

Phylum Echinodermata

(Characters, Classification and Types)

32

Phylum **Echinodermata** (Gr., *echinos* = hedgehog; *derma* = skin) includes about 6000 species of marine **spiny skinned animals** such as starfishes, brittle stars, sea urchins, sea cucumbers, sand dollars and sea lilies. They distinctly have a unique **water vascular system** equipped with **podia** or **tube feet** which are used in locomotion and feeding. Echinodermata forms the only major group of **deuterostome** (Box 32.1) Invertebrata.

Box 32.1 Protostomia vs. Deuterostomia

1. **Protostomes** (Gr., *proto* = first; *stoma* = mouth). Animals in which **blastopore** (which is a groove of early gastrula through which cells move inside to form endoderm and mesoderm) develops into the mouth, e.g., all metazoan invertebrates except echinoderms.
2. **Deuterostomes** (Gr., *deutero* = second; *stoma* = mouth). Animals in which blastopore becomes anus and mouth formation is secondary, e.g., Echinodermata and Chordata.

32.1 DEFINITION

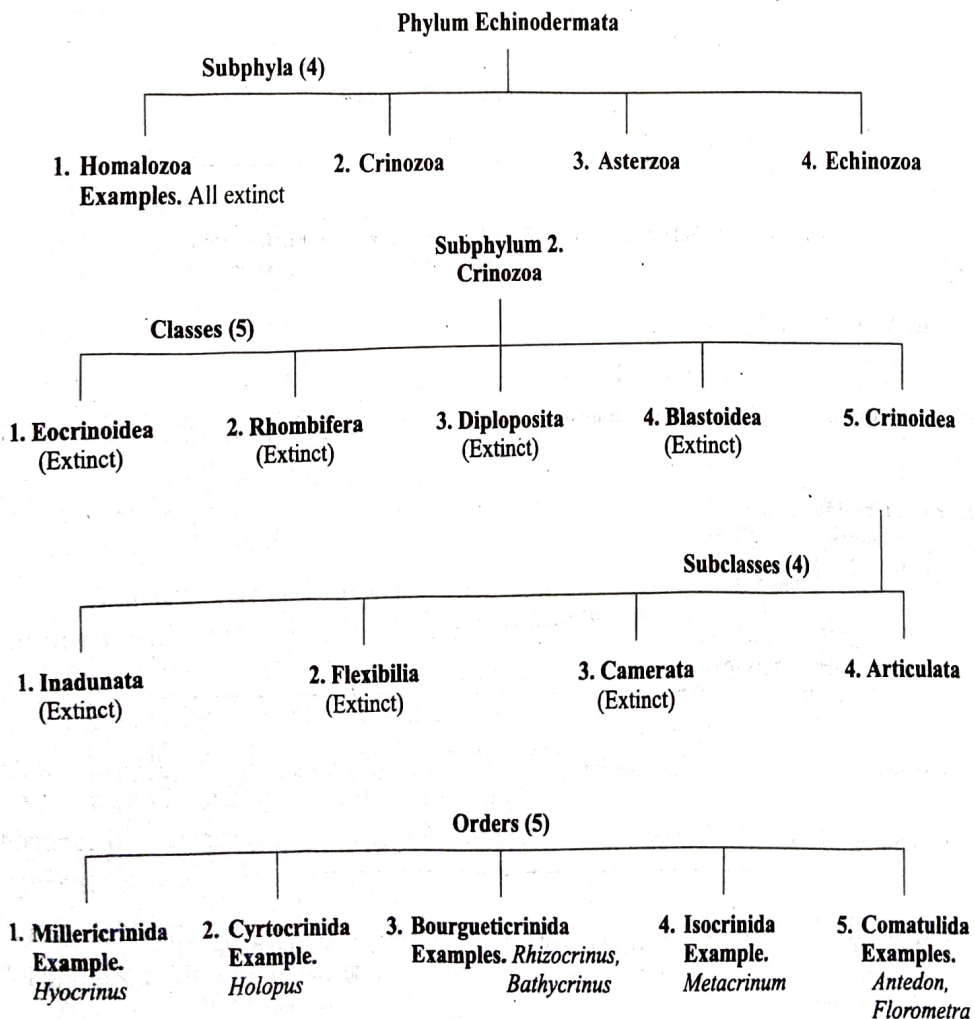
The echinoderms are triploblastic, unsegmented, enterocoelous coelomate animals having pentamerous radial symmetry (*i.e.*, biradial symmetry with an oral-aboral axis). Their larvae are bilaterally symmetrical. They contain an endoskeleton of calcareous plates or ossicles and a peculiar hydraulic ambulacral or water vascular system of coelomic origin. They have a complete alimentary canal, diffuse nervous system and no excretory system.

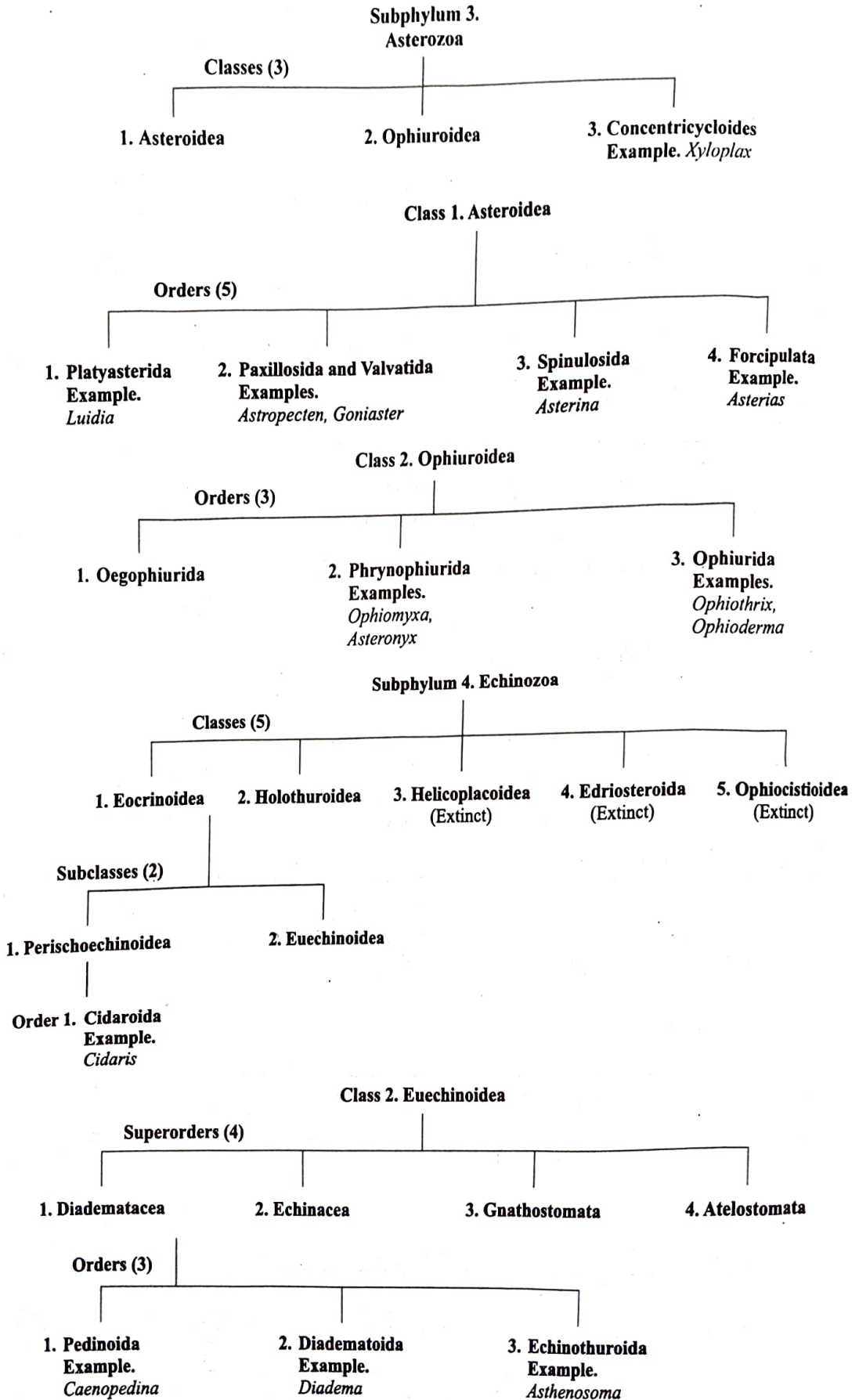
32.2 GENERAL CHARACTERISTICS

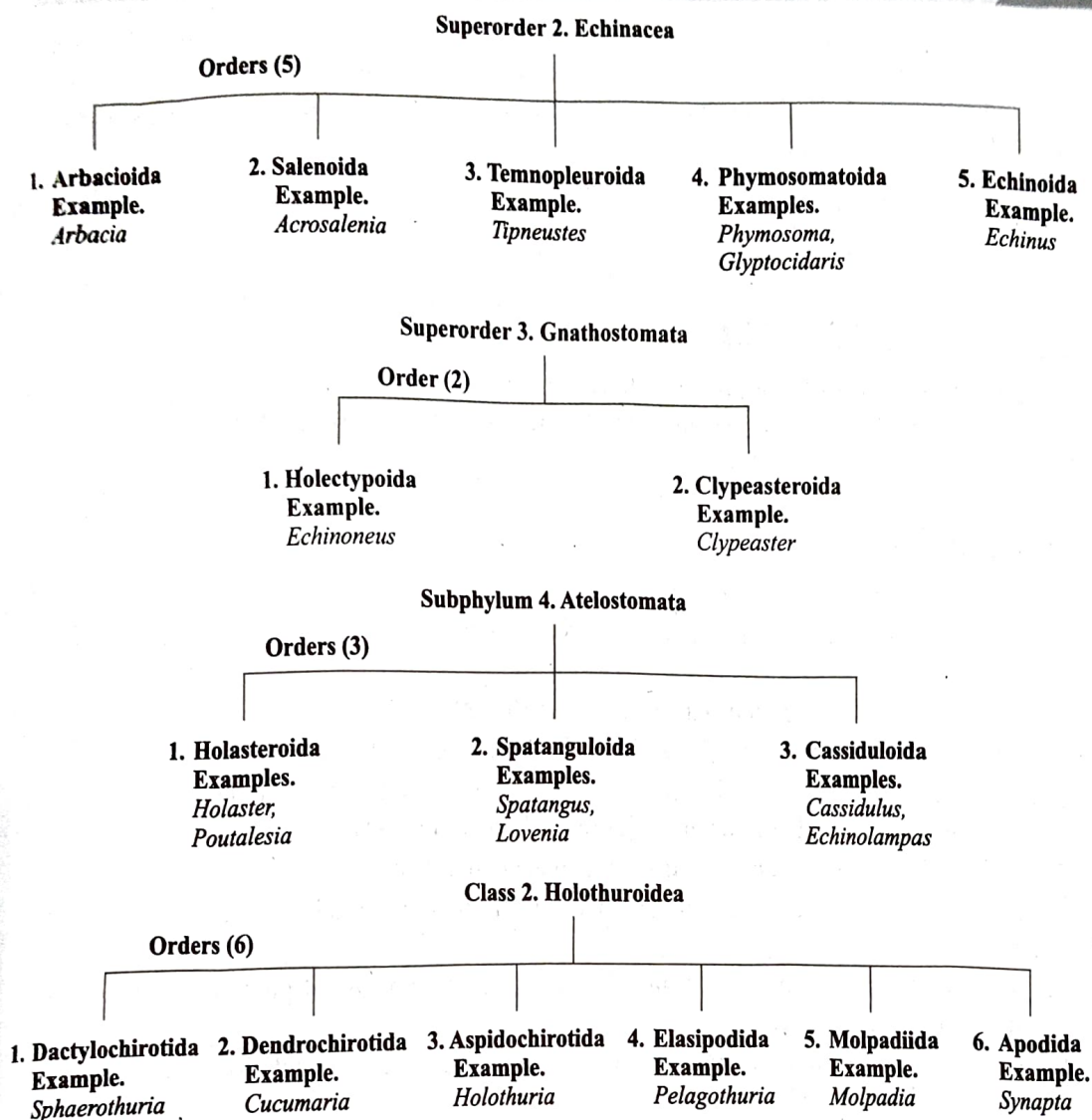
1. The echinoderms are exclusively **marine**, free-living and mostly bottom-dwellers.
2. They are **triploblastic**, **coelomate** and **unsegmented** animals.
3. **Head** is absent but body is differentiated into **oral** and **aboral surfaces**.
4. Adults show **radial symmetry** (usually **pentamerous**, *i.e.*, body parts occurring in fives) but their larvae are bilaterally symmetrical.
5. They are of moderate to considerable size but none are microscopic.
6. The body wall consists of an outer layer of **epidermis**, a middle **dermis** and an inner lining of peritoneum.
7. **Endoskeleton** consists of closely fitted calcareous plates of mesodermal origin forming a shell, many called **theca** or **test** or may be composed of separate small ossicles. Skeleton bears projecting **spines** or tubercles that give the body surface a warty or spiny appearance. Some echinoderms such as sea urchins have long movable spines.
8. A part of embryonic coelom is modified into a unique or distinctive **water vascular system** which consists of an array of radiating canals (ambulacral grooves) and tube-like appendages called **tube feet**.

9. Due to presence of water vascular system, the oral surface remains divided into **ambulacra** and **inter-ambulacra (inter-radial)**.
10. Coelom is spacious.
11. Digestive system is well developed. The coiled alimentary canal extends from the **mouth** on oral surface to the **anus** on the aboral surface.
12. Blood vascular system (also called **haemal** or **blood lacunar system**) is present but poorly developed.
13. Respiration occurs through **body wall, podia, respiratory tree** or **gills** (or **papulae**).
14. Excretory organs are absent.
15. Nervous system is simple and consists of networks concentrated into **circum-oral ring** and **radial ganglionated nerve cords**.
16. Sense organs are poorly developed.
17. Sexes are usually separate; sexual dimorphism is not well marked. Fertilization is external.
18. Development is indeterminate and indirect including characteristic larvae which undergo metamorphosis into the radially symmetrical adults.

32.3 OUTLINE CLASSIFICATION







32.4 DETAILED CLASSIFICATION

Phylum Echinodermata is divided into following **four** subphyla.

Subphylum 1. Homalozoa

1. These echinoderms are called **carpoids**. They all are extinct now. Carpoids existed from **Cambrian** period to **Devonian** period of **Palaeozoic** era.
2. They lacked any evidence of radial symmetry.

Example. *Dendrocystites*.

(**Note.** Subphylum Homalozoa is divided into three classes: **Homostela**, **Homoistela** (e.g., *Dendrocystites*) and **Stylophora**).

Subphylum 2. Crinozoa

1. These echinoderms are most primitive and were abundant during the **Palaeozoic** era.
2. They are radially symmetrical.
3. Their body has a globoid or cup-shaped **theca** or **test**.
4. They remain attached with substratum by aboral stalk.
5. Oral surface is directed upward. The mouth is surrounded by slender arms or **brachioles**.
6. This subphylum includes mostly extinct and some living echinoderms.

Subphylum 3. Asterozoa

1. Unattached (free moving) radially symmetrical, star-shaped echinoderms.
2. Body is composed of a flattened central disc and radially arranged arms or rays.

Subphylum 4. Echinozoa

1. Radially symmetrical globoid or discoid echinoderms.
2. Arms or brachioles are absent.
3. Mostly unattached (*i.e.*, free moving).

SUBPHYLUM 2. CRINOZOA

Subphylum Crinozoa contains the fossil eocrinoids (class **Eocrinoidea**), cystoids (class **Cystoidea**) and the fossil and living crinoids (class **Crinoidea**). Only the classification of the class Crinoidea is covered here.

Class Crinoidea

1. It includes both extinct and living forms.
 2. Living members are without stalk and free-moving but extinct forms were attached by a stalk.
 3. They are commonly called **sea lilies** and **feather stars**.
 4. Sea lilies are attached animals while feather stars are unattached.
 5. Pentamerous body of crinoids consists of an aboral cup, the **calyx** and oral cover or **roof**, the **tegmen**. Oral side or surface of body is directed upward.
 6. Oral surface contains a central **mouth** and eccentric **anus**.
 7. They contain five movable arms. Each arm is divided into two branches at the base so that there appears to be ten arms.
 8. Arms are with or without **pinnules**. Pinnate arms bear a row of pinnules on each side of the ambulacral groove.
 9. They contain five ambulacral grooves which are open and extend along each of the five arm and pinnules up to tip.
 10. Spines and pedicellariae are absent.
 11. Water vascular system is peculiar. There are about 1500 minute ciliated funnels which perforate the membrane that covers the oral surface. **Stone canal** is present but **madreporite** is absent.
 12. Sexes are separate. Gonads are indefinite masses of gametes located in the arms or pinnules. **Genital pinnules** generally lack an ambulacral groove. Males shed sperm first; this then stimulates the female to shed the eggs.
 13. Larva of crinoids is non-feeding barrel-shaped **vitellaria** or **doliolaria**.
- The class Crinoidea is divided into **four** subclasses.

Subclasses 1 to 3. Inadunata, Flexibilia and Camerata

1. These subclasses include extinct crinoids.
2. All were stalked Palaeozoic echinoderms.
3. They were with or without cirri.
4. Arms were branched, with or without pinnules.
5. Calyx was either (i) rigid, monocyclic or dicyclic and with lower arms free from it (**Inadunata**); (ii) flexible, dicyclic and with arms flexibly incorporated in it (**Flexibilia**); or (iii) rigid, mono—or dicyclic, lower arms incorporated into it (**Camerata**).

Examples. *Hybocystites* (**Inadunata**); *Forbesiocrinus* (**Flexibilia**); *Xenocrinus* (**Camerata**).

Subclass 4. Articulata

1. Extinct as well as all the living crinoids belong to this subclass.
 2. Calyx flexible, pentamerous and dicyclic. Lower arms incorporated into it.
 3. Tegmen leathery containing calcareous particles (ossicles) or small plates.
 4. Mouth and ambulacral grooves exposed (*i.e.*, they are not covered with tegminal plates).
- Living members of subclass Articulata are included in the following **five** orders:

Order 1. Millericrinida

Examples. *Hyocrinus*, *Calamocrinus*.

Order 2. Cyrtocrinida

Example. *Holopus*.

Order 3. Bourgueticrinida

Examples. *Rhizocrinus*, *Cenocrinus*, *Bathycrinus*.

Order 4. Isocrinida

Examples. *Metacrinum*, *Cenocrinum*.

Order 5. Comatulida

Examples. *Antedon*, *Florometra*, *Neometra*, *Capillaster*.

Subphylum 3. Asterozoa

Subphylum Asterozoa is divided into following **three** classes.

Class 1. Asteroidea

1. Body flattened, pentagonal or star-shaped.
2. They are commonly called **starfish** or **sea stars**; there are 1500 species of these.
3. Oral and aboral surface are distinct. The oral surface is directed downward and aboral surface upward.
4. Arms are wide and not sharply set-off from the central disc.
5. Ambulacral grooves are open and have podia or tube feet.
6. A large coelomic cavity is present in the selectively wide arms.
7. Endoskeleton is flexible, made of separate ossicles.
8. Development is indirect and includes **bipinnaria** or **brachiolaria** larva.

Class Asteroidea includes following **five** orders.

Order 1. Platyasterida

Examples. *Platyasterias*, *Luidia*.

Order 2 and 3. Paxillosida and Valvatida (= Order Phanerozonia)

Examples. *Astropecten*, *Pentaceros*, *Culcita*, *Ctenodiscus*, *Goniaster* (cushion star).

Order 4. Spinulosida

Examples. *Asterina*, *Echinaster*, *Henricia*, *Acanthaster*.

Order 5. Forcipulata

Examples. *Asterias*, *Heliaster*, *Zoroaster*, *Pycnopodia* (many-rayed star), *Leptasterias*.

Class 2. Ophiuroidea

1. This class includes **brittle stars**, of which there are about 2000 species.
2. They contain extremely long five or more arms which are sharply set off from the central axis.
3. Arms largely filled with vertebral ossicles.
4. They lack ambulacral grooves, intestine and anus.
5. Madreporite is present on oral surface.
6. Tube feet play no role in locomotion except in *Ophionereis annulata*.
7. Podia help in food collection and transport.
8. Development is indirect and includes a freely swimming pluteus larva.

Class Ophiuroidea includes following **three** orders.

Order 1. Oegophiurida

Example. An Indonesian species.

Order 2. Phrynophiurida

Examples. Brittle stars such as *Ophiocanops*, *Ophiomyxa*; and **Basket stars** such as *Asteronyx*, *Gorgonocephalus*.

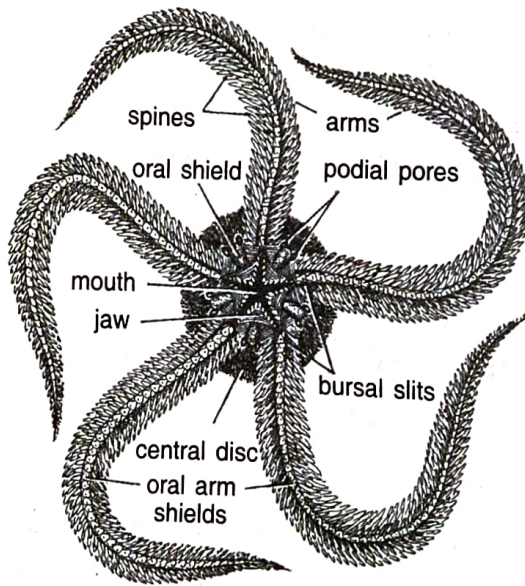


Fig. 32.1. *Ophiothrix*. Oral view of spiny brittle star.

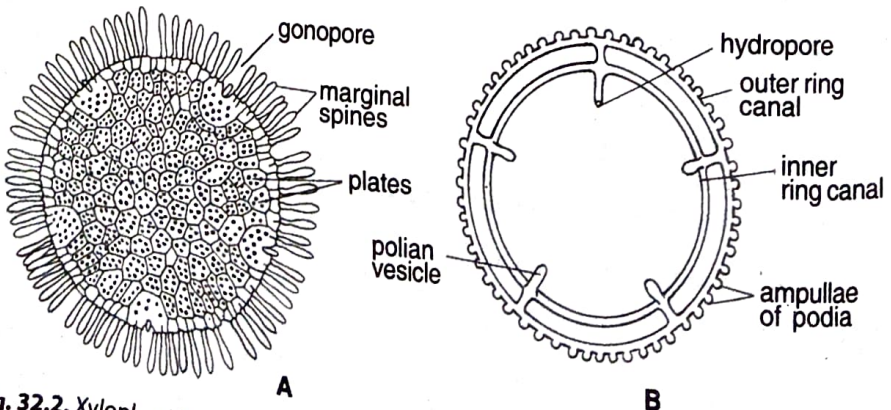


Fig. 32.2. *Xyloplax* (Class Concentricycloides). A—Dorsal view; B—Water vascular system.

Order 3. Ophiurida

Examples. *Ophioderma*, *Ophiothrix* (Fig. 32.1), *Ophioscolex*, *Ophiomaza*, *Ophionereis*.

Class 3. Concentricycloides

1. Minute deep-water echinoderms (which were collected in 1983 and 1984 from coast of New Zealand and described in 1986 by **Baker et al.**).
2. Body is disc-shaped and covered aborally with plate-like ossicles.
3. Gut is present or absent.
4. Water vascular system have two ring canal with podia arising from the outer one.

Example. *Xyloplax* (Fig. 32.2).

Subphylum 4. Echinozoa

Subphylum Echinozoa is divided into **five** classes; three of which namely class **Helicoplacoidea** (e.g., *Helicoplacus*), Class **Edrioasteroidea** (e.g., *Lepidodiscus*) and class **Ophiocistoidea** (e.g., *Volchovia*) include all extinct Echinozoa. The rest two classes namely **Echinoidea** and **Holothuroidea** include living as well as extinct members.

Class 1. Echinoidea

1. It includes about 950 species of **sea urchins**, **heart urchins** and **sand dollars**.
2. The name Echinoidea means "like a hedgehog". It is called so because it contains movable spines (like the hedgehog) that covers the body.
3. Body is spherical, disc-shaped, oval or heart-shaped and lacks arms.
4. Body is enclosed in an endoskeletal shell or test of closely fitted calcareous plates covered with movable spines.
5. Podia or tube feet come out from the pores of ambulacral plates and are locomotory in function.
6. **Mouth** is centrally placed on oral surface. **Anus** is located at the aboral pole.
7. Mouth is generally provided with an elaborate jaw apparatus.
8. They contain peripharyngeal coelom.
9. Ambulacral grooves are absent.
10. Pedicellariae (pinching organs) are stalked and three jawed.
11. They contain five pairs of gills for respiration.
12. Sexes are separate. Gonads are pentamerous.
13. Development is indirect and includes free swimming **echinopluteus larva**.

Class Echinoidea is divided into **two** subclasses.

Subclass 1. Perischoechinoidea

Subclass Perischoechinoidea includes mainly primitive fossil urchins of the Palaeozoic seas. It is divided into four orders. Members of three orders are completely extinct now. **Cidaroida** is the only one (order) that survived the Palaeozoic era and became the ancestor of the remaining echinoids, most of which belong to the next subclass.

Order Cidaroida

Examples. *Eucidaris*, *Cidaris*, *Notocidaris*.

Subclass 2. Euechinoidea

This subclass includes majority of living echinods. Its members have two columns of ambulacral and inter ambulacral plates.

Subclass Euechinoidea is divided into following **four** superorders.

Superorder 1. Diadematacea

1. Test is regular or radially symmetrical.
2. Tubercles are perforated.
3. Anus is aboral.
4. Gills are usually present.
5. Aristotle's lantern is present.
6. Teeth are grooved.

This superorder is divided into following **three** orders.

Order 1. Pedinoida

Examples. *Caenopedina* (only living genus of order Pedinoida).

Order 2. Diadematoida

Examples. *Diadema*, *Plesiadiadema*.

Order 3. Echinothuroidea

Examples. *Asthenosoma*, *Echinothuria*.

Superorder 2. Echinacea

1. It includes sea urchins having radial symmetry, rigid test and solid spines.
2. Gills are present.
3. Peristomal membrane with ten buccal plates.
4. Aristotle's lantern is well developed.

This superorder is divided into following **five** orders.

Order 1. Arbacioidia

Example. *Arbacia*.

Order 2. Salenoida

Example. *Acrosalenia*.

Order 3. Temnopleuroida

Examples. *Tripneustes*, *Toxopneustes*, *Temnopleurus*.

Order 4. Phymosomatoida

Examples. *Phymosoma*, *Glyptocidaris*.

Order 5. Echinoida

Examples. *Echinus*, *Echinometra*, *Paracentrotus*, *Strongylocentrotus*.

Superorder 3. Gnathostomata

1. It includes irregular (bilaterally symmetrical) urchins.
2. Lantern is present.
3. Ambulacral plates are simple or weakly compound.
4. Teeth are keeled.

5. Mouth is in the centre of oral surface but anus has shifted out of centre.
This superorder is divided into following **two** orders.

Order 1. Holoctypoida

Examples. *Echinoneus* and *Micropetalon* are only living members.

Order 2. Clypeasteroida

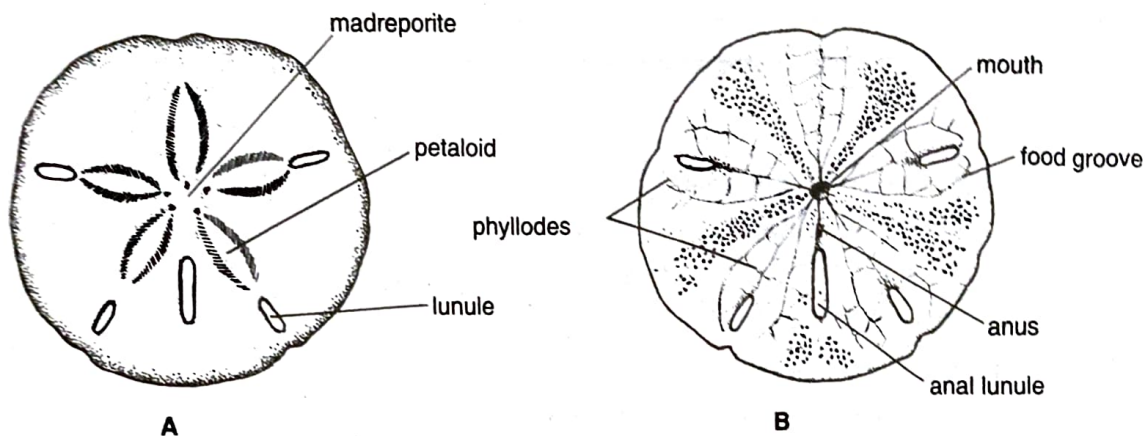


Fig. 32.3. *Mellita quinquiesperforata*, the five slotted sand-dollar of the Atlantic coast of USA.

A– Dorsal (aboral) view of test; B– Ventral (oral) view of test (after Ruppert et. al. 2004).

Examples. *Clypeaster* (sea biscuits), *Fibularia*, *Rotula*, *Mellita* (key hole sand-dollar, Fig 32.3).

Superorder 4. Atelostomata

1. It includes regular (bilaterally symmetrical) urchins.
2. Lantern is absent.
3. Ambulacral plates are simple.
4. Test is rigid.

This suborder is divided into following **three** orders.

Order 1. Holasteroida

Examples. *Holaster*, *Pourtalesia* (a deep-water species).

Order 2. Spatanguloida

Examples. *Spatangus*, *Echinocardium*, *Moiria*, *Meoma*, *Lovenia*.

Order 3. Cassiduloida

Examples. *Cassidulus*, *Echinolampas*.

Class 2. Holothuroidea

1. It includes 900 species of **sea cucumbers**.
2. Warty body is elongated along the oral-aboral axis. As a result animal lies with the side of body on the substratum.
3. Endoskeleton is very much reduced. It is represented by microscopic **ossicles**.
4. Oral or buccal podia form a circle of **tentacles** (10 to 30) around the mouth (See Box 32.2).

Box 32.2 Tentacles in Holothuroidea

Oral tentacles of Holothuroidea may be of following four types:

1. **Digitate** or finger-like, e.g., *Molpadia*, *Deima*.
2. **Dendritic** or arborally branched, e.g., *Thyone*.
3. **Pinnate** or with side branches on a central axis, e.g., *Leptosynapta*.
4. **Peltate** or flattened, with a short stalk and terminal disc, often with horizontal branches, e.g., *Actinopyga*, *Peniagone*.

5. Mouth and anus are situated at the opposite ends. Arms are absent. Cloaca contains respiratory tree.
6. Ambulacra are reduced.
7. No ossicle form the jaw apparatus.
8. Tiedman's bodies are absent.
9. Some move on the bottom; others live beneath stones or in crevices.
10. They are deposit-and suspension feeders.
11. Madreporite is located in the coelom.
12. Development is indirect including **doliolaria** larva.

Class Holothuroidea is divided into following **six** orders.

Order 1. Dactylochirotida

Examples. *Sphaeothuria*, *Echinocucumis*.

Order 2. Dendrochirotida

Examples. *Cucumaria*, *Thyone*, *Psolus*.

Order 3. Aspidochirotida

Examples. *Holothuria*, *Actinopyga*, *Stichopus*.

Order 4. Elasipodida

Examples. *Pelagothuria*, *Peniagone*.

Order 5. Molpadiida

Examples. *Molpadia*, *Caudina*.

Order 6. Apodida

Examples. *Synapta*, *Leptosynapta*, *Euapta*.

Evaluate Yourself

Multiple Choice Questions

1. Water vascular system is peculiarity of

(a) Porifera	(b) Coelenterata
(c) Mollusca	(d) Echinodermata
2. Which phylum is exclusively marine?

(a) Echinodermata	(b) Porifera
(c) Protozoa	(d) Arthropoda