I P.G Functional Morphology and Palaeontology of Invertebrates S.code: 18KP1Z01

UNIT – I

Taxonomy :- An organisms occupies a particular place (or) position in the system of classification is known as taxa. Taxonomy refers to certain rules and principles of identification, nomenclature and classification of organisms. The branch of knowledge dealing with these aspects is referred to as taxonomy, arranged in an evolutionary sequence from simplicity to complexity.

Systematics and Taxonomy :-

systematics is the science that deals with diversity of organisms and their comparative and evolutionary relationships and grouping of organisms at every levels of classification right from species to the kingdom All living organisms are classified into various groups based on their characteristics according to the principles of identification, nomenclature and classification. This branch of study is known as taxonomy.

Taxonomic Hierarchy :-

* Taxonomic hierarchy is the classification of organisms in a definite sequence of categories (taxonomic categories) in a descending order starting from kingdom and reaching upto species or an ascending order from species to kingdom.

* Each taxonomic category is referred to as taxon (plural taxa), which is a unit of classification and represents any level of grouping of organisms. The common categories are.

* Species - is a group of individuals with similar morphological characters, which are able to breed among themselves and produce their own kind.

* Genus - is the first higher category above the species level, it is group of species, which are related and have fewer characters in common as compared to species.

* Family - including one or more related genera, differentiated from other related families by certain characteristic differences.

* order - is an assemblage of families resembling one another in few characters, These characters are less similar as compared to characters of many genera placed in a family

* Class - includes one or more related orders.

* phylum (Division) - includes all organisms belonging to different classes having a few common characters. Botanists use the term division for phylum.

* Kingdom - includes all organisms that share a set of distinguishing common characters, plants are put in plant kingdom while animals are included in animal kingdom. This is the highest taxonomic category.

* Techniques, procedures and stored information that are useful in identification and classification of organism are called taxonomic aids.

II Binomial Nomenclature :- ("two-term naming system") also called binominal nomenclature ("two-name naming system") or binary nomenclature, is a formal system of naming species of living things by giving each a name composed of two parts, both of which use Latin grammatical forms, although they can be based on words from other languages. Such a name is called a binomial name (which may be shortened to just "binomial"), a binomen, binominal name or a scientific name, more informally it is also called a Latin name. The binomial nomenclature was proposed by Linnaeus (1737).

* Rules of Nomenclature :-

=> A biologist from all over the world follows a uniform set of principles for naming the organisms. There are two international codes which are agreed upon by all the biologists over the entire world for the naming protocol. There are

=> International code of Botanical Nomenclature (ICBN) - Deals with the biological nomenclature for plants.

=> International code of Zoological Nomenclature (ICZN) - Deals with the biological nomenclature of animals

=> These codes make sure that each organism gets a specific name is globally identified

* All the animals must be named by two words - binomial. The subspecies can be named by three words - trinomial.
* In case several names have been given to a single animal by different scientists. the earliest name is to be considered valid. The duplicate Names are called synonyms.
* Scientific names should be derived from Latin.
* The genus name is a single word. It must begin with a capital letter.
* The species name may be single or compound word. It must begin with a lower letter.
* The scientific name should be printed in italics If it is hand written or typed, it must be under - lined to indicate italics.
* The name of the author, who first publishes the name, should follow the species name

Eg. Rana tigrina Daud

* When the name is changed, the original author's name is given in parentheses.
* The name of the family is derived by adding idea to the name of the genus. Eg. Trypanosoma - tidae. The name of the sub-family is derived by adding inae Eg. Euglenoidinae

⇒ The important of Binomial nomenclature there are millions of species of organisms distributed through - out the world. furthermore, the same organisms are known by different names around the world and this can cause confusion when trying to identify (or) classify. Hence, binomial nomenclature was seen as a viable solution to this problem.

III Biological classification :-

Since the dawn of civilisation, there have been many attempts to classify living organisms. It was done instinctively not using criteria that were scientific but borne out of a need to use organisms for our own use - for food, shelter and clothing. Aristotle was the earliest to attempt a more scientific basis for classification. He used simple morphological characters to classify plants into trees, shrubs and herbs. He also divided animals into two groups those which had red blood and those that did not.

* In a Library or a store, all the articles are orderly arranged. This order helps in finding the right thing in right place. It quickens the work and avoids confusion. Such orderly arrangement is called classification

(a) Types of classification :-

(i) Natural classification

(ii) Artificial classification

(iii) practical classification.

(i) Natural classification :-

Natural classification is based on morphological similarities and common ancestry. This system of classification is followed in the field of zoology, the following characters are considered:

* Morphological similarity
* common ancestry
* Levels of organization
* symmetry
* coelom
* Number of germ layers
* Metamerism
* Unique features like nematocytes in platyhelminthes, pedicellaria in Echinoderms etc --

(ii) Artificial classification :-

This classification is based on the following factors
* Animals are classified based on their habit, habitat
For example, animals are classified into oviparous and viviparous and they are classified into herbivo-res, carnivores and omnivores on the basis of their food habits. and based on the places where they live. For example, aquatic, terrestrial and aerial.

(iii) practical classification :-

This classification is based on the utility of anim-als to man. Eg: Animals are classified into harmful animals and useful animals. similarly they are classified into edible animals and inedible animals

(a) Two kingdom classification :-

Linnaeous gave the two kingdom system of classification comprising of kingdoms Plantae and Animalia. Kingdoms was developed that included all plants and animals respectively. this system was used till very recently. This system did not distinguish between the eukaryotes and prokaryot-es unicellular and multicellular organisms and photosynthetic and non-photosynthetic (fungi) organisms. classification of organisms into plants and animals was easily done and was easy to understand. but a large number of organisms did not fall into either category. Hence the two kingdom classification used for a long time was found inadeq-uate. A need was also felt for including, besides gross morphology, other characteristics like cell struct-ure, nature of wall, mode of nutrition, habitat, methods of reproduction, evolutionary relationships etc -- classification systems for the living organisms hence, undergone several changes over time.

(b) Five Kingdom classification :-

R.H. Whittaker 1969 proposed a Five Kingdom class-ification. The kingdom defined by him were named Monera, protista, Fungi, plantae and Animalia. The main criteria for classification used by him include cell structure, thallus organisation, mode of nutriti on, reproduction and phylogenetic relationships. let us look at this five kingdom classification to understand the issues and consideration that influenced the classification system. Earlier classification systems included bacteria, blue green algae, fungi mosses ferns, gymnosperms and the angiosperms under 'plants'. The character that unified this whole kingdom was that all the organisms had a cell wall in their cells. This placed together groups which widely differed in other characteristic

Outline classification of Animals Kingdom :-

All the animals of the Biosphere are incl-uded in a large group called Animal Kingdom or Animalia. The animal Kingdom is subdivided into two sub-kingdoms, namely protista and Metazoa.

Animal Kingdom (Animalia)

- Sub-kingdom protozoa
- Sub-kingdoms Metazoa
  - Mesozoa
  - parazoa
    Ex: porifera
  - Eumetazoa
    - Radiata
      Ex: Coelenterata (Cnidaria)
    - Bilateria
      - Acoelomata
        Ex: platyhelminthes
      - pseudocoelomata
        Aschelminthes
      - Coelomata
        Annelida
        Arthropoda
        Mollusca
        Echinodermata
        Chordata

Fig: outline classification of Animal :-

(i) Sub-Kingdom 1. protista :-

This sub-kingdom includes microsco-pic, unicellular animals. It contains a single phylum called protozoa Eg: Euglena Amoeba paramecium

(ii) sub-Kingdom 2. Metazoa :-

This sub-Kingdom includes multicell-ular animals Ex: porifera to Chordata. The subkin-gdom Metazoa is divided into three branches, name-ly, Mesozoa, parazoa and Eumetazoa.

(a) Mesozoa (Branch-1)

It is intermediated between protozoa and Meta zoa. It includes endoparasitic animals. They are worm-like. The cells are differentiated into somatic cells and reproductive cells

Ex: Dicyema, Rhopalura, etc.

(b) parazoa (Branch-2)

It includes sponges. They are multicellular with poorly defined tissues and without organs. phylum porifera is included in parazoa

(c) Eumetazoa (Branch-3)

It includes true multicellular organisms. They have organ and organ system grade organization

Ex: colenterata to chordata

Eumetazoa is further divided into Radiata and Bilateria

Radiata (Grade-1)

It includes radially symmetrical animals
Eg: coelenterata.

Bilateria (Grade-2) it includes bilaterally symme-trical animals Eg: platyhelminthes to Chordata.
The grade Bilateria is further divided into three divisions, namely acoelom, pseudocoelomata and coelomata.

Coelomata

- The coelom develops by the splitting of meso-derms.
  - **phyla**
    1. Ectoprocta
    2. phoronidea
    3. sipunculoidea
    4. Echiuroidea
    5. priapulida
    6. Annelida (Earth worm)
    7. Mollusca (Pila)
    8. Arthropoda (cockroach)
- Enterocoela
  The coelom deve-lops from the enterom (Gut)
  - **phyla**
    1. Brachiopoda
    2. Chaetognatha
    3. Tardigrada
    4. Echinodermata
    5. pogonophora
    6. Hemichordata
       Ex: Balanoglossus
    7. prochordata
       EX: Amphioxus
    8. vertebrata
       Eg: Fishes, Frog, calotes, pigeon, Rabbit.

1. Acoelomata:-

In this group of animals, a coelom cavity lying between the gut and the body wall is absent Ex: platyhelminthes.

2. pseudocoelomata:-

In this group of animals, a false coelom (cavity not lined with coelomic epithelium) is present
Eg: Aschelminthes

3. Coelomata :-

In this group, a true coelom is present

Ex: Annelida to Chordate.

The Bilateria is further divided into two groups, namely protostomia and Deuterostomia.

1. Protostomia :-

In this group of animals, the blastopore develops into the mouth Eg: Platyhelminthes to Mollusca

2. Deuterostomia :-

In this group of animals, the blastopore develops into the anus. Eg. Echinodermata and Chordata

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UNIT – II   Sub. Code: 18KPZ01

LOCOMOTION IN INVERTEBRATES:-

Locomotion is the displacement of animals from one place to another. Locomotion is mainly in search of food, light and shelter (or) for suitable environment.

LOCOMOTION IN PROTOZOA:

Pseudopodium is a temporary projection of cytoplasm formed on the body. Four types of pseudopodia, namely.

1. Lobopodia (Amoeba)
2. Filopodia (Euglypha)
3. Reticulopodia (Globigerina)
4. Axopodia (Actinosphaerium)

METHOD OF LOCOMOTION:-

Protozoa exhibits four types of locomotion.

1. Amoeboid Movement
2. Flagellar Movement
3. Ciliary movement
4. Metabolic movement.

1. AMOEBOID MOVEMENT:-

Walking movement : Amoeba walks on the substratum using pseudopodia as legs.

Rolling movement : The Amoeba moves by the rolling of the body on the substratum. This is brought about by the streaming movement of the cytoplasm.

Sol-gel theory :- Active contraction of cytoplasm (plasma gel) like a tube at posterior end cause endoplasm (plasma sol) flow forwards, Again expanded sol contracts and force gel forward. Thus solation and gelation continues.

2. FLAGELLAR MOVEMENT :

Paddle stroke:- Common movement of a flagellum is sideways lash, consisting of an effective down stroke and a relaxed recovery stroke.

Undulating motion :- Wave-like undulations in flagellum, proceed from tip to base and from base to tip.

Simple conical gyration :- Butschli's srew theory postulates a spiral turning of flagellum like screw. This exerts propelling action, pulling the animal forward through water.

3. CILIARY MOVEMENT :

Some protozoan's move with the help of cilia. These are small hair-like structures, present usually in large numbers on the body surface.

A cilium has a particularly the same histology as that of flagellum. The cilia act as small oars and the backward strokes are swift, which push the animal forward.

4. METABOLIC MOVEMENT :

This is a typical of certain flagellates (Euglena) and most sporozoans at certain stages of their life cycles. such organism are seen to show gliding or wriggling or peristaltic movement. Contractile myonemes or microtubules, present in their pellicular walls. Movement of this kind are also referred as greparine movements.

LOCOMOTION IN PORIFERA :-

Porifera includes pore-bearing animals. They are commonly called sponges. Adult is sessile. But Amphiblastula larva swim freely in water. Swimming flagellated pole is directed anteriorly and force of swimming is supplied by beating of flagella uniformly by paddle stroke effect. In suitable area the larvae settles down and gastrulation occurs and sedentary adult is formed. Flagella of choanocytes in choanoderm beats by paddle stroke effect to make continious water flow. (to maintain physiology).

LOCOMOTION IN COELENTERATA :-

Floating : Hydra produces a bubble of air in the pedal disc. Hydra floats on the surface of the water and is carried by the water current.

Swimming : Hydra swims in water by the movements of tentacles.

walking : Hydra stands on its tentacles and tentacles are used as legs for walking.

Gliding : Hydra glides on its pedal disc.

Climbing : Hydra climbs on water plants using tentacles as hands

Somersaulting : The pedal disc a firmly attached to the substratum. The pedal disc is raised upwards and animal is inverted. now the pedal disc moves forward and is attached to the substratum. Then the tentacles freed and the Hydra becomes upright.

Looping :- The pedal disc is attached to the substratum. Then the body extends, bends downwards and the tentacles are attached to the substratum. Here the pedal disc is attached firmly. The tentacles are freed, the body is extended forwards and the tentacles are attached to the new place.

LOCOMOTION IN PLATYHELMINTHES :-

Gliding :- Gliding is brought about by backward beating of cilia and by muscular waves that pass over the body from front to rear.

Gliding is facilitated by mucous tract secreted by the mucous gland that open out through the epidermis of the ventral surface. The mucous affords a grip to the cilia and also protects them from injury by the substratum. The worm keeps its head slightly elevated during gliding.

Muscular contraction :- This type of movement is occasionally made by alternate contraction and Expansion on circular and longitudinal muscles alternatively. It cause lateral undulations to move.

ciliary movement : For locomotion is seen in miracidium larvae of fasciola hepatica, until reaches the vector.

Active floating :- Active floating by slight undulation of flat body is seen in cercaria larvae of fasiola hepatica, that reach the host blood.

LOCOMOTION IN ASCHELMINTHES :-

As circular muscles are absent, there is no active Locomotion. but 154. movement is seen due to fibres of cuticle. These fibres are elastic and disposed as spiral mesh and permits limited changes in length.

LOCOMOTION IN ANNELIDA :-

slow creeping and fast creeping :- nereis parapodia perform a circular movement involving an effective stroke (backward) and recovery stroke (forward)

Muscular contraction : Earthworm moves with the help of mucles and setae. This action done by cirular and longitudinal muscles contraction alternate action, anchoring is done by setae. Earth move 25 cm in a minute.

Looping or crawling movement :-(Leech) This type of movement is brought about by the contraction and relaxation of muscles. The two suckers serve for attachment during movement.

Swimming movement :- Leech swims in water by undulating movements of the body.

LOCOMOTION IN ARTHROPODA :-

Walking : walking legs and mode of action vary with classes and species. Crustaceans have 5 pairs of walking legs, Arachnids have 4 pairs of walking legs, Insects have 3 pairs of walking legs.

(prawn) Crustaceans walk slowly on substratum. walking legs are known as Palaeopods. 3 chelate legs and 2 non-chelate legs. Each leg have 7 segments as coxa, basis, ischium, merus, carpus, propodus and dactylus.

Arachnids walk fast and they are terrestrial. Each legs ~~have~~ 7 segments. coxa, Trochanter, femur, Patella, tibia, protarsus & tarsus. Tarsus have 2 or 3 curved horny claws (scorpion).

3 pairs of walking legs in Insects. Each legs with 5 segment. Coxa, Trochanter, femur, tibia, tarsus, Tarsus contains 1-5 tarsomeres. It bear a pair of claws (House fly).

Violent backward darting:-

It is a special movement in prawns, where uropod is extended backward, abdomen bend and flex to create violent force of water front ward and animal jerks back.

Flying :- wings of insects aid flying. wings made of 2 sheets of cuticle, a system of tubular cavities veins & nerves framework or skeleton for wings. Expressor muscle expand the depressor of centre contract and tergum also contract as wings move up. And alternately of expressor muscle contract and elongate depressor muscle expand, and tergum also expand. So wings come down. Thus the muscle act alternately and help flying.

LOCOMOTION IN MOLLUSCA :

Foot : Mostly all molluscans both terrestrial and aquatic forms have foot. In Pila the foot is broad, flat and has a creeping sole (or) pedal muscle. Pedal muscle are two, namely Anterior protractor and posterior retractor muscle. There is no direct contact with substratum. pedal muscle secretes mucous. protractor muscle anchor foot forward while retractor muscle pull posterior body to forward. The animal slimes front. (Pila).

Lateral fins: The fins bring about swimming by their undulations (sepia).

molluscans like octopus swim occasionally by undulation of arm propulsion of water by funnel back ward.

LOCOMOTION IN ECHINODERMATA:

Tube feet :- water vascular system is certain physiology that aids locomotion. There are four rows of tube feet in each ambulacral groove. A tube feet is a hallow, elastic, thin walled, closed cylinder or saclike structure It consist of an upper saclike ampulla, a middle tubular podium and a lower disc like sucker. muscle fibers are present in the walls of the ampulla and the podium.

The inner wall of the water vascular canals are provided with cilia. The beating of the cilia causes the seawater to enter through the madreporite Finally, the seawater reaches the tube feet and their ampullae, The ampullae contract : the values at the junction of the lateral canals and tube feet, prevent the flow of water into radial canals.

NUTRITION IN INVERTEBRATES :-

Nutrition is the process of obtaining nourishment. It includes food, ingestion, digestion, absorption and egestion.

NUTRITION IN PROTOZOA :

Protozoans exhibits 6 types of nutritions. They are as follows.

1. HOLOPHYTIC NUTRITION :

Here the protozoans synthesize carbohydrate by photosynthesis. They are provided with chlorophyll. They synthesize carbohydrate with the help of CO_2, water and minerals. Holophytic nutrition is exhibited by protozoans bearing chlorophyll. (eg) Euglena, Chlamydomonas, volvox etc.

2. HOLOZOIC NUTRITION :

Holozoic nutrition the solid or semi-solid food is swallowed (eg) Amoeba. The food consists of plants, or animals or both. Holozoic nutrition involves the following steps.

1. Ingestion
2. Digestion
3. Absorption
4. Egestion.

INGESTION IN AMOEBA : Ingestion refers to the capture and passage of food into the cytoplasm. In Amoeba, food is taken into the cytoplasm in any one of the following ways.

a. circumvallation
b. circumfluence
c. Invagination
D. Import.

INGESTION IN PARAMECIUM : Paramecium has a well developed oral apparatus for feeding purposes. The beating of cilia creates a water current. The water current brings in food particles. The food particles are collected at the tip of the cytopharynx in a vesicle called food vacuole. It separates from the cytopharynx and enters the cytoplasm.

INGESTION IN EUGLENA: Euglena has a cytostome, a cytopharynx and a reservoir. Food materials are directed towards the cytostome by the lashing movements of flagellum. There the food materials are swallowed by the cytostome.

2. DIGESTION : In most of the protozoans, digestion is intracellular. It mainly occurs inside the food vacuole.

3. ABSORPTION : The digested food from the food vacuole is absorbed into the cytoplasm by diffusion. In paramecium, the movement of food vacuole is cyclic in nature and it is called cyclosis.

4. EGESTION : Egestion is the passing out of undigested waste materials.

3. SAPROZOIC NUTRITION :

The absorption of decayed organic materials as food is called saprozoic nutrition. (eg) Euglena, Entamoeba.

4. MIXOTROPHIC NUTRITION :

Certain protozoans feed by more than one method. (eg) Euglena. It exhibits holophytic nutrition, holozoic nutrition and saprozoic nutrition.

5. PARASITIC NUTRITION :

Parasites obtain their food from their hosts. Parasites may feed on the digested food of the host or on the tissues of the host.

6. COPROZOIC NUTRITION :

In this method, the faecal materials are swallowed as food. It is exhibited by copromonas living in the faeces of vertebrates.

NUTRITION IN PORIFERA

A water current flows into the spongocoel through the ostia and it goes out through the osculum. The water current has three functions namely nutrition, excretion and respiration. The water current brings the organisms which are its prey. They are captured by choanocytes and amoebocytes. Digestion is intracellular. Eg: sponges.

NUTRITION IN COELENTERATA :

The gut is simple. It consist of a mouth and a gastrovascular cavity. There is no anus. It is a carnivorous animals. The tentacles capture prey. The nematocysts paralyse them. The tentacles help the passage of food in to the mouth. Digestion is of two types, namely extracellular and intracellular. Extracellular digestion occurs in the gastrovascular cavity. Intracellular digestion occurs inside the endodermal cells. Undigested food materials are passed out throughthe mouth.

(eg) Hydra, Obelia, Aurelia and Sea Anemone.

NUTRITION IN PLATYHELMINTHES :-

The digestive system is very simple, It is formed of a mouth, the Pharynx, Oesophagus and the intestine. The liver fluke feeds on the blood and bile of the host. It sucks the liquid food by the muscular pharynx. As food is already in the digested state and fit for absorption, the digestive gland are completely absent. The food is absorbed in intestine.

Platyhenminthes (eg) Planaria, liver fluke, Tapeworm.

NUTRITION In ASCHELMINTHES :-

(eg) Ascaris lumbricoides, Filarial worm.

The alimentary canal is a simple straight tube. The mouth is situated at the anterior end. It is surrounded by three lips.

Ascaris feed on the digested food of its host. The food is sucked by the muscular pharynx. The digestion is extracellular in the intestine. The digested food is absorbed through intestinal cells.

NUTRITION IN ANNELIDA:

(eg) Nereis, Earthworm, Leech

Earthworm feeds on the dead organic matter of the soil. It swallows large amount of soil.

Digestion in earthworm is intracellular and extracellular. Intracellular digestion takes place in the epithelial cells of the intestine. Absorption takes place in the posterior part of the intestine. The typhlosole increases the area of absorption.

The undigested material and the soil are collected at the posterior ~~and~~ parts of the intestine. They are passed out through the anus in the form of worm castings.

NUTRITION IN ARTHROPODA:

Ex: prawn, Crab, scorpion, cockroach, Housefly.

Prawn is an omnivorous animal. The chelate legs and third maxillipedes capture and convey the food to the mouth. The mandibles cut into smaller pieces. The food is further ground in the gastric mill and digested in the stomach. The digested food is absorbed in the midgut. The undigested food materials are passed out through the anus..

Scorpion is carnivorous. It feeds on insects, spiders, etc. It also exhibits cannibalism. The prey is captured by the pedipalps. The sting paralyses the prey. The chelicerae tear the prey into pieces. The food is then passed into the preoral cavity where it is ~~sq~~ squeezed. The fluid oozing out is sucked by the pharynx. The solid particles are thrown away.

NUTRITION IN MOLLUSCA :-

Ex, Pila, oysters, squids and octopuses.

Pila is a herbivore. The food consists of aquatic plants. They are cut into pieces by the jaws. They are made into small particles by the rasping activity of the radula. The secretion of the salivary glands is poured in to the buccal cavity and the food is mixed up with the secretion. It helps in digesting starch.

The digestion of cellulose is mainly completed here. Digested food is absorbed by the resorptive cells of hepatopancreas. These cells digest the food by intracellular method. The digested food diffuses into the blood. The undigested food is passed into the mantle cavity through the anus.

NUTRITION IN ECHINODERMATA :-

Ex-Starfish, sea urchins, sea cucumbers.

Starfish is carnivorous and it feeds on crustaceans, molluscs and fishes. The digestion is completed, the cardiac stomach is withdrawn into the body. Thus digestion is extracellular.

Digested food is absorbed into the pyloric caeca. Here the undigested particles are digested by intracellular digestion. The surplus food is stored in the storage cells of caeca. From the caeca the food is difused into the coelomic fluid. The coelomic fluid distributes the digested food to the various parts of the body. The undigested food is passed out through the anus.

RESPIRATION IN INVERTEBRATES:

Respiration is an essential physiological activity of all living organisms. Respiration provides energy for the organism through the oxidation of food. Typically with intake of oxygen and release of Carbon dioxide from the oxidation of complex organic substances.

RESPIRATION IN PROTOZOA:

Respiration takes place by diffusion of oxygen and gives off carbon dioxide through the body surface most of the protozoans breathe by aerobic respiration and others breathe by anaerobic respiration. (eg) Amoeba

Respiration takes place by diffusion through the body surface. eg Euglena.

RESPIRATION IN PORIFERA:

Sponges Lack of respiratory organs. Gaseous exchange occurs by simple diffusion. Porocytes open and allow water in. choanocytes ('Collar cells') absorb the oxygen. Archaeocytes transport the oxygen to other areas of the cells. other oxygen is absorbed directly through cell membranes. Waste products are pumped out through the osculum.

RESPIRATION IN COELENTERATA:

Obelia does not have any respiratory organs. and the gas exchange take place by diffusion through the general body Surface.

In hydra gases diffuse directly across a moist body surface.

Aurelia does not have respiratory organ. Oxygen from the surrounding water diffuses directly into the cells. carbondioxide diffuse out of the cells and carried out of the body by the circulating water.

RESPIRATION IN PLATYHELMINTHES:

Respiration is aerobic in Dugesia. there is no respiratory organ. oxygen from the surrounding water diffuses in to the tissues directly through the body surface. carbondioxide of the body passes out in the same manner.

Liver fluke has no special respiratory organs. The respiration is of anaerobic type. That is, the stored glycogen in the body is broken up into CO_2 and volatile fatty acids by the process of glycolysis. The CO_2 diffuses out through the body wall. The fatty acids are excreted by the excretory organs. The energy produced during glycolysis is enough to maintain the various activities of the animals.

RESPIRATION IN ASCHELMINTHES:

In the intestine of man there is no oxygen. Hence respiration occurs without oxygen. This type of respiration is called anaerobic respiration. During anaerobic respiration, energy is released from glycogen by a process called glycolysis.

$$\text{Glycogen} \xrightarrow{\text{Glycolysis}} \text{Fatty acid} + CO_2 + \text{Energy}.$$

RESPIRATION IN ANNELIDA :

Respiratory organs are absent from earthworm. Respiration takes place through the skin and it is called cutaneous respiration. The exchange of gases occurs by simple diffusion.

There is no special respiratory organ in Leech. The skin serves as a respiratory organ. The capillaries containing the haemocoelomic fluid extend in between the cells of the epidermis, act as a permeable membrane through which the exchange of gases takes place by diffusion.

In Nereis, respiratory organs are lacking. Respiration occurs by diffusion through body surface.

RESPIRATION IN ARTHROPODA :-

Respiration involves the exchange of gases between the body and the environment. Two types of respiration in arthropoda.

1. Aquatic respiration and
2. Aerial respiration.

1. AQUATIC RESPIRATION: Aquatic respiration involves the utilization of oxygen dissolved in water. It occurs in aquatic arthropods. Aquatic respiration is carried out by the following organs.

1. Gills
2. Epipodite
3. Branchiostegite
4. Rectal gills
5. Tracheal gills
6. Blood gills
7. Book gills and
8. Body surface.

*** Gills :** The gills are delicate feathe-like outgrowth of the thoracic appendages. It is covered by branchiostegite. gills are classified into three types.

a) Phyllobranch -- Palaemon.
b) Dendrobranch - Penaeus.
c) Trichobranch - Astacus.

Gills live in brachial chambers. The gills are always immersed inside the water. Exchange of gases takes place between the water and the blood.

Epipodites: They are located on the thoracic appendages. They are highly vascular and they exchange gases between the blood and the water.

Branchiostegite: The branchiostegite is the gill cover. It is constantly bathed by the water current. Hence exchange of gases occurs between the water and the blood.

Rectal gills: The gills are located in the inner surface of rectum. Water is drawn in and expelled out via anus for respiration.

Tracheal gills: These are the outgrowths of the body wall. They are finger shaped or leaf shaped. They contain a system of tracheae.

Blood-gills:- They are the gills of insect-larvae supplied with blood and not with tracheae.

Book gills: Book gills are book-like gills. These are the respiratory organs of limulus. Each book gill is formed of 150 to 200 leaf-like lamellae. The lamellae are richly supplied with blood.

Body surface:- In many arthropods respiration occurs through the general body surface by diffusion.

AERIAL REPIRATION:

Aerial respiration involves the utilization of oxygen present in the air. Aerial respiration occurs in terrestrial arthropods. The respiratory organs are as follows.

1. Tracheal system
2. Book lungs
3. Simple lungs
4. Air tubes.
5. Spiracular gills.
6. Plastron and
7. Respiratory tubes.

RESPIRATION IN MOLLUSCA :-

Pila is an amphibious animal. It has two modes of respiration. They are aquatic respiration and Pulmonary respiration.

Aquatic Respiration: ~~When the pila is in water~~
when pila is in the water, aquatic respiration takes place. The respiratory organs for aquatic respiration is the gill or ctenidium. The exchange of gases takes place between the blood of ctenidium and water.

Pulmonary Respiration: It occurs when pila is on land. The respiratory organ is the lung or Pulmonary sac. The blood of the Pulmonary sac takes in O_2 from the air and gives out CO_2.

RESPIRATION In ECHINODERMATA :

eg-Starfish - Respiration is carried out by thousands of dermal branchiae or papulae. O_2 dissolved in sea-water is extracted by these gills in exchange of CO_2. The thin walls of the tube feet may also serve for exchange of gases.

The respiratory system in sea cucumber Consists of respiratory organs such as Skin, tube feet and respiratory trees.

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UNIT-III

Reproduction in invertebrates

Reproduction. Like vertebrates, most **invertebrates reproduce** at least partly through sexual **reproduction**. They produce specialized reproductive cells that undergo meiosis to produce smaller, motile spermatozoa or larger, non-motile ova. These fuse to form zygotes, which develop into new individuals. In **invertebrates** asexual **reproduction** may involve subdivision of a multicellular body into two or more parts (fission) or the production of diploid eggs (parthenogenesis). See Sexual **reproduction** and Epitoky. Metamorphosis of the whole individual into a sexually mature epitoke

The basic **processes** of **life** include organization, metabolism, responsiveness, movements, and **reproduction**.

Asexual reproduction includes fission, **budding**, **fragmentation**, and parthenogenesis, while sexual reproduction is achieved through the combination of reproductive cells from two individuals. ...

- Methods of Reproduction: Asexual & Sexual.
- Asexual Reproduction. ...
- Fission. ...
- **Budding**. ...
- **Fragmentation**. ...
- Parthenogenesis.

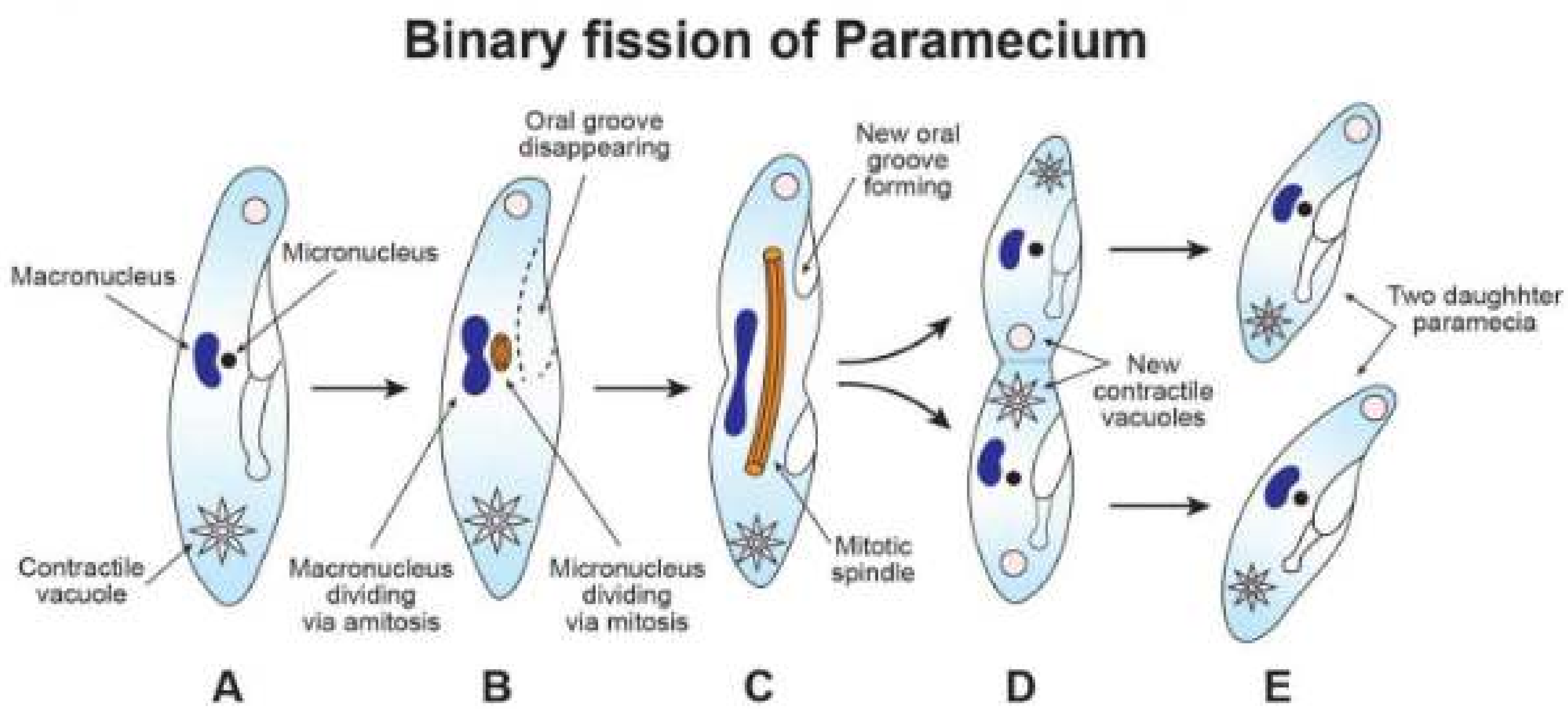
Bacterium undergoes **binary fission** in which the cell divides into two along with the nucleus. Blackworms or mudworms reproduce through **fragmentation**. Hydras reproduce through **budding**. Organisms such as copperheads undergo parthenogenesis

What is the importance of reproduction?

Reproduction is the process by which new individuals are produced by the **parents**. The process of reproduction ensures that a plant or animal species does not disappear from Earth. This process is very important in maintaining stability in the ecosystem and for the continuation of life on earth.

Most **protozoans** (one-celled organisms) **reproduce** asexually, usually by fission (splitting in two); in some species, however, sexual as well as asexual **reproduction** occurs and may be complex. The colonial organism Volvox, which may be either of one "sex" or composed of cells of both sexes, produces true eggs and sperm

Protozoa reproduce by both asexual and sexual means, though sexual **reproduction** is less common and occurs in certain groups. Most **protozoa reproduce** asexually by cell division producing two equal or sometimes unequal cells. ... In some **protozoa** multiple fission or schizogamy is known to occur.



Sponge Reproduction

Sponges reproduce both asexually and sexually. **Asexual reproduction** occurs by budding. Figure below shows the sponge life cycle when **sexual reproduction** is involved. Adult sponges produce eggs and sperm

Sponges **have** three **asexual** methods **of** reproduction**: after fragmentation; by budding; and by producing** gemmules

Asexual reproduction in sponges is by

1. Budding
2. Fission
3. Formation of reduction bodies
4. Formation of gemmules

Budding

By this method the number of individuals in the colony may increase or new colonies may be formed. An outgrowth from the sponge body wall may arise either at the base or near the attached end to form bud. This bud is the result of bulging of pinacoderm to receive numerous archeocytes collected at the internal surface of the body wall.

The bud so formed grows in size, breaks off an osculum at its free distal end and thus becomes an adult individual. It either remains attached to the parent sponge or may get detached to form a new sponge by fixing itself to a suitable substratum.

Fission

In this type of reproduction parts of the sponge body are thrown off from the sponge body. The sponge is hypertrophied over a limited area developing a line of weakness. Hypertrophy is the non-tumorous enlargement of a tissue or an organ as a result of the increase in the size rather than the number of constituent cells.

Along this weak line, splitting occurs and this part is thrown off. The part of parental sponge thus thrown off develops into an adult individual, breaks off an osculum at its free distal end and gets attached to a suitable substratum. This new individual develops a new colony by budding.

Formation of reduction bodies

It is very unusual method of asexual reproduction found in sponges. Some fresh water and marine sponges get disintegrated during adverse conditions. During unfavourable conditions, the sponge collapse leaving small rounded balls called as reduction bodies.

Each reduction body consists of internal mass of amoebocytes covered externally by pinacoderm. When the favourable conditions return, each reduction body develops into a complete new sponge. It gets attached to a suitable substratum and breaks off an osculum at its free distal end.

Formation of gemmules

Gemmules are internals buds formed within the sponge body. It is the characteristic feature of all fresh water and some marine forms like Ficula and Tethya. Gemmules eventually get detached when the parent sponge is decayed. Gemmules help the sponge to tide over unfavourable conditions. Gemmules can withstand freezing and considerably greater degree of desiccation than the adult sponges.

A gemmule is a small, round, hard ball consisting of internal mass of food laden archaeocytes surrounded by chitinous double membrane. The outer protective membrane may be strengthened by siliceous amphidisc spicules (Ephidatia) or by monaxon spicules (Spongilla).

In autumn fresh water sponges suffering from cold and food scarcity get disintegrated leaving behind number of gemmules which remain inert throughout the winter. Gemmules are set free after the decay of the parent sponge. The gemmules thus formed may sink to the bottom or may flow away with the water. In spring, when the conditions become suitable, the gemmules begin to hatch.

The living contents of the gemmules escape out through the micropylar opening and form the new sponge. These new sponge gives rise to summer generation by producing spermatozoa and ova. The summer generation dies off in autumn living behind gemmules which hatch in spring. The life history of such sponges illustrates alternation of generation.

SEXUAL REPRODUCTION IN SPONGES

Though some unisexual sponge species are also known, most sponges are monoecious or bisexual. Although sponges are bisexual (hermaphrodite) cross fertilization occurs as a rule as the production timing of sperm and ova are different. The sperm and ova are derived from the undifferentiated amoebocytes called as archaeocytes. The sperm and ova are also known to be derived from choanocytes which later undergo gametogenesis to form sperm or ova.

Sponges exhibit protandry, production of sperms first and ova later or protogyny, production of ova first and sperms later. Both protandry and protogyny facilitate cross fertilization.

Spermatogenesis

The sperm mother cell or a spermatogonium is the enlarged archaeocytes. This spermatogonium is surrounded by one or more flattened cover cells to form spermatocyst. These cover cells are derived from other amoebocytes. Now these spermatogonia undergo two to three maturation divisions to form spermatocytes and these spermatocytes later give rise to spermatozoa. A matured spermatozoon consists of a rounded nucleated head and a tail. The lashing movement of the tail helps the spermatozoon to reach other sponges.

Oogenesis

The egg mother cell or an oocyte is derived from large archaeocytes which have distinct nucleus. Sometimes the oocytes also arise from the choanocytes. This oocyte moves like an amoebocytes engulfing other cells. These engulfed cells act as the nursing cells for the oocyte. When fully grown the oocyte undergoes two maturation divisions to form ovum which lies in the wall of the radial canal or spongocoel, ready to be fertilized by the sperm of other sponge.

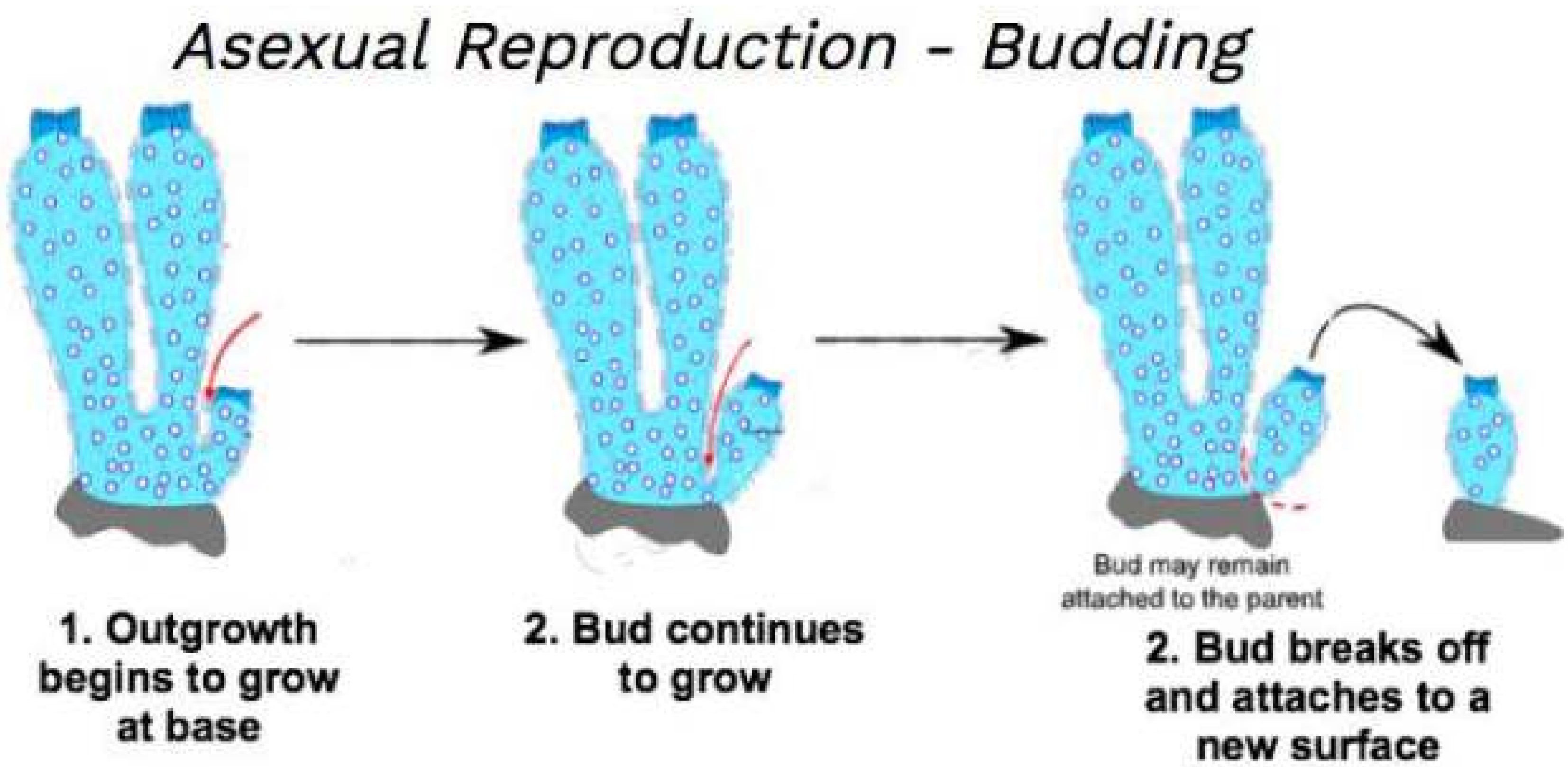
Fertilization

Sperms are released out from sponge through the outgoing water from osculum. The sperms thus releases make their way into another sponge through incoming water by ostia. Choanocytes act as nurse cells and transport the sperm to the ova which lie in the flagellated choanoderm. The fertilization is internal and cross type.

Development

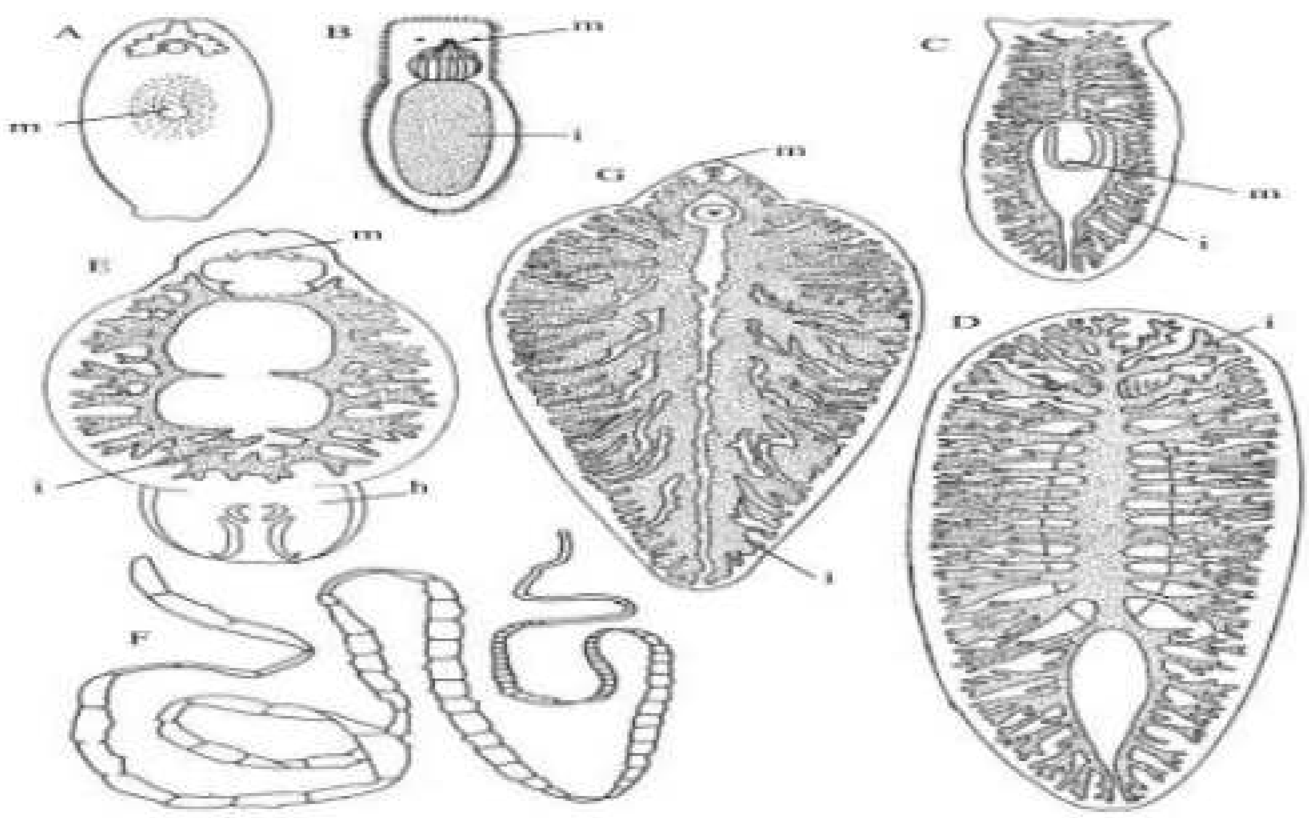
Early development takes place within the maternal sponge leading to the formation of larval stages. The larval stages bear flagella, which help them to escape out from the maternal sponge body. The larva thus escaped gets attached to a suitable substratum, metamorphose and grow into adult sponge. Sponges have two types of larvae,

Amphiblastula: It is hollow, oval larval stage characteristic of calcareous sponges (Scypha). Anterior half of amphiblastula bears flagella while the posterior half is free from flagella.



Platyhelminths (flatworms) have unsegmented, bilaterally symmetrical, soft bodies, with a triploblastic construction (comprising three layers of cells) and lacking a coelom (body cavity), skeleton and anus. The relatively large flatworms (e.g. planarians, tapeworms) are indeed dorsoventrally flattened but many of the small free-living platyhelminths are cylindrical.

Representatives of the main groups of the Phylum Platyhelminthes are illustrated in Fig. 1. Three of these groups, the Monogenea, Cestoda (tapeworms) and Digenea (flukes) are exclusively parasitic. Monogeneans have a single-host life cycle and are mostly external parasites (ectoparasites) on the skin and gills of fishes. Cestodes and digeneans are endoparasites (internal parasites) and have more complex life-cycles, each with two or three hosts, one of which is a vertebrate. Digeneans have an additional endoparasitic stage in a mollusc.



Characteristics. All coelenterates are aquatic, mostly marine. The bodyform is radially symmetrical, diploblastic and does not have a coelom. The **body** has a single opening, the hypostome, surrounded by sensory tentacles equipped with either nematocysts or colloblasts to capture mostly planktonic prey.

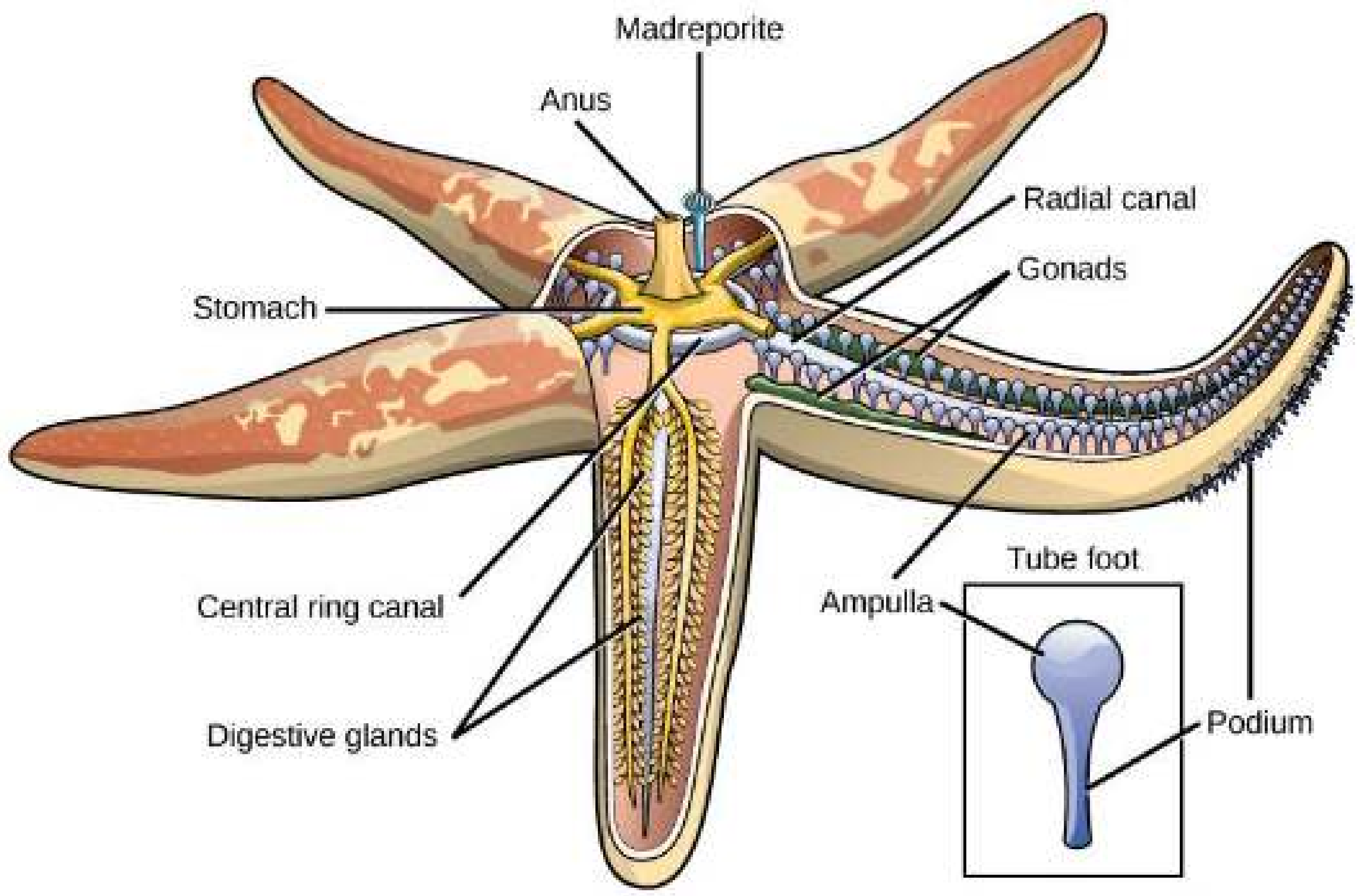
Coelenterata is the term including the animals belonging to the phylum Cnidaria. For example, **Sea anemones**, Sea pen, Coral animals etc. They reproduce asexually by **budding**. Some groups are observed in which **sexual reproduction** takes place.

AnnelidReproduction

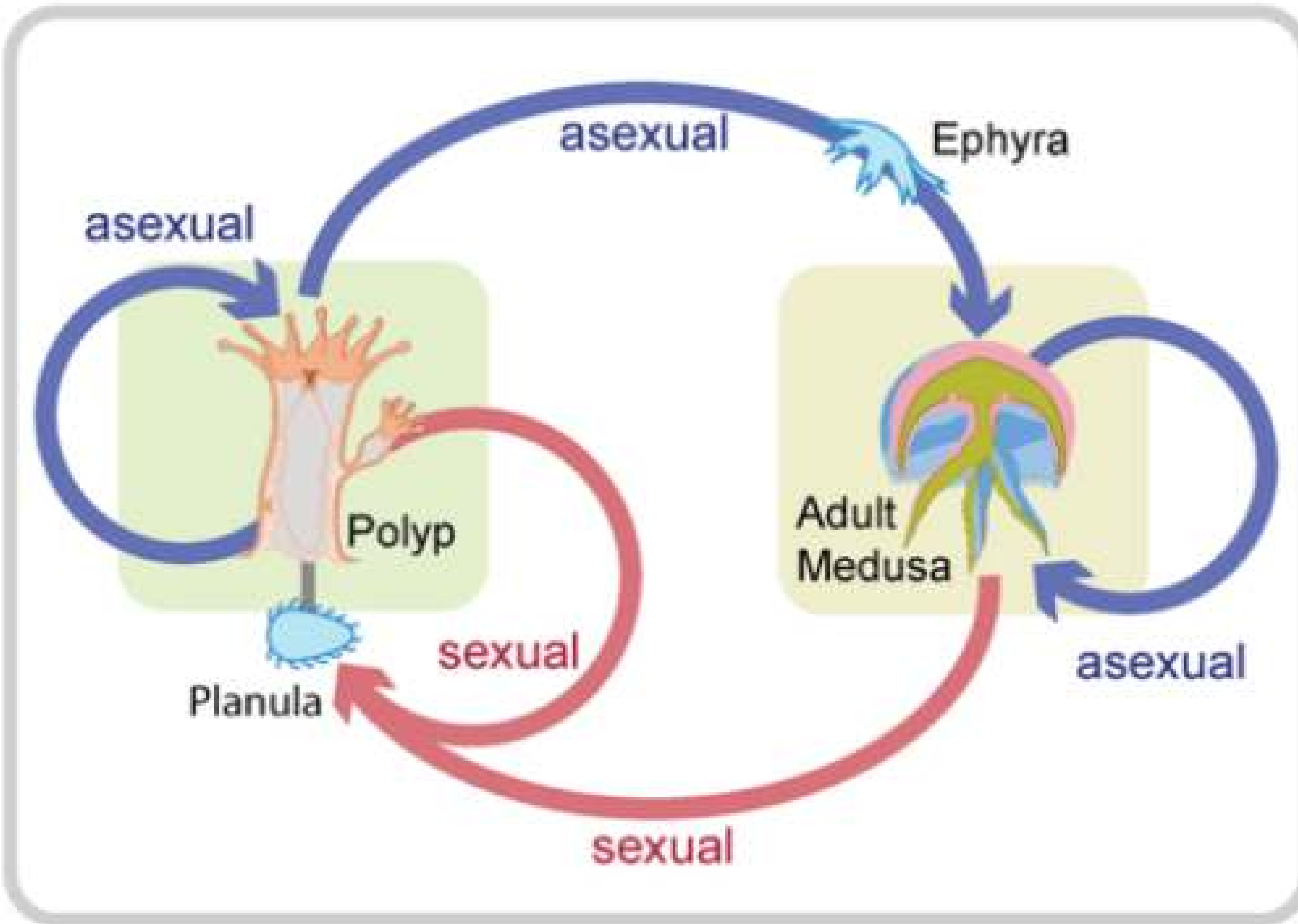
Asexual reproduction may occur by budding or **fission**. Sexual reproduction varies by species. In some species, the same individual produces both sperm and eggs. But worms mate to exchange sperm, rather than self-fertilizing their own eggs

Arthropods reproduce by sexual **reproduction**, which involves the generation and fusion of gametes. Most **arthropods** are either male or female, and they undergo internal fertilization. Once the egg has been fertilized, the female usually lays the egg, and it continues developing outside of the mother's body

Reproduction. Echinoderms are sexually dimorphic and release their eggs and sperm cells into water; **fertilization** is external. In some species, the larvae divide asexually and multiply before they reach sexual maturity. Echinoderms may also reproduce asexually, as well as regenerate body parts lost in trauma.



Some **arthropods** fertilize their eggs externally. Most species are dioecious, meaning they have two distinct sexes. ... For example, a single **earthworm** will produce both eggs and sperm. Two worms rub against each other to exchange sperm and to fertilize one another's eggs.



Endocrine glands in crustaceans

Introduction

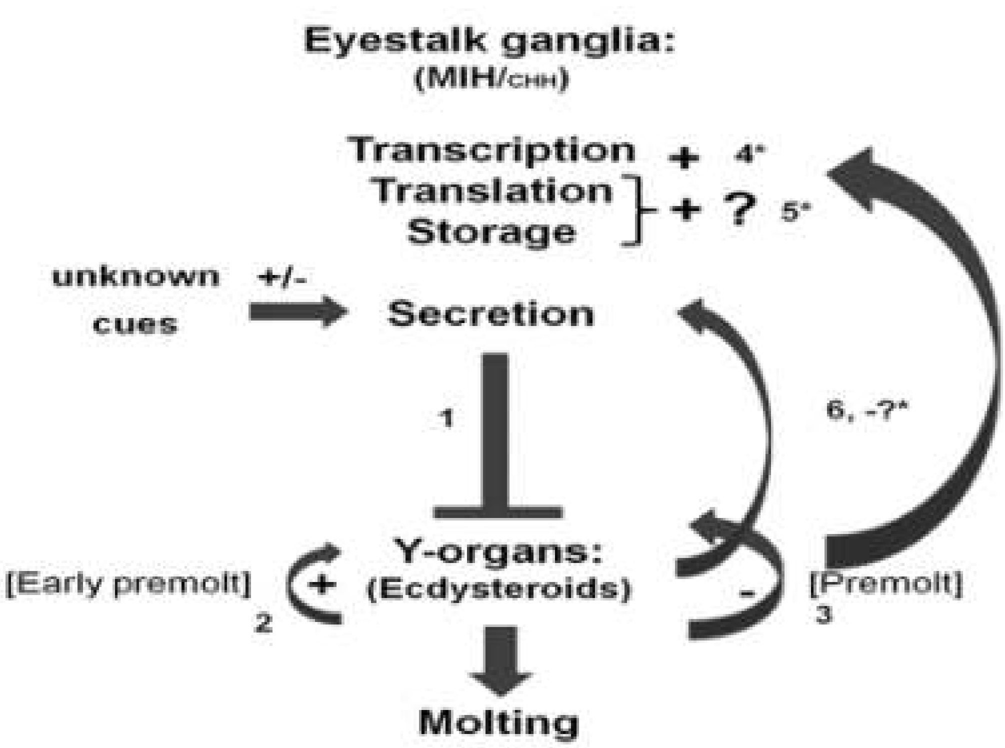
- The **endocrine system** consists of cells, tissues, and **organs** that secrete hormones as a primary or secondary **function**.
- The **endocrine gland** is the **major** player in this **system**. The primary **function** of these ductless **glands** is to secrete their hormones directly into the surrounding fluid.Among the **crustaceans**,
- the major neuroendocrine **system** consists of the neurosecretory X-organ and its associated neurohemal organ, the sinus **gland**.
- Both an X-organ and a sinus **gland** are located in each eyestalk, and together they are termed the eyestalk complex.
- Two endocrine glands are well known: the **Y-organ** and the **Androgenic gland.** As in insects, hormones and neurohormones of the crustacean **regulate molting**, **reproduction**, **osmoregulation**, **metabolism**, and **heart rate**.
- In addition, the regulation of colour changes is well developed in crustaceans, whereas only a few insects exhibit hormonally controlled colour changes.

Molting

- The steroid ecdysone secreted from the Y-organ stimulates molting.
- After it is released into the blood, ecdysone is converted to a 20- hydroxyecdysone, which is the active molting hormone.
- Secretion of ecdysone is blocked by a neurohormone called molt-inhibiting hormone, produced by the eyestalk complex.
- The existence of several additional molting factors has been proposed from experimental studies, and the regulation of molting may be much more complicated than suggested here

Reproduction

- The eyestalk complex appears to produce a neurohormone that inhibits vitellogenesis by the fat body and blocks vitellogenin uptake by oocytes in the ovary.
- Older follicles in the ovary, however, may secrete a vitellogenin-stimulating hormone that overrides the effects of the eyestalk neurohormone.
- In shrimps and other crustaceans that exhibit sequential hermaphroditism, the androgenic gland produces a peptide hormone that is necessary to masculinize the gonad.
- These animals function first as males, and later with the degeneration of the androgenic gland they become females. Surgical removal of the androgenic gland causes a precocious change of a male to a female.



Schematic Representation of endocrine Secretion in crustaceans

Osmoregulation

- There are four known sources of factors that influence water and ionic balance (osmoregulation) in crustaceans.
- The brain factor is known to regulate function of the antennal glands (paired "kidneys" located at the base of each antenna), the intestine, and the gills.
- The thoracic ganglion factor affects the stomach, intestine, and gills. Both the antennal glands and the gills are affected by a factor from the eyestalk complex.
- Finally, the pericardial organs (neurohemal glands located in the pericardial cavity) influence salt and water metabolism by heart muscle and gills.

Myotropic factor

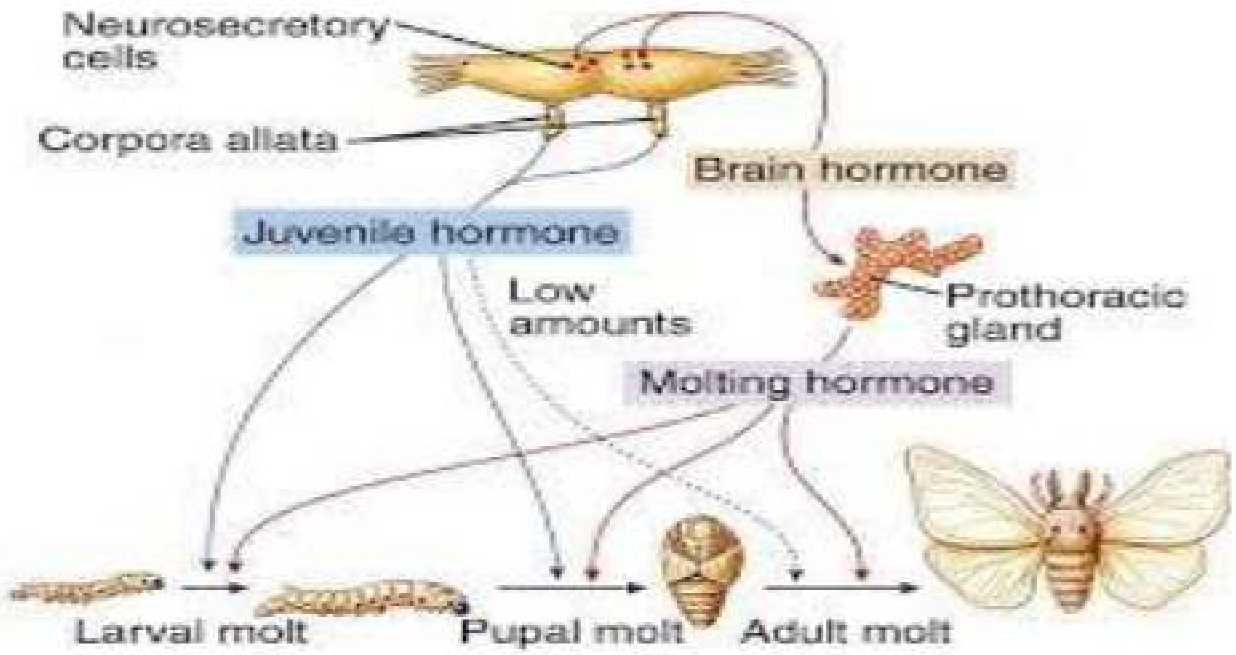
- Heart rate is accelerated in crustaceans by a factor released from the pericardial organs.
- It is not known if this factor is the same one that has osmoregulatory actions mentioned above.
- There is evidence to suggest that the crustacean cardioacceleratory factor is identical to one of the insect cardioacceleratory factors.

Colour changes

- Several neurohormones that regulate colour changes (chromatophorotropins) by pigment cells (chromatophores) have been found in extracts of the eyestalk complex.
- The best known are the light-adapting hormone and the red-pigment-concentrating hormone.
- This latter peptide is chemically similar to the insect adipokinetic and myotropic factors. Regulation of the chromatophores allows an animal to adapt to different backgrounds by changing colours or by becoming lighter or darker.
- Together, these hormone-secreting **structures** form an **endocrine system** that helps maintain homeostasis, coordinate behavior, and regulate growth, development, and other physiological activities.
- In **insects**, the largest and most obvious **endocrine glands** are found in the prothorax, just behind the head

Class insecta

- Neurosecretory, neurohemal, and endocrine structures are all found in the insect endocrine system.
- There are several neurosecretory centres in the brain, the largest being the pars intercerebralis.
- The paired corpora cardiaca (singular, corpus cardiacum) and the paired corpora allata (singular, corpus allatum) are both neurohemal organs that store brain neurohormones, but each has some endocrine cells as well.
- The ventral nerve cord and associated ganglia also contain neurosecretory cells and have their own neurohemal organs; ***i.e.,*** the multiple perisympathetic organs located along the ventral nerve cord.
- The insect endocrine system produces neurohormones as well as hormones that control molting, diapause, reproduction, osmoregulation, metabolism, and muscle contraction.



Molting

- A peptide neurohormone that controls molting is secreted by the pars intercerebralis and is stored in the corpora cardiaca or corpora allata (depending on the group of insects).
- This brain neurohormone is known as the prothoracotropic hormone (PTTH), and it stimulates the prothoracic glands (also called ecdysial or molting glands).
- In turn, the prothoracic glands release the steroid ecdysone, which is the actual molting hormone. Ecdysone initiates shedding of the old, hardened cuticle (exoskeleton).
- In the 1940s Sir Vincent (Brian) Wigglesworth discovered that distention of the abdomen of the blood-sucking hemipteran bug **Rhodnius prolixus** following consumption of a blood meal sends neural impulses to the brain and triggers the release of PTTH.
- A similar mechanism has been found in a herbivorous (plant-eating) hemipteran as well. Size seems to trigger molting in lepidopterans (moths, butterflies), although the mechanism is not understood.
- Each molt is aided by a small amount of juvenile hormone (JH) secreted by endocrine cells of the corpora allata.
- Without JH during a critical time of the intermolt period of the last larval stage, either a pupa stage (diapause, or a resting state) or an adult stage is achieved.
- Juvenile hormone also keeps the epidermis in a larval state and causes it to secrete larval cuticle. Without JH, the epidermis changes and secretes the adult cuticle type.
- Three different closely related forms of JH have been isolated from seven major insect orders.

Diapause.

- Some insects enter diapause during development.
- Diapause is characterized by cessation of development or reproduction, decrease in water content (dehydration), and reduction in metabolic activities.
- It is typical of many insects and mites, a few crustaceans and snails, and perhaps certain other animal groupsThis period of suspended development is an apparent response to the approach of adverse environmental conditions.
- It may occur during any life stage but is most common among pupae (*e.g.*, the cocoons of moths).
- It usually is preceded by an accumulation of nutrients resulting in hypertrophy of the fat bodies.Environmental factors (such as temperature, photoperiod, and food availability) cause storage of neurohormones, and the corpora allata become inactive. Termination of diapause can be brought about by reversing the environmental conditions that induced the diapause.
- Although juvenile hormone can terminate diapause, it triggers diapause in some insects.
- The stage of the life history may be important in determining the role of JH. For example, in imaginal diapause (characterized by cessation of reproduction in the imago, or adult), the absence of JH initiates diapause. In lepidopterans, a peptide that initiates diapause has been isolated from the subesophageal ganglion.

Reproduction

- In some insects the pars intercerebralis secretes a neurohormone that stimulates vitellogenesis by the fat body (vitellogenesis is the synthesis of vitellogenin, a protein from which the oocyte makes the egg proteins).
- This neurohormone is stored in either the corpora cardiaca or the corpora allata, depending on the species.
- Uptake of vitellogenin by the ovary is enhanced by JH.
- In most insects, JH also stimulates vitellogenin synthesis by the fat body. There is evidence that other neurohormones secreted by the pars intercerebralis also influence reproduction.
- Some induce other tissues to secrete pheromones that influence reproductive behaviour of other individuals. In the live-bearing tsetse fly, ***Glossina***, a neurohormone released from

the corpora allata stimulates milk glands that provide nourishment to the developing larvae.

Osmoregulation

- In biology, maintenance by an organism of an internal balance between water and dissolved materials regardless of environmental conditions.
- In many marine organisms osmosis (the passage of solvent through a semipermeable membrane) occurs without any need for regulatory mechanisms because the cells have the same osmotic pressure as the sea.
- Other organisms, however, must actively take on, conserve, or excrete water or salts in order to maintain their internal water-mineral content.
- All insects produce a diuretic hormone and many produce an antidiuretic hormone as well.
- Insects feeding exclusively on a liquid diet (such as plant sap or blood) have only the diuretic hormone that allows them to eliminate excess fluid and salts through the malpighian tubules (the insect kidney).
- These osmoregulatory neurohormones are produced both in the brain and in the ventral nerve cord.

Myotropic and metabolic factors

- One or more small peptide neurohormones are produced in the brain and ventral nervous system and are stored in the corpora cardiaca and perisympathetic organs, respectively.
- These myotropic factors stimulate heart rate as well as contractions of the kidney tubules and digestive tract.
- The corpora cardiaca were named for the heart-stimulating action produced by extracts of these organs.
- The glandular portion of the corpora cardiaca is thought to secrete the hyperglycemic hormone that causes a rapid increase in blood levels of trehalose, the "blood sugar" of insects.
- It is sometimes called the hypertrehalosemic hormone.
- This hypoglycemic hormone apparently is identical to the myotropic factors in at least one species, the American cockroach.
- An adipokinetic neurohormone released from the orthopteran corpora cardiaca (locusts, grasshoppers) causes the release of diglycerides into the blood during, and immediately after, flight. It is a peptide similar to the myotropic factors.

Section - A

1. Budding 2. Fission
3. Molting 4.Diapause 5. Osmoregulation

Section – B

Describe the Reproduction process

Write About the Types of Reproduction

Enlist the Types of A sexual reproduction in Invertebrates

Write a short note on Endocrine glands in crustaceans

What is Diapause ? explain it

Explain about the Osmoregulation

Section – C

Give a detailed account on Reproduction in Invertebrates

Explain Briefly about the Role of Endocrine gland secretion in crustaceans

Describe the Endocrine gland in Insects.

MINOR PHYLA :

The animals grouped under minor phyla are comparatively few in number, quite uncommon and small sized. They are unimportant as source of food or disease of man. so such groups of animals are known as minor phyla.

PHORONIDA :

Phoronidae are tubicolous, vermiform, coelomate, bilaterally symmetrical animals. It has two genera, the phoronis and Phoronopsis.

* They are Lophophorate animals. They are sedentary animal
* The phoronids are exclusively marine and tubicolous.
* They live in groups. But they have no organic connection.
* The body of phoronids is elongated, cylindrical and unsegmented. It is transparent and colourless. but some times yellowish or greenish.
* The body is divided into an anterior lophophore and a posterior trunk.
* The lophophore is a horse-shoe shaped tentacular crown. It consists of two prominent ridges outer and inner.
* The mouth lies between the two rows of tentacles and is continious with the lophophoral groove on each side. lophophoral gland are present.
* The anus lies outside the Lophophore.
* The trunk is narrow, cylindrical and is without any appendages.
* The body wall consists of cuticle, epidermis, basement membrane, muscular layers and the coelomic epithelium.

* The body cavity is a coelom. The coelom is lined with a coelomic epithelium.
* The alimentary canal is 'U' shaped and it consists of a mouth oesophagus, the stomach, the intestine and rectum. rectum opens out through the anus.
* Phoronids are filter feeders. Circulatory system is closed type. specialised respiratory organs are absent.
* Excretory system consists of a pair of metanephridia.
* The nervous system includes nerve fibres and nerve cells which form a distinct nervous layer beneath the epidermis.
* Special sense organs are absent.
* Phoronis is hermaphrodite. some may be dioecious.

AFFINITIES WITH BRACHIOPODA:

1. occurrence of horse shoe shaped lophophore.
2. Presence of an epistome. 'U' shaped alimentary canal.
3. A septum is present. presence of a subepidermal nervous plexus.
4. A pair of metanephridia occur which also serves as gonoducts.
5. mouth originates directly from the blastophore.
6. Short dorsal surface between mouth and anus.

AFFINITIES WITH ECTOPROCTA:

1. Same type of divisions in the body and coelom with definite septum between mesocoel and metacoel.
2. Presence of horse shoe shaped lophophone.
3. Presence of an epistome. The alimentary canal is 'U' shaped
4. The nerve centre is located in the mesocoel and supraenteric
5. But they differ from both anatomical and embryo-logical point of view.

AFFINITIES WITH ANNELIDA :

1. The tentacular lophophore of Phoronida can be comparable to the tentacular crown of Sipunculus.
2. Nephridial tubes act as gonoducts in both the groups.
3. The actinotrocha larva is considered to be a modified trochophore. Both are free swimming, ciliated, pelagic forms with pre-oral lobe.
4. But Phoronids and annelids are fundamentally different in their organization.

AFFINITIES WITH HEMICHORDATA :

1. The division of body of Hemichordata (proboscis, collar and trunk) corresponds to the body division of phoronida (epistome, mesosome and metasome)
2. A pair of glandular pockets opening into the anterior end of the stomach of Phoronida, is supposed to be the notochord.
3. A septum is pesent between the middle and posterior part of the body.
4. The location of lophophore is similar to be tentaculated arms of cephalodiscus.

ACANTHOCEPHALA :

* Acanthocephala are endoparasitic, Pseudocoelomate and bilaterally symmentrical worms. They are commonly known as piny headed worms.
* They are closely related to platyhelminthes.
* They are endoparasites living in the intestine of vertebrates
* They are digenic parasites. The body is cylindrical or laterally compressed.
* The body is divisable into a proboscis, a neck and a trunk..

* The proboscis is a cylindrical projection at the anterior end. It is covered with many rows of recurved hooks.
* The neck is short, but sometimes much elongated.
* The trunk is cylindrical or flattened with a smooth wrinkled or segmated surface.
* The mouth, anus and nephridiopores are absent.
* A single gonopore occurs at the posterior end.
* The body wall consists of cuticle, epidermis.
* The number of nuclei are constant for each species
* The epidermis contains a lacunar system.
* Below the epidermis is dermis. Dermis are the muscle layer of outer circular and inner longitudinal fibres
* The body cavity is a pseudocoel filled with a clear fluid.
* The alimentary canal, respiratory and circulatory organs are absent.
* A pair of protonephridia is present at the posterior end near the genital opening.
* The nephridial ducts of both sides unite into a common duct, which opens into the sperm duct in the male and the uterus in the female.
* There is a large cerebral ganglion. The ligament sacs are peculiar to Acanthocephala.
* The sexes are separate. The reproductive organs occupy the greater part of the body.
* Fertilization is internal. The cleavage is spiral and determinate.

An embryo is developed with rostellum and six hooks resembling the hexacanth larva of the cestodes. This is enclosed in the thick embryonic wall and now it is known as acanthor larva.

AFFINITIES WITH NEMATHELMINTHES:

1. The presence of armed proboscis. Absence of gut.
2. presence of circular muscles.
3. presence of flame cells.
5. Nature of reproductive organs.

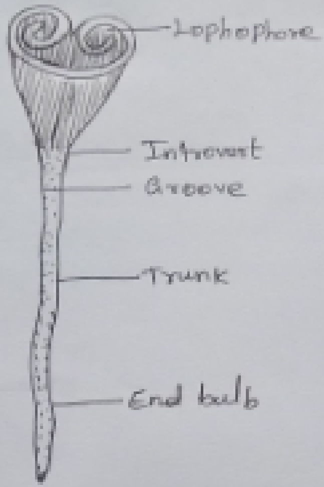
AFFINITIES WITH ASCHELMINTHES:-

1. The division of the body into presoma and trunk as in priapulids and gordiacean larva.
2. An armed proboscis is found among the aschelminthes.
3. Both exhibit superficial segmentation.
4. presence of cuticle and syncytial epidermis.
5. ligament sac resemble mesenteries.
6. presence of flame bulbs.
7. close association of excretory and reproductive organs

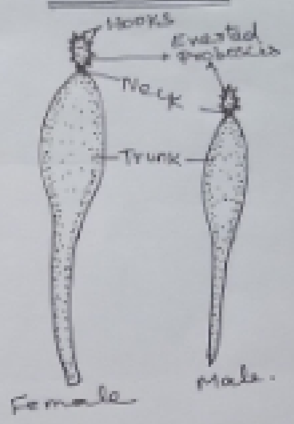
AFFINITIES WITH PLATYHELMINTHES:

1. An armed and protrusible proboscis occurs in certain Cestodes such as Trypanorhyncha.
2. cuticle and syncytial epidermis.
3. Circular and longitudinal muscle fibres.
4. Protonephridia with flame cells.
5. male reproductive system resembles that of many flatworms. Absence of alimetary canal.
6. Hooked rostellum in the larval form.
7. serological tests indicate a close relationship with cestodes.

Phoronis



Acanthocephala.



NEMERTINEA :

* Nemertinea are elongated, vermiform, flattened, acoelomate, bilateral animals.
* They are commonly known as ribbon worms or bootlace worms. They are marine and free living.
* There about 500 to 600 species. They remain coiled beneath stones, among algae, in burrows or in tubes.
* The body is narrow and elongated, cylindrical or dorsoventrally flattened. It is unsegmented.
* Some are pelagic. Few occur in freshwater and moist earth
* The body is highly extensile. The body is covered by cilia. A distinct head is absent. The anterior end has a proboscis.
* The posterior end bears a tail like caudal cirrus and with anus at its base.
* The proboscis is the most characteristic feature of nemertines.

* It is an elongated coiled, hollow and muscular organ. Proboscis sheath is retractile in nature.
* when the proboscis is protruded, the stylet projects freely and the fluid is injected into the wound of the victim.
* Proboscis has the folloing functions as Feeding, organ of offence and defence, Tactile organ, Locomotion, Attachment, Burrowing.
* The body wall consists of epidermis with it ciliated.
* The coelom is absent. Inter spaces between the organs are filled with gelatinous parenchyma.
* The alimentary canal start with a mouth. The digestive tract is a ciliated tube extending the whole length of the body. They are carnivorous.
* Circulatory system is a closed type. The blood is usually colourless and contains rounded nucleated corpuscles.
* The blood is kept in circulation by the movement of the body.
* Excretory system is formed of a pair of longitudinal protonephridia.
* There are no special organs for respiration. Respiration takes place by diffusion of oxygen through the general body surface.
* The nervous system consists of a brain. The sensory nerve cells are slender and bears a hair-like process on the outside. They are tactile in function.
* Eyes are present in most of the nemertines.
* Most nemertines are dioecious but some may be hermaphro-ditic

* The gonads are paired. Gonads arise from mesenchyme.
* Fertilization may be either external or internal.
* The development is usually direct. But in some the youngones are hatched as a larval form called Pilidium larva. It has a helmet shaped body with a band of cilia around the base. Two side lobes are also present.
* In other forms, a ciliated creeping larva is produced. This larva is known as Desor larva.
* The Pilidium and Desor larvae undergo a complicated metamorphosis to become a young nemertinean.
* The nemertines have great power of regeneration.

AFFINITIES WITH LOWER HEMICHORDATES:-

1. Elongated vermiform body. No external metamerism.
2. Skin is smooth containing unicellular glands. Terminal anus.
3. Ectodermal nerve plexus. Metamerically located simple gonads.
4. Retractile proboscis of nemertines is equivalent to non-retractile proboscis of Balanoglossus.

AFFINITIES WITH VERTEBRATES:-

1. Dorsal nerve resembles the spinal cord of vertebrates.
2. The lateral nerves represent the nerves of lateral lines of fishes.
3. The cerebral ganglion ~~represent~~ resembles the brane of vertebrates.
4. Proboscis sheath suggests the notochord of vertebrates.

AFFINITIES WITH PLATYHELMINTHES:-

1. The shape of the body is flat, ribbon like without external segmentation.

2. Body is completely covered with a ciliated epidermis containing gland cells.
3. Below the integument, thick and contractile muscle fibres are present.
4. the space between the body wall and the gut is filled with a solid mass of mesenchyme. True coelom is absent.
5. Excretory system consists of flame cells.
6. nervous system similar to that of flatworms.
7. spiral type of cleavage
8. occurence of frontal glands, pits + structure of the ocelli, cerebral organ, etc. is similar to platyhelminthes.

BRYOZOA [ECTOPROCTA]:

Ectoprocta are microscopic, sessile unsegmented and coelomate animals. They form colonies called "sea mats" or corallines. which bear superficial resemblance to hydroids. Eg. Bugula, Flustra, Alcyonidium.

* In Ectoprocta, the anus is situated outside the tentacular circle.
* Most of the Ectoprocta are marine and a few live in fresh and brackish water. They are permanently attached to rocks, seaweeds, other animals etc.
* They are strictly benthic but larval stages are pelagic
* A colony is called a Zoarium. It is composed of several zooids. Each is enclosed in a exoskeletal case called Zoecium.
* The Zoecium consists of an outer cuticle and inner layer of epidermal cells.
* The external opening of the Zoecium is called orifice.
* On each zoecium there is an appentages called avicularians

* The free end of the introvert bears a circlet tenta-cles on a circular ridge called lophophore.
* The tentacles are ciliated. Tentacles serve as tactile and respiratory organs.
* The main body of the zooid is the trunk. It is immovably attached inside the zoecium. It contains the coelom and other internal organs.
* The body wall has the cuticle, epidermis, two muscular layer and parenchyma.
* The body cavity is a coelom. A strand of mesentery, the funiculus is extending between the alimentary canal and the aboral body wall.
* The digestive tract is an 'U' shaped tube. It consists of the mouth, the pharynx, the oesophagus, the stomach and the intestine which terminates in anus.
* The Ectoprocta are ciliary feeders and feed on micro-organisms specially the diatoms.
* The circulatory system is entirely absent. Definite excretory organs are absent.
* The nervous system consists of a ganglion or brain on the dorsal side of the pharynx and a nerve ring encircling it. Special sense organs are absent.
* Ectoprocta are hermaphrodites. Testes originate from the cells of funicular tissue.
* The ovary is formed from the coelomic wall.
* A free-swimming, bell shaped, Cyphonautes larva is produced.
* Ectoprocta also reproduce asexually by budding, statoblasts, hybernacula, brown bodies and regeneration.

AFFINITIES WITH ENDOPROCTA :

1. presence of a crown of ciliated tentacle. presence of 'U' shaped alimentary canal.
2. The larva of endoprocta sperficially resemble the cyphonautes larva of Ectoprocta.
3. They exhibit following difference – The tentacular crown does not surround the anus in Ectoprocta, but in Endoprocta, the anus is included within the crown of tentacles.
4. True coelom is present in ectoprocta, where as in Endoprocta the true coelom is absent.

AFFINITIES WITH PHORONIDA :

1. A horse shoe shaped lophophone is present in both. Presence of epistome.
2. looped alimentary canal.
3. Similar disposition of the coelom and the presence of a septum separating the mesocoel and metacoel.
4. presence of subepidermal nervous plexus.
5. Simple gonads derived from the Peritoneum.
6. The origin of coelom is different.

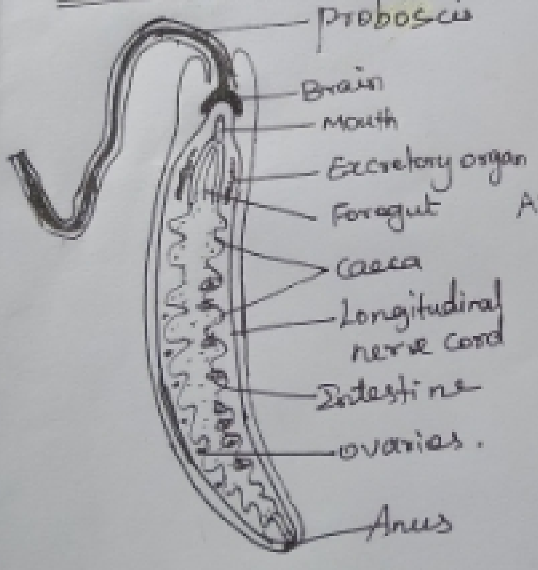
AFFINITIES WITH BRACHIOPODA :

1. The shell of Branchiopoda is comparable to that of the bivalve shell of cyphonautes larva of Ectoprocta.
2. Both have similar body organization.

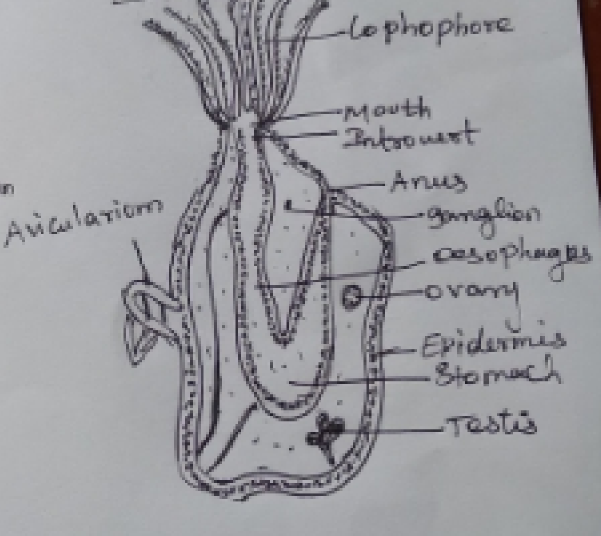
3. Presence of coelomic septum between the mesocoel and metacoel.
4. U shaped alimentary canal.
5. There are many structural differences between the two groups.
6. The Branchiopod shell cannot be comparable to that of the exoskeleton of Ectoprocta.
7. In Ectoprocta larva, the shell is laterally placed, whereas in branchiopods the shell is dorsoventrally placed.
8. The chitinous setae present in branchiopods are absent in ectoprocta.

The Branchiopoda closely resembles Phoronida and Ectoprocta: Annelida.

Nemertinea:



Ectoprocta:



INVERTEBRATE FOSSILS

1. Trilobites

Trilobites are "three lobed" extinct group of marine artiopodan arthopods that form the class **Trilobita**. Trilobites form one of the earliest-known groups of arthropods. The first appearance of trilobites in the fossil record defines the base of the Atdabanian stage of the Early Cambrian period (521 million years ago), and they flourished throughout the lower Paleozoic before slipping into a long decline, when, during the Devonian, all trilobite orders except the Proetida died out. The last extant trilobites finally disappeared in the mass extinction at the end of the Permian about 252 million years ago. Trilobites were among the most successful of all early animals, existing in oceans for almost 300 million years.

By the time trilobites first appeared in the fossil record, they were already highly diversified and geographically dispersed. Because trilobites had wide diversity and an easily fossilized exoskeleton, they left an extensive fossil record. The study of their fossils has facilitated important contributions to biostratigraphy, paleontology, evolutionary biology, and plate tectonics. Trilobites are often placed within the arthropod subphylum Schizoramia within the superclass Arachnomorpha (equivalent to the Arachnata), although several alternative taxonomies are found in the literature. More recently they have been placed within the Artiopoda, which includes many organisms that are morphologically similar to trilobites, but are largely unmineralised.

Trilobites had many lifestyles; some moved over the seabed as predators, scavengers, or filter feeders, and some swam, feeding on plankton. Some even crawled onto land. Most lifestyles expected of modern marine arthropods are seen in trilobites, with the possible exception of parasitism (where scientific debate continues). Some trilobites (particularly the family Olenidae) are even thought to have evolved a symbiotic relationship with sulfur-eating bacteria from which they derived food. The largest trilobites were more than 45 centimetres long and may have weighed as much as 4.5 kilograms

Fossil record of early trilobites

Redlichiida, such as this *Paradoxides*, may represent the ancestral trilobites

Meroperix, from the Silurian of Wisconsin

Walliserops trifurcatus, from Jebel Oufatene mountain near Fezzou, Morocco

The earliest trilobites known from the fossil record are redlichiids and ptychopariid bigotinids dated to some 540 to 520 million years ago. Contenders for the earliest trilobites include *Profallotaspis jakutensis* (Siberia), *Fritzaspis* spp. (western USA), *Hupetina antiqua* (Morocco) and *Serrania gordaensis* (Spain). All trilobites are thought to have originated in present-day Siberia, with subsequent distribution and radiation from this location.

All Olenellina lack facial sutures (see below), and this is thought to represent the original state. The earliest sutured trilobite found so far (*Lemdadella*), occurs almost at the same time as the earliest Olenellina, suggesting the trilobites origin lies before the start of the Atdabanian, but without leaving fossils. Other groups show secondary lost facial sutures, such as all Agnostina and some Phacopina. Another common feature of the Olenellina also suggests this suborder to be the ancestral trilobite stock: early protaspid stages have not been found, supposedly because these were not calcified, and this also is supposed to represent the original state. Earlier trilobites may be found and could shed more light on the origin of trilobites.

Three specimens of a trilobite from Morocco, *Megistaspis hammondi*, dated 478 million years old contain fossilized soft parts.

Final extinction

Exactly why the trilobites became extinct is not clear; with repeated extinction events (often followed by apparent recovery) throughout the trilobite fossil record, a combination of causes is likely. After the extinction event at the end of the Devonian period, what trilobite diversity remained was bottlenecked into the order Proetida. Decreasing diversity] of genera limited to shallow-water shelf habitats coupled with a drastic lowering of sea level (regression) meant that the final decline of trilobites happened shortly before the end of the Permian mass extinction event. With so many marine species involved in the Permian extinction, the end of nearly 300 million successful years for the trilobites would not have been unexpected at the time.

Trilobites have no known direct descendants. Their closest living relatives would be the chelicerates. Though horseshoe crabs are often cited as their closest living relatives, they are no closer evolutionarily than other cheliceratans

Trilobites appear to have been primarily marine organisms (though some trackways suggest at least temporary excursions onto land), since the fossilized remains of trilobites are always found in rocks containing fossils of other salt-water animals such as brachiopods, crinoids, and corals. Within the marine paleoenvironment, trilobites were found in a broad range from extremely shallow water to very deep water. Trilobites, like brachiopods, crinoids, and corals, are found on all modern continents, and occupied every ancient ocean from which Paleozoic fossils have been collected. The remnants of trilobites can range from the preserved body to pieces of the exoskeleton, which it shed in the process known as ecdysis. In addition, the tracks left behind by trilobites living on the sea floor are often preserved as trace fossils.

There are three main forms of trace fossils associated with trilobites: *Rusophycus*, *Cruziana* and *Diplichnites*—such trace fossils represent the preserved life activity of trilobites active upon the sea floor. *Rusophycus*, the resting trace, are trilobite excavations involving little or no forward movement and ethological interpretations suggest resting, protection and hunting. *Cruziana*, the feeding trace, are furrows through the sediment, which are believed to represent the movement of trilobites while deposit feeding. Many of the *Diplichnites* fossils are believed to be traces made by trilobites walking on the sediment surface. Care must be taken as similar trace fossils are recorded in freshwater and post-Paleozoic deposits, representing non-trilobite origins.

Trilobite fossils are found worldwide, with many thousands of known species. Because they appeared quickly in geological time, and moulted like other arthropods, trilobites serve as excellent index fossils, enabling geologists to date the age of the rocks in which they are found. They were among the first fossils to attract widespread attention, and new species are being discovered every year.

The study of Paleozoic trilobites in the Welsh-English borders by Niles Eldredge was fundamental in formulating and testing punctuated equilibrium as a mechanism of evolution.

Identification of the 'Atlantic' and 'Pacific' trilobite faunas in North America and Europe implied the closure of the Iapetus Ocean (producing the Iapetus suture), thus providing important supporting evidence for the theory of continental drift.

Trilobites have been important in estimating the rate of speciation during the period known as the Cambrian explosion because they are the most diverse group of metazoans known from the fossil record of the early Cambrian.

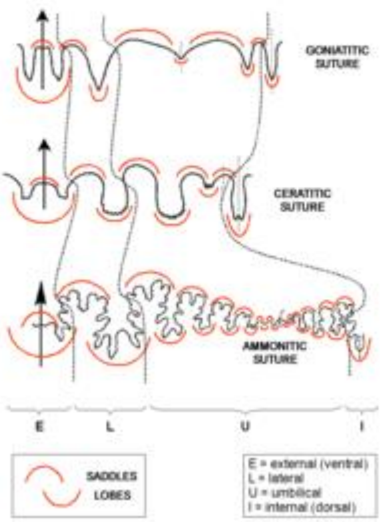
Trilobites are excellent stratigraphic markers of the Cambrian period: researchers who find trilobites with alimentary prosopon, and a micropygium, have found Early Cambrian strata. Most of the Cambrian stratigraphy is based on the use of trilobite marker fossils.

Trilobites are the state fossils of Ohio (*Isotelus*), Wisconsin (*Calymene celebra*) and Pennsylvania (*Phacops rana*).

2. <u>Ammnonoids</u>

Ammonoids are a group of extinct marine mollusc animals in the subclass Ammonoidea of the class Cephalopoda. These molluscs, commonly referred to as ammonites, are more closely related to living coleoids than they are to shelled nautiloids such as the living Nautilus species. Ammonites are excellent index fossils, and it is often possible to link the rock layer in which a particular species or genus is found to specific geologic time periods. Their fossil shells usually take the form of planispirals, although there were some helically spiraled and nonspiraled forms (known as heteromorphs). Ammonoid septa characteristically have bulges and indentations and are to varying degrees convex when seen from the front, distinguishing them from nautiloid septa which are typically simple concave dish-shaped structures. The topology of the septa, especially around the rim, results in the various suture patterns found. While nearly all nautiloids show gently curving sutures, the ammonoid suture line (the intersection of the septum with the outer shell) is variably folded, forming saddles ("peaks" which point towards the aperture) and lobes ("valleys" which point away from the aperture). The suture line has four main regions. The external or ventral region refers to sutures along the lower (outer) edge of the shell, where the left and right suture lines meet. The external saddle lies directly on the lower midline of the shell and is edged by external lobes. On suture diagrams the external saddle is supplied with an arrow which typically points towards the aperture. The lateral region involves the first saddle and lobe pair past the external region as the suture line extends up the side of the shell. Additional lobes developing towards the inner edge of a whorl are labelled umbilical lobes, which increase in number through ammonoid evolution as well as an individual ammonoid's development. Lobes and saddles which are so far towards the center of the whorl that they are covered up by succeeding whorls are labelled internal lobes and saddles. Three major types of suture patterns are found in the Ammonoidea:

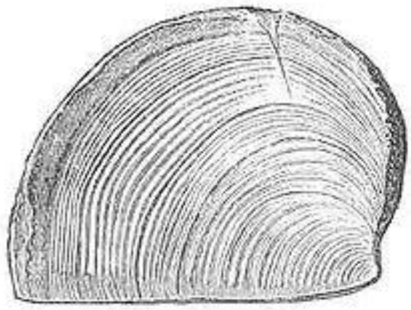
- **Goniatitic** - numerous undivided lobes and saddles; typically 8 lobes around the conch. This pattern is characteristic of the Paleozoic ammonoids.
- **Ceratitic** - lobes have subdivided tips, giving them a saw-toothed appearance, and rounded undivided saddles. This suture pattern is characteristic of Triassic ammonoids and appears again in the Cretaceous "pseudoceratites".
- **Ammonitic** - lobes and saddles are much subdivided (fluted); subdivisions are usually rounded instead of saw-toothed. Ammonoids of this type are the most important species from a biostratigraphical point of view. This suture type is characteristic of Jurassic and Cretaceous ammonoids, but extends back all the way to the Permian.



Suture Pattern in Ammnonoids

Distribution

Starting from the mid-Devonian, ammonoids were extremely abundant, especially as ammonites during the Mesozoic era. Many genera evolved and ran their course quickly, becoming extinct in a few million years. Due to their rapid evolution and widespread distribution, ammonoids are used by geologists and paleontologists for biostratigraphy. They are excellent index fossils, and it is often possible to link the rock layer in which they are found to specific geologic time periods.



A drawing of an aptychus which was mistakenly described as a bivalve and named *Trigonellite latus*

Extinction

The extinction of the ammonites, along with other marine animals and non-avian dinosaurs, has been attributed to the K-Pg extinction event, marking the end of the Cretaceous Period.

Eight or so species from only two families made it almost to the end of the Cretaceous, the order having gone through a more or less steady decline since the middle of the period. Six other families made it well into the upper Maastrichtian (uppermost stage of the Cretaceous), but were extinct well before the end. All told, 11 families entered the Maastrichtian, a decline from the 19 families known from the Cenomanian in the middle of the Cretaceous.

One reason given for their demise is the Cretaceous ammonites, being closely related to coleoids, had a similar reproductive strategy in which huge numbers of eggs were laid in a single batch at the end of the lifespan. These, along with juvenile ammonites, are thought to have been part of the plankton at the surface of the ocean, where they were killed off by the effects of an impact. Nautiloids, exemplified by modern nautiluses, are conversely thought to have had a reproductive strategy in which eggs were laid in smaller batches many times during the lifespan, and on the sea floor well away from any direct effects of such a bolide strike, and thus survived.

Many ammonite species were filter-feeders, so they might have been particularly susceptible to marine faunal turnovers and climatic change.

There have been reliable reports of ammonite fossils from the early Paleocene. The main fossil find of a Paleocene ammonoid is a scaphitid ident from Turkmenistan.

3. Belemnites

Belemnites is a genus of an extinct group of cephalopods belonging to the order Belemnitida. These cephalopods existed in the Early Jurassic period from the Hettangian age (196.5–199.6 mya) to the Toarcian age (175.6–183.0). They were fast-moving nektonic carnivores.

Preservation

Belemnoids were numerous during the Jurassic and Cretaceous periods, and their fossils are abundant in Mesozoic marine rocks, often accompanying their cousins the ammonites. The belemnoids become extinct at the end of the Cretaceous period along with the ammonites. The belemnoids' origin lies within the bactritoid nautiloids, which date from the Devonian period; well-formed belemnoid guards can be found in rocks dating from the Mississippian (or Early Carboniferous) onward through the Cretaceous.

Other fossil cephalopods include baculites, nautiloids and goniatites.

Normally with fossil belemnoids only the back part of the shell (called the *guard* or *rostrum*) is found. The guard is usually elongated and bullet-shaped (though in some subgroups the rostrum may only exist as a thin layer coating the phragmocone). The hollow region at the front of the guard is termed the *alveolus*, and this houses a chambered conical-shaped part of the shell (called the *phragmocone*). The phragmocone is usually only found with the better preserved specimens. Projecting forwards from one side of the phragmocone is the thin *pro-ostracum*.

While belemnoid phragmocones are homologous with the shells of other cephalopods and are similarly composed of aragonite, belemnoid guards are evolutionarily novel and are composed of calcite or aragonite, thus tending to preserve well. Broken guards show a structure of radiating calcite fibers and may also display concentric growth rings.

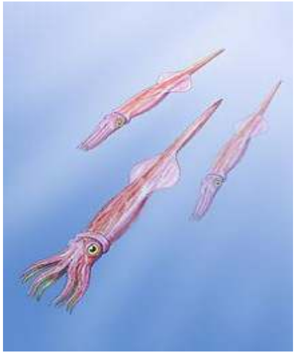
Diagenetic modifications of the shells are complex. Radiating calcitic crystals are thin, or very large, with a shape indicative of a strong alteration. In other samples, the aragonite - calcite boundary is not dependent on growth lines. In a given fossil sites, some specimens are calcite, others are aragonite.

The guard, phragmocone and pro-ostracum were all internal to the living creature, forming a skeleton which was enclosed entirely by soft muscular tissue. The original living creature would have been larger than the fossilized shell, with a long streamlined body and prominent eyes. The guard would have been in place toward the rear of the creature, with the phragmocone behind the head and the pointed end of the guard facing backward.

The guard of the belemnoid *Megateuthis gigantea*, which is found in Europe and Asia, can measure up to 46 centimetres (18 in) in length, giving the living animal an estimated length of 3 metres (10 ft).

Thunderstones

The name "thunderbolt" or "thunderstone" has also been traditionally applied to the fossilised rostra of belemnoids. The origin of these bullet-shaped stones was not understood, and thus a mythological explanation of stones created where lightning struck has arisen.




Some of the Belemnoids

Uses

The stable isotope composition of a belemnoid rostrum from the Peedee Formation (Cretaceous, southeast USA) has long been used as a global standard (Peedee Belemnite, "PDB") against which other isotope geochemistry samples are measured, for both carbon isotopes and oxygen isotopes.

Some belemnoids (such as *Belemnites* of Belemnitida) serve as index fossils, particularly in the Cretaceous Chalk Formation of Europe, enabling geologists to date the age the rocks in which they are found.

4. Nautiloids

Nautiloids are a large and diverse group of marine cephalopods (Mollusca) belonging to the subclass Nautiloidea that began in the Late Cambrian and are represented today by the living Nautilus and Allonautilus.

Taxonomic Relationship

Nautiloids are among the group of animals known as cephalopods. The cephalopods are an advanced class of molluscs. The cephalopods also include ammonoids, Belemnites and modern coleoids such as octopus and squid.

Traditionally, the most common classification of the cephalopods has been a three-fold division into the nautiloids, ammonoids, and coleoids. This article is about nautiloids in that broad sense, sometimes called Nautiloidea *sensu lato*.

Cladistically speaking, nautiloids are a paraphyletic group united by shared primitive (basal) features not found in derived cephalopods. In other words, they are a evolutionary grade that is thought to have given rise to both ammonoids and coleoids. They are defined by the exclusion of both those descendent groups. Both ammonoids and coleoids probably descended from bactritids, which in turn arose from straight-shelled orthocerid nautiloids.

The ammonoids (a group which includes the ammonites and the goniatites) are extinct cousins of the nautiloids which evolved early in the Devonian, some 400 million years ago.

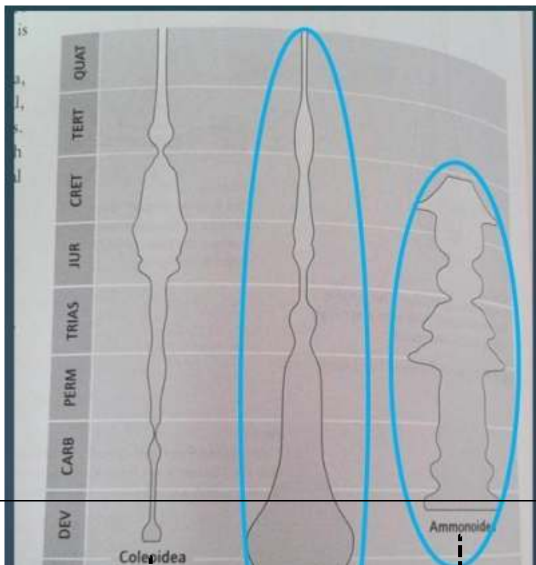
-The class now contains two, **only distantly related, extant subclasses**: **Coleoidea**, which includes o**ctopuses, squid, and cuttlefish**; and **Nautiloidea,** represented by **Nautilus**

Nautiloids and **Ammonoids** are sub-classes (**orders**) of the class Cephalopoda.

Modern cephalopods **are marine dwellers** and tend to be predators such as squid, cuttlefish and the octopus. One living Cephalopod, the Nautilius, has an **external shell**, a survivor from the days when cephalopods were extremely successful in the **late Palaeozoic and Mesozoic seas**. They are **globally distributed** throughout geological history.

The variety/biodiversity shown in cephalopods makes the a useful fossil **zone indicator** for the **Mesozoic**, Nautilius provides valuable information on how fossil cephalopods functioned and their **mode of life**.

Coleoidea (internal shell)



Nautiloids (external shell)

Key terms

- **The body chamber** is the cavity where the animal lived.
- **The protoconch** is the initial, embryonic shell in the centre of the coiled animal. New chambers are added onto this as the animal grows.
- **Septal necks** are where the septa are pierced to allow the tube of soft tissue (siphuncle) through. Septal necks extend to support the soft tissue.
- **The septum** is the wall of the chamber. This is the back wall when it is part of the body chamber.
- **A siphuncle** is a continuous delicate tube connecting all the chambers.

- **A suture** is a line along which the septum of the shell fuse.
- **The umbilicus** is the diameter of the depression between the inside margins of the last coil.

TYPES OF COILING

Almost all Ammonoids and Nautiloids are **planispirally coiled**. This means that the shell **coils in a single horizontal plane** (with the **diameter increasing** away from the axis of coiling/centre) opposed to a helical coiling system.

However, there are 2 forms of coiling mode:

Involute coiling

The inner coils are almost completely hidden by more recent coils. This type of coiling is demonstrated by Nautilius. Involute coiling results in a narrow umbilicus, and presumably a weaker shell(?).

This type of coiling is shown by the Nautilus.

Evolute coiling

Describes a coiling growth opposite to involute, in which the inner coils are easily seen, they are NOT hidden by more recent coils, giving a wider umbilicus.

This type of coiling is common in Ammonoids

NAUTILOIDS

~ Cambrian to recent (with their acme in the early Palaeozoic)

- Extant and fully marine
- Often found in early Palaeozoic rocks (much, much less in recent strata). Some species of Nautiloids had shell ornament with spines and ribs, but most have a smooth shell.
- Their shells are formed from aragonite. The modern Nautilus is shown below.

The modern-day Nautilus lives in a coiled shell, which originates at a

protoconch.

As the organism grows in the final body chamber, it se**als off older chambers** with a wall called a **septum (plural septa)**. These then are empty chambers joined by a narrow tube called a **siphuncle.** The siphuncle extends all the way back to the original chamber and can be used to alter the **proportions of gas and liquids** in the chambers. This, in turn, helps control the position of the organism in the **water column.**

The shells of fossil Nautiloids may be either straight (i.e. orthoconic as in Orthoceras **NOT BELEMNITES**), curved (as in Cyrtoceras) coiled (as in Cenoceras).

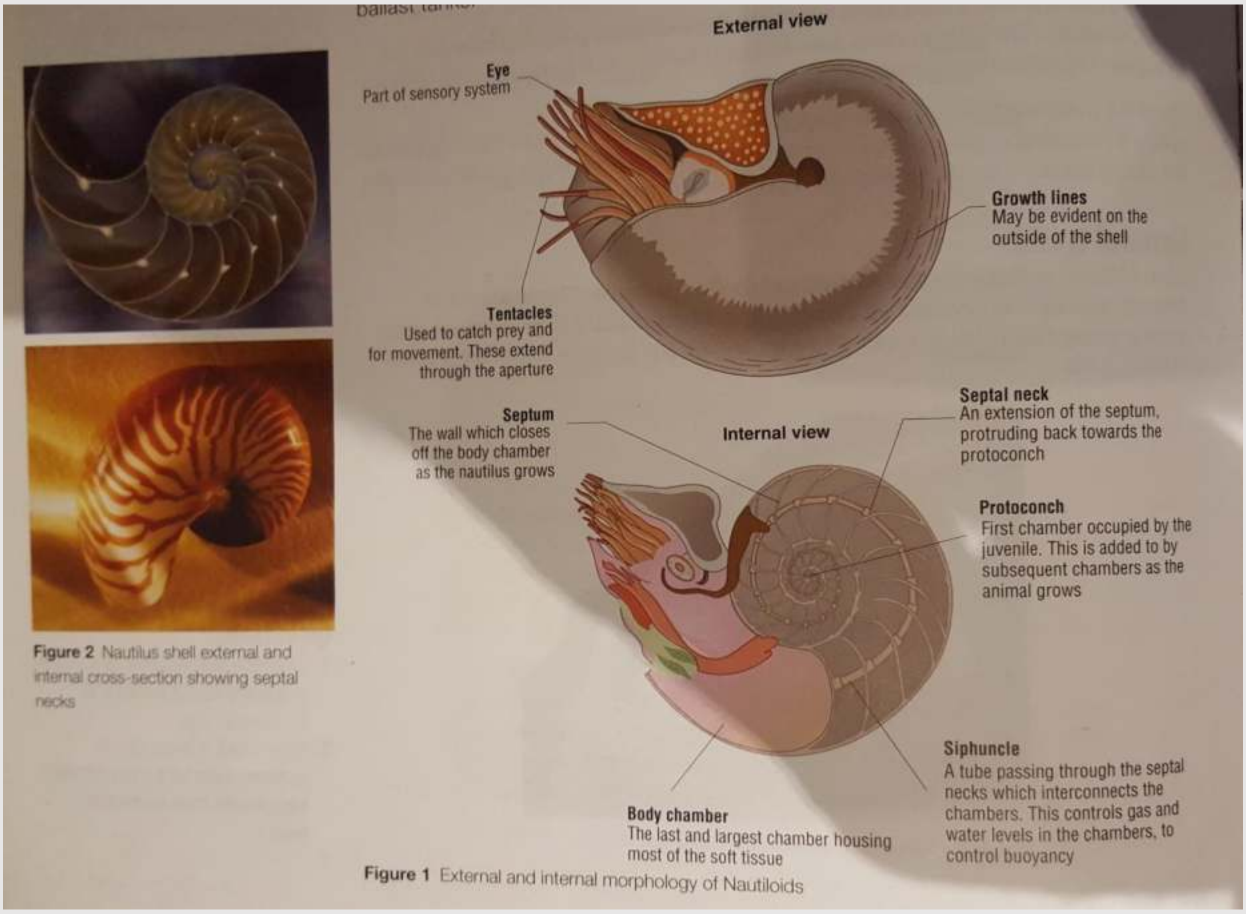


Figure 2 Nautilus shell external and internal cross-section showing septal necks

Figure 1 External and internal morphology of Nautiloids

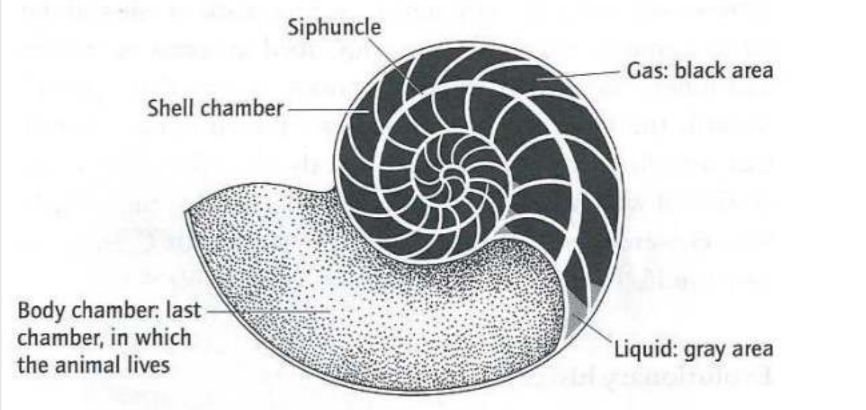
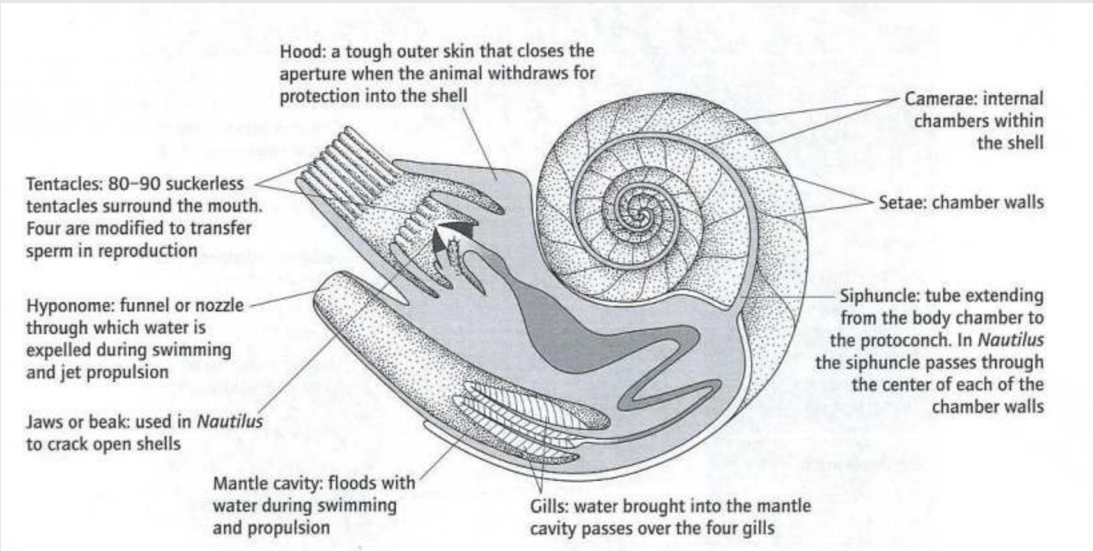
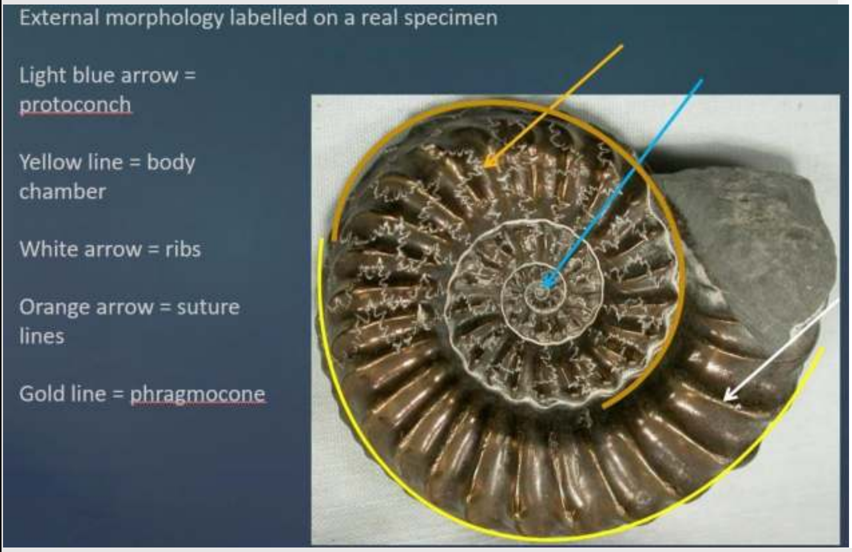


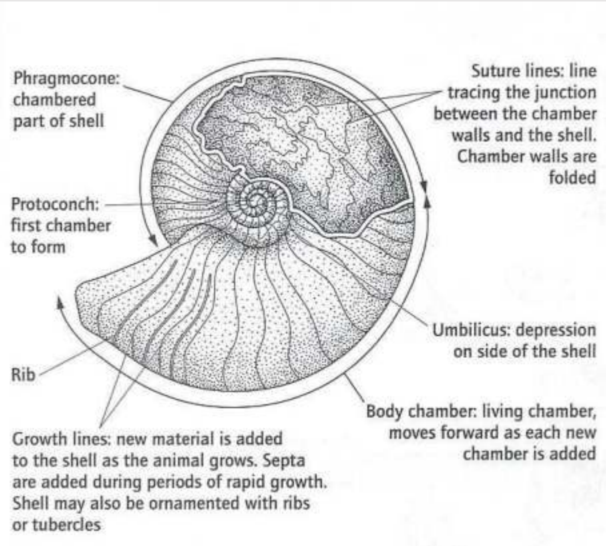
Fig. 9.11 The buoyancy mechanism of *Nautilus*.



AMMONOID MORPHOLOGY

- Ammonoids are an **extinct group** of invertebrates. Counter-intuitively they are more closely related to living Coleoids than they are to shelled Nautiloids. The earliest Ammonoids appeared **during the Devonian**, and the last species died out during the **Cretaceous-Tertiary (K-T) extinction event**.
- Ammonites are excellent index fossils. It is often possible to link the rock layer in which a particular species or genus is found to specific geological time periods, to accuracies of just 100 000 years!
- Their fossil shells usually take the form of **planispirals**, although there were some helically spiralled and non-spiralled forms.
- In contrast to Nautiloids, their coiling is **evolute** and there may be **ornament** such as **ribs** on the exterior of the shell.
- Some also have **a keel**, which stuck out from the **outer margin** and probably **provided stability** when the cephalopod **was in motion**.
- Some forms have a slot in **the outer** (**ventral) margin** called a **sulcus**, which presumably had the same effect.





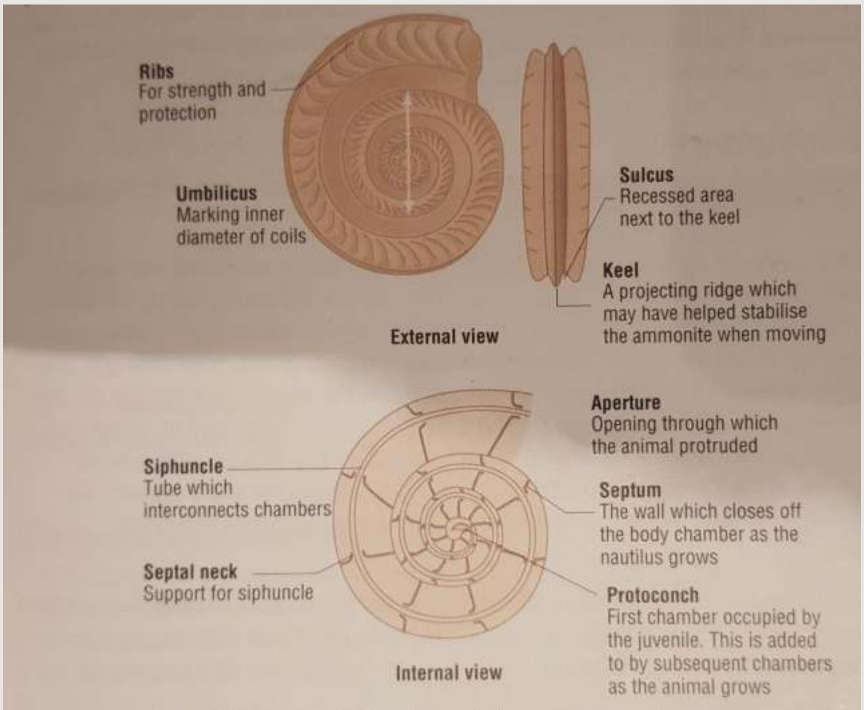
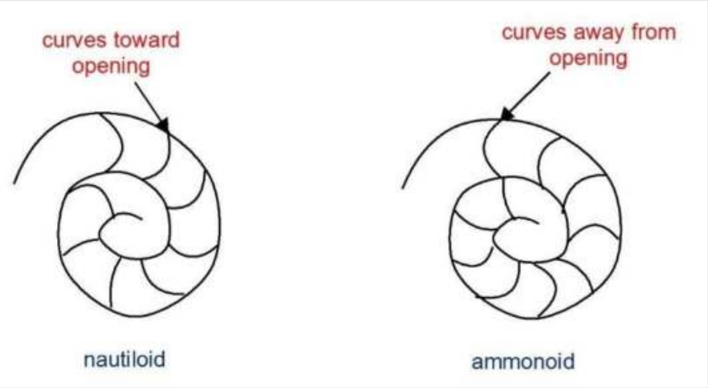


Figure 3 External and internal morphology of ammonoids

A GOOD METHOD FOR DETERMINING THE DIFFERENCE BETWEEN AMMONOIDS AND NAUTILOIDS.

1. If the internal shell/fossil can be observed then this method is useful. The shape of the septa curvature differs between Nautiloids and Ammonoids (not to be confused with ribs which are external).



2. A Nautiloid shell will usually be smooth on the exterior with no ornament or ribbing. In contrast, an Ammonoids shell can have ornament and ribbing on its exterior. Some also have a keel and sulcus that stuck out from its outer (ventral) margin.

3. Another big difference is that Nautiloids will tend to be involute producing a narrow umbilicus. Ammonoids, however, are commonly evolute with a wider umbilicus in relation to its size.
   Remember, this is much harder to tell is a fossil specimen has been sliced in half to see earlier coils.

4. The Siphuncle of a Nautiloid will always connect the body chamber to the original chamber through the CENTRE of all previous chambers. In Ammonoids, the siphuncle also interconnects previous chambers but it has the tendency to run closer to the outer (ventral) margin rather than the centre.

5. The sutures of Nautiloids tend to be more regular and simple (straight like orthocone Nautiloid cephalopods) or gently curved. Modern Nautilus only shows the curvature of septa. Ammonoids, however, tend to have complex sutures with crenulations. Ammonites show such frilly and complex sutures on both lobes and saddles that they are termed ammonitic sutures.

5. <u>Echinoderms (Echnoids)</u>

Echinoids have lived in the seas since the Late Ordovician, about 450 million years ago, which is about 220 million years before dinosaurs appeared. The remains and traces of these animals were buried in sediment that later hardened into rock, preserving them as fossils. The living representatives of echinoids are the familiar sea-urchins that inhabit many shallow coastal waters of the world. Fossil echinoids closely resemble some living sea-urchins which helps us to understand how they must have lived.

Echinoids are one of the more diverse and successful echinoderm groups today, including familiar echinoderms such as the sea urchins and sand dollars. The roe (egg mass) of some species, notably certain sea urchins, is eaten in some cultures, notably in Japanese sushi; as a result, certain echinoid species are commercially fished. The larval development of echinoids has also been studied extensively, and many discoveries in developmental biology have been made using echinoids. Echinoids also have a substantial fossil record.

In echinoids, the skeleton is almost always made up of tightly interlocking plates that form a rigid structure or **test** -- in contrast with the more flexible skeletal arrangements of starfish, brittle stars, and sea cucumbers. Test shapes range from nearly globular, as in some sea urchins, to highly flattened, as in sand dollars. Living echinoids are covered with spines, which are movable and anchored in sockets in the test. These spines may be long and prominent, as in typical sea urchins. In sand dollars and heart urchins, however, the spines are very short and form an almost felt-like covering. The mouth of most echinoids is provided with five hard teeth arranged in a circlet, forming an apparatus known as **Aristotle's lantern**.

Echinoids are classified by the symmetry of the test, the number and arrangement of plate rows making up the test, and the number and arrangement of respiratory pore rows called **petals** Traditionally, echinoids have been divided into two subgroups: **regular** echinoids, with nearly perfect pentameral (five-part) symmetry; and **irregular** echinoids with altered symmetry. Regular echinoids include the **Cidaroida** (pencil urchins) and **Echinoida** (sea urchins, including the long-spined sea urchin shown above left). The **Clypeasteroida** (sand dollars and sea biscuits, above center), the **Spatangoida** (heart urchins, including *Brissus* *laticarinatus* shown above right), and the **Cassiduloida**, a somewhat sand-dollar-like group whose members are rare today, make up the irregular echinoids.

Because most echinoids have rigid tests, their ability to fossilize is greater than that of more delicate echinoderms such as starfish, and they are common fossils in many deposits. The oldest echinoids, belonging to an extinct regular taxon called the **Echinocystitoidea**, appear in the fossil record in the late Ordovician. Cidaroids or pencil urchins appear in the Mississippian (Early Carboniferous) and were the only echinoids to survive the mass extinction at the Permo-Triassic boundary. Echinoids did not become particularly diverse until well after the Permo- Triassic mass extinction. True sea urchins first appear in the late Triassic, cassiduloids in the Jurassic, and spatangoids or heart urchins in the Cretaceous. Sand dollars, a common and diverse group today, do not even appear in the fossil record at all until the Paleocene.

Despite their alien appearance, echinoids, or sea-urchins as they are better known, are very common in the seas and oceans of today and are common fossils too. Their name derives from the Greek 'echin' ('spiny'), referring to their protective spines and presumably 'ooid' (egg-like) in reference to their globular shell, or test as it is known. Echinoids are part of a much larger group of animals known as the Echinoderms ('spiny-skins'), which also includes the Asteroids (starfish), Holothurians (sea cucumbers), Crinoids (sea lilies and feather stars) and the *Ophiuroids* (brittle stars).

Though their body plans are varied, all echinoderms possess key features which unite the group:

- A complex skeleton of calcareous plates, with a unique spongy structure known as stereom.
- Five planes of symmetry, referred to as penta-radial.
- An internal hydrostatic (water-vascular) system, external extensions of which are used for locomotion, respiration and feeding.
- All live in marine waters.

Why are Echinoids important?

Echinoids are very useful to palaeontologists because of their functional morphology; basically this means that by studying their anatomy you can tell a great deal about their mode of life and the environment in which they lived. They are also very common, and their robust tests and spines are easily fossilised and collected. Anyone who has hunted for fossils in the Jurassic and Cretaceous rocks of the UK will no doubt be very familiar with echinoids.

Regular or Irregular?

Echinoids fall into two categories; regular and irregular. This isn't referring to how common they are, rather to what shape they are. Regular echinoids have no front or back end and can move in any direction. Irregular echinoids have a definite front and back and do move in a particular direction. This is because regulars and irregulars have very different ways of life. Irregulars evolved from regulars, and their anatomy is therefore a modified version of the regular anatomy. For this reason we will deal with regulars first.

Regular Echinoids

As mentioned above, regular echinoids have no front or back end. Instead, the opening for the mouth (peristome) is on their underside, and the opening for the anus (periproct) is on top. When viewed from above or below their profile is circular and radially symmetrical; hence the term regular ('repeating', 'uniform'). This is because regular echinoids roam the surface of the sea floor in search of food and need to be able to move in any direction. This mode of life leaves them very exposed to predators and they have evolved elaborate spines both for defence and to act as stilts for locomotion.

Pedicellaria

Aritotle Lantern

Regular echinoids possess large, powerful, and highly complex jaws, known as Aristotle's Lanterns, which extend through the mouth to collect food or scrape organics from shells or other hard surfaces. The jaws are complex beaks with five teeth. These leave a distinctive star-shaped grazing trace called Gnathichnus pentax. Isolated echinoid jaw-parts are not uncommon fossils, but because they are unfamiliar to most collectors they are either overlooked of misidentified.

Echinoids are armoured with minute defensive spines called pedicellariae. These are venomous or possess pincers to deter parasites and clear detritus. Pedicellariae are only preserved in exceptional circumstances.