الجامعة المستنصرية

كلية العلوم

قسم علوم الحياة

فرع علوم الحيوان

المرحلة الثالثة

اللافقريات المائية النظري

Aquatic Protozoa

New

أعداد

Dr.Nebrass Faleh

يطلب من

مكتبة حسنين

للطباعة والأستنساخ

07709265858

السعر-2000

Aquatic Protozoa

General characteristic

1- Microscopic Organisms ranging (10-52mm) while some of them large they deep – sea dwelling *Xenophyophores* called Foraminifera whose shells can reach 20 cm in diameter .

2- Free living forms are restricted to moist environments , such as soil , mosses and aquatic habitats although many them from resting cysts which enable them to survive drying

3- Many species are symbiosis some are Parasites and some are Predators of bacteria , algae and other protests.

4- They move by flagella , Cilia , and Pseudopodia some them are sessile .

5- May take food by Osmotrophy (Absorbing nutrients through their cell membranes) or they may feed by Phagocytosis or taking food through a mouth- like aperture called Cytostome . All protozoa digest their food in vacuoles (like stomach in human).

6- Protozoa can also be parasitic causing various diseases in humans and animals (like diarrhea) caused by *Entamoeba histolytica* , Malaria by *Plasmodium* .

Classification of Protozoa

Phylum : Protozoa

Subphylum : Ciliophora

Class: Gymnostomatida

Order : Pleurostomatida

Family : Litonotidae

G.: *Litonotus*.

Phylum : Protozoa

Subphylum: Bryozoa

Class: Gymnolaemata

Order:Cheilostomata

Family : Bugulidae

G. : *Bugula*.

Phylum : Protozoa

Subphylum : Ochrophyta

Class: Actinochrysophyceae

Order : Actinophryida

G.: *Actinoshaerium*

Phylum : Protozoa

Subphylum : Sarcomastigophora

Super class: Sarcodina

Class: Cryptophyceae

Order : Cryptomonadales

Family : Campylomonadaceae

G. : *Chilomonas.*

Pellicle

It is thin layer supporting the cell membrane in various Protozoa such as Ciliates , protecting then and allowing them to retain their shape especially during locomotion , allowing the organism to more hydrodynamic . The Pellicle varies from flexible too rigid although somewhat stiff . The pellicle is also flexible and allow the protest to fit into lighter spaces .

In Ciliates it is formed from closely packed Vesicles called Alveoli . In *Euglena* formed from protein strips arranged spirally along the length of the body.

Reproduction in Protozoa

There are two types of Reproduction in Protozoa :

1- Asexual reproduction divided into :

Binary fission - Multiple fission (Sporulation) – Budding and Plasmotomy .

2- Sexual reproduction : Syngamy - Cojugation .

Important of Protozoa

1- Helpful in Sanitation of water bodies : Numerous holozoic Protozoa feed on bacteria present in water bodies and hence contribute to water purification . They contribute towards sanity betterment of the modern civilized world in general water detoxification in the water bodies .

2- **Serve as food :** Sea planktons also include certain harmless floating Protozoa serving as nutrition sources to aquatic animals in the aquatic food web these animals provide substantial seafood for human consumption .They are important components of the aquatic food chain .

3- Symbiotic Protozoa : Some of Protozoa enter into Symbiotic relationships with other organisms . These associations are usually beneficial to both the partners and make them Obligatory to each other's lives. Most prominent examples of such an association are intestinal (Protozoa) parasites of Termites .

4- Oceanic Ooze and Fossil Protozoa : The dead Protozoa invariably settle down to the bottom of the sea forming soft mud (Oceanic Ooze) which intern are used of filtering .

5- As Bio indicators : The presence or absence of specific Protozoa in an environment is reliable indicator of its goodness and health , like weather it is ecologically integrated or disturbed .These Protozoa may be analyzed for the presence of toxic substances as well as for any damage to their cellular substures by pollution .

6- In carbon cycling : Photosynthetic Protozoa use CO_2 and convert it into glucose during Photosynthesis . This way they contribute in reducing the severity of global warming.

7- In Research : Since Protozoans are simple and unicellular but at the same time possessing forms and structures like those of Metazoans , they serve as good study materials for understanding the animal Kingdom .Since they are miniature sized and fast diving yet many of them are easy to observe using a compound microscope , Protozoans serve as optimum study material candidates .

8- Feed on Nitrifying Bacteria in Soil: When Protozoans feed on nitrifying bacteria in soil , they undesirably limit the nitrogen content of the soil imparted by it .

* Some Protozoans cleans the water , some other may cause water pollution. Like dinoflagellates give odor to sea water or causes to killing of fish and toxification of Mollusca .

Litonotus

1- Body slightly contractile .

2- Posterior and elongated tail – like tapering but not pointed .

3- Laterally flattened , without dorsal ribs or furrows .

4- Locomatry by Cilia.

Actinosphaerium

1- Called Heliozoans or Sun – animals (Spherical bodies) .

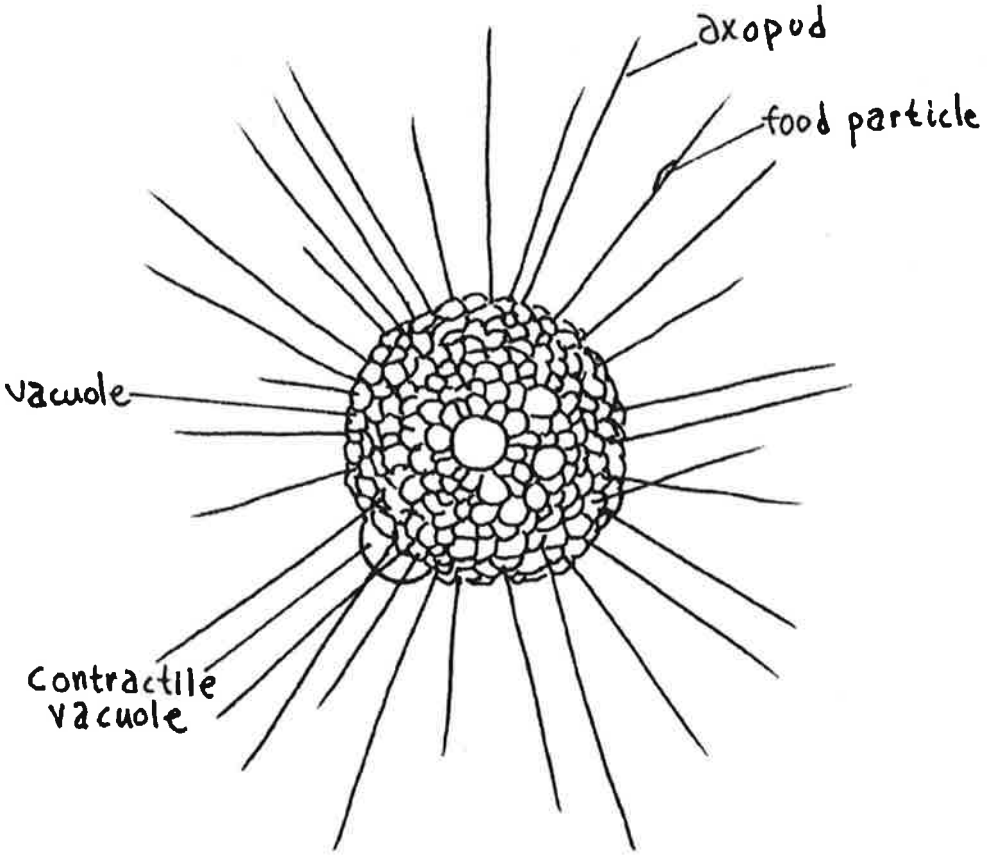
2- Un branched arms radiating in all directions .

3- Like sea Urchin and is from 200 – 1000 micrometers wide , and predominantly freshwater and are found either floating or stalked.

4- Enveloped by shell (or test) composed of Silica or organic material and they multinucleate animals.

5- The numerous radiation cytoplasmic masses called Pseudopodia (axopodia) are used more for capturing food than for locomotion .

6- Ingest Protozoans , algae and other small organisms and reproduce asexually that comes across their paths since they have little locomotive ability.



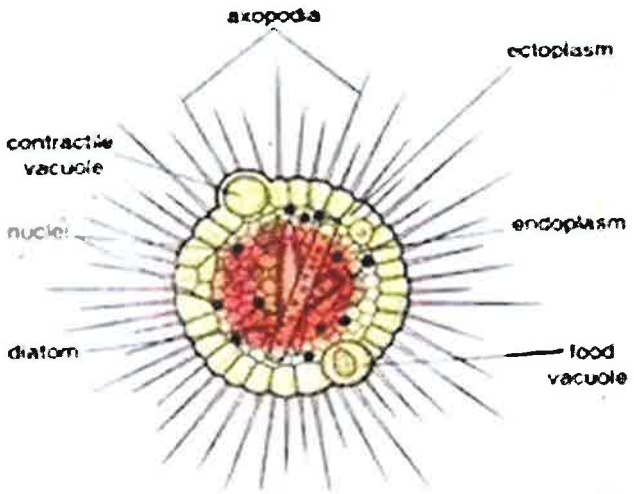


Fig. 23.24. *Actinosphaerium*.

Bugula

1- They bushy colonies , branching bi serial , to about (10 cm) high and is purplish –brown in color .

2- Differs from other species in this genus in that it possess no a vicularia and no spines .

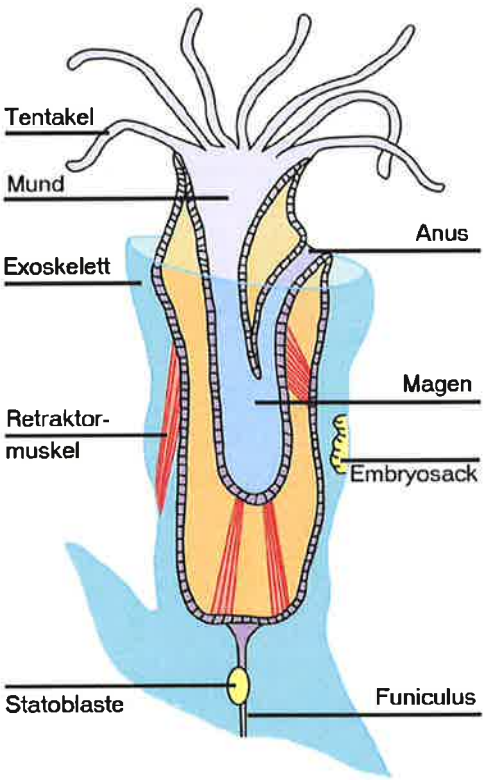
3- Embryos brooded in ovicells are dark brown in color and measure approximately (0.25 mm) in diameter .

4- Widespread before surveys commenced in most areas .

5- Larvae colonies a variety of artificial substrate including hulls , studies have shown *Bugula* larvae prefer to attach to rougher surface and prefer to organic material.

6- Sexual or Asexual reproduce while most of them hermaphrodite in asexual reproduce (budding to reproduce group of daughter) while in sexual reproduce *Bugula* producing sperm and eggs , sperms is released into the Coelom and the fertilized eggs are retained and brooded in ovicells for a time before being released .

7- *Bugula* source of a novel compound (bryostation) which has been shown to be effective against leukemia and a number of other kinds of cancer .



Bugula

Chilomonas

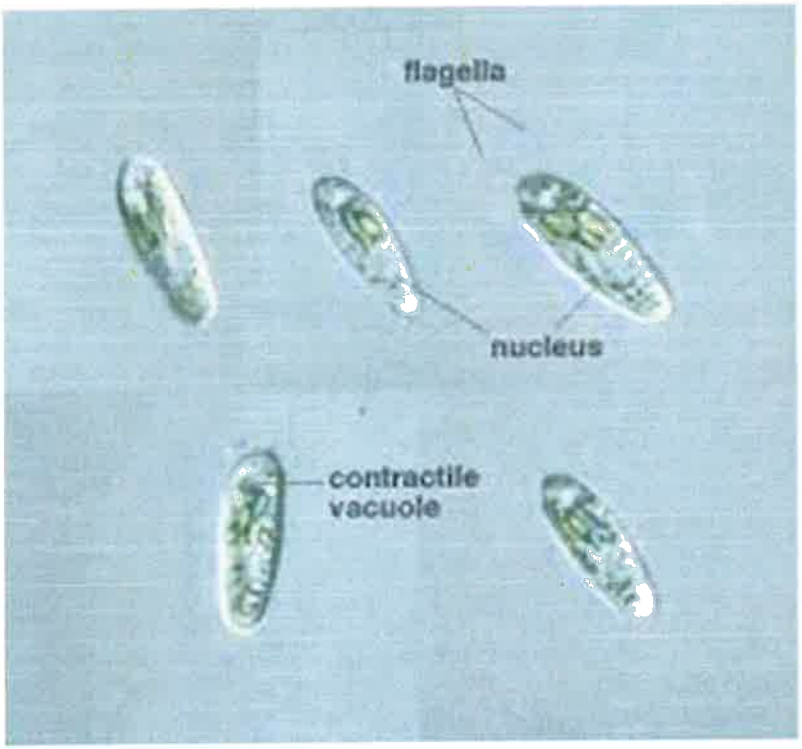
1- They have plastids.

2- Live in freshwater and marine also in brackish water .

3- Flattened in shape and have eyespot .

4- Have typically two slightly unequal flagella and without paranoids .

5- Vary in color (brown – red – blue- green) .



Annelida

General characters:

1- Habitat : mostly aquatic marine or freshwater , burrowing free living .

2- Body is elongated and vermiform .

3- Triploblastic , segmented body .

4- Cuticle (secreted by epidermis) covers the whole body (outer covering).

5- Locomotory organ : setae or chetae (hair like) and parapoda .

6- Respiration through body surface , in some by gills .

7- Blood vascular system close type (blood is red because contain hemoglobin).

8- Excretion by nephredia (paired in each segment).

9- Nervous system consist of Brain and segmented ganglia.

10- Some of them sex separate and other hermaphrodite .

Classification of Annelida

Phylum : Annelida

1- Class: Polychaeta → *Nereis*

2- Class: Clitellata

Subclass: Oligochaeta

A- Order :Naidomorpha ---- Family : Tubificidae (*Branchiura sowerbyi)*

B- Order : Lumbriulidae ---- Family :Lumbriculidae (*Lumbricus* variegatus)

3- Class : Hirudinea ------- *Hirudo*

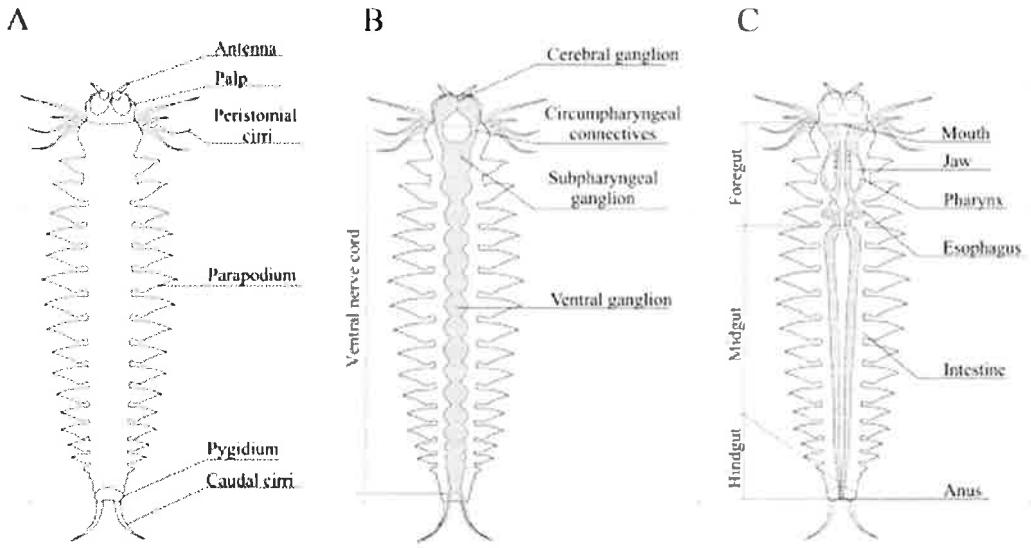
4- Class : Archiannelida ----- *Nerilla*

General characters of Clitellata

1- Having clitellum (collar that forms reproductive cocoon during part of their life cycle .

2- All of them are hermiphrodites .

3- Zygote then evolve further directly in the cocoon without passing through a larva stage as opposed to other annelids (Polychaete).



Nereis

Branchiura sowerbyi

1- ***B.sowerbyi*** **is easily differentiated from other tubificids by present of gills , it has dorsal and ventral gill pair on each segment in the posterior of body .**

2- **The worm lives with its head in the mud and its tail waving actively in the water a bove.**

3- **Larger , deep red worm usually 10 – 15 cm long as an adult .**

4- **They live in freshwater benthic deposit feeder that prefers rivers and warmer water .**

5- **That worm has been host of Myxosporean parasites which cause fish pathogens such as swim – bladder diseases .**

6- **Consider as bio indicator in environment to chemicals and heavy metals such as cooper are likely to eliminate tubificids .**

Hirudo

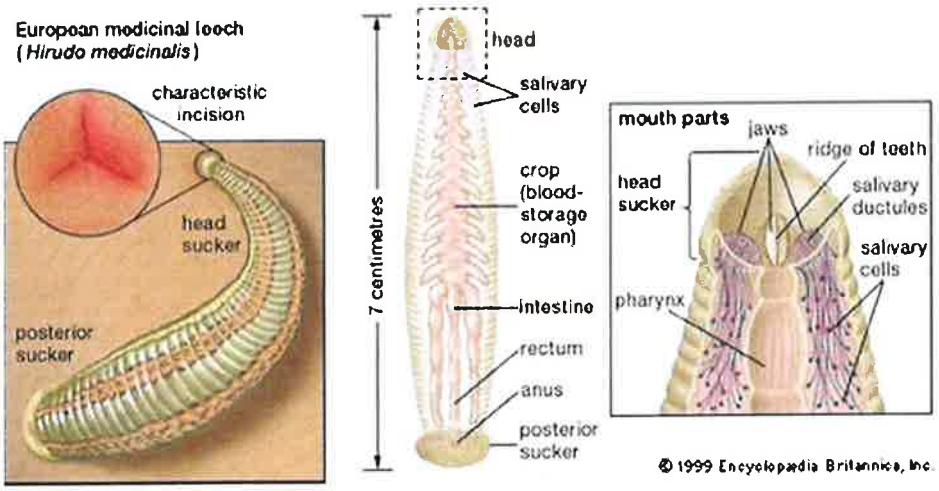
1- Commonly known as Leeches .

2- Leeches are well known for their blood sucking habits and their head to tail looping mode of locomotion .

3- They have two suckers which in most cases are located one at the anterior (head).

4- Live in freshwater , Marine and terrestrial environments.

5- Medicinal leeches have been found secrete saliva containing about 60 different proteins. These achieve a wide variety of goals useful to the leech as it feeds, helping to keep the blood in liquid form and increasing blood flow in the affected area. Several of these secreted proteins serve as anticoagulants (such as hirudin), platelet aggregation inhibitors. It is also thought that the saliva contains an anesthetic, as leech bites are generally not painful.



Hirudo

Arthropoda

General characters

1- Cosmopolatin in distribution found in aquatic , terrestrial and aerial forms , some are ectoparasitic and vectors of disease.

2- Body have jointed appendages or legs (which are modified to different structures to perform different function like jaws ,gills , walking legs , paddle) .There may be 3 pairs , 4 pairs , 5pairs , many pairs .

3- Body is triploblastic .

4- Bilaterally symmetrical .

5- Organ system level Organization .

6- Body is divisible into head , thorax and abdomen.

7- This is the first group to develop a true head , which contains sense organs and feeding organs specialized for their particular habitats .

8- Body is covered with chitins exoskeleton .

9- They are haemo coelomate, body cavity is filled with blood or fluid .

10- Head bears a pair of compound eyes and antenna.

11- Locomotion takes place by jointed appendages .

12- Digestive system is complete , straight and well developed.

13- Respiration takes place by general body surface or gills (in Crustaceans)or trachea (in Insect , Diplopoda and Chilopoda) or book lungs (Arachnida) and book gills .

14- Circulatory system is open type , the blood is colorless .

15- Excretion takes place through Malphigian tubules or green glands or Coxal glands (in aquatic forms) .

16- Nervous system is of Annelida type , which consist of brain and ventral nerve cord .

17-Uni sexual (sexes are separate).

18- Fertilization is internal or external.

19- They are either oviparous or ovoviviparous .

20- Development may be direct or indirect .

21- Sensory organ include antenna , sensory hairs for touch and chemoreceptor , simple and compound eyes , auditory organs (in Insects) and statocysts (in Crustacean).

Classification of Arthropoda

Phylum : Arthropoda

1- Sub phylum : Trilobitomorpha

2- Sub phylum : Cheliceriforms

3- Sub phylum : Myriapoda

4- Sub phylum : Hexapoda

5- Sub phylum : Crustacea

- Class : Branchipoda ------ *Daphnia*
- Class : Maxillopoda ------- *Clocalanus*
- Class : Mlacostraca -------- *Cambarus*

Sub phylum : Crustacea

1- Most Crustaceans are free – living aquatic animals , but some are terrestrial (Woodlice) , some are parasitic like fish lice and tongue worms and are some sessile .

2- A hard exoskeleton made of calcium – no internal skeleton .

3- Head has two compound eyes , two pairs of antennae and three pairs of mouthparts .

4- A pair of green glands excrete wastes near the base of antennae .

5- The abdominal segments have swimmerets (swimming legs).

6- The sexes are separate , eggs are attached to the swimmerets of the female . The first pair is enlarged in the male (it is used to pass sperm to the female).

7- The tail is fan – shaped , and ends in Uropods and atelson .

8- The circulatory system is open : there is no heart and the blood is pumped by vessels into sinuses and does not flow in a closed loop.

9- The nervous system consist of a primitive ventral nerve cord and ganglia system (similar to those of an earthworm).

Daphnia

1- Planktonic crustaceans that belong to the the Branchiopoda .

2- Flattened leaf like legs used to produce a water current for the filtering apparatus .

3- The body is enclosed by an un calcified shell and known as the carapace (is largely made of chitin a polysaccharide).

4- Has up of (10) pairs of appendages which are Antennules , Antennae , maxillae , mandibles and in *Daphnia* followed by 5 or 6 limbs an apparatus for feeding and respiration , at the end of the abdomen is a pair of claws .

5- Males are distinguished from female by their smaller size , larger antennules ,modified post – abdomen and first legs which are armed with a hook used in clasping.

6- They live in freshwater , shallow ponds , they live as a filter feeders .

7- They feed on small , suspended particles in the water , by locomotion flattened leaf – like legs that produce a water current , collect particles that are transferred into the food groove by special setae , they feed on algae and green algae and bacteria .

8- Gut more or less tubular with three parts , esophagus , the midgut and hindgut , there are two small digestive Ceca , midgut lined with an epithelium and bears microvilli , epithelial cells do not phagocytose particles but absorb molecules.

9- Color of *Daphnia* adapts to the food that is predominant in their diet.

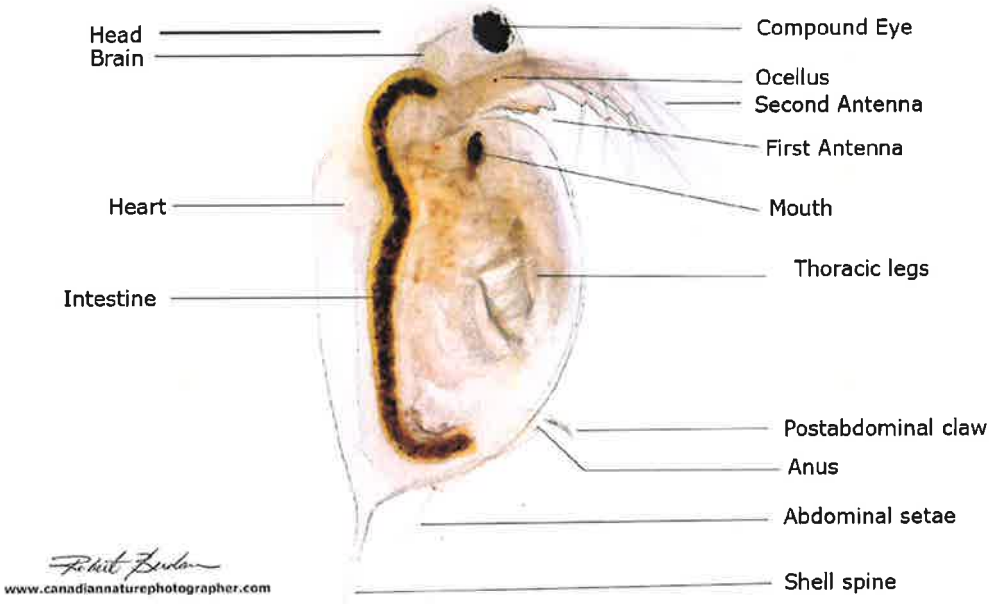
10- Have an open blood circulation . The heart is located dorsally and anterior from the brood chamber , blood cells are easily visible

through the transparent body as they flow rapidly through the body cavity ,blood is red because there is Hb (Hemoglobin).

11- Shell – gland = maxillary gland may have role in excretion and some regulation .

12- Nervous system is characterized by the cerebral ganglion which is located close to the gut and near the eye .

13- The produce by asexual reproduction during season , and eggs develop directly and they parthenogenesis eggs .



Daphnia

Cambarus

General characters

1- Live in bottom of streams , lakes and small rivers .

2-Construct burrows , sometime called chimneys .

3- Vary in size , largest opening being about (8 cm).

4- Its eyes are on movable stalks .

5- Tough exoskeleton is dark brown in color – sometimes with slightly red tint.

6- Chelipeds appendages are attached to the thorax and are also referred to as the first walking legs , they have claws and are used for protection and catching food not walking also has four pairs of walking legs attached to the thorax.

7- Abdominal appendages are called swimmerets or (Pleopods) and they are smaller than walking legs and they not suitable for swimming .

8- Male swimmerets are modified to transfer sperm packets to the female during reproduction and have spatulas shape.

9- Uropod they appendages like fan in shape and they on the end of the abdomen and they many broad flat .

10- Abdomen is large and usually extended and flexed under the cephalothorax ,the first abdominal segment is usually smaller than those posterior it .

11- Circulatory system is open ,it possess a diamond shaped heart which lies just anterior to the abdominal segments on the dorsal midline , heart surrounded by thin pericardial sac.

12- The brain lies between and beneath the eye stalk , the ventral cord lies beneath the anterior organs .

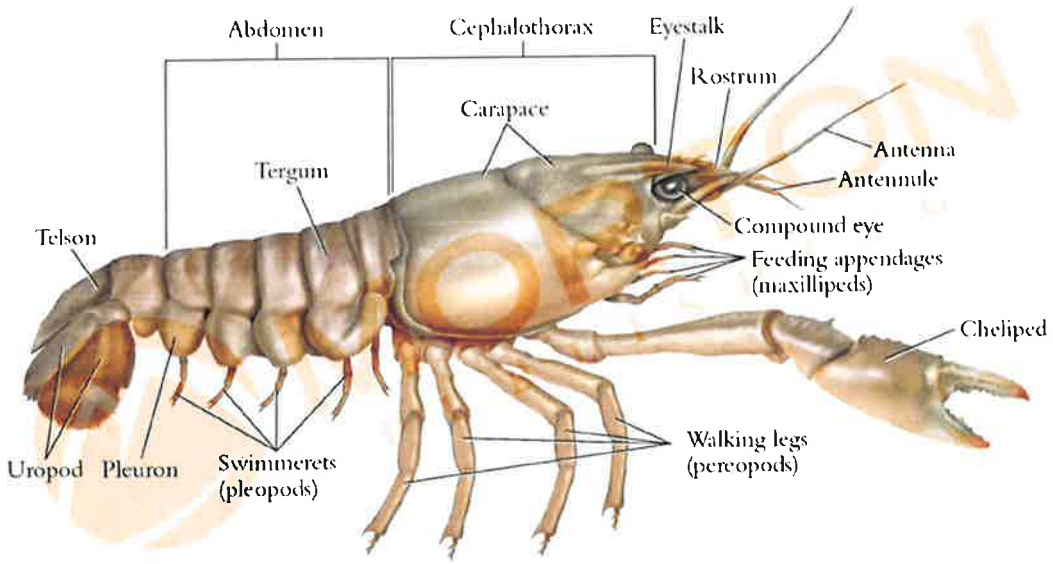
13- Along the dorsal midline of cephalothorax lie the cardiac stomach and the pyloric stomach in the posterior at laterally to the stomach(two type) lies a large digestive gland .

14- *Cambarus* is predator and scavenger , feed on decaying organic remains but also catches small animals .It main sources of food include snails ,insect larva , various types of worms and tadpoles , it finds its food on the bottom of the water source in inhabits or in the soil near the water , while the predators on *Cambarus* include various bird and turtle species.

Reproduction system of *Cambarus*

The gonad of *Cambarus* lie in the interior to the heart

the testes are white and the ovaries organs. Mating occurs most commonly in the spring and may also occur during the summer , reproduction involves pairing and can occur in two ways . The first is the deposit of sperm into seminal receptacle in the female . This occur when a sperm from the male flows down the grooves of the first pleopods and into the female receptacle. Sperm exists the male at the base of the fifth pair of walking legs through a pore . Eggs are released at the base of the third pair of walking legs . The other form of reproduction involves the transfer of spermatophore , in which case fertilization is internal ,the fertilized eggs are retained for maturation on the pleopods of the female . They hatch on the pleopods and stay attached to the mother until shortly after their second molt. Female carrying eggs is said to be (in berry) because the mass of eggs look like a berry . Female are most commonly (in berry) during May and June .



Cambarus

Phylum : Tardigrada

General characters

1- Known as (water bears) or moss piglets meaning slow stepper .

2- Water dwelling , eight legged and segmented micro animals .

3- They are the most resilient animal known , they can survive extreme conditions that would be rapidly fatal to nearly all other known life forms , can live in (- 272 C^0) and pressures about six times greater than those found in the deepest ocean trenches , ionizing radiation at doses hundreds of times higher than the lethal dose for a human and the vacuum of outer space they can go without food or water for more than 30 years , drying out to the point where they are 3% or less water.

4- They are about (0.5 mm) long when they are fully grown .

5- They are short and plump with four pairs of legs , each with four to eight claws also known as disks , the first three pairs of legs are directed ventrolaterally and are the primary means of locomotion while the fourth pair is directed posteriorly on the terminal segment of the trunk and is used primarily for grasping the substrate .

Anatomy and Morphology

1- Have barrel – shaped bodies with four pairs of stubby legs .

2- Most range from (0.3-0.5 mm) and largest species may reach (1.2mm).

3- Body consist of head , three body segments with a pair of legs each and a caudal segment with a fourth pair of legs , the legs are without joints while the feet have (4-8) claws each.

4- The body cavity consist of haemocoel , but the only place where a true coelom can be found is around the gonad.

5- No respiratory organs are found , with gas exchange able to occur across the whole of the body.

6- There are three tubular glands associated with the rectum as excretory organs .

7- Mouth opens into a triradiate muscular , sucking pharynx → short esophagus → Intestine → short rectum → anus . anus located at the terminal end of the body , leaving the feces behind with the shed cuticle .

8- Tubular mouth is armed with styles which are used to pierce the plant cell , algae or small invertebrates on which the tardigrades feed releasing the body fluid where styles lost their (pair of glands) lie on either side of mouth secreted new pair .

9- Brain includes multiple lobes , mostly consisting of three bilaterally paired clusters of neurons , brain attached to a large ganglion below the esophagus , from which a double ventral nerve cord runs the length of the body , the cord possess one ganglion per segment each of which produces lateral nerve fibers that run into the limbs.

10- There are pigment – cup eyes , numerous sensory bristles are on the head and body.

Reproduction

1- Some species are parthenogenic both males and female are usually present , each with a single gonad located above the intestine and they hermaphrodite .

2- Two ducts run from the testis in males , opening through a single pore in front of the anus , while female have a single duct opening either just above the anus or into the rectum which thus forms acloaca.

3- They oviparous and fertilization is usually external , mating occurs during the molt with the eggs being laid inside the shed cuticle of the female and then covered with sperm then eggs are left inside the shed cuticle to develop then eggs hatch after no more than 14 days .

4- Sexual reproduction is common and all individuals become sexually mature at the same time in the beginning of the summer .

Communication and Perception

Tardigrade bodies are covered with sensory bristles or spines , similar to setae most thickly in their anterior and ventral regions . Their bodies often terminate with long sensory cirri ,some known as clava which are likely chemoreceptors . Tow eyespots made up of five cells one of which is light sensitive and pigmented are often through not always present .

Classification od Tardigrada

Phylum : Tardigrada

Class: Eutardigrada

A- Order : Apochela → *Milnesium tardigradum*

B- Order : Parachaela → *Beom leeggi*

Class: Heterotardigrada

A- Order: Arthrotardigrada → *Batillipes*

B- Order: Echiniscadea → *Echinscus*

Class: Mesotardigrada → *Thermozodium esakii*

Milnesium tardigradum

General characteristic

1- Cosmopolitan species that can be find in a diverse range of environment .

2- Has a symmetrical body with 8 legs.

3- Utilize claws , total length of the body varies with some measuring up to 0.7mm in length .

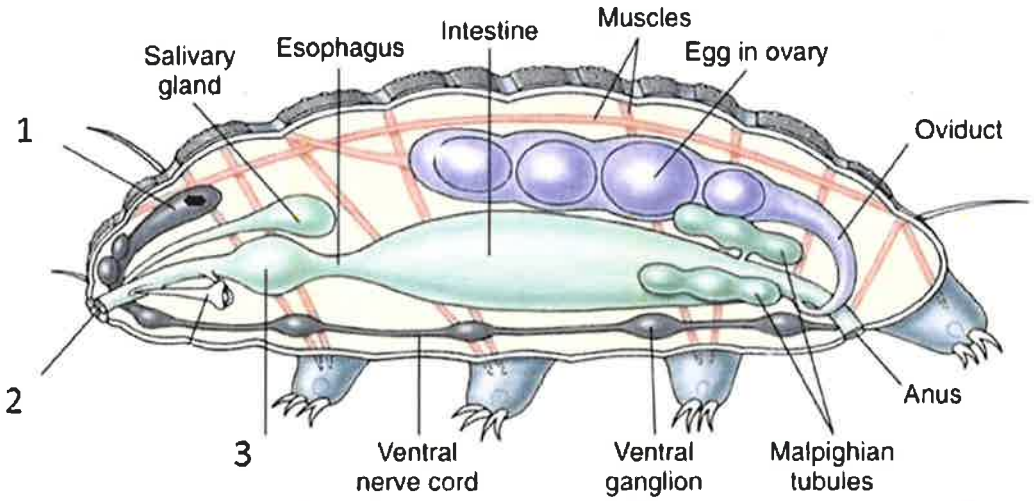
4- Has been found to have a high level of radio resistance and live in space and in absolute zero conditions .

5- Is an omnivorous predator , feed on other small organism such as algae , rotifers and nematodes and can feeding on other smaller tardigrades.

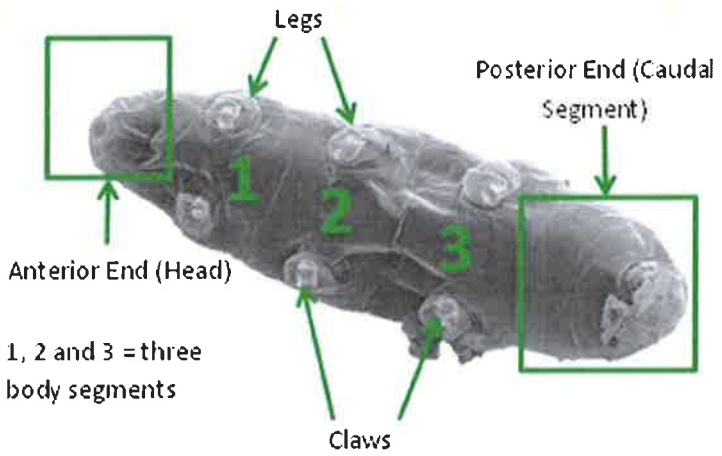
6- These species occupies mostly aquatic environments such as marine ,coastal and terrestrial areas .

7- Reproduction both sexually and parthenogenesis , female lay-up to (12) eggs which hatch after several days (5-16) days .

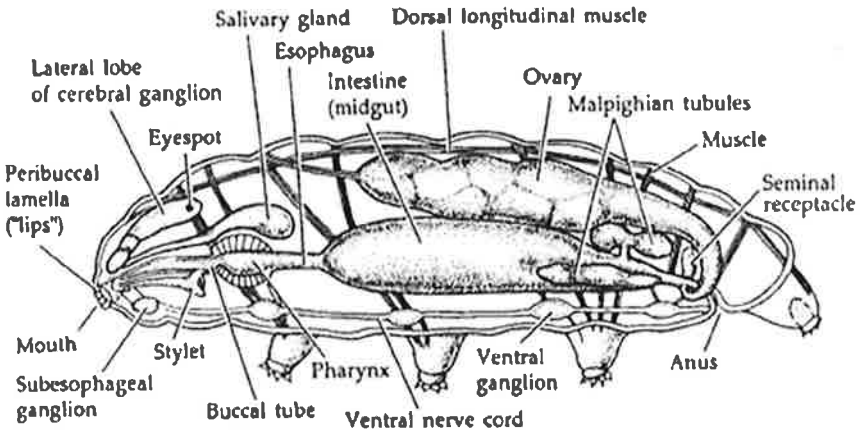
8- Larvae development from shape to another by molting and that molting depended on the nutrition of species .



Some systems in *Milnesium tardigradum*



External morphology of *Milnesium tardigradum*



Intarnal structure of *Milnesium tardigradum*

Phylum : Mollusca

General characteristics

1- Bilaterally symmetrical live in most environments .

2- Body has more than two cell layers , tissues and organs .

3- Open digestive system(have mouth and anus).

4- There is dorsal or lateral shells of protein or calcareous spicules .

5- Has a nervous system with a circum oesophagal ring ganglia and paired nerve chords.

6- Has an open circulatory system with a heart and an aorta and sinuses.

7- Has gaseous exchange organs called Ctenidial gills .

8- Reproduction is sexual and asexual .

9- Feed wide range of material .

10- Mollusks are eaten by humans (clams , *Octopus* , snails) and their shells used as decorations.

11- Body is soft and unsegment enclosed in glandular mantle covered by shell.

12- Locomotor structure is represented by muscular foot.

13- Mantle secret a calcareous shell which may be external or internal .

14- Visceral hump is covered by a thin , fleshy fold called mantle.

15- Body is divisible into head ,dorsal visceral mass , ventral muscular foot and mantle (is dorsal glandular fold of the body wall) , it is thick and muscular and encloses mantle cavity .

16- Excretion takes place by paired metanephridia (kidney)or pericardial gland or Kebers organ .

17- Sense organs are eyes , tentacles , osphradium and statocyst .

18- Fertilization is external or internal .

19- Development may be direct or indirect , larva is trocophor or veliger and glochidium larva.

20- Blood consist of copper containing pigment called haemocyanin so blood color is blue or green .

Classification of Mollusca

Phylum : Mollusca

1- Class : Gastropoda (called stomach –footed Mollusca) → *Helix*

2- Class: Bivalva (Lamellibranchiate or Pelecypod) (Bi= mean two that Mollusca possess two shells) → *Anodonta*

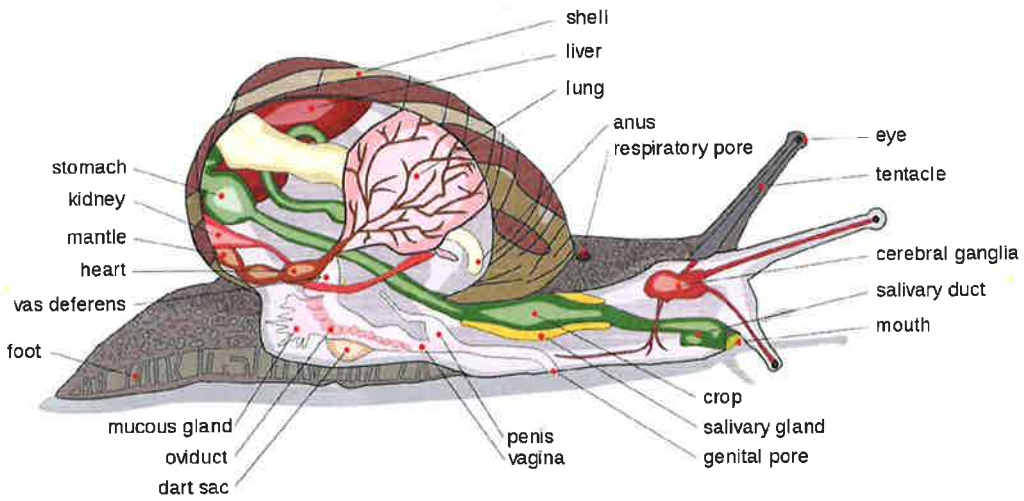
3- Class: Aplacophora (these benthic deep water) not have shell but have small calcareous spicules embedded in their mantle → *Nomenia*

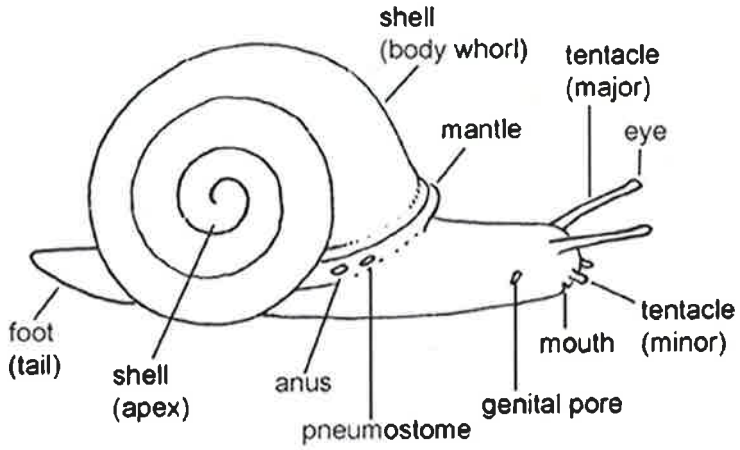
4- Class: Monoplacophora (the name with one plate) single shell like → *Neopilina*

5- Class: Polyplacophora (with 8 plates) → *Acanthochitem*

6- Class :Scaphopoda (boat –footed) → *Dentalium*

7- Class: Cephalopoda (head – footed) have large head eyes and tentacles → *Octopus*.





Helix

Mantle in Mollusca

The mantle is important part of Mollusca body , it forms the outer wall of the body . Mantle enclosed visceral mass of Mollusca which is internal organs including the heart , stomach , intestine and gonad . Mantle is muscular and many species have modified it to use for siphoning water for feeding . In Mollusca that have shells , such as clams , mussels and snails so mantle secretes calcium carbonate and matrix to form the shell . In Mollusca that lake to shells you can see the mantle is completely visible . Mantle contain many floods creates mantle skirt and inside it there is mantle cavity which contain gills, anus and genital pore that cavity allow to water or air to circulate and bringing nutrients , oxygen and carry away wastes .

Mantle cavity used as abroad chamber in some species , there are many functions of mantle like :

1- Secrete shell . 2- Sensory function . 3- Respiratory function (control inflow of water into the body chamber).

Shell (valve) in Mollusca

Shell is typically a calcareous exoskeleton which encloses supports and protects the soft parts of an animal in Mollusca (like snails ,

clams-----) , shell is composed mostly of $CaCo_3$ and have three layers

1- Inner or Nacreous layer (mother of pearl)

2- Middle or Prismatic layer (form most of the shell)

3- Outer or Periostracum layer (brown leathery layer which is often missing through a abrasion or weathering in older animals

Class : Bivalve

1- Live in marine and freshwater , bury themselves in sediments to save themselves from predation .

2- Body enclosed by shell consisting of two hinged parts , the shell contain of $CaCo_3$ and two similar parts called valves .

3- They not have head and lack radula .

4- Growth happen by increased by length or increases in total or soft body weight or they vary and increase the growth and it vary with season .

5- There are two valves of shell that may or may not be equal and may or may not completely enclosed the inner soft parts ,they variety of shapes and colors depending on species .

6- Valves have three layers and have mantle secret shell .

7- Digestive system contain from

Large gills → labial palps → mouth → esophagus → stomach (surrounded by liver)→ Intestine (contain crystalline style) → Rectum → Anus .(open digestive system = complete).

Crystaline style: is rod made of glycoprotein located is midgut of most bivalves and some gastropods which aids in extra cellular digestion . It consists of a protein matrix coated with digestive enzymes secreted by the style sac in the animals stomach .

When feeding its projecting end is scraped against the stomach wall and abraded , thus releasing the enzymes , when they starvation or desiccation some bivalves have been known to re – ingest this organ.

9- Open circulatory system (heart + sinuses) organs , heart has three chambers , two auricles receiving blood from the gills , and single ventricle .The ventricle is muscular and pumps hemolymph into aorta then to the rest of the body .

10- There is no brain and consist of nerve network and series of paired ganglia 1- Cerebral ganglia . 2- Pleural ganglia .

3- Pedal ganglia . 4- Visceral ganglia .

11- Sexes are separate (Dioecious) or Hermaphrodites , male gonad is white in color and female is red even in hermaphrodite species .

12- There are two kidneys , small , brown and sac like bodies that are lie flattened against the anterior part of the adductor muscle .

Senses

1- Mechanoreceptors . 2- Chemoreceptors .

3- Many bivalves have no eyes , some have simple eyes , some consist of photosensory cells and lens and some have complex eyes with lens.

Classification

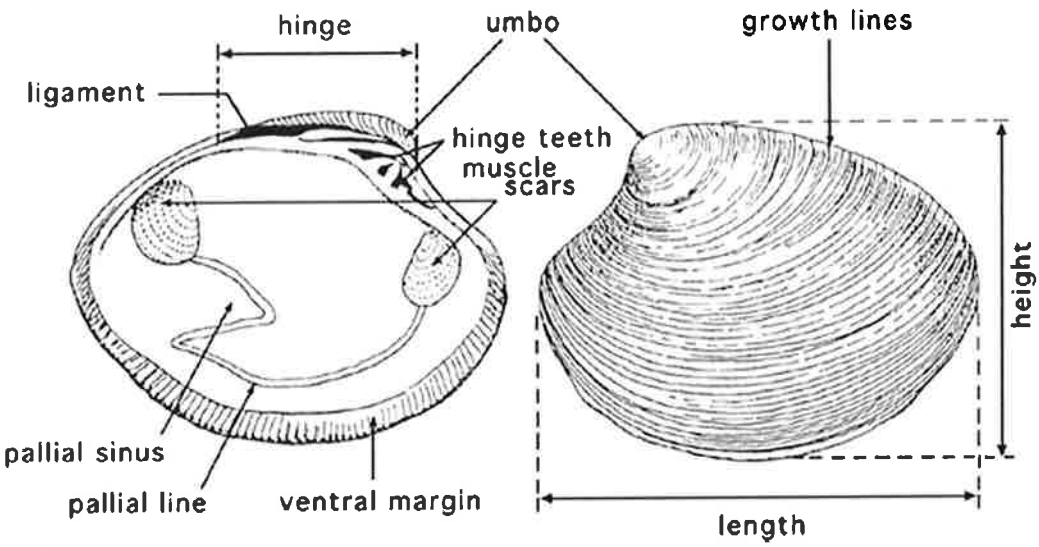
Phylum : Mollusca

Class: Bivalva(Lamellabranchiate = Pelecypoda = Clams)

1- Family : Unionidae → *Lasmigona complanata*

Anodonta grandis

2- Family : Sphaeriidae → *Sphaerium* .



Anodota

Super phylum : Aschelminthes

General characteristics

1- Round worms have elongated , cylindrical and vermiform body with tapering ends .

2- Body is unsegment but may be wrinkled , it is not distinguished two regions .

3- Body un pigmented being either white or with a yellowish tinge .

4- Caudal end of the body generally straight in female but coiled in males and the males are shorter than femals .

5- Anterior cephalization is not prominent therefore the body is without any definite regions .

6- Buccal cavity terminal surrounded by lips . In strongyloides the lips are modified into teeth known as leaf crown .

7- Amphids and papillae are the main sensory organs .

8- Body is covered by rough resistant cuticle, having bristles , spines , warts and papillae .

9- Caudal end with a pouch of cuticular nature known as phasmids and common in parasitic forms .

10- Cuticle is modified into bursa (an umbrella – like which is generally supported by muscular rays .

11- Epidermis is syncytial where they are usually divided in four sections in the four longitudinal chords one dorsal , one ventral and two lateral in position .

12- The body cavity is pseudocoel.

13- Digestive tract well development (open) generally made up of mouth , buccal cavity , pharynx or esophagus are of various types intestine and anus .

14- Nervous system consist of a nerve – ring (circum esophageal ring) from it nerves are given out anteriorly and posteriorly .

15- Protonephridia absent but the excretory system is made up of canals or gland – like organs .

16- Sexes are separate , Testis and Ovaries are tubular and coiled .Usually there is a single testis .The ducts from the testis open into the Cloaca and this Cloaca is associated with accessory structures such as circular spicule ovaries , oviduct and uteri are double .

17- Aschelminthes are ovo-viviparous or viviparous .

18- Life cycle complicated may be without intermediate host .

19- Larval stage four – third stage of larva is infective.

Classification

Super phylum : Aschelminthes

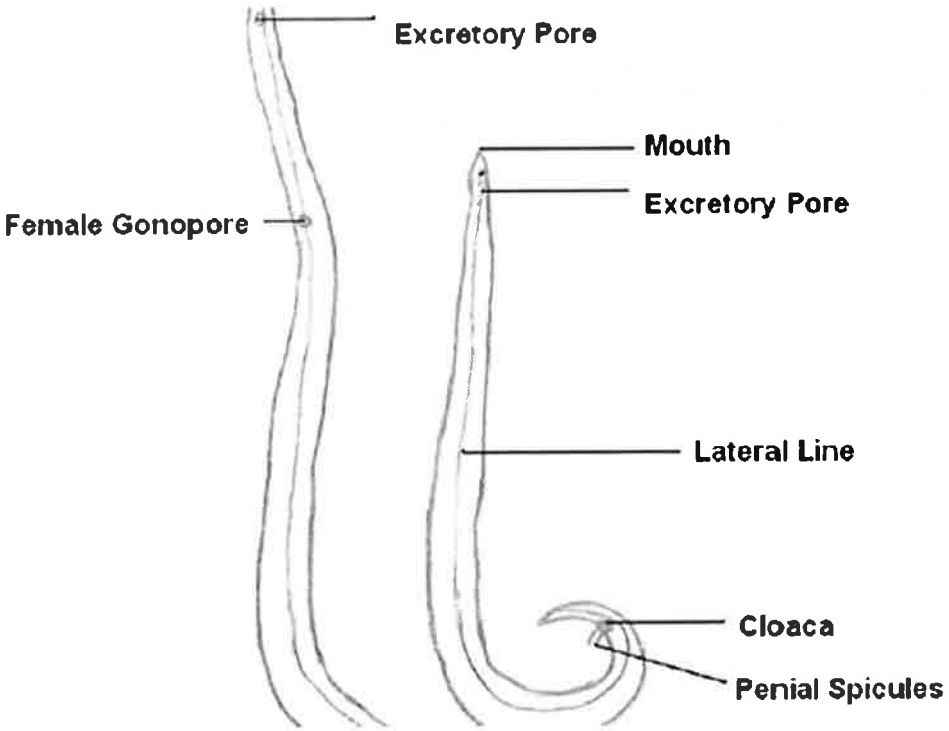
1- Phylum: Nematoda → *Ascaris*.

2- Phylum : Nematomorpha → *Gordious*.

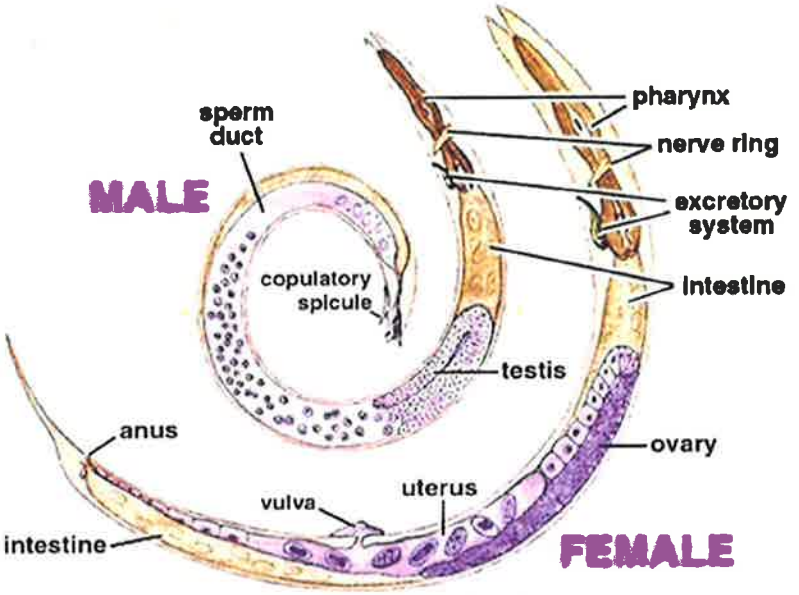
3- Phylum : Rotifera → *Philodina*.

4- Phylum : Gastrotricha → *Torbanella*.

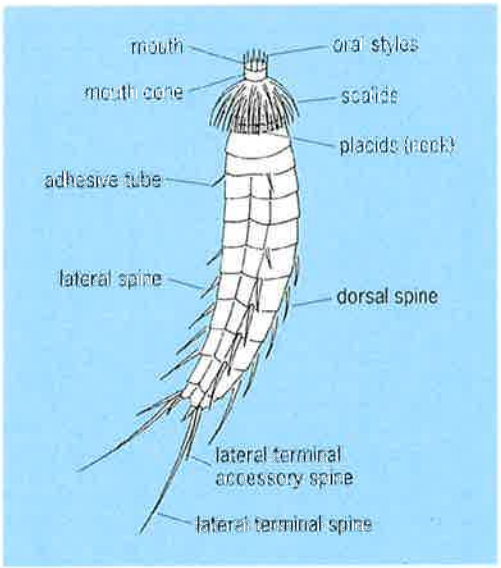
5-Phylum :Kinorhyncha → *Echinoderes* .



Ascaris



Ascaris



Echinoderes

Phylum : Rotifera

General characteristic

1- Bilaterally symmetrical .

2- Body has more than two cell layers , tissues and organs .

3- Body cavity is pseudo coelom .

4- There is open digestive system .

5- Body covered by external layer of chitin called a lorica

6- Has a nervous system with a brain and paired nerves.

7- There are no Circulatory and Respiratory system .

8- Reproduction mostly Parthenogenetic and sexual reproduction.

9- Feed on bacteria and Protista , or they are Parasitic.

10- All live in aquatic environments either free swimming or attached .

11- Have to ring of cilia at their anterior end (Corona).

12- Name(Rotifera) means (wheel- breares) in latin that because it has two rings of cilia (hair like structure) on its head which on moving appear like two rotating wheels .

13- The body wall is colorless and therefore all organs are visible . The food present in the digestive system decides what color the animal takes on temporarily.

14- Corona or the rings of cilia on the head are used to suck food into the mouth or to move by creating water currents .

15- Rotifers consume dead and decomposing substances algae , bacteria , small rotifer after ingesting their trophi (Jaws) crush the particles to make them smaller .

16- A few Rotifera have been described as being parasitic on algae , sponges, crustaceans and fishes .

Classification of Rotifera

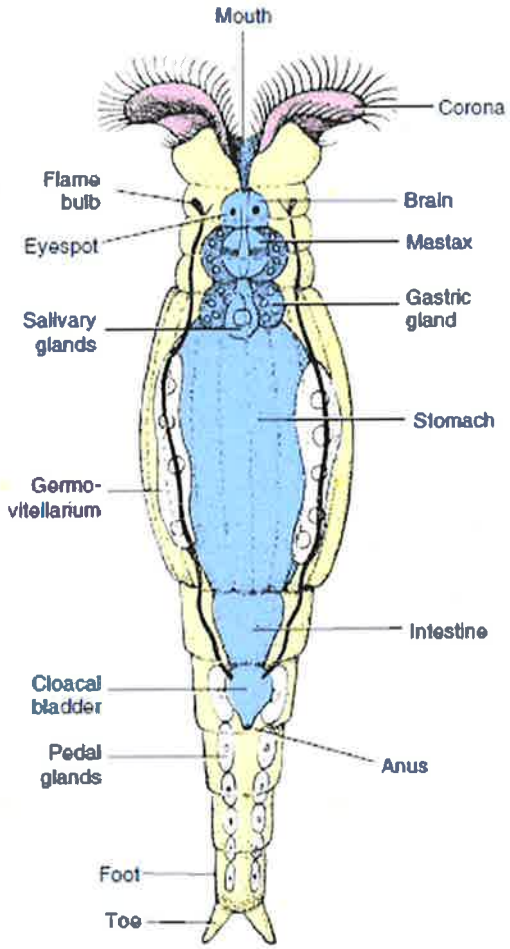
Phylum : Rotifera

1- Class: Digononta → *Philodina*.

2- Class : Monogononta → *Collotheca*.

Digononta : Have two ovary (oviparous)

Monogonanta : Have one ovary.


Mouth
Corona
Flame bulb
Brain
Eyespot
Mastax
Gastric gland
Salivary glands
Stomach
Germo-vitellarium
Intestine
Cloacal bladder
Pedal glands
Anus
Foot
Toe

Rotifera

Philodina gregaria

1- Relatively large for Rotifera phylum and easily observed through a microscope , so they used in studies to investigation Rotifera behavior and anatomy .

2- They have more than two layers as well as tissues and organs .

3- They possess a gut with an anus (open system).

4- Covering the body is an external layer of chitin referred to also lorica .

5- Nervous system is comprised of a brain and paired nerves .

6- Respiration is carried out through simple diffusion .

7- Reproduction is mostly parthenogenic (no male) .

8- They live for long periods in a frozen state and in summer months can found in the bottoms of lakes and pools like a large aggregate and that give to water a rusty red color .

Phylum : Echinodermata

Echinodermata

General characteristics:

1- These are exclusively marine animals.

2- The larval forms show bilateral symmetry and adult forms show radial symmetry and they are triploblastic .

3- The body is uniquely shaped. It can star like, elongated or spherical and they have a true coelom.

4- The body is unsegmented without a head.

5- The body surface is covered with calcareous spicules.

6- Body cavity has the distinguishing water vascular system.

7- Tube feet help in locomotion and Respiration occurs through tube feet and gills.

8- The brain is absent but a nervous system is present with a nerve ring and radial nerve cords.

9- Sense organs are poorly developed and include tactile organs, chemoreceptors, terminal tentacles etc.

10- Sexes are separate and Fertilisation is external finally Lost parts can be regenerated.

11- **Body wall consists of an outer epidermis, a middle dermis and an inner lining of peritoneum.**

12- Respiration occurs through a variety of structures, i.e., papulae, peristomial gills, genital bursae in brittle stars and cloacal respiratory trees.

Classification of Phylum Echinodermata

Phylum Echinodermata is classified into the following classes:

- Asteroidea :common called (Starfishes)(Sea stars) *Asterias*
- Ophiuroidea : common called (brittle stars) *Ophioderma.*
- Echinoidea : common called (Sea urchins)(Sand dollars)*Echinus.*
- Holothuroidea : common called (Sea cucumbers) *Holothuria.*
- Crinoidea : common called (Sea lilies)(Feather stars)*Antedon.*

Asterias

General characteristic :

1- They are marine invertebrates. They typically have a central disc and five arms, though some species have a larger number of arms (the number varies with the group. Some species have six or seven arms and others have 10–15 arms and some have over fifty.
2- The aboral or upper surface may be smooth, granular or spiny, and is covered with overlapping plates.
3- Many species are brightly coloured in various shades of red or orange, while others are blue, grey or brown.
4- They are opportunistic feeders and are mostly predators on benthic invertebrates. Several species have specialized feeding behaviours including eversion of their stomachs and suspension feeding

5- hey have complex life cycles and can reproduce both sexually and asexually. Most can regenerate damaged parts or lost arms and they can shed arms as a means of defence.

Body wall

The body wall consists of a thin cuticle, an epidermis consisting of a single layer of cells, a thick dermis formed of connective tissue and a thin coelomic myoepithelial layer, which provides the longitudinal and circular musculature. The dermis contains an endoskeleton of calcium carbonate components known as ossicles. These are honeycombed structures composed of calcite microcrystals arranged in a lattice. They vary in form, with some bearing external granules, tubercles and spines, but most are tabular plates that fit neatly together in a tessellated manner and form the main covering of the aboral surface. Some are specialised structures such as the madreporite (the entrance to the water vascular system), pedicellariae and paxillae. Pedicellariae are compound ossicles with forceps-like jaws. They remove debris from the body surface and wave around on flexible stalks in response to physical or chemical stimuli while continually making biting movements. They often form clusters surrounding spines. Paxillae are umbrella-like structures found on starfish that live buried in sediment. The edges of adjacent paxillae meet to form a false cuticle with a water cavity beneath in which the madreporite and delicate gill structures are protected. All the ossicles, including those projecting externally, are covered by the epidermal layer.

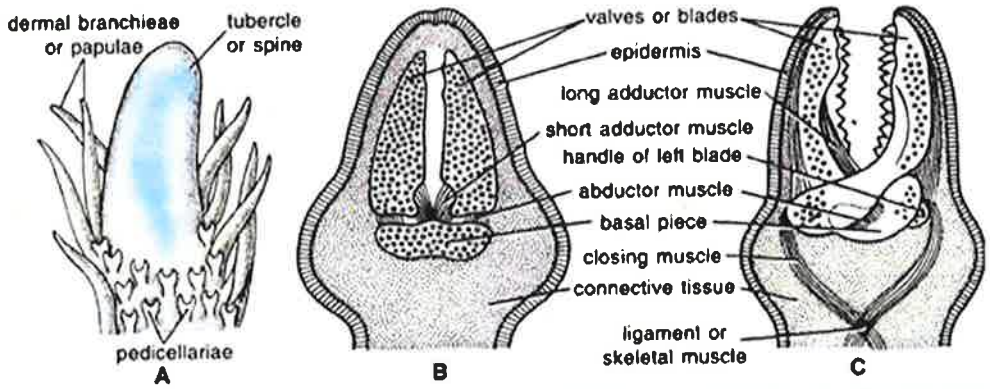
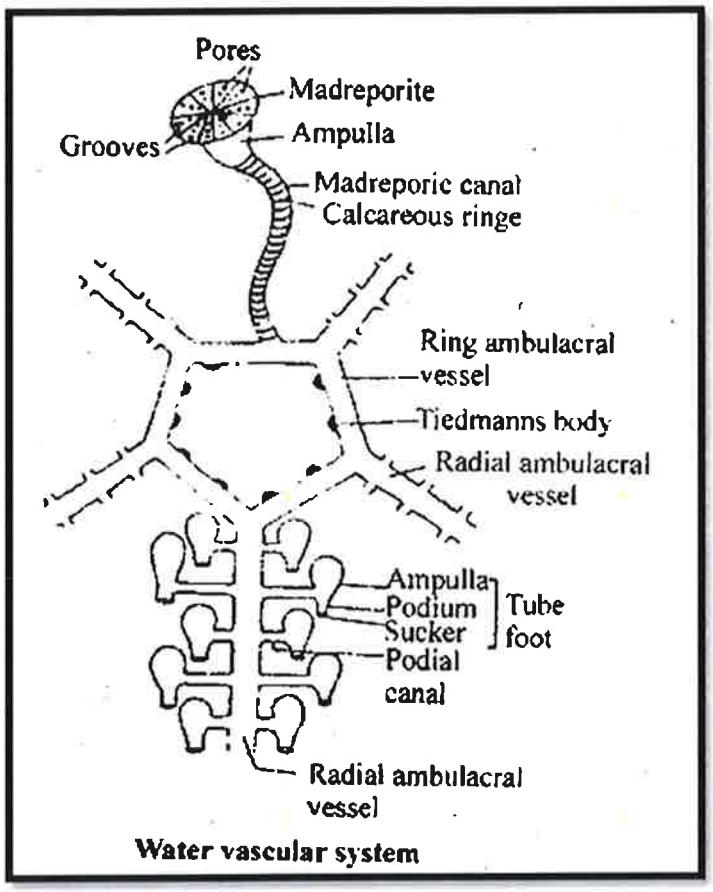


Fig. 85.3. *Asterias*. A—A cluster of pedicellariae, papulae, and tubercle; B—Straight type pedicellaria; C—Crossed type pedicellaria.

Water vascular system

The water vascular system of the starfish is a hydraulic system made up of a network of fluid-filled canals and is concerned with locomotion, adhesion, food manipulation and gas exchange. Water enters the system through the madreporite, a porous, often conspicuous, sieve-like ossicle on the aboral surface. It is linked through a stone canal, often lined with calcareous material, to a ring canal around the mouth opening. A set of radial canals leads off this; one radial canal runs along the ambulacral groove in each arm. There are short lateral canals branching off alternately to either side of the radial canal, each ending in an ampulla. These bulb-shaped organs are joined to tube feet (podia) on the exterior of the animal by short linking canals that pass through ossicles in the ambulacral groove. There are usually two rows of tube feet but in some species, the lateral canals are alternately long and short and there appear to be four rows. The interior of the whole canal system is lined with cilia.



Digestive of *Asteries* (Starfish)

Digestive system and excretion

The gut of a starfish occupies most of the disc and extends into the arms. The mouth is located in the centre of the oral surface, where it is surrounded by a tough peristomial membrane and closed with a sphincter. The mouth opens through a short oesophagus into a stomach divided by a constriction into a larger, eversible cardiac portion and a smaller pyloric portion. The cardiac stomach is glandular and pouched, and is supported by ligaments attached to ossicles in the arms so it can be pulled back into position after it has been everted. The pyloric stomach has two extensions into each arm: the pyloric caeca. These are elongated, branched hollow tubes that are lined by a series of glands, which secrete digestive enzymes and absorb nutrients from the food. A short intestine and rectumrun from the

pyloric stomach to open at a small anus at the apex of the aboral surface of the disc.

Primitive starfish, such as *Astropecten* and *Luidia*, swallow their prey whole, and start to digest it in their cardiac stomachs. Shell valves and other inedible materials are ejected through their mouths. The semi-digested fluid is passed into their pyloric stomachs and caeca where digestion continues and absorption ensues. In more advanced species of starfish, the cardiac stomach can be everted from the organism's body to engulf and digest food. When the prey is a clam or other bivalve, the starfish pulls with its tube feet to separate the two valves slightly, and inserts a small section of its stomach, which releases enzymes to digest the prey. The stomach and the partially digested prey are later retracted into the disc. Here the food is passed on to the pyloric stomach, which always remains inside the disc. The retraction and contraction of the cardiac stomach is activated by a neuropeptide known as NGFFYamide. .

Because of this ability to digest food outside the body, starfish can hunt prey much larger than their mouths. Their diets include clams and oysters, arthropods, small fish and gastropod molluscs. Some starfish are not pure carnivores, supplementing their diets with algae or organic detritus. Some of these species are grazers, but others trap food particles from the water in sticky mucus strands that are swept towards the mouth along ciliated grooves.

The main nitrogenous waste product is ammonia. Starfish have no distinct excretory organs; waste ammonia is removed by diffusion through the tube feet and papulae. The body fluid contains phagocytic cells, coelomocytes, which are also found within the hemal and water vascular systems. These cells engulf waste material, and eventually migrate to the tips of the papulae, where a portion of body wall is nipped off and ejected into the surrounding water. Some waste may also be excreted by the pyloric glands and voided with the faeces.

Starfish do not appear to have any mechanisms for osmoregulation, and keep their body fluids at the same salt concentration as the surrounding water. Although some species can tolerate relatively low salinity, the lack of an

osmoregulation system probably explains why starfish are not found in fresh water or even in many estuarine environments.

Sensory and nervous systems

Although starfish do not have many well-defined sense organs, they are sensitive to touch, light, temperature, orientation and the status of the water around them. The tube feet, spines and pedicellariae are sensitive to touch. The tube feet, especially those at the tips of the rays, are also sensitive to chemicals, enabling the starfish to detect odour sources such as food. There are eyespots at the ends of the arms, each one made of 80–200 simple ocelli. These are composed of pigmented epithelial cells that respond to light and are covered by a thick, transparent cuticle that both protects the ocelli and acts to focus light. Many starfish also possess individual photoreceptor cells in other parts of their bodies and respond to light even when their eyespots are covered. Whether they advance or retreat depends on the species.

While a starfish lacks a centralized brain, it has a complex nervous system with a nerve ring around the mouth and a radial nerve running along the ambulacral region of each arm parallel to the radial canal. The peripheral nerve system consists of two nerve nets: a sensory system in the epidermis and a motor system in the lining of the coelomic cavity. Neurons passing through the dermis connect the two. The ring nerves and radial nerves have sensory and motor components and coordinate the starfish's balance and directional systems. The sensory component receives input from the sensory organs while the motor nerves control the tube feet and musculature. The starfish does not have the capacity to plan its actions. If one arm detects an attractive odour, it becomes dominant and temporarily over-rides the other arms to initiate movement towards the prey. The mechanism for this is not fully understood.

Circulatory system

The body cavity contains the circulatory or haemal system. The vessels form three rings: one around the mouth (the hyponeural haemal ring), another around the digestive system (the gastric ring) and the third near the aboral surface (the genital ring). The heart beats about six times a minute and is at

the apex of a vertical channel (the axial vessel) that connects the three rings. At the base of each arm are paired gonads; a lateral vessel extends from the genital ring past the gonads to the tip of the arm. This vessel has a blind end and there is no continuous circulation of the fluid within it. This liquid does not contain a pigment and has little or no respiratory function but is probably used to transport nutrients around the body.

Sexual reproduction

Most species of starfish are gonochorous, there being separate male and female individuals. These are usually not distinguishable externally as the gonads cannot be seen, but their sex is apparent when they spawn. Some species are simultaneous hermaphrodites, producing eggs and sperm at the same time and in a few of these, the same gonad, called an ovotestis, produces both eggs and sperm. Other starfish are sequential hermaphrodites. Protandrous individuals of species like *Asterina gibbosa* start life as males before changing sex into females as they grow older. In some species such as *Nepanthia belcheri*, a large female can split in half and the resulting offspring are males. When these grow large enough they change back into females.

Each starfish arm contains two gonads that release gametes through openings called gonoducts, located on the central disc between the arms. Fertilization is generally external but in a few species, internal fertilization takes place. In most species, the buoyant eggs and sperm are simply released into the water (free spawning) and the resulting embryos and larvae live as part of the plankton. In others, the eggs may be stuck to the undersides of rocks. In certain species of starfish, the females brood their eggs – either by simply enveloping them. or by holding them in specialised structures. Brooding may be done in pockets on the starfish's aboral surface, inside the pyloric stomach (*Leptasterias tenera*) or even in the interior of the gonads themselves. Those starfish that brood their eggs by "sitting" on them usually assume a humped posture with their discs raised off the substrate. *Pteraster militaris* broods a few of its young and disperses the remaining eggs, that are too numerous to fit into its pouch. In these brooding species, the eggs

are relatively large, and supplied with yolk, and they generally develop directly into miniature starfish without an intervening larval stage. The developing young are called lecithotrophic because they obtain their nutrition from the yolk as opposed to "planktotrophic" larvae that feed in the water column. In *Parvulastra parvivipara*, an intragonadalbrooder, the young starfish obtain nutrients by eating other eggs and embryos in the brood pouch. Brooding is especially common in polar and deep-sea species that live in environments unfavourable for larval development and in smaller species that produce just a few eggs.

Asexual reproduction

Some species of starfish are able to reproduce asexually as adults either by fission of their central discs or by autotomy of one or more of their arms. Which of these processes occurs depends on the genus. Among starfish that are able to regenerate their whole body from a single arm, some can do so even from fragments just 1 cm (0.4 in) long. Single arms that regenerate a whole individual are called comet forms. The division of the starfish, either across its disc or at the base of the arm, is usually accompanied by a weakness in the structure that provides a fracture zone.

The larvae of several species of starfish can reproduce asexually before they reach maturity. They do this by autotomising some parts of their bodies or by budding. When such a larva senses that food is plentiful, it takes the path of asexual reproduction rather than normal development. Though this costs it time and energy and delays maturity, it allows a single larva to give rise to multiple adults when the conditions are appropriate.

Regeneration

Some species of starfish have the ability to regenerate lost arms and can regrow an entire new limb given time. A few can regrow a complete new disc from a single arm, while others need at least part of the central disc to be attached to the detached part. Regrowth can take several months or years, and starfish are vulnerable to infections during the early stages after the loss of an arm. A separated limb lives off stored nutrients until it regrows a disc and mouth and is able to feed again. Other than fragmentation carried out for the purpose of reproduction, the division of the body may happen inadvertently due to part being detached by a

predator, or part may be actively shed by the starfish in an escape response. The loss of parts of the body is achieved by the rapid softening of a special type of connective tissue in response to nervous signals. This type of tissue is called catch connective tissue and is found in most echinoderms. An autotomy-promoting factor has been identified which, when injected into another starfish, causes rapid shedding of arms.