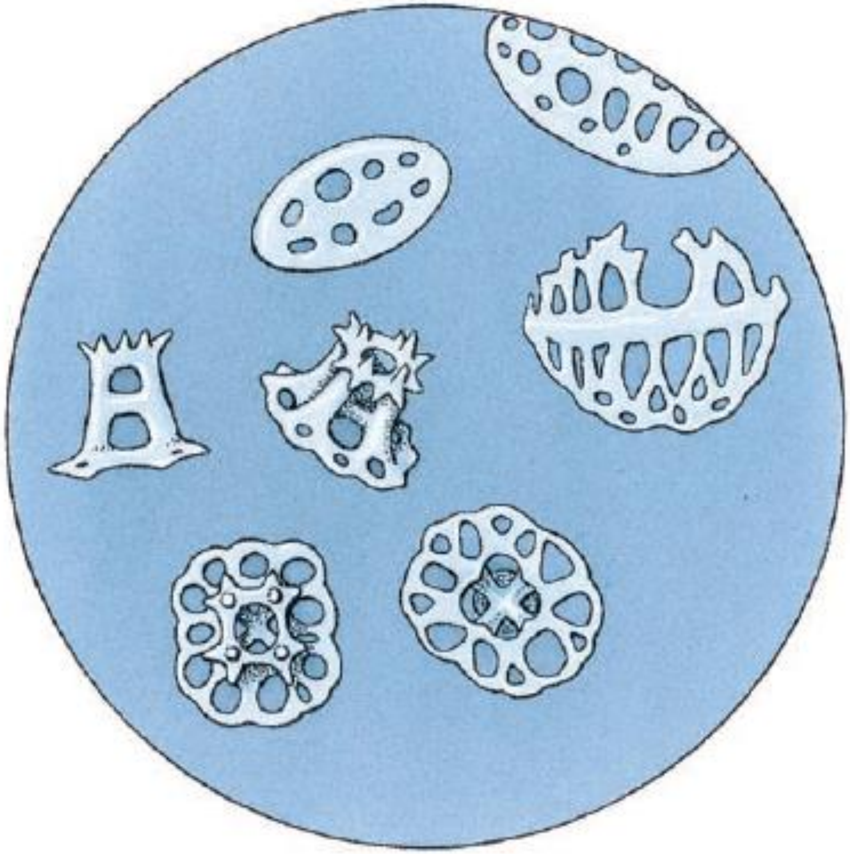


Figure 22.25

Ossicles of sea cucumbers are usually microscopic bodies buried in leathery dermis. They can be extracted from this tissue with commercial bleach and are important taxonomic characteristics. The ossicles shown here, called tables, buttons, and plates, are from *Holothuria difficilis*. They illustrate the meshwork (stereom) structure observed in ossicles of all echinoderms at some stage in their development (×250).

Photo Copyright © Diane R. Nelson

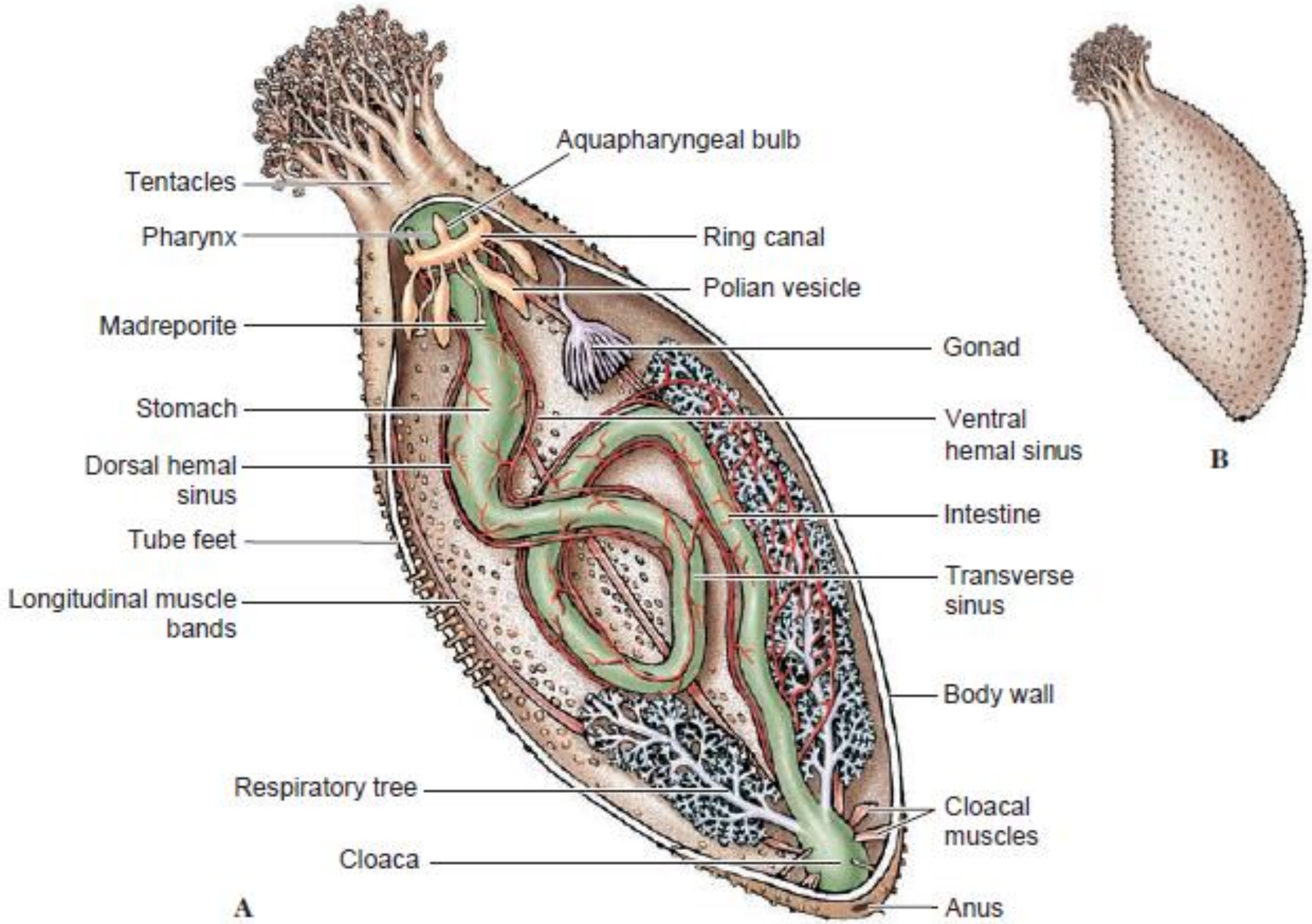
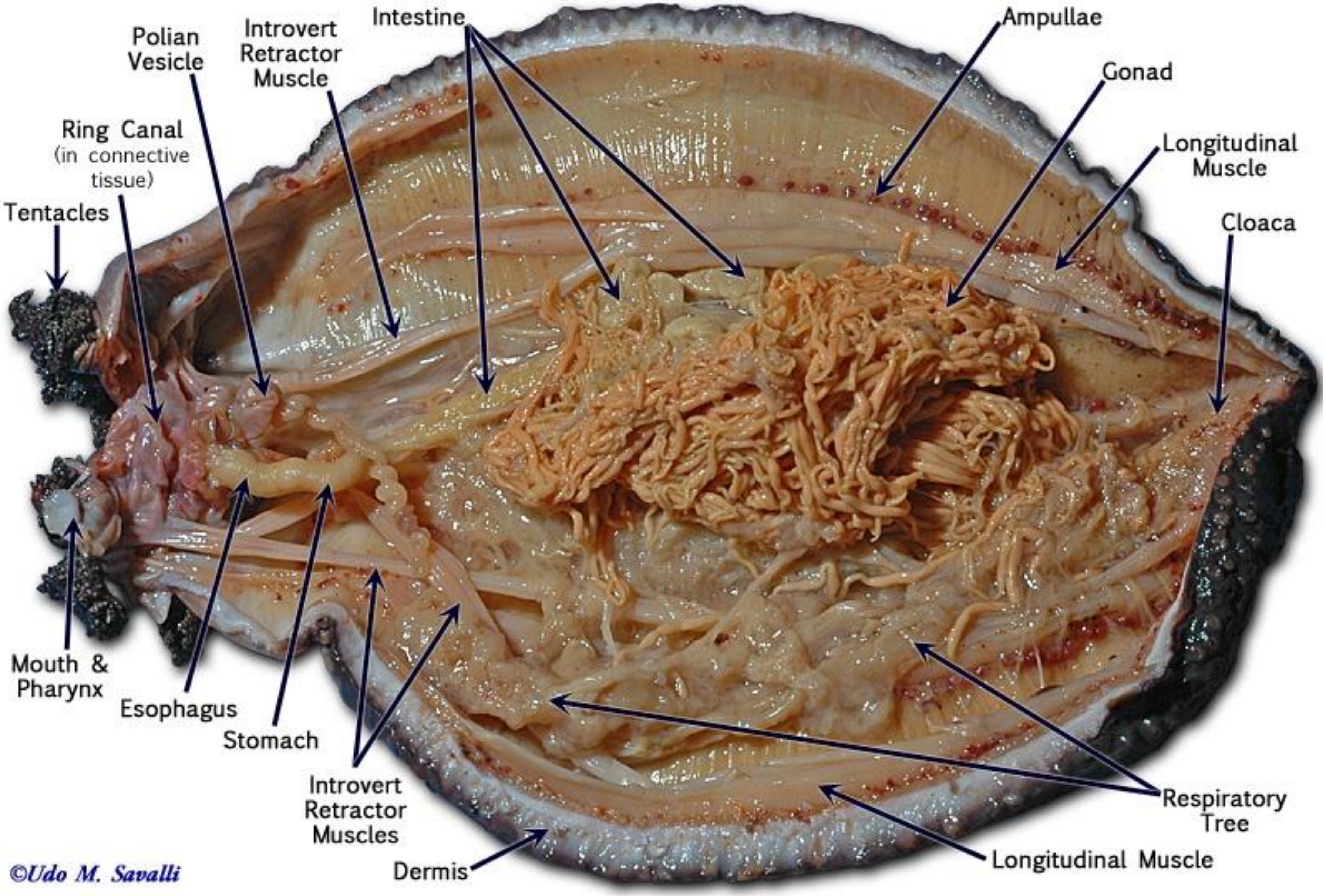


Figure 22.26

Anatomy of a sea cucumber *Sclerodactyla*. **A,** Internal. *Red,* hemal system. **B,** External.


Intestine
Ampullae
Polian Vesicle
Introvert Retractor Muscle
Gonad
Ring Canal (in connective tissue)
Longitudinal Muscle
Tentacles
Cloaca
Mouth & Pharynx
Esophagus
Stomach
Introvert Retractor Muscles
Respiratory Tree
Dermis
Longitudinal Muscle
©Udo M. Savalli

Class Holothuroidea

- Oral tentacles are modified tube feet located around the mouth.
- Food particles are gathered by the oral tentacles.
  - Tentacles are put into the pharynx one by one so food can be sucked off.

- Sea cucumbers move using ventral tube feet and waves of contraction along the muscular body wall.

- Sea cucumbers have a very unusual defense mechanism:
  - They are able to cast out part of their viscera.
  - The lost parts regenerate.
  - Some have organs of Cuvier that can be expelled in the direction of an enemy.
    - These tubules become long and sticky, sometimes containing toxins.

Class Crinoidea

- **Crinoids** include sea lilies and feather stars.
- At **metamorphosis**, juveniles become sessile and stalked.
- Adults are free-moving in some species.
- Long, many branched arms.

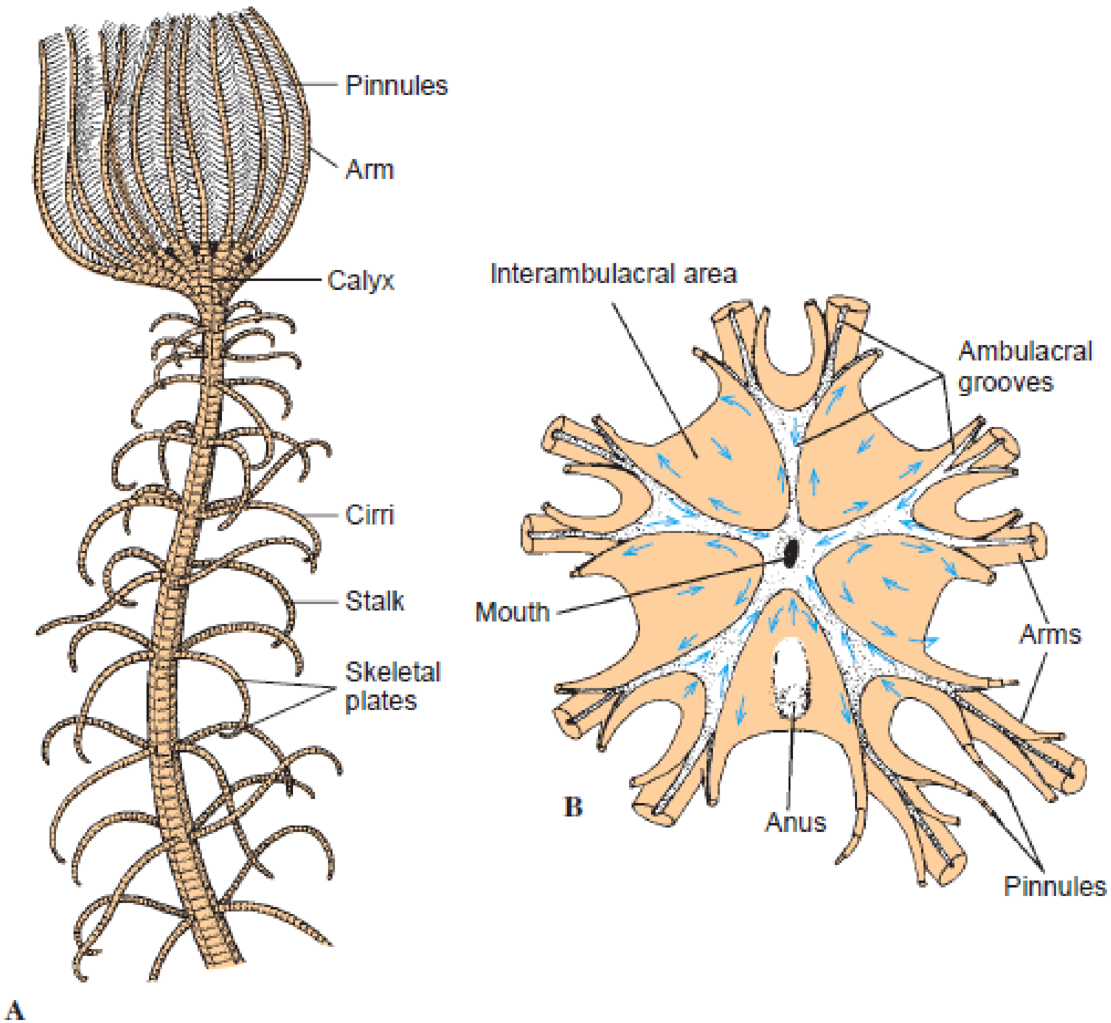
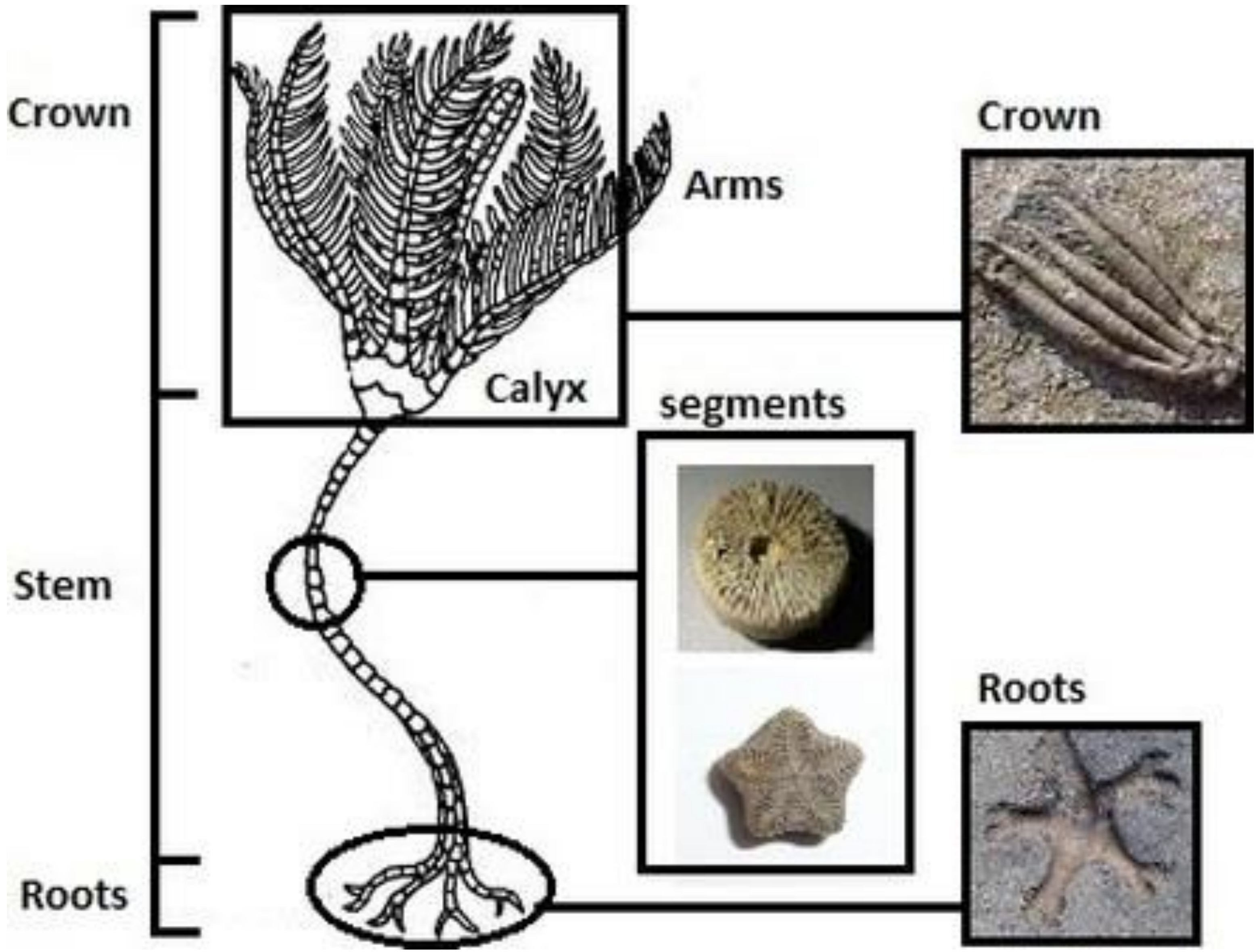
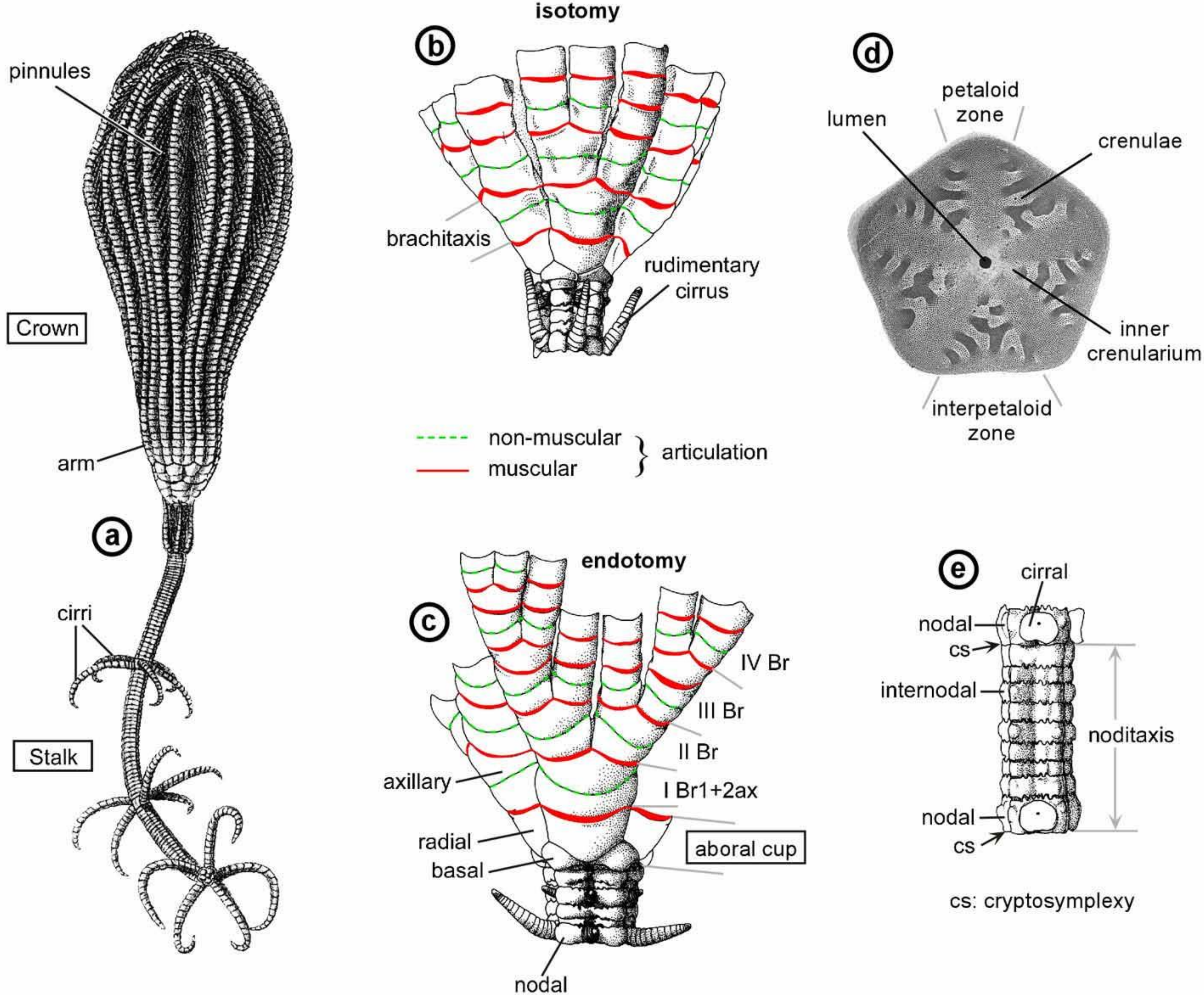


Figure 22.28

Crinoid structure. **A,** Sea lily (stalked crinoid) with portion of stalk. Modern crinoid stalks rarely exceed 60 cm, but fossil forms were as much as 20 m long. **B,** Oral view of calyx of a crinoid, *Antedon,* showing direction of ciliary food currents. Ambulacral grooves with podia extend from mouth along arms and branching pinnules. Food particles touching podia are tossed into ambulacral grooves and carried, tangled in mucus, by strong ciliary currents toward mouth. Particles falling on interambulacral areas are carried by cilia first toward mouth and then outward and finally dropped off the edge, thus keeping the oral disc clean.


Crown
Arms
Crown
Calyx
segments
Stem
Roots
Roots



pinnules
Crown
arm
a
cirri
Stalk
isotomy
b
brachitaxis
rudimentary
cirrus
non-muscular
muscular
articulation
endotomy
c
IV Br
III Br
II Br
I Br1+2ax
axillary
radial
basal
aboral cup
nodal
d
petaloid
zone
lumen
crenulae
inner
crenularium
interpetaloid
zone
e
cirral
nodal
cs
internodal
noditaxis
nodal
cs
cs: cryptosymplexy

Phylogeny

- Echinoderms are probably derived from bilateral ancestors.
- Pentaradial symmetry may have been an adaptation to a sessile existence.
- Some forms then become mobile.
  - Some mobile forms are secondarily bilateral.

“ Jadi Apakah Patrick Bintang Laut Lebih Pintar dari Spongebob??“