Economic Importance of Arthropoda :

[I] Merostomata:

The American species *(Limulus polyphemus)* is sometimes fed to chickens and pigs. The female specimens are preferred on account of their eggs of which half-a-pint may be crowded into a cephalic shield. There is a belief that this diet makes the poultry lay more eggs. Undoubtedly, it fattens both fowls and pigs, but also tmparts a shocking flavour to their flesh. Asian species of horseshoe crabs are consumed by human beings.

[II] Arachnida:

Scorpions are studied as a type of arachnid in most of the universities. In tropical Countries, it enters house and often becomes a nuisance. It is a poisonous animal and its bite can be painful, sometimes resulting in death, especially in children. Scorpions are benificial also to some extent, as they feed largely on unwanted insects, as cockroaches and beetles, etc. Besides, the scorpion venom is used for pharmacological, Biochemlcal and Immunological researches. The scientists at these centers "milk" the scorpions of their venom by giving them weak electric shocks, while holding their stingers in glass pipettes.

Certain mites cause damage to the crop fruits like apple, pear and grapes e.g. blister mite*(Eriophyee).* Ticks suck the blood of man and domestic animals. They also act as vector of protozoa causing Taxas fever in cattle and tick fever in man.

[III] Crustacea:

Crustacea are of considerable economic significance to man. Group is of great value directly or mdirectly for his health and economic progress.

1. As food: A large number of crustaceans are consumed by man, especially the lobsters, shrimps, prawns, squillae, crabs and crayfishes, etc. They form an important diet of man with great nutritive value. Most edible portions are
their tails (abdomens) almost all of which are composed of muscles. There is also some good "meat" in their chelipedes. In mud crabs the claws are the best part of the animal to eat. Muscles are either freshly cooked or canned. Blue crab (*Callinectes)* is held captive until it molts, then sold in the soft-shelled condition; after removal of the viscera the whole animal is cooked and eaten.

Prawn fishery is very much advanced in several countries including India giving employment to thousands of people. India' has earned by exporting prawns and other products worth more than 2000 millions of Rs. in 1955. Smaller species of Crustacea form the bulk of zooplankton which plays a Vital role in food chains of both salt and freshwater fishes and other aquatic animals that eventually come to our table. Man eats fish, and there is 'a stage, when they, must feed on some forms of small Crustacea, such as a larval stage of some larger form like 'crayfish, or a minute adult such as *Cyclops* and *Daphnia.* Whales which are hunted by man for their various economic products depend on crustaceans for their food.

Amphipods and euphalisids form a great part of diet of other animals like the seals, sea gulls and penguins. Two tons of *Calanus,* a marine copepod about 5 mm long, have been found in the stomach of a blue whale. Aquarium dealers collect the adults and eggs of *Artemia* 'and *Daphnia* and sell them as fish food.

2. As fish bait: In most parts of America, the caryfishes, especially the soft -shelled individuals, are quite popular among fisherman as a fish bait.

Soft -shelled individuals are kept soft for a week or so on ice since refrigeration slows metabolism so that the shell develops slowly.

3. As scavengers: Some Crustacea, such 'as crayfish, are beneficial, as they serve as an agency in the destruction of decaying vegetables arid animal bodies in water.

4 As intermediate host: Although some crustaceans are parasites of aquatic animals, none is a parasite of man or other land animals. However, a handful of them" serve as intermediate hosts to certain dangerous worm parasites of man and other vertebrates. Dreaded, human lung-fluke, *Paragonimus westennani,* uses a crayfish for this purpose. Species of *Cyclops* which live in freshwater, serve as intermediate hosts for the human guineaworm *(Dracunculus medinensis)* and ' for the broad ' tapeworm *(Diphyllobothrium latum).* Guineaworm disease was once very ' common in India, Egypt and

Central Africa.

5. As pests : Crayfishes damage cultivated crops by eating young corn and cotton plants. Sow-bugs and pill bugs, which also feed on vegetation, may turn pest in green houses and fields when sufficiently numerous. CrayfIshes occasionally burrow, making holes in dams and levees and weaken them, thus causing serious damage.

Some crustaceans bore into marine timber structures (jetties, piles, poles, props, etc.) anddestroy them causing loss of several crores of rupees. Some crustacean wood borers are *Chelura terebrans* (Amphipoda) and species Of' *Spheroma* and *Limnoria* (Isopoda). They burrow into and damage wharves in salt water. Branacles form one of the fouling animals by attaching to the hulls of ships.

[IV] Diplopoda:
Millipedes may be useful as they are scavengers and can dispose of the dead organic matter. They cause demage to plants as they feed also on plant roots and destroy the green houses and gardens.
[VJ Chilopoda:
They are beneficial to man as they feed oninsects some of which may be injurious also. They are also reported to feed on snakes too. Some species are harmless to man, but some longer tropical ones inflect a painful bite and cause fever, dizziness and headache. *Scolopendra gigantea* cause human death, especially if the victim is a child.

[VI] Insecta:

A. Beneficial Insects:
Insects which produce honey, wax, lac, dyes and silk are commercially beneficial. Some insects are very helpful in destroying injurious insects.

1. Commercial Products:
Apis, the honeybees produce millions of tons of honey every year, it also gives bees wax from its combs.

Benefits of bees are cosmopolitan, not only in producing honey and wax, but also in bringing about cross-pollination of many fruits and flowers without which these plants could not exist. Tachardia, the lac insect secretes commercial lac produced from integumentary glands as a protective covering by females, shellac is made from lac in India.

Dactylopius, the cochineal insect of Mexico is found on cacti, dried bodies of females of this scale insect are used for making cochineal dyes. Bombyx and Eupterote are silk moths, they are reared in India, China, Japan and Europe, their larvae called silk worms spin cocoon of raw silk, the silk fibre is reeled off and used for making silk.

In Asiatic countries over 25 million kilograms of silk are produced annually. Dried elytra of two beetles, Lytta and Mylabris are used for making cantharidin, a powerful aphrodisiac (love drug).

The larvae of two flies, Lucilla and Phormia are used in healing such wounds of bones which do not respond to medicines, the larvae are put in wounds of bones and bone marrow, they clear away suppurating and dead tissues, prevent bacterial growth and excrete allantoin which heals the wounds.

2. Useful Predaceous Insects:
Some insects are predaceous, they feed upon and destroy a large number of injurious insects. Stagomantis, a mantis is voracious, it feeds on flies, grasshoppers and caterpillars, some of which are injurious to crops. The larvae and adults of Chilomenes, a lady-bird beetle, feed on aphids which infect cotton plants.

Novius, a lady-bird bettle, destroys scale worms which are pests of orange and lemon trees. Epicauta is a blister beetle, it deposits eggs where locusts occur, the larvae on hatching enter egg capsules of locusts and eat up masses of eggs. Calasoma, a ground beetle preys upon many kinds of lepidopterous larvae which destroy cereals and cotton.

3. Beneficial Parasitic Insects:
Some insects parasitise injurious insects, they usually lay eggs in the bodies of larvae and adults of harmful insects; the young on hatching from eggs finally kill their hosts. The larvae of Tachina and related flies are parasites of injurious lepidopterous larvae, such as army-worms which are injurious to cereals.

Larvae of hymenopteran flies and carnivorous wasps devour aphids in large numbers. Chalcids and ichneumon flies are parasitic, laying eggs in cocoon and larvae of phytophagous Lepidoptera. Apanteles, a hymenopteran fly lays eggs in army-worms and boll worms, the parasitic larvae gnaw their way through the skin of the host.

4. Scavengers:
Some insects are scavengers, they eat up dead animal and vegetable matter, thus, they prevent decay. Some ants and larvae of some flies can devour entire animal carcasses.

B. Injurious Insects:
Compared with beneficial insects the number of injurious insects is very large.

1. Disease Transmitting Insects:

Mosquitoes are perhaps the best known invertebrate vector and transmit a wide range of tropical diseases including malaria, dengue fever and yellow fever. Another large group of vectors are flies. Sandfly species transmit the disease leishmaniasis, by acting as vectors for protozoan *Leishmania* species, and tsetse flies transmit protozoan trypansomes (*Trypanosoma brucei gambiense* and *Trypansoma brucei rhodesiense*) which cause African Trypanosomiasis (sleeping sickness). Ticks and lice form another large group of invertebrate vectors. The bacterium *Borrelia burgdorferi*, which causes Lyme Disease, is transmitted by ticks and members of the bacterial genus *Rickettsia* are transmitted by lice. For example, the human body louse transmits the bacterium *Rickettsia prowazekii* which causes epidemic typhus.

Although invertebrate-transmitted diseases pose a particular threat on the continents of Africa, Asia and South America, there is one way of controlling invertebrate-borne diseases, which is by controlling the invertebrate vector. For example, one way of controlling malaria is to control the mosquito vector through the use of mosquito nets, which prevent mosquitoes from coming into contact with humans.

2. Household Insects:

Human food is spoiled by cockroaches, ants, flies and weevils. Tinea, Teniola and Trichophaga are clothes moths, they lay eggs on warm clothes, the larvae on hatching eat and destroy clothes, they also feed on furs, carpets and dry fruits. Anthrenus is a carpet beetle, it is a scavenger eating decaying animal matter, but its larvae destroy carpets and preserved biological specimens.

Tenebrio is the mealworm beetle, its larvae are mealworms, they eat meal, flour and stored grains, such as rice. Lepisma, the silver fish and Liposcelis, the book louse live in and destroy books and old manuscripts. Termites, the white ants cause untold destruction of books, carpets, furniture and wood-work of buildings.

3. Injurious to Domestic Animals:

Glossina, the tsetse fly transmits Trypanosoma brucei which causes nagana in horses. Tabanus and Stomoxys, the blood sucking flies inject Trypanosoma evansi into horses and cattle which causes surra in India.

The larvae of Hypoderma, the warble fly bore below the skin of oxen and make holes for breathing, then they pass through the gullet and again pierce the skin on the sides of the spine to form swellings, they not only injure the host but also reduce the meat and milk supply.

Gasterophilus, the bot-fly lays eggs on hair of horse, the larvae enter the stomach in large numbers. Melophagus, the sheep tick and Hippobosca, the forest fly of cattle and horses suck blood of their hosts and often cause haemorrhage. Menopon, the chicken louse sucks blood and causes destruction of fowls.

4. Injurious to Crops:

Many insects damage forest trees, growing farm crops, fruits and stored grain, the damage they cause annually runs into millions of rupees.

The number of such insects is innumerable, they are mostly Lepidoptera, Coleoptera, Diptera and Hemiptera. Euproctis, the brown tail moth and Lymantria, the gipsy moth are serious pests of shade and foliage trees, their larvae are a menace and destroy forest trees

The larvae of two Lepidoptera Chilo in India, and Diatraea in America bore into stems of sugar-cane and cause a great deal of damage. Pyrilla, a hemipteran sugar-cane leaf hopper sucks the juice of sugar-cane, both as adult and nymph, causing great loss of sugar.

The larvae of two Lepidoptera, Agrotis and Gnorimoschema are potato cut-worms in India, the former feeds on potato leaves and cuts off the stems, while the larvae of the latter eat the potatoes in the field. Larvae of Agrotis are also destructive to peas, cabbage, tobacco, ground nuts, wheat and cauliflowers.

The larvae of some Coleoptera are called wire-worms, such as Agriotis and Limonius, they are root-feeders and are extremely destuctive to cereals, root crops and grasses. Many insects and their larvae destroy vegetables in India.

Many insects attack fruit trees, they damage roots, trunks, stems, leaves, inflorescence and fruit. Drosicha, a mealy bug causes destruction of mangoes, plums, papaya, jack fruit, pears and citrus fruits in India. The nymphs and adults of Ideocerus, a mango leaf hopper attack the inflorescence and suck the sap, thus, they cause tremendous damage by preventing formation of mango fruit.

Many moths, caterpillars and beetle cause a great deal of damage to stored grains: two beetles Tenebrio and Tribolium have similar habits and are commonly found in stores and granaries, the former is found in all stages in meal, flour and stored goods, its larvae are known as meal worms. Tribolium eats stored wheat and grain. Calandra, a weevil bores through grains of rice and other stored grain in India.

Social Life in Insects

[I] Social behaviour

In a broader sense any interaction between two or more individuals constitutes *social behaviour.* Usually, social relationship implies interactions among members of the same species. The mere presence of more than one individual does not mean that the behaviour is social. Various types of associations occur among insects.

1. Solitary insects. When each individual is more or less independent, insects are called solitary. They forage independently and the two sexes come in contact only to mate. The female deserts her eggs or dies after laying and does not look after the offsprings.

2. Gregarious insects. Many solitary insects are *greganous,* that is, they form dense but temporary populations or aggregations in response to factors of physical environment or to share certain common needs or tracts. Thus, light at night stimulates large numbers of moths and other Insects to collect around it. High humidity under a log causes aggregations of wood lice. Catterpillars of the same or different species may live together and act in mutual cooperation. Ladybird beetles assemble together for hibernatlon. Locust and may-flies come out in huge swarms. None of these groups is strictly speaking, social. Gregariousness being a temporary habit it does not involve any association of the parents and the offsprings and has nothing to do with the evolution of the social behaviour among insects.

3. Social insects. On the other hand, insects of a given species that live together in organized groups or colonies are known as *social insects.* In a social organisation many individuals of species live together in an integrated manner so that each contributes in some specialized way to the welfare of all.

[II] Evolution of social habit

Among the oldest and most highly developed societies in the animal kingdom are those of insects. Three hundred million years ago these societies were already in existence. Social habit has arisen independently in several orders of insects. Transition from solitary to social life in these usually short-lived animals was made possible by the prolongation of adult or parental life and increasing parental care. First the progeny depended on the parents, then the parents on the progeny.

III] Orders of social insects

Social species of insects belong to seven orders, namely Orthroplcra (cockroaches, gryllotalpa), Dermaptera (earwigs), Isoptera (termites), Embioplera (web spinners), Psocoptera (book lice), Coleoptera (beetles) and Hymenoptera(bees, wasps and ants). About 6,000 species of insects in all exhibit social instincts, including nearly 500 species of bees, 800 species of wasps,1,000 species of termites and 3,500 species of ants.

[IV] Gradations of social behaviour

Various gradations between the two extremes of solitary and social insects are evident in existing species.
Soiitary insects, such as mosquitoes and dragonflies, drop their eggs anywhere and go about their business. Butterflies and fleshflies lay their eggs on food suitable for the young. Solitary digger wasp digs a hole, provisions it with food such as paralysed caterpillars and spiders, lays an egg, seals the entrance and departs, never to see its offspring which later hatches out , and grows independently.

Sub-social insects *a*re present a further step towards social habit. They provide a mass of food for each egg but remain to guard the nest or young. In some species of dung beetles female collects and rolls a ball of dung, excavates a burrow, drops the ball in, lays eggs and departs. In other species, the male assists by guarding the dung balls while the female excavates. In still another species, both sexes dig chambers, stock them with dung on which the female lays eggs, than guard them until the eggs hatch. At this time all disperse. A female earwig guards her eggs and later the young. Cockoaches, crickets, some bugs, web spinners and book lice do likewise.

True social insects*,* on the other hand, forage for food for the colony continuously, the two parents live longer so as to come in association with many generations of their progeny, and the youngs cooperate in caring for the next generation. Only a few insect species have been able to develop social habit completely. Most highly developed and complex -of insect societies are found in the termites (Isoptera), and the ants, bees and wasps.

[V] Characteristics of social insects

All the social insects possess certain characteristics in common, which are as follows :
1. Large populations (colonies). Many individuals of a species of social insects live together in an integrated manner in a comparatively large group or population which is not gregarious. Term "colony" is commonly applied to

the complex society they form. Number of individuals forming a colony ranges from 35,000 to 50,000 in honey bees, upto 600,000 in ants and several millions in termites. Colonies are *matriarch,* i.e. all members of a colony are the offspring of a single female and hence all have very similar genotypes. Ordinarily, a society of social insects does not accept members from other colonies of the same species.

2. Elaborate nests. Social insects construct more or less elaborate nests for protection, storage of food and maintenance of broods. Some interesting Habits of bees, ants and, termites regarding their nest and broods are summarized in the adjacent table.

3. Extra population of nests. Some small crustaceans, mites, beetles and other insects are attracted by the high temperature and surplus food of the nests of the ants and termites and get protection from their enemies. They live in close *symbiotic* relationship with the hosts. *Guests* or the outsiders feed upon the debris or waste of the nests and the dead bodies of the hosts. Slave-making ants bring eggs, pupae and adults of other ants and take from them functions of *slaves*
Intruders or *thieves* rob the social insects of their food and brood. Some beetles (e.g. *Atemeles)* live in brood chambers of the ants, where the beetle larvae eat the ant larvae with impunity. Both larvae and adults of the beetle secrete pheromone-like substances which serve to appease the aggressive tendencies of the ants.
Predator insects prey upon the social insects, stylopids attack wasps and bees, while, bee moth attacks the wax of honey bee hives.

4. Polymorphism (caste system). Typically social insects have a division of labour. Members are differentiated into distinct *castes,* which are specialized in structure, fuDction (reproduction, feeding, guarding, etc.) and behaviour. Principal castes are the *reproductives* (king and queen) and the *sterile* members (workers and soldiers).Workers are the smallest in size. Queen is the largest with a long abdomen and lays eggs. It lives for several years. Males are intermediate in size and develop parthenogenetically from unfertilized eggs. In social wasps, bees and ants, workers are only sterile females. In termites and some higher ants, workers and soldiers belong to both sexes. In termites, a special soldier-caste exists, called the *nasute,* with an elongated projection on the head. The greatest diversity of castes (polymorphism) is found among ants, and all forms may have large and dwarf individuals.

Habits	Honeybees	Ants	Termites
Position of nest	Trees, etc	Leaves,wood,ground	Wood, ground

Material of nest	Wax	Leaves, wood,earth	wood, soil
Shape of nest	Hexagona cells	Chambers & galleries	Chambers & galleries
Nest started by	Female & workers	Female or male and workers	Female,Male and Workers
Numbers of population	35-50 thousand	600 thousand	Several millions
Nature of brood	Perennial	Perennial	Perennial
Food of brood	Pollen & nectar	Vegetables, wood & Insects	wood & insects
Type of feeding	Progressive	Progressive	Progressive
Swarming	Yes	Only in some species	Yes

Caste determination depends upon a number of factors. In Hymenoptera (bees, wasps and ants), genetics and nutrition form the basis of differentiation. Males are haploid and develop parthenogenetically from unfertilized eggs. Queens, workers and soldiers are diploid females which develop from fertilized eggs. Differences between queen and worker are mainly due to differences in the quantity and quality of their food. Bee larvae destined to become queens are fed on royal jelly for a few days and then are fed bee bread (honey and pollen). Bee larvae destined to become workers and drones are fed entirely on beebread .

In Isoptera (termites), determination of castes is due to extrinsic factors rather than to genetical ones. Reproductives and soldiers secrete ectohormones containing inhibitory substances. When fed to nymphs, these substances prevent them from developing into like forms (soldiers and reproductives).

5. Cohesiveness of Colony. Division of labour or separation of function requires great co-ordinatlon, for the group must perform as a biological unit. All the members of an insect society live in an integrated or cohesive manner subordinate to the life of the community. As a result, various castes, which differ in structure and physiology, can not live independently. They work in cooperation and with mutual benefit. For instance, many females mutually cooperate so that one worker looks after an egg (larva) laid by another female (queen) and so on. Success with them is measured in terms of the colony and not of the individual. Different castes are bound together by chemical and physiological mechanisms rather than structure.

6. Parental care. Basis for the family relationship is the provision of shelter, food and defence for the young. Thus social life in insects is correlated with the lengthening of the adult or parental life and increasing parental care. It
provides greater association of parents and young. Parental care includes various activities such as provisioning of food, cleaning and feeding of young and queen, removal of debris and bodies, taking away and putting eggs in proper chambers, cooling of chambers in summer and protecting queen from winter by clinging and clustering about her, by workers. Parental care is instinctive behaviour.

7. Progressive provisioning of food. Stingless bees and potter wasps lay their eggs singly or in Small groups and provide sufficient mass of food at the same time for the complete development of the larvae which hatch out from the eggs. This is known as mass provisioning of food. But true social insects (bees,ants and termites) feed their young extensively and continuously from day to day until they metamorphose into the adults. This is known as *progressive provisioning of food.*
Ants show a progression of food habits such as probably occurred in man's history. Lowest kinds (army ants) hunt insects or flesh. Pastoral ants feed on the honey dew produced by aphids. They carry these "ant cows" (aphids) into overwintering quarters and protect them from predators. Harvester ants gather and store seeds in summer to tide them through the winter. Finally, the leaf-cutter or fungus growing ants *(Atta)* grow their own pure crops of fungi in underground gardens fertilized with organic debris. These ants cut leaves and carry them underground to serve as a substrate for growing pure strains of fungi on which they feed. A young queen, upon setting out to find a new colony, carries a seed stalk of fungal hyphae in a pouch below the mouth.

8. Tropballaxis. Exchange of food between one insect and other is known *trophallaxis.* Ants and termites feed one another from mouth to mouth. Young exchange food with the adult. Some ants feed some beetles, coccids and aphids and in return imbibe a fluid secreted by them.
In termites, trophaiiaxis plays an important role in the regulation and determination of castes. Ectohormones containing inhibitory substances are secreted by the reproductives and the soldiers. During mutual feeding (trophallaxis), these are passed on .to the nymphs, and prevent them from developing into individuals of the same sex or caste. This tends to keep caste numbers within bounds. Some undifferentiated nymphs may not

come under the influence of trophallaxis and may become additional members of the same caste.

9. Swarming. Swarming occurs as a means of alleviating cogestion in the overcrowded colony, or as a means of distribution. In many, swarming occurs for feeding, migration and mating. Mostly mating takes place between the queen and the males during swarming, called the *nuptial* or *marriage flight.* Honeybees propagate colonies by swarming. Each swarm consists of an old queen and many workers and produces a new colony. C.G. Butler (1961) found that the queen has over her body a so-called queen substance, secreted by her mandibular glands. It inhibits workers from becoming queens when they share this substance (trophallaxis). Swarming may come about in an overcrowded colony because this substance may not be distributed properly to all workers.

10. Protective devices. Social insects develop several devices. *Stings* are developed in most bees and certain ants. *Jaws* are highly developed in stingless bees and soldiers of ants and termites toward off enemies. Sometimes, a few *guards* are posted at certain convenient places near the nests. Guards protect the nest and attack the intruders in a few cases. Nests are also made in *protective localities* such as ground, hollow trees, mud, paper etc. and have numerous side exits through which rapid escape is possible at the time of danger.

11. Commuuication. Both social and nonsocial insects utilize chemical, tactile, visual and auditory signals as methods of communicating with each other. Chemical communication occurs with the help of body secretions called *pheromones.* These are secretions of exocrine glands that pass to the outside of the body and ply an important role in regulating and coordinating the activities of a colony of the same species (E.O. Wilson, 1965). Pheromones attractants, the queen substance and influences are useful to the colony. Substances deposited on the ground by returning from a foraging trip serve as a trail marker for other ants. Substances released by the dead body of an ant within the colony stimulate other workers to remove the body.

In honey bees, a *queen substance* produced by the queen's mandibulate glands, controls nursing behaviour of the workers, caste determination and swarming. *Language* of the bees (Von Frisch 1950) represents a most revealing method of communication known among insects. Some aspects, such[as the tail wagging dance, set the honeybees apart from all other social insects.

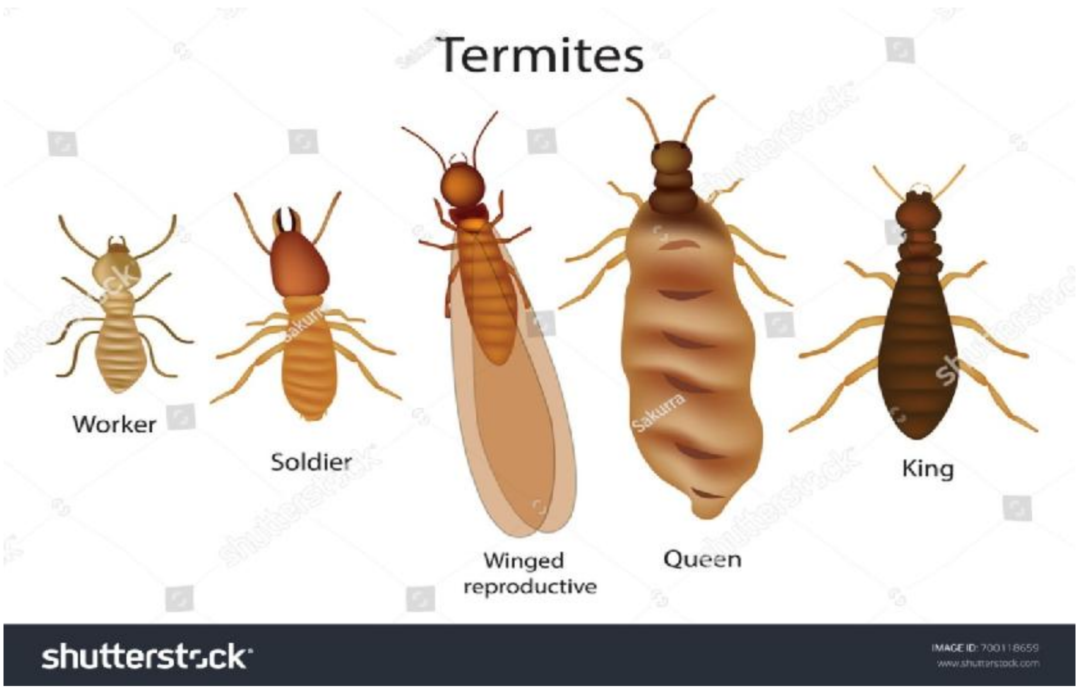
VI] Comparison of human and insect societies

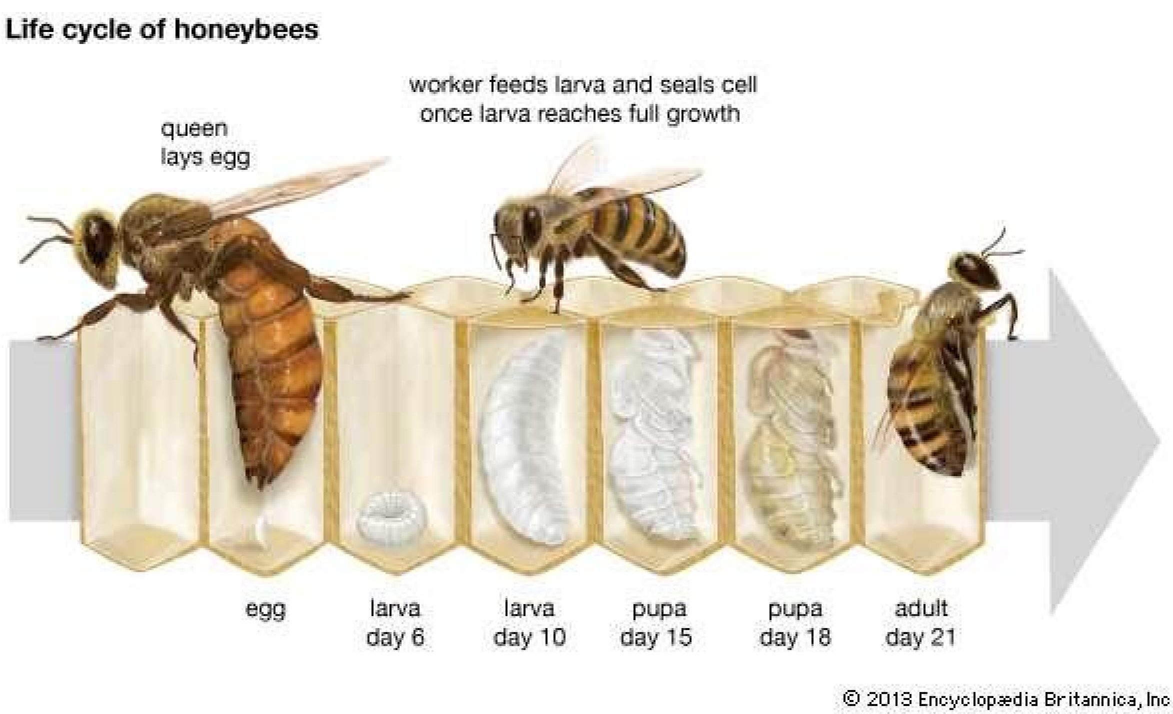
Highly evolved organization and cohesiveness of insect societies often prompts comparison With human societies.

1. Similarities. Some notable similarities are as follows -
(1) Human societies originally began as discrete families (one female and her offspring), but this is not repeated phylogenetically. Insect societies also arise from discrete families and by swarming frequently found new colonies.
(2) Human societies comprise integrated groups of like individuals (castes) that specialize in different trades or professions. They benefit both the individuals and the group by their cooperative effort. Insect societies also have distinct castes performing various functions and living together in an integrated manner.
(3) Man has tradition and social heredity. Ants bequeath fungi and real estate (hunting grounds).
(4) Man constructs and uses tools. The Indian red tree ants (*Oecophylla smaragdina)* use their larvae as spinning shuttles to fasten leaves together with larval silk.
(5) Man controls and modifies the environment to his own advantage, including the production of food. Ants cultivate their own specific strains of fungi, and bees andtermites also control the temperature of their nests.
(6) Man domesticates animals. Ants domesticate aphids (ant-cows).
(7) Men has a language. Bees and ants communicate by dances and pheromones.

2. Differences:

(1) Man has evolved learning and abstract intelligence whereby he meets different situations. Adaptation provides him with a flexible society. Insects evolved different castes each of which meets the specific need. Their society therefore, is a rigid one.
(2) Success in Human society is measured both in terms of the individuals as well as the community. In an Insects society, success is measured in terms of the colony and not the individuals.
Trophallaxis


Termites
Worker
Soldier
Winged reproductive
Queen
King
shutterstock
IMAGE ID: 700118659
www.shutterstock.com


Life cycle of honeybees
queen lays egg
worker feeds larva and seals cell once larva reaches full growth
egg
larva day 6
larva day 10
pupa day 15
pupa day 18
adult day 21
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Economic Importance of Phylum Mollusca

1. Benificial Molluscs:

As Food :

Edible Oysters:

From ancient times the Romans and Greeks used the oysters as a main dish in their meals. The Red Indians were great oyster eaters. The maximum amount of oyster meats are collected from two genera— Ostrea and Crassostrea, which belong to the family Ostreidae and class Bivalvia.

In Japan, United States and Europe over billion pounds of oyster meat are sold each year. In Europe, Ostrea edulis and Crassostrea angulata are very popular among oyster eaters. The Virginia osyter, Crassostrea virginica is harvested from Southern Canada to Mexico.

In India though molluscan species are varied and plentiful, but a small number of poor population in the coastal areas utilize molluscs as food. The edible oysters are found along the sea shores, estuaries and back waters where the substratum is suitable for the attachment. Oysters are sold in the markets alive or after freezing.

Edible Clams:

The edible clams are harvested throughout the world and its meat is a source of food since prehistoric times. Major portion of the edible clams are harvested in Japan and United States.

The Quahogs (family Veneridae), Razor clams (family Solenidae) and soft shelled clam (family Myacidae) of the class Bivalvia are in great demand in the markets of United States. The Quahog clam. Mercenaria mercenaria is harvested in the Gulf of Mexico. Next is the United States, Japan, Malayasia, and Europe which consume a large proportion of clams; mainly cockles are harvested in North-West Europe and Malayasia.

In India, poor coastal people consume the edible clams mostly. The edible clam species in India are Bay clam, Meretrix meretrix, the Inflated clam, Katelysia opima, the Backwater clam, Meretrix casta, the cockcle clam, Gafrarium tumidum, etc., belonging to the family veneridae of the class Bivalvia. They are found in the coastal shallow waters and are collected by hand-picked method or often used mechanical devices.

Edible Scallops:

The sweet, delicate meat of the scallops, holds a high rank to the people of shell fish consumers, especially to the gourmets. The people of United States, Japan and Southern Australia consume a large amount of scallop meats. The Deep Sea Scallop, Placopecten magellanicus is very popular in the east coast of the United States. The scallops are also extensively harvested in Japan and Australia.

Edible Sea Mussel and other Edible Molluscs:

The edible Sea Mussels mainly include Mytilus, Perna under the family Mytilidae which remain attached to the rocky substratum by byssus threads. The European edible Mussels, Mytilus edulis, though not popular in the United States but in France it has gained vast countries. Along the Pacific coast of the United States, the people do not prefer mussels extensively for the dangers of paralytic mussel poisoning in some cases. The people of the West Indies use the meat of Pink Conch, Strombus gigas extensively.

In India, the Sea Mussel, Mytilus is mainly restricted from Quilon to Kanyakumari in the south-west coast and up to Tirunelveli district in Tamil Nadu in south-east coast.

The Green Mussel, Perna viridis is found along Mumbai, Ratnagiri and Karwar coasts and also in Cochin (Kerala), Tamil Nadu and in some parts of Odisha. The Green Mussels not only found in coastal waters but also in Bays and backwaters. The mussels are fished by iron chisels and are kept in coir bag or in nylon bag.

The gastropoda includes a number of species for edible purposes; such as the Top shell, Trochus niloticus, the Turban shell, Turbo marmoratus, the winged shell, Strombus canarium, the Purple shell, Thais bufo, etc.

Edible Cephalopods:

The edible cephalopods include cuttle fish, squid and octopuses and occupy the second place next to the oyster fishery. A vast amount of octopuses are consumed by the Japanese, Spaniards, Italians and Australians. Over 8000 tons of squid are sold annually in the fish markets of New York city, Washington and California.

The squids are eaten mainly by Chinese, Italians, Spaniards and Puerto Ricans. The Australian giant cuttle fish, Sepia apama found in the southern part of Australia is sold in the fish markets for human consumption. The golden cuttle fish, Sepia esculenta is fished in Western Japan and Shantung and Kiangsu provinces of China.

The flesh is used as food in Japan and south-east Asian countries. It is caught by otter trawls and hook-and-line. The flesh of kisslip cuttle fish, Sepia lycidas is in great demand in Japan and Hong-kong.

The common cuttle fish, Sepia officinalis, occurs along the eastern Atlantic from the Baltic Sea to South Africa and the meat is highly appreciated food item in Italy, Spain, Japan and Republic of Korea. The catch is usually marketed fresh and frozen.

Since prehistoric times octopuses are exploited for human consumption. The most commercial fisheries and markets are located in Japan and in Mediterranean countries.

In India, not well known cephalopod fishery has developed along our coastal areas. Sepia pharaonis, Sepia brevimana, Sepia prashadi, Sepia aculeata, Sepiella inermis, Sepioteuthis lessoniana, Loligo indica, Loligo hardwickii, Loligo duvaucelli, Octopus hummelincki and Octopus incertus are the known cephalopods used for food.

In Rameswaram the reef squid specimens are sundried on sand extracting shell and ink gland. Most of the catches are consumed by the local men and the rest is exported.

The huge number of Nautilus are caught each year in Philippines, Caledonia, and Fiji, etc. for the human consumption of the meat.

In Bihar and West Bengal (India) freshwater gastropods are also much in demand for food, and heaps of these molluscs are kept for sale in the market.

As Bait :

Gastropds are useful to Man as bait for catching fish. Squids also make excellent bait for marine fishes especially Cod in United States. Fishermen of Palk Bay use small octopuses as bait. In the American Virgin Islands the meat of Conch is used as bait in fish traps.

Money :

Red Indian tribes of America used the common Dentalium indianorum as money and value of shell was calculated lengthwise. Gastropod shells were source of money for various native races, including Vampum of American Indians. American Oyster, Crassostria viginica, is commercially cultivated and harvested and provides millions of dollars to the industry.

Squids, cuttle fish and octopus are money earners as they are sold in market for food in China, Japan, India and Italy.

Medicinal Value:

Cockcle clam is supposed to be the good for heart trouble. Molluscan food is an important ingredient for good health and is helpful for sexual activities. Pliny recommended that raw molluscs can be used for sore throat and cough. It is reported that the extracts of hard-shelled clams are the growth inhibitors of cancers in mice.

Placuna placenta (window pane oyster) helps in the preparation of "Mouktik Bhasma" which helps in gaining of youth and vitality. The pearl powder mixing with milk and various herbs are used for the cure of stomach troubles in China. A virus preventive, Paolin, derived from some oysters, is useful against poliomyelitis and influenza. The venom from Conus can be used as a muscle relaxant during heart operations.

Chank in Religion:

The sacred chank is a white, massive, pear-shaped shell with three spiral ridges on the inner lip. They are common in Indian Ocean and are found in the south-east coast and west coast of India.The sacred chanks has played a main role in Indian religion. It held in high esteem by Hindus.

The sacred chank is one of the symbols associated with god Vishnu and his many incarnations are also associated with the chank. It is widely used as trumpet in the temples and as woman's wrist bangles. Chank blowing is a common custom in Hindu marriages of some castes, specially in Bengal.

Cowries and Money:

In earlier days cowries were used as money. The mostly two species of cowries—money cowries, Cypraea moneta and gold ringer cowries, Cypraea annulus are also referred to as money cowries. The, earliest graves in Egypt contained numerous cowries.

Since 2000 B.C. the cowries were used as coins in China and lasted about 600 B.C. Till recently Cypraea moneta was used as money in many parts of Africa. Even in 19th century they were used as coins in Uganda and Central New Guinea (Africa).
During Livingstone's travelling period (1871-1876) in Congo and Lake Tanganyika regions, Cypraea moneta was used extensively as coin. In the years of the English East India Company, specially in Bengal, the cowries were exchanged for rice from the Maldive Islands.

During these years the cowries were shipped to Europe, England, the Netherlands and Portugal in Barrels or sacks. It is known from the record that about 1,000 million cowries were exported from Maldives only in the year of 1800.

Decorative Ornamental and other Purposes:

Shells are collected from Sri Lanka, Western Australia, Philippines, Thailand, Fiji, Japan, South Africa and Hawaiian Islands for commercial purposes. In India the shell is collected from Andaman and Nicobar Islands, and from South Indian coasts. The shells are used for making ornaments and jewelleries.

The shell curio trade of Nautilus and other shells has developed in India, Philippines and Indonesia. In India, the shell curio trade is seen in some tourist places or pilgrim centres near the shore, such as Digha (W. Bengal), Puri (Orissa), Chennai, Rameswaram, Kanyakumari (Tamil Nadu), Kovalam beach near Tiruvantapuram (Kerala), etc.

Several hundred tons of internal calcareous cuttle fish bone are collected from Sepia and squids along the shore of Mediterraneen Sea and are sold to the manufacturers of tooth paste. For centuries, the ink of Sepia has been used as a brown colouring matter and also as a writing ink.

Nowadays it has been replaced by aniline dyes because Sepia's ink fades in light. 'Pearl' buttons prepared from shells of bivalves are extensively used.

The top shells (Trochus sp.), turbans (Turbo sp.) are used for beautiful shell lamps and are collected from the rocks and coral reefs of Andaman and Nicobar Islands. The royal tyrian purple dye was the source of two snails—Murex brandaris and Nucella lapillus and was used by the ancients.

The manufacture of the dye was perfected by Phoenicians and the use was known as early as 1600 B.C. in the Mediterranean Islands. This dye was very strong and did not fade after 100 years. The dye was collected as a fluid first from the hypobranchial gland of the snail situated on the roof of the mantle. Then it would turn to purple red gradually in presence of direct sunlight.

Shell lime is prepared from shells and is used for white washing on the walls of buildings. The shells are collected along the East coast near Berhampur, Visakhapatnam, Kakinada and Chennai, and Cochin from West coast.

In Literature : There are stories about giant Squids and Octopuses cited to play exaggerated role in popular literature. One such story, pictures a huge Squid, which dragged a small ship beneath the waves and grabbed the helpless sailors in its snake like arms and crushed them to death.

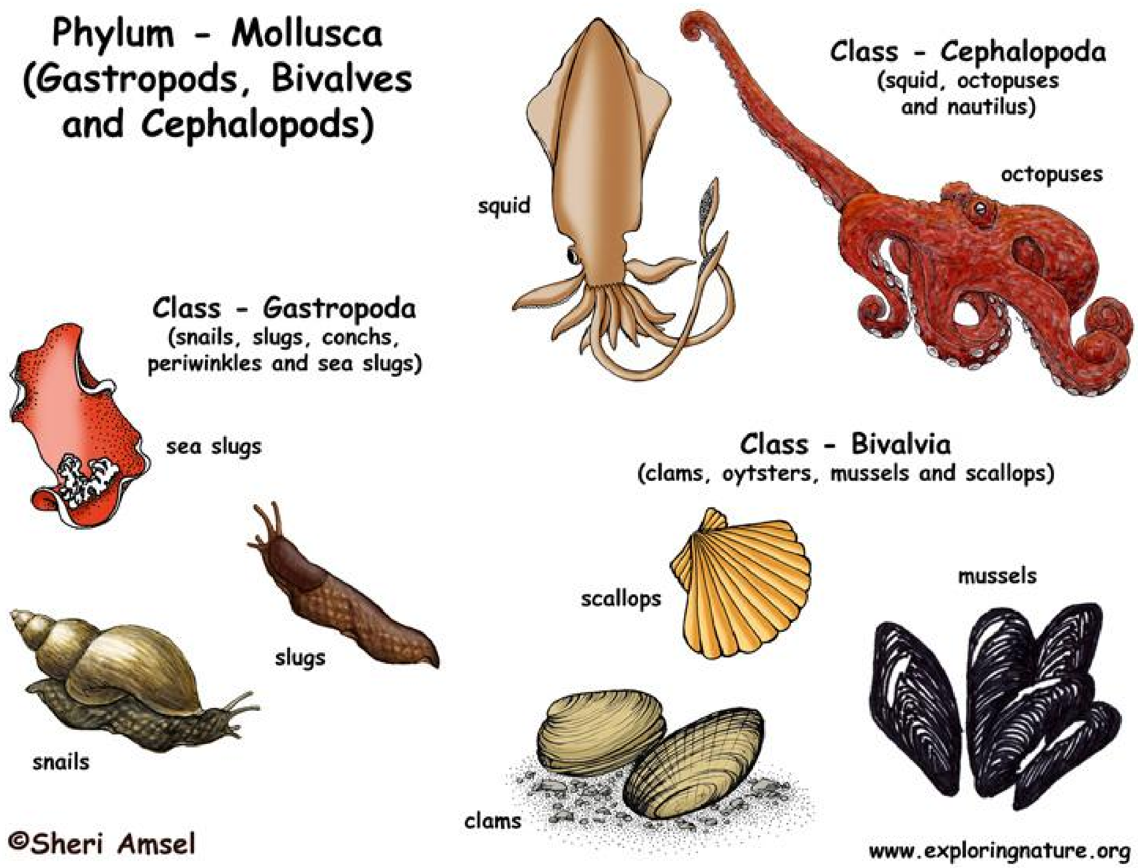
Animal Inventions : Cephalopods are credited with two major animal inventions. One of them is the “ Jet propulsion” principle discovered quite late by man but was used by Squids and Octopuses for million of years. The second novel invention is the use of “smoke screen”, in offence and defence by Cephalopds. A smoke screen is created by ejecting a brownish ink into water. This diffuses into a large area and allows Cephalopods to walk through the smoke searching for its prey or to escape from enemy. Man used such a dyes not earlier than first World war.

(ii) Harmful Molluscs:

Freshwater snails of Philippines, China, Venezuela are responsible for the death of thousands of people because the snails are the intermediate host of blood fluke disease of Schistosomiasis. In India the disease Fasciolopsiasis is caused because the snails are the intermediate host of the intestinal fluke, Fasciolopsis fuelleborni.

Many peoples in the United States become paralyzed when they consume infected clams and mussels which are carriers of paralytic shell fish poisoning.

The garden snail, Achatina sp., is the most terrestrial destructive gastropod which eats not only leaves but also destroys tender stems of the gardens. The cone, conus omaria, possesses venomous stings which can inflict injuries and may even death. Teredo, Bankia, Pholas damage the wooden portion of the ship immersed in water by boring through it.


Phylum - Mollusca
(Gastropods, Bivalves
and Cephalopods)
Class - Cephalopoda
(squid, octopuses
and nautilus)
squid
octopuses
Class - Gastropoda
(snails, slugs, conchs,
periwinkles and sea slugs)
sea slugs
Class - Bivalvia
(clams, oytsters, mussels and scallops)
scallops
mussels
slugs
snails
clams
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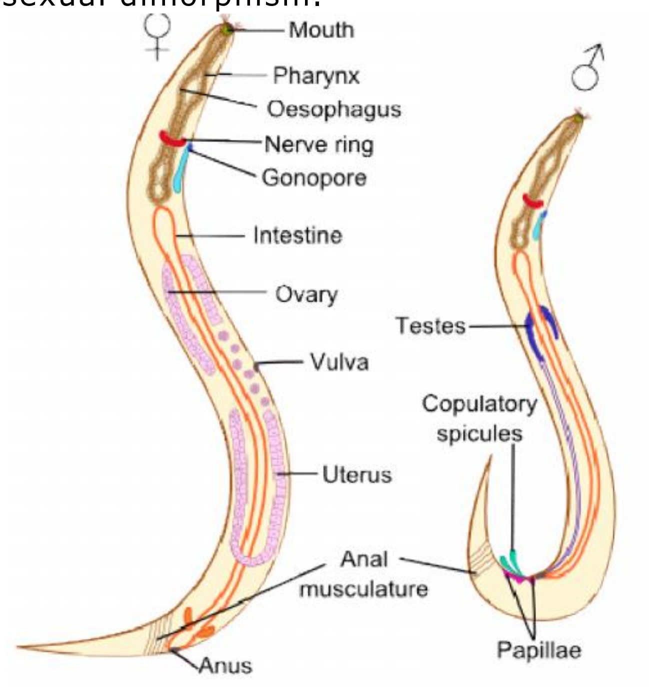
FILARIAL WORM AND FILARIASIS

Common names: *Wuchereria bancrofti* is also called as Bancrofti worm, Elephantiasis worm, Filariasis worm

Distribution: Filariasis worm is worldwide or cosmopolitan in distribution except at Polar Regions. It is more common in tropical regions like Arabia, India, Malaya, Korea, China, Japan and Brazil. It is almost absent in Europe, North America and African continents.

Habit and Habitat: *Wuchereria bancrofti* is a dangerous human parasite found in human blood and lymph. It is a digenetic parasite and it requires two hosts to complete its life cycle. The two hosts are man and female culex mosquito. The adult worms are harbored in a coiled state in human lymph glands and lymph passage. These worms obstruct the passage of the lymph.

Identification: Adult worms are cylindrical in shape. They are creamy white in color. The male and female sexes are separate and they exhibit sexual dimorphism.



WUCHERERIA - ADULT FEMALE AND MALE
©studyandscore.com

The female worms are slightly longer and thicker than that of their male counterparts. Female worms measure 65 to 100 mm in length and 0.25 mm in diameter whereas male worms measure 40 mm in length and 0.2

mm in diameter. The posterior end of the female worms is sharply curved with genital papillae, while the posterior end of the male not much curved.

STRUCTURE

The anterior ends of these worms terminate bluntly whereas the posterior end is a little pointed. The male and female worms are found coiled round each other in the lymph vessels and thus block the flow of lymph and this results in the enlargement of the concerned organ.

A mouth with no oral lips is present at the anterior end. The alimentary canal of this worm includes mouth, pharynx, oesophagus, intestine and anus. The anterior part of the pharynx is muscular and the posterior part is glandular.

The posterior end of the female is straight and bears anus. The female genital pore called vulva is present ventrally at about one third length of the body from the anterior tip. The posterior end of the male worm is curved bearing cloaca. A pair of unequal copulatory spicules is present in cloacal region. Many copulatory papillae are present in the posterior region.

LIFE CYCLE OF FILARIAL WORM

Wuchereria is a heterogeneous parasite which completes its life cycle in two different hosts namely man and female culex mosquito.

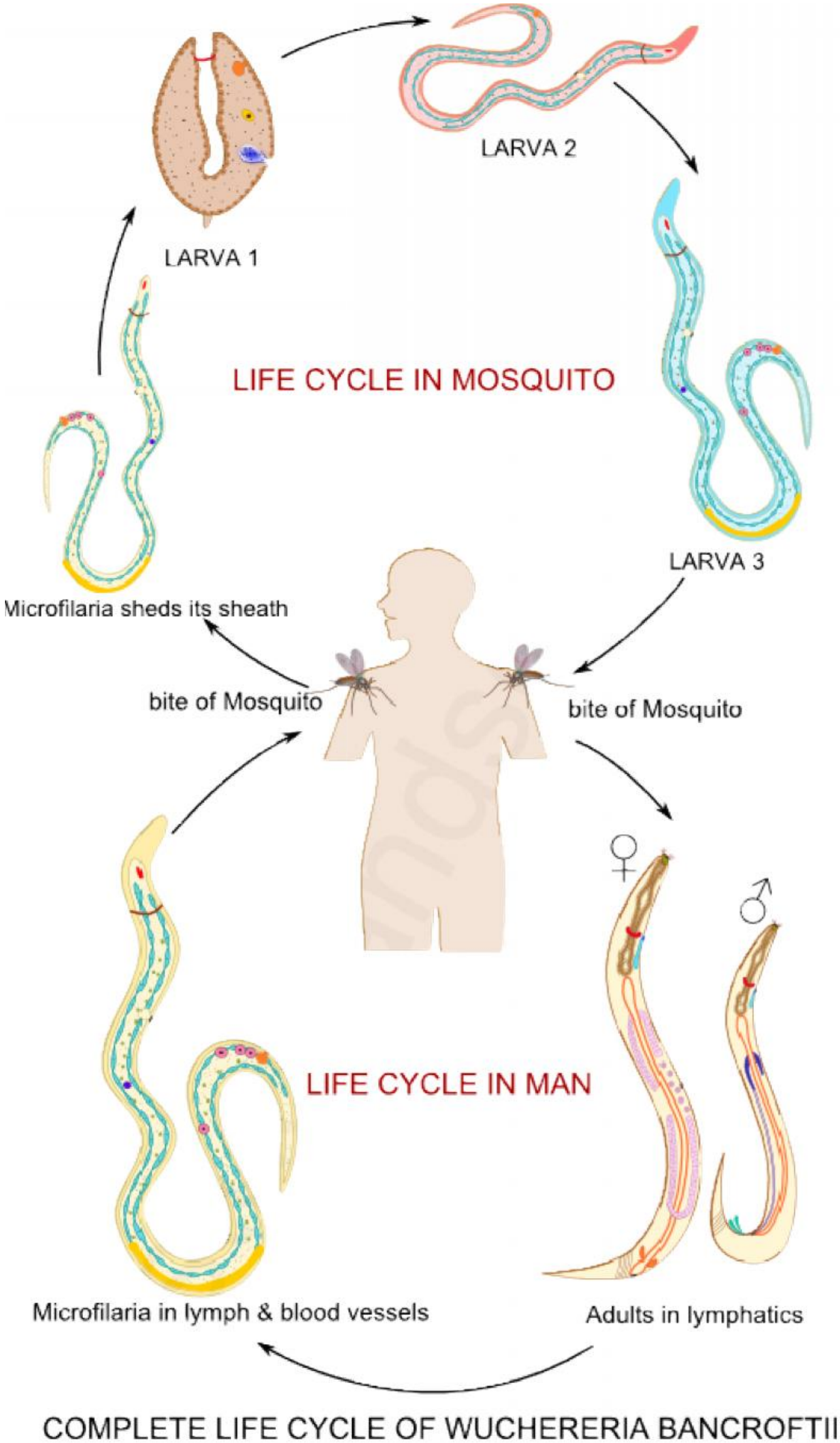
Life cycle in Man: Human Phase

Copulation takes place in Human lymphatic system. Male and female worms copulate when they are present in the same lymph gland. The female worms are ovoviviparous and produce eggs which hatch within the body of the female without obtaining nourishment from it. Numerous microscopic juvenile larvae called microfilariae are released into the lymph.

Each microfilaria is about 0.2 to 0.3 mm in length and is surrounded by loose cuticular sheath, also known as egg membrane.

The microfilaria after being released into the lymph vessels, enter the blood vessels and circulate with the blood. Ultimately they migrate to the visceral organs and reside in deeper blood vessels of thorax region. In this thorax region the larvae do not undergo any additional change as further development can happen only inside the intermediate host.

Thus, these larvae move to the peripheral blood vessels during the night time, to suit the feeding habit of mosquito. During the day time these larvae live in large deep-seated blood vessels but during night they migrate to the peripheral blood vessels. This movement of the larvae is called as nocturnal periodicity or diurnal rhythm. The microfilariae die if they are not transferred to the mosquito within 70 days. Microfilaria is the infective stage to mosquitoes.



COMPLETE LIFE CYCLE OF WUCHERERIA BANCROFTII

Life cycle in Mosquito: Mosquito Phase

When the female Culex quinquefasciatus mosquito sucks the blood from the Wuchereria-infected person, the microfilaria from the peripheral blood, enter the midgut of the mosquito. In the midgut they shed their protective sheath within 6 hours. They penetrate the stomach wall and migrate to the thoracic muscles where they metamorphosis and grow.

Initially they metamorphose into a flat sausage-shaped larva also called as first-stage larva. Later this larva undergoes first moulting and grows into a slender elongated second-stage larva. Finally this second stage larva undergoes second moulting transforming into a long infective stage also called as the third-stage larva. All these changes take place within 10-20 days. The final third-stage larva moves to the labium of the mosquito so that it can be transferred to man.

In man the filarial larva first enters the blood circulation through the bite of the mosquito and then it enters into the lymphatic vessels where it undergoes third and fourth moulting and transforms into adult. The adult male and female worms copulate and the female delivers microfilariae.

FILARIASIS IN INDIA

Lymphatic Filariasis (LF) also called as filariasis or elephantiasis, renders the patient with severe weakness and disability. It imposes social and economic burden to the affected individuals as well as their families. Lymphatic filariasis is an obstacle to socioeconomic development.

LF is the world's second leading cause of long-term disability in the affected patients. The current estimate reveals that globally 120 million people are infected with lymphatic filarial parasites and about 20% of the world's population is at risk of getting infected. According to the World Health Organization, India, Indonesia, Nigeria and Bangladesh alone contribute about 70% of the infection.

Control and elimination of Filariasis in India

National Filaria Control Programme, launched in 1955 has a three dimensional approach to curb filarial infections. The strategies include in this programme are

- Vector control
- Detection and treatment of filarial cases
- Delimitation of endemic areas

The World Health Assembly resolution (1997) has targeted to eliminate filariasis by 2020, whereas India's National Health policy envisaged elimination of filariasis by the year 2015. But this target is missed out and currently as many as 35 crore people in 13 states continue to remain under the risk of filarial infection. Odisha, UP, Bihar, West Bengal, Jharkhand and Chhattisgarh are the states at extremely high risk.

The Union health ministry has prepared the National Roadmap for Elimination of Lymphatic Filariasis (NRELF) with clear goals, objectives, strategies, timelines with activities and functions at appropriate level to achieve the target.

The current elimination strategy is based on two pillars that is annual mass drug administration with Diethylcarbamazine (DEC) along with albendazole for five years or more to the population excluding children below two years, pregnant women and seriously ill persons in affected areas to interrupt transmission of the disease.

Eliminating filaria in India is a big public health success story after receiving polio-free certification. Currently India is reaching elimination targets with the increase in population coverage during mass drug administration and decrease in overall microfilaria rate at the national level.

MALARIA

Plasmodium Life cycle

Plasmodium species that infect humans

Until recently, there were four *plasmodium* species that were considered responsible for malaria disease in humans: ***P. vivax***, ***P. falciparum***, ***P. ovale*** and ***P. malariae***. In 2008, ***P. knowlesi***, a species that used to infect exclusively apes of the genous *Macaque*, was recognised by WHO as the fifth *plasmodium* species that infect humans.

Transmission routes

The main mode of transmission of the disease is by bites from infected Anopheles mosquitoes that have previously had a blood meal from an individual with parasitemia. Less common routes of transmission are via infected blood transfusion, transplantation, infected needles, and from a mother to her fetus during pregnancy.

Plasmodium life cycle

The life cycle (Figure 1) is almost the same for all the five species that infect humans and follows three stages:

(I) infection of a human with sporozoites
(II) asexual reproduction
(III) sexual reproduction

The two first stages take place exclusively into the human body, while the third one starts in the human body and is completed into the mosquito organism.

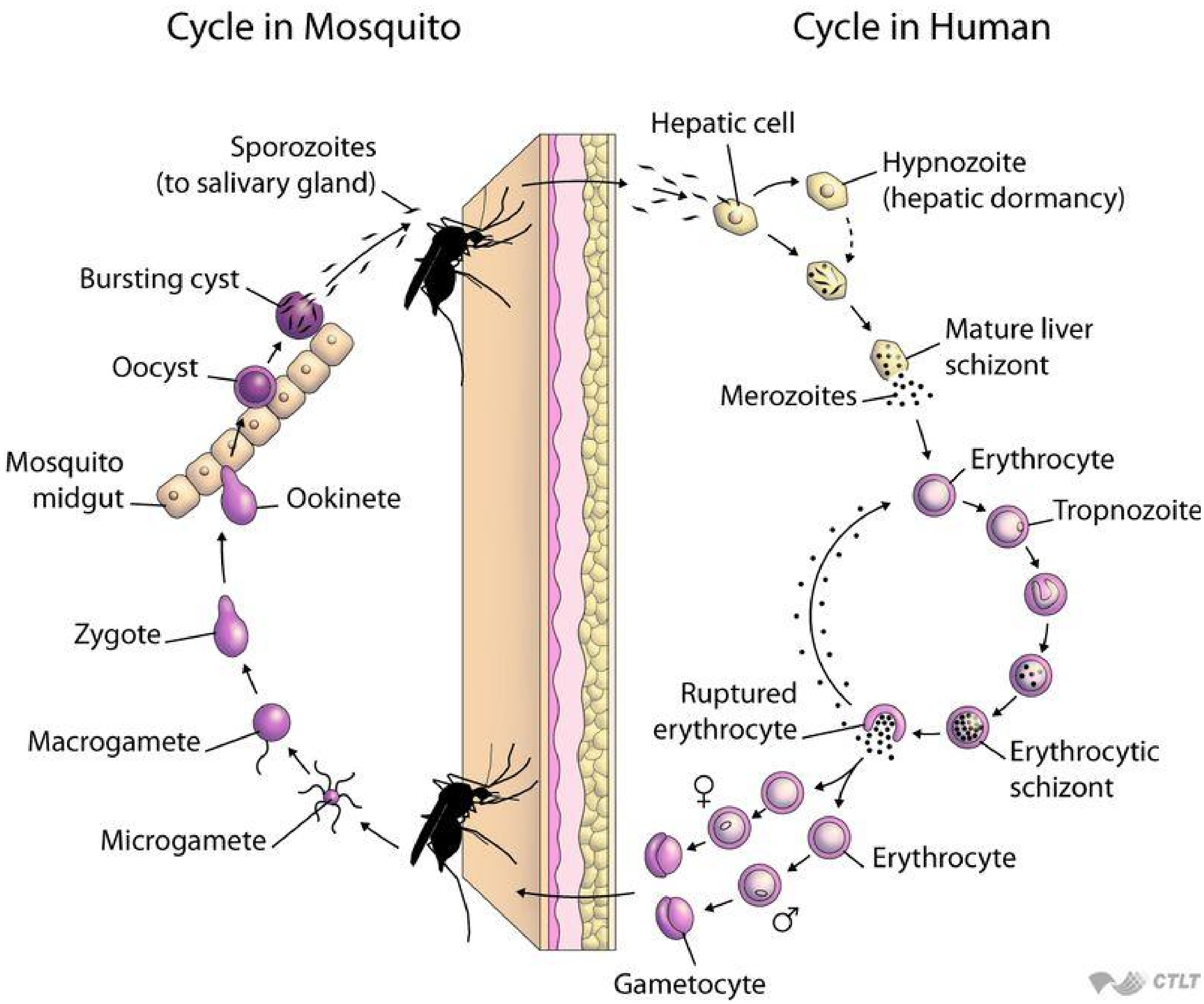


Figure 1. *Plasmodium* life cycle

The human infection begins when an infected female anopheles mosquito bites a person and injects infected with **sporozoites** saliva into the **blood circulation**. That is the first life stage of plasmodium (**stage of infection**).

The next stage in malaria life cycle is the one of asexual reproduction that is divided into different phases: the pre- erythrocytic (or better, **exoerythrocytic**) and the erythrocytic **phase**. Within only 30- 60 minutes after the parasites inoculation, sporozoites find their way through blood circulation to their first target, the **liver**. The sporozoites enter the liver cells and start dividing leading to **schizonts** creation in 6- 7 days. Each schizont gives birth to thousands of **merozoites** (**exoerythrocytic schizogony**) that are then released into the blood stream marking the end of the exoerythrocytic phase of the asexual reproductive stage.

It is worth mentioning that, concerning ***P. vivax*** and ***P. ovale,*** sporozoites may not follow the reproduction step and stay dormant (**hypnozoites**) in the liver; they may be activated after a long time leading to relapses entering the blood stream (as merozoites) after weeks, months or even years. The exoerythrocytic phase is not pathogenic and does not produce symptoms or signs of the disease. Its duration is not the same for all parasite species.

Merozoites released into the blood stream, are directed towards their second target, the **red blood cells** (RBCs). As they invade into the cells, they mark the beginning of the erythrocytic phase. The first stage after invasion is a ring stage that evolves into a **trophozoite**. The trophozoites are not able to digest the haem so they convert it in haemozoine and digest the globin that is used as a source of aminoacids for their reproduction. The next cellular stage is the **erythrocytic schizont** (initially immature and then mature schizont). Each mature schizont gives birth to **new generation merozoites** (**erythrocytic schizogony**) that, after RBCs rupture, are released in the blood stream in order to invade other RBCs. This is when parasitaemia occurs and cinical manifestations appear. The liver phase occurs only once while the erythrocytic phase undergoes multiple cycles; the merozoites release after each cycle creates the febrile waves.

A second scenario into the RBCs is the parasite differentiation into male and female **gametocytes** that is a non pathogenic form of parasite. When a female anopheles mosquito bites an infected person, it takes up these gametocytes with the blood meal (mosquitoes can be infected only if they have a meal during the period that gametocytes circulate in the human's blood). The gametocytes, then, mature and become **microgametes** (male) and **macrogametes** (female) during a process known as gametogenesis. The time needed for the gametocytes to mature differs for each plasmodium species: 3- 4 days for *P. vivax* and *P. ovale*, 6- 8 days for *P. malariae* and 8- 10 days for *P. falciparum*.

In the mosquito gut, the microgamete nucleus divides three times producing eight nuclei; each nucleus fertilizes a macrogamete forming a **zygote**. The zygote, after the fusion of nuclei and the fertilization, becomes the so-called **ookinete**. The ookinete, then, penetrates the midgut wall of the mosquito, where it encysts into a formation called oocyst. Inside the oocyst, the ookinete nucleus divides to produce thousands of **sporozoites** (**sporogony**). That is the end of the third stage (stage of sexual reproduction/ sporogony). Sporogony lasts 8- 15 days**.**

The oocyst ruptures and the sporozoites are released inside the mosquito cavity and find their way to its salivary glands but only few hundreds of sporozoites manage to enter. Thus, when the above mentioned infected mosquito takes a blood meal, it injects its infected saliva into the next victim marking the beginning of a new cycle.

The duration of each above desribed phase is different for each of the plasmodia as shown in Table 1 that follows.

	Plasmodium species			
	P. vivax	***P. ovale***	***P. malariae***	***P. falciparum***
Pro-erythrocytic phase (days)	6-8	9	14-16	5-7
Erythrocytic cycle (hours)	48	50	72	48
Incubation period (days)	12-17 or even 6-12 months	16-18 or more	18-40 or more	9-14
Sporogony (days)	8-10	12-14	14-16	9-10

Pathogenicity of Plasmodium

Plasmodium vivax causes benign tertian malaria which is less dangerous form of this disease. The clinical features of malaria include, febrile paroxysm (spells of fever) followed by anemia and enlargement of spleen. A febrile paroxysm includes three stages,

- Cold stage, with symptoms of chills, headache and giddiness
- Hot stage, with high fever, increase in breathing rate & pulse rate
- Sweating stage, with symptoms of profuse sweating with body temperatures receding to normal

In some cases relapse of malaria disease takes place when some stages of the plasmodium remain dormant for a longer duration in liver. These dormant forms are called as hypnozoites. These hypnozoites may get reactivated in course of time leading to initiation of fresh erythrocytic cycle and new attack of malaria.

Preventive measures and prophylaxis

Malaria can be controlled by the following methods,

Protection against mosquitoes:

- Spraying of DDT, BHC and other insecticides in the house to kill the mosquitoes
- Fumigation in the dwelling places
- Use of mosquito nets
- its repellents to avoid mosquito bites

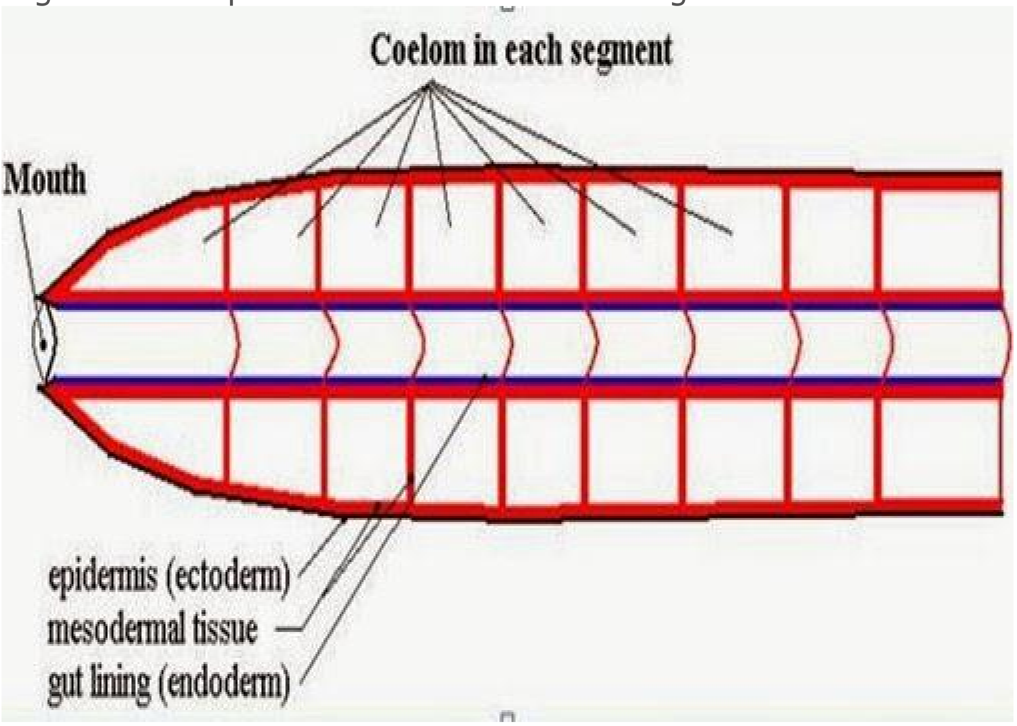
Destruction of mosquito larvae:

- Kerosene and pyrethrum oil are sprayed on the stagnant waters like sewage gutters and ditches were the mosquitoes lay their eggs. The oil film on the water surface affects the respiration of the larvae and the larvae die of suffocation.
- Use of insecticides in the mosquito breeding places to kill the larvae.
- Biological control is one of the most effective methods of destructing the mosquito larvae. Use of larvivorous fishes like Gambusia is one such biological method.

METAMERISM IN ANNELIDA

METAMERISM IS SEEN IN DIFFERENT ANIMALS

The body of Annelids is divided into a number of segments longitudinally. All the segments look alike. They are called metameres and this is called metamerism. In these segments all systems are repeatedly arranged. Usually the metamerism is confined to the trunk region of the organisms. Cephalic and anal regions may not show metameric nature in the caphalic region sense organs are concentrated, where in the anal region new segments are produced in front of anal segment.



1. Metamerism first observed in Annelida in the animal kingdom.

2. The most successful animals of animal kingdom like arthropoda and chordate will also show metameric segmentation.

3. In annelids the metameric segmentation is both external and internal. The body is divided into a number of segments which contain all body organs repeatedly but the alimentary canal is long and straight tube extending through all the segments.

4. In arthropods the segmentation is external.

5. In chordates the segmentation is internal.

Complete and incomplete metamerism:

In annelid, metamerism is complete, affecting practically all the system. The metameres are usually similar or homonomous, each having segmental blood vessels, nerves, nephridia and coelomoducts. If all the metameres are similar throughout the body it is called Homonomous metamerism. But in some groups like arthropoda and chordate, show incomplete metamerism. Because of division of labour, the segments or metameres of different regions of their body become greatly dissimilar. Such metamerism is called "**Heteronomous metamerism.**

(Even in annelids some anterior segments look different. Hence typical homonomous segmentation is not seen in any animal.)

In embryonic stages the metamerism is complete and uniform. But in adult condition it will change due to cephalisation.

Origin of metameric segmentation: The origin of metamerism is not clearly known. Many theories were proposed to explain the development of metamerism.

1. Fission theory:

1) Metamerism is derived from non-segmented ancestor, which might have under gone transverse fissions repeatedly and gave metamerism.

2) This theory was improved by Perrier.

3) This theory infers annelids might have developed from Platyhelminthes.

Objections:

1. Because of fission the organism will divide into separate individuals but they will not unite to form a metameric individual.

2. Reproduction by fission is confined to sessile animals but not in free moving organisms.

2. Pseudometamerism theory:

This theory was supported by Hyman & Goodrich.

According to this theory the body parts like coelom, blood vessels, nephridia muscles etc. will be repeatedly formed. In between them septa are formed.

Thus metamerism is derived. This can be seen in some larval forms and adults of some annelids.

3. Embryological theory: In the embryonic stage by some stress in the mesoderm fragmentation is developed which gave metameric segmentation.

4. Locomotory theory:

This theory is a combination of pseudometamerism theory and embryological theory.

It is believed that metamerism is derived as an adaptation to locomotion:

1. In annelids the segmentation is developed as an adoptation for burrowing.

2. In chordates the metamerism is developed as an adoptation for swimming, undulatory movements.

Most probable annelid ancestors were long coelomate organism. In these animals by the development of septa the liquid skeletons and muscles function will be localised and is advantageous for burrowing. Afterwards the nervous system, excretory system etc. are also undergone segmental organization.

In chordates the metameric segmentation of body wall and musculative allow alternate waves of contraction which will help in swimming. Thus locomotion might have caused metameric segmentation in these animals.

Significance of Metamerism :

1. Metameric segmentation helps the animals in their locomotion. The coordination of muscular action and fluid filled coelomic compartments cause efficient swimming and creeping which is an advancement over the simple ciliary and creeping movement of lower invertebrates. Fluid-filled coelomic compartments also provide hydrostatic skeleton for burrowing.

2. The segments will show high structural development which gave scope for evolution.

Economic Importance of Annelida

Economic Importance of Earthworm

Useful Affairs of Earthworms:

The earthworms are better known as the friend of farmers due to the following reasons:

1. The earthworms improve the fertility of soil in different ways and, therefore, they are of utmost importance in agriculture. Actually, the burrowing and soil feeding habits of earthworms make the soil porous which permit both aeration and quick absorption of water. It also permits easy and deep penetration of the plant roots.

They also bring the fresh subsoil to the surface which is still finer and rich in organic matters. Charles Darwin has estimated that an acre of earth is inhabited by nearly 50,000 earthworms (a recent estimate suggests that their number may reach up to 25, 00,000 per acre) which may bring more than 18 tons of deeper subsoil to the surface in one year.

This may in 20 years form a layer of 7.5 cm thick surface on the earth in the form of their castings. The castings of earthworm contain fine soil having mixed with its nitrogenous wastes and faeces of nice manurial value. The faeces of earthworm contain nitrate, calcium, magnesium, potassium and phosphorus which constitute an important component of the humus essential for plant growth.

They also reduce the alkalinity and acidity of the soil to provide better conditions for plant growth. After their death and decomposition, they increase the organic constituents of the soil. Thus, the earthworms make the soil fertile to a great extent. Thus, these worms are also known as natural ploughmen or tillers of the soil.

2. These are used as bait and food. As bait they are used in fishing. The earthworms were used as food by so many uncivilized people of the world and they are still used as food by Macrea people. The earthworms are eaten upon by frogs, toads, moles, hedgehogs and birds which are of many uses to mankind.

3. Many people earn their livelihood by catching these worms and supplying to scientific laboratories.

4. Ayurvedic and Unani system of therapy suggests that these worms were used in making medicines for the cure of diseases like bladder stones, jaundice, pyorrhoea, piles, rheumatism, etc. Even today, these are used in making various medicines of vital importance in India as well as other countries.

Harmful Affairs of Earthworms:
They may damage young and tender plants by eating them bit by bit. They also damage the grass lands by making tunnels in the ground when present in huge numbers. They are also said to help soil erosion. Some earthworms act as secondary hosts for the completion of life stages of some parasites which are directly or indirectly harmful to mankind.

Economic importance of Polychaeta :

1. As food: The sexual parts or epitoke of palolo worms are used as food by the native people. Epitokes are highly nutritive consisting of almost pure yolk-laden eggs.

2. Transporter of soil: Lugworm (Arenicola) is a transpoter of soil and considered even more effective than the common earthworm.

3. Fish bait: Arenicola is one of the commonest bait for certain fish. Other polychaetes used are species of Neanthes and Glycera.

4. Reef-building agents: Some sand and lime –concreting tubicolous polychaetes are important reef-building agents in some parts of the world.

5. Harmful polychaetes: Species of Polydora are oyster-pets, causing mud blisters in the nacreous layers of shells and making the oysters unfit to be sold. Some sedentary polychaetes cause fouling on the bottoms of ships,

dikes and other harbor installations. They cause destruction to the building materials and add to the submerged weight resulting in lessening of speed of vessels. Species of Fireworms Odontosyllis are large polychaete worms, about 30cm long, found along tropical shores, are injurious to people.

Importance of Medical Leeches

Because of their important salivary components, blood-sucking leeches, such as Hirudo medicinalis, have engendered great interest for anticoagulants to prevent blood clotting during microsurgeries. Scientific research reveals that the beneficial effects of leeching, in addition to decongestion, include injection of a cocktail of several medicinally useful bioactive molecules present in their saliva. Owing to its therapeutic potential, the research is continuing as many new salivary compounds are being isolated and synthesized.

Despite the historical variations in leech therapy, the art of leech therapy remains useful to modern medicine. The spectrum of pharmacological activities of leech saliva is vast. Using recombinant DNA technology, scientists are exploring the potential of other therapeutically active compounds. Pharmaceutical companies are seeking to expand their repertoire of leech salivary components as anticoagulants. Identification of the neurite-stimulating activity of the salivary components provides new therapeutic agents for the treatment of neurodegenerative diseases. Further search for biologically active compounds from the saliva of other sanguivorous leech species, including Hirudinaria granulosa (Indian medicinal leech) or Hirudinaria manillensis, is warranted.More medicinal compounds will undoubtedly be discovered in the future. In addition, the therapeutic concentration of these compounds is yet to be determined.

METAMORPHOSIS IN INSECTS:

Transformation of an immature larval individual into asexually mature reproducing adult of very different form, structure and habit, is called metamorphosis.

Types of metamorphosis:

1. No-metamorphosis or Ametabolous development.

In case of no-metamorphosis, newly hatched creature looks like an adult except in size and differences in armature of spines and setae. Examples: Silver-fish, Spring-tail.

2. Incomplete metamorphosis or Hemi-metabolous development.

In case of incomplete metamorphosis, immature stages are the nymphs or naids, which are aquatic and respire by tracheal gills, whereas the adults are terrestrial or aerial and respire by tracheae.

Examples: Mayflies, Dragonflies, Stone-flies.

3. Gradual metamorphosis or Pauro-metabolous development.

In case of gradual metamorphosis, the newly hatched creature resembles an adult in general body form, but lacks wings and external genital appendages. Young or the nymph undergoes several nymphal stages through successive moultings to become an adult.

Examples: Grasshoppers, Aphids, Stink bug.

4. Complete metamorphosis or Holometabolous development.

This type of metamorphosis includes four developmental stages – egg, larva, pupa and adult. Larva, after hatching, moults several times to become a fully grown one. It later becomes a pupa within a secreted case, called the puparium. Pupa differentiates into the young adult that breaks the puparium open and emerges outside. It grows to a mature form.

Examples: Housefly, Mosquitoes,butterfly.

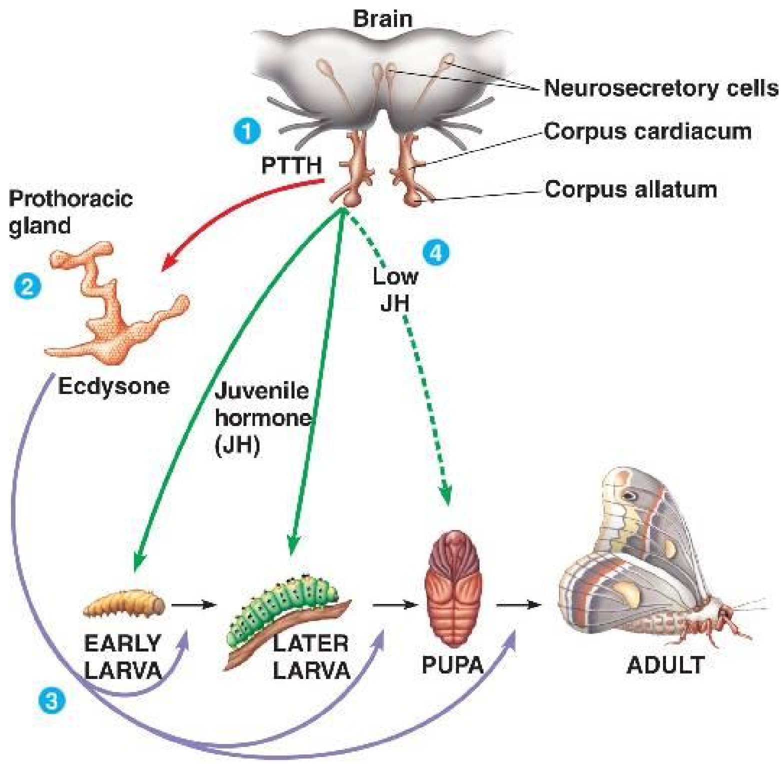
Hormonal control of Metamorphosis:

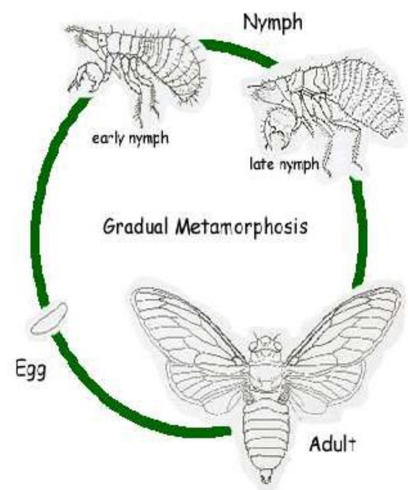
1. Brain hormone (BH): It is secreted by the neurosecretory cells of the brain. Chemically it is alipid. This hormone serves to activate the corpora cardiac, a component of the retro-cerebral complex of the stomatogastric nervous system.

2. Prothoracicotropic hormone (PTTH): This hormone is secreted by the corpora cardiac, which in turn stimulates the prothoracic glands.

3. Prothoracic glang hormone (PGH):This hormone is secreted by the paired, bilateral sheet of cells in the thorax, constituting the prothoracic glands. Chemically it is ecdysone. This hormone is known to trigger moulting as it acts on the tissues to promote all of the changes characterizing a moult.

4. Juvenile hormone (JH): This hormone is secreted by another component of the retrocerebral complex, the corpora allata. Chemically it is an unsaponifiable, non-sterolic lipid. This hormone regulates morphogenesis and so promotes metamorphosis, that is development of the larva into adult through pupal stage.





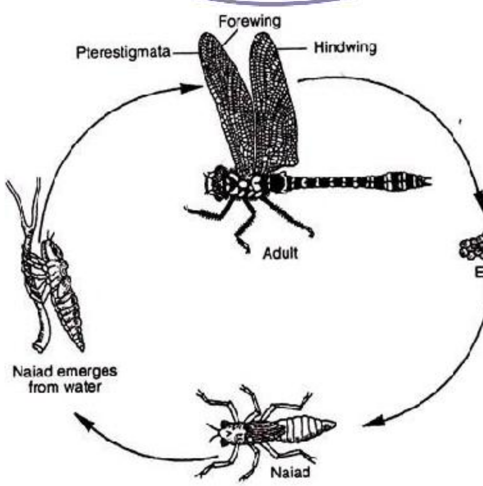


Fig. 18.136: Hemimetabolous metamorphosis in dragon fly.

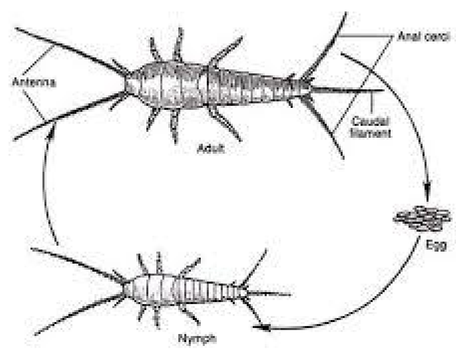


Fig. 18.134: Ametabolous development in *Lepisma*.

Nutrition and Protozoa :

Nutrition: Mode # 1. Holozoic or Zoo-Trophic Nutrition:
Majority of Protozoa nutrite holozoically, i.e., like animals on solid food. The food of Protozoa consists of microorganisms like bacteria, diatoms, rotifers, crustacean larvae, other protozoans, algae, small fragments of large animals and plants, etc. This mode of nutrition essentially involves the processes like intake of food, i.e., ingestion, digestion, absorption and egestion of undigested residues.

Mode # 1. Holozoic:
(holos = whole + zoon = animal). Most of the free-living protozoon's depend on engulfing the whole of the solid food particle.

The food capturing devices are of the following types:

a. Circumvallation:
Encircling the active prey by pseudopodia. Example: Amoeba proteus (Fig. 18.14A).

b. Invagination:
The prey is immortile, food cup is formed and cytoplasm flows around to engulf it. Example: Amoeba dubia (Fig. 18.14B).

c. Import:
The prey is first killed by toxin and taken in the cytoplasm by invagination. Example: Amoeba sp. (Fig. 18.14C).

d. Circumfluence:
Food like algae is simply drawn into the body. Example: Amoeba sp. (Fig. 18.14D). The digestion mostly occurs in food vacuoles, in which acids or alkalis and digestive enzymes are secreted by the surrounding cytoplasm. Nutrients are absorbed by the cytoplasm and the undigested portion of the food in the vacuole is egested by repulsion (Amoeba), or through anal aperture or cytopyge (Paramoecium, Nyctotherus, etc.).

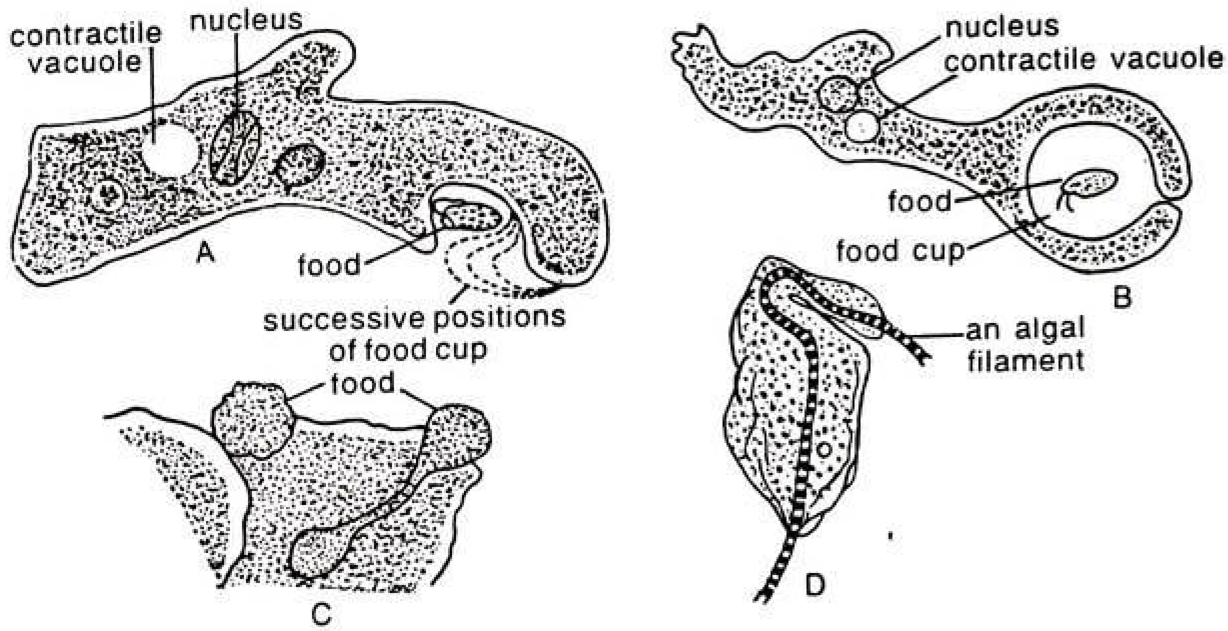


Fig. 18.14. Feeding in lobose rhizopods. (Amoeba sp.) : A Circumvallation. B. Invagination (food cup). C. Import. D. Circumfluence.

Ingestion:

The mode of food ingestion in Protozoa is characteristically referred to as phagocytosis or phagotrophy. In fact, in flagellates which are colourless or who have lost their chromatophores capture food with the help of their flagella.

The captured food is ingested either at definite sites on their naked bodies like Budo or through characteristic oral apparatus like Euglena where cytostome and cytopharynx help in ingestion. In some other flagellates like Peranema, special rod-like structures called trichites help in capturing the food.

In Sarcodina, pseudopodia help in food capturing by forming food cups. Rhumbler (1930) has reported that the ingestion of food in Amoeba occurs by circumvallation, circumfluence, import and invagination. Different types of pseudopodia like axopodia in heliozoans and radiolarians; reticulopodia in foraminifera’s also help in catching the prey.

In ciliates like Paramecium, the feeding apparatus is well developed with a definite cytostome. The cytostome is usually present at the base of the oral groove leading into the cytopharynx. The feeding apparatus is provided with some specialised cilia. The beating of the cilia of cytopharynx creates a whirl pool of water current. The food particles in the water current are directed into the cytopharynx through cytostome.

The mode of feeding in suctorians is very characteristic; they feed with the help of their tentacles which are mostly knobbed at their tips (Fig. 23.6A). Each tentacle consists of a central tubular canal surrounded by a contractile sheath. The prey, as and when comes in contact with the tips of tentacles, soon gets adhered and paralyzed by some toxin secreted by the suctorian.

The prey's cytoplasm is then gradually sucked into the suctorian body through the central tubular canal of the tentacles.

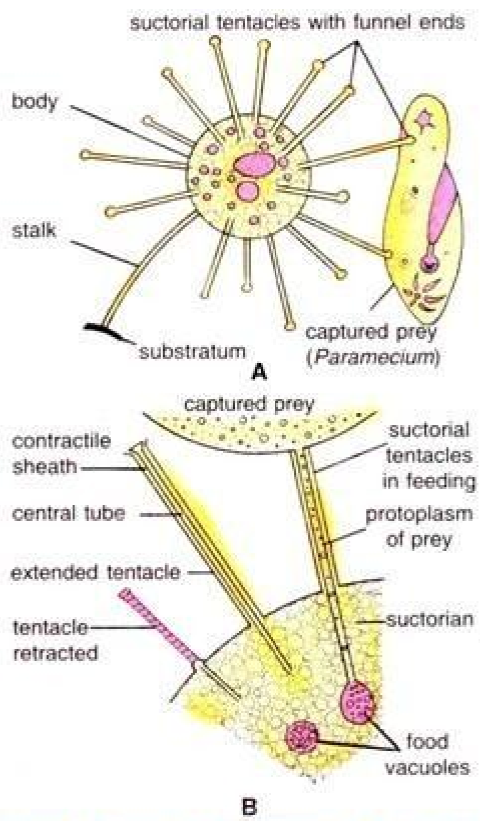


Fig. 23.6. Mode of feeding in *Suctoria*. A—*Podophrya* (a suctorian) sucking *Paramecium* (prey). B—Prey's cytoplasm flowing through tubular tentacle in suctorian's body.

Digestion:

Digestion in Protozoa is intracellular within food vacuoles. The food vacuoles undergo changes in pH and in their size during digestion. At first the contents of the food vacuole are acidic and the vacuoles decrease in size, during this phase living prey dies.

After the initial acid phase the cytoplasm of the protozoan produces enzymes in an alkaline medium, the enzymes pass into the food vacuoles and the vacuoles increase in size and become alkaline.

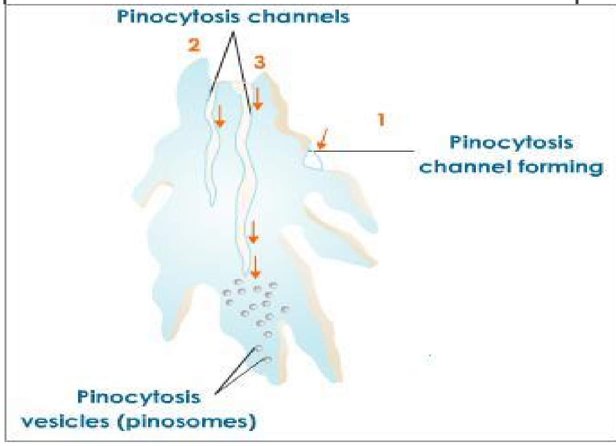
Then the contents of the vacuoles are digested. In fact, proteolytic and carbohydrate digesting enzymes are reported in Protozoa; the proteins are converted into dipeptides in acidic medium and the dipeptides into amino-acids in alkaline medium. The carbohydrates are hydrolysed in alkaline medium. The fat digesting enzymes have also been reported in some Protozoa.

Absorption and Assimilation:
The digested food from the food vacuole is diffused out into the endoplasm and finally assimilated in the body to manufacture the protoplasm. The excess of food is stored in form of glycogen paramylon, Para glycogen bodies in the endoplasm.

Egestion:
The un-digestible remains of the food are egested out from the body at anybody surface, e.g., in Amoeba. But ciliates possess a definite opening for the egestion of undigested remains called cytoproct or cytopyge.

Nutrition: Mode # 2. Pinocytosis:
Pinocytosis or cell-drinking has also been reported in some Protozoa like Amoeba proteus, and also in certain flagellates and ciliates. It is related to the ingestion of liquid food by invagination of the general body surface. It may occur at any part of the body; during pinocytosis, some pinocytic channels are formed from the outer body surface deep into the body.

The inner ends of these channels' contain pinocytic vesicles or pinosomes which get separated after engulfing liquid food through the channels. The separated pinosomes become the food vacuoles. This process is induced in presence of certain salts and some proteins



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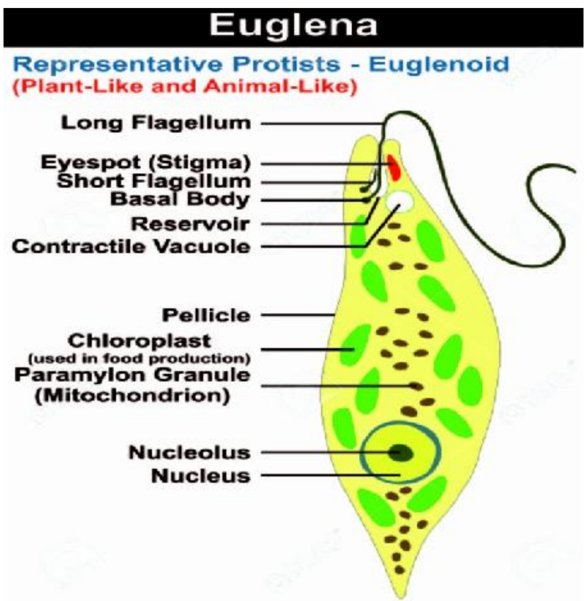


Nutrition: Mode # 3. Autotrophic or Holophytic Nutrition:

Protozoa with chlorophyll or some allied pigment can manufacture complex organic food, like those of green plants, from simple inorganic substances, e.g., Euglena, Noctiluca. Often there may be protein bodies called pyrenoids which are the centres of photosynthesis.

Some Protozoa have no chromatophores but they have chlorophyll-bearing algae Zooxantliellae or Zoochldrellae which manufacture organic food for the host by photosynthesis, e.g., Stentor, Thalassicola, Paramecium bursaria. Nitrates or ammonium compounds are sufficient as the source of nitrogen for autotrophic forms.

Nutrition: Mode # 4. Saprozoic Nutrition:
Some Protozoa absorb complex organic substances in solution through the body surface by the process of osmosis called osmotrophy. These Protozoa are called saprozoic. Saprozoic forms need ammonium salts, amino acids, or peptones for their nutritional requirements. Decaying of animals and plants in water forms proteins and carbohydrates.

The saprozoic Protozoa are usually parasites like Monocystis. But some parasites, like Entamoeba histolytica and Balantidium coli feeding holozoically also absorb dissolved organic substances through their general body surface. However, some colourless flagellates like Chilomonas, Polytoma and species of Euglena absorb nutrients from their surrounding environment through their general body surface.

Nutrition: Mode # 5. Parasitic Nutrition:
The parasitic forms feed either holozoically or saprozoically.

Thus, the parasites may be grouped into two categories on the nature of food and their mode of feeding:
(i) Food-robbers:
The parasites feeding upon the undigested or digested foodstuffs of their hosts are known as food-robbers, such as some ciliate parasites like Nyctotherus, Balantidium. These parasites feed holozoically on solid food particles, while few others like Opalina feed upon the liquid food by the process of osmosis through their general body surfaces. The food-robbers are generally non-pathogenic to their hosts.

(ii) Pathogenic:
The protozoan parasites causing harm to their hosts, usually feed upon the living tissues of the host. They absorb liquid food through their general body surface, e.g., Trypanosoma, Plasmodium, etc.

Nutrition: Mode # 6. Coprozoic Nutrition:
Certain free-living protozoans are in habit of feeding upon the faecal matters of the other organisms like Clamydophrys and Dimastigamoeba.

Nutrition: Mode # 7. Mixotrophic Nutrition:

Some Protozoa nourish themselves by more than one method at the same time or at different times due to change in environment. This is called mixotrophic nutrition, e.g., Euglena gracilis and Peranema are both saprozoic and autotrophic in their nutrition, and some flagellates are both autorophic and zootrophic.

However, Protozoa which feed on a large variety of food organisms are called euryphagous, and those which feed only on a few kinds of food are stenophagous.

On the basis of the nature of food and feeding mechanism in Protozoa, they are placed in the following groups:
(a) Macrophagous feeders are those which feed on large pieces of food (Amoeba),

(b) Microphagous feeders are those which feed on very small particles, they rarely stop feeding and their food is drawn in with a current of water (Paramecium).

(c) Fluid feeders are saprozoic and parasitic Protozoa which absorb liquid food through their surface (Monocystis).

Phylum Protozoa: General characteristic and Classification

General Characteristics of phylum Protozoa

1. **Kingdom:** Protista
2. They are known as acellular or non-cellular organism. A protozoan body consists of only mass of protoplasm, so they are called acellular or non-cellular animals.
3. **Habitat:** mostly aquatic, either free living or parasitic or commensal
4. **Grade of organization:** protoplasmic grade of organization. Single cell performs all the vital activities thus the single cell acts like a whole body.
5. Body of protozoa is either naked or covered by a pellicle.
6. **Locomotion:** Locomotory organ are pseudopodia (false foot) or cilia or flagella or absent.
7. **Nutrition:** Nutrition are holophytic (like plant) or holozoic (like animal) or saprophytic or parasitic.
8. **Digestion:** digestion is intracellular, occurs in food vacuoles.
9. **Respiration:** through the body surface.
10. **Osmoregulation:** Contractile vacuoles helps in osmoregulation.
11. **Reproduction:**

- Asexually reproduction is through binary fission or multiple fission or budding.
- Sexual reproduction is by syngamy conjugation.

Classification of Protozoa:

Phylum protozoa is classified into four classes on the basis of locomotary organs

Class 1 Rhizopoda (Sarcodina)

- Locomotary organ: Pseudopodia

- Mostly free living, some are parasitic
- Body naked or with internal shells or external tests.
- Nutrition: Holozoic or pinocytosis.
- **Reproduction:** asexually by binary fission and sexually by syngamy.
- No conjugation.
- Examples: *Amoeba, Entamoeba, Arcella*

Class 2 Mastigophora/ Flagellata

- Locomotory organ: Flagella
- Free living or parasite.
- Body covered with cellulose, chitin or silica.
- Nutrition autotrophic, heterotrophic or mixotrophic.
- Reproduction: Asexual reproduction by longitudinal fission.
- No conjugation.
- Examples: *Giardia, Euglena, Trypanosoma*

Class 3 Sporozoa

- Locomotory organ: Absent
- Exclusively endoparasites, Nutrition saprozoic.
- Contractile vacuoles is absent
- Body covered with pellicle.
- Reproduction: Asexual reproduction by fission and Sexual reproduction by spores
- Examples: *Plasmodium, Monocystis*

Class 4 Ciliata

- locomotary organ: Cillia
- Body covered by pellicle.
- Nutrition is Holozoic.
- Reproduction: Asexual reproduction by binary fission. Sexual reproduction by conjugation.
- Nuclei two types i.e. macronucleus and micronucleus.
- Examples: *Paramecium*, *Vorticella, Blantidium*

Phylum Porifera: General characteristics and Classification

General characteristics of Phylum Porifera

1. **Kingdom:** Animalia
2. **Habitat:** Aquatic, mostly marine, few are terrestrial
3. **Habit:** They are solitary or colonial.
4. **Grade of organization:** cellular grade of body
5. **Shape:** Body shape is variable, mostly cylinder shaped
6. **Symmetry:** Asymmetrical or radially symmetrical.

7. **Germ layer:** Diploblastic animals. The adult body wall contains two layers, outer dermal layer and inner gastral layer. In between these two layers, there is a gelatinous and non-cellular mesoglea containing numerous free amoeboid cells.
8. **Coelom:** Absent; acoelomate but spongocoel is present
9. Surface of the body has numerous perforation called ostia (for the entry of water) and a large pore at the apex called osculum (for the exit of water).
10. Water canal system present
11. **Endoskeleton**: Either calcareous spicules (calcium carbonate) or siliceous spicules (silica) or sponging fibers (protein).
12. **Nutrition:** holozoic
13. **Digestion:** Intracellular
14. **Nervous system:** absent
15. **Circulatory system:** absent
16. **Reproduction:**

- **Asexual:** by budding or gemmule or regeneration
- **Sexual: g**amatic fusion

17. **Fertilization:** Internal

Classification of Phylum Porifera

Based on the type of skeleton system the phylum Porifera is divided into three classes

Class 1: Calcarea or Calcispongiae

(calcarius: lime / calcium))

- Habitat: Exclusively marine
- Habit: Solitary or colonial nature.
- Endoskeleton: calcareous spicules composed of calcium carbonate
- Symmetry: Radially symmetry
- Shape: Cylindrical shape
- Examples: Sycon, *Leucosolenia*

Class 2: Hexactinellida or hyalospongiae:

(Hex: six, actin: ray, idea: terminal)

- Habitat: Exclusively marine (deep sea)
- Habit: Solitary in nature.

- Endoskeleton: six- rayed siliceous spicules.
- Symmetry: Radially symmetry
- Shape: Cylindrical shape.
- Examples: *Euplectella*, *Hyalonemma*

Class 3: Demospongiae

(Demos: frame)

- Habitat: Mostly marine and some are freshwater
- Endoskeleton: Siliceous spicules or sponging fibres or both or none.
- The spicules are monaxon or tetraxon but never six-rayed.
- Symmetry: asymmetrical.
- Shape: Irregular
- Canal system complicated.
- Spongocoeal is totally absent.
- Examples: *Spongilla*.

Phylum Coelenterata: General Characteristic and Classification

General characteristics of Phylum Coelenterata

1. Kingdom: Animalia
2. Habitat: aquatic, mostly marine.
3. Habit: solitary or colonial. Each individual is known as zooid.
4. Symmetry: radially symmetrical
5. Grade of organization: tissue grade of organization.
6. Germ layer: diploblastic, outer ectoderm and inner endoderm. Mesogloea separates these two layer
7. The body has a single opening called hypostome urrounded by sensory tentacles.
8. Coelom: gastrovascular cavity or coelenteron.
9. Nematocyst: organ for capturing and paralyzing pray, present in tentacles
10. Nutrition: holozoic
11. Digestion is both intracellular and extracellular.
12. Respiration and excretion are accomplished by simple diffusion.

13. Circulatory system: absent
14. Nervous system: poorly develop
15. Many forms exhibit polymorphism ie. Polyp and medusa
16. Polyps are sessile, asexual stage
17. Medusa are free swimming, sexual stage
18. Metagenesis: asexual polypoid generation alternate with sexual medusoid generation
19. Reproduction:

- Asexual: by budding
- Sexual: by gamatic fusion

20. Fertilization: internal or external
21. Development: indirect with larval stage
22. (Koilos: hollow, enteron: cavity)

Classification of Phylum Cnidaria/Coelenterata

The phylum coelenterate is divided into three classes on the basis of development of zooids:

Class1: Hydrozoa

(Hydra; water; zoon: animal)

- Habitat: mostly marine, few are fresh water
- Habit: some are solitary and some are colonial
- Asexual Polyps is dominant form
- Medusa possess true velum
- Mesogloea is simple and acellular
- Examples: *Hydra, Obelia, Physalia physalis* (portuguese man of war), Tubularia

Class 2: Scyphozoa or Scyphomedusae

- Habitat: exclusively marine
- Habit: solitary, freely swimming
- Medusa is dominant and it is Large bell or umbrella shaped
- Polyps is short lived or absent
- Mesogloea is usually cellular
- Examples: *Aurelia aurita* (Jelly fishe), *Rhizostoma*

Class 3: Anthozoa or Actinozoa

(Anthos: flower; zoios: animal “flower like animals”)

- Habitat: exclusively marine
- Habit: Solitary or colonial
- Polyp form present and Medusa stage is absent
- Mesogloea contains fibrous connective tissue and amoeboid cells.
- Examples: *Metridium* (sea anemone), *Telesto, Tubipora,*

Phylum Platyhelminthes: General Characteristics and Classification

General characteristics of phylum Platyhelminthes

1. (Platys: flat; helminthes: worms)
2. Kingdom: Animalia
3. Habitat: mostly parasitic, few are free living in sea water or fresh water
4. Grade of organization: Organ- system grade of organization
5. Symmetry: Bilateral symmetry and Body is dorso-ventrally flattened
6. Germ layer: Triploblastic. Ectoderm is very specialized with distinct epidermis
7. Coelom: Absent (acoelomate).
8. Digestive system: incomplete or absent

- No mouth (oral opening directly into pharynx).
- No true stomach structure (pharynx opens into a complex “intestinal” structure).
- In tapeworms, Direct absorption of soluble nutrients by cells and tissues.

8. Excretory system: Protonephridia with Flame cell
9. Respiration: by simple diffusion of gases through body surface
10. Circulatory system: Absent
11. Reproduction

- Sexual: by gamatic fusion in hermaphrodite species
- Asexual : by regeneration and fission

12. Fertilization: internal.
13. Life cycle is complex involving one or more hosts.

Classification of Phylum Platyhelminthes

Phylum Platyhelminthes is divided into three classes on the basis of body shape, mouth position and habitat

Class 1 Turbellaria

- Mostly Free-living fresh water organism
- Body: Unsegmented, dorsoventrally flattened and covered with ciliated epidermis.
- Mouth is ventral side and intestine is produced by muscular pharynx.
- Hooks and suckers are usually absent
- Examples: *Planaria, Bipalium.*

Class 2 Trematoda

- Mostly parasitic
- Body: Unsegmented, dorso-ventrally flattened leaf like
- Hooks and suckers are present
- Alimentary canal with mouth, simple pharynx and two main branches of intestine.
- Examples; *Fasciola hepatica* (Liverfluke), *Schistosoma*.

Class 3 Cestoda

- Exclusive parasitic
- Body: dorso-ventrally flattened, elongated, tape like
- Hooks and suckers are present
- Digestive system-absent
- Excretion: Protonephridia with flame cell
- Examples: *Taenia spp* (tapeworm) *Echinococcus.*
-

Phylum Aschelminthes/Nemathelminthes: General characteristics and classification

General characteristics of Phylum Aschelminthes

1. Gr. Askos: cavity; helmins: worms. Nema: thread, helmins: worms
2. Habitat: They are marine or freshwater animal.

3. Habit: They are endoparasite.
4. Coelom: Pseudocoelomate which means they have a cavity called pseudocoel between the gut and body wall.
5. Symmetry: bilateral
6. Germ layer; triploblastic
7. Grade of organization: Organ system grade
8. They are non-segmented round worm.
9. Their body is covered with cuticle.
10. Digestive system: simple type
11. The mouth is provided with hooks and suckers
12. Respiratory system: Absent
13. Circulatory system: Absent
14. Nervous system: poorly developed
15. Excretory system: Protonephridia and canals
16. They are unisexual or dioecious animals
17. Reproduction: sexual by gamatic fusion
18. Fertilization: internal

Classification of phylum Aschelminthes/Nemathelminthes

Aschelminthes is classified into five classes

Class 1 Nematoda (Nema: thread)

- They are endoparasites
- Body is Bilaterally symmetrical and vermiform.
- Body covered in a complex cuticle.
- Sexes are separate
- Examples: *Ascaris* (round worm), *Ancyclostoma* (hook worm), *Enterobius* (pinworm)

Class 2 Rotifera

- They are minute microscopic aquatic
- Sexes are separate
- Excretion: two protonephridia tubes
- Examples: *Brachionus, Colotheca, Philodina*

Class 3 Gastrotricha

- They are minute aquatic free living
- Sexes are separated or united
- Excretory organ: present or absent
- Examples: *Urodasys, macrodasys, Chaetonotus*

Class 4 Kinorhyncha

- Minute microscopic marine
- Body is internally segmented
- Sexes are separates
- Development: indirect (with larval form)
- Examples: *Echinoderes, Centroderes*

Class 5 Nematomorpha

- They are long slender un-segmented worm
- Known as hair worm
- Sexes are separate
- Examples: *Nectonema, Gordius*

Annelida: General Characteristics and Phylum Classification

General characteristics of Phylum Annelida

1. (Annelus: little ring)
2. Kingdom: Animalia
3. Habitat: mostly aquatic, some are terrestrial
4. Habit: free living
5. Symmetry: bilateral symmetry
6. Coelom: coelomate (Body cavity is a true coelom, often divided by internal septa)
7. Body is metamerically segmented
8. Grade of organization: organ system grade
9. Germ layer: triploblastic

10. Body possesses 3 separate sections, a prosomium, a trunk and a pygidium.
11. Digestive system: complete and developed
12. Respiration: by general body surface
13. Nervous system: nervous system with an anterior nerve ring, ganglia and a ventral nerve chord.
14. Circulatory system: Has a true closed circulatory system.
15. Excretion: by nephridia
16. Reproduction: Sexual and gonochoristic or hermaphoditic.
17. Fertilization: Internal or external
18. Development: direct with no larval stages

Classification of Phylum Annelida

Phylum Annelida is divided into four main classes, primarly on the basis of setae, parapodia, metameres and other morphological features.

Class 1 Polychaeta (Polys: many; chaite:hair)

- Habitat: They are marine, terrestrial, and freshwater.
- Head is distinct with eyes, palps and tentacles.
- Bilaterally symmetry, segmented worm.
- Clitellum is absent..
- Lateral epidermal setae(parapodia) with each segment.
- Dioecious or hermaphroditic.
- Fertilization: external
- Examples: *Nereis* (sandworm), *Sabella*

Class 2 Oligochaeta (Oligos: few, chaite: hair)

- Habitat: mostly terrestrial and few are freshwater
- Body metamerically segmented
- Clitellum present
- Hermaphrodite but cross fertilization occur
- Fertilization: external
- Cocoon formation occur
- Examples: *Pheretima posthuma* (Earthworm), *Lumbricus,*

Class 3 Hiradinea (Hirudo: leech)

- Habitat: primarily freshwater annelids but some are marine, terrestrial and parasitic
- The body has definite number or segments(33)
- Both anterior and posterior ends of body with suckers.
- The tentacles, parapodia and setae are totally absent.
- They are hermaphrodite.
- Fertilization: internal and a larval stage is absent.
- Examples: .*Hirudinaria* (Leech)

Class 4 Archiannelida(Arch; first)

- Habitat: They are strictly marine.
- The body is long and worm like.
- The setae and parapodia normally absent.
- They may be unisexual or hermaphrodite.
- The development: indirect forming trochophore larva.
- Examples: .*Protodrillus*. *Dinophilus, Protodrilus*

Phylum Arthropoda: General characteristics and Classification

Gereral Characteistics of Phylum Arthropoda Arthros; Jointed, podos; Foot)

1. Habitat: mostly terrestrial, also aquatic
2. Insects are the most successful life form on the planet: they make up more than half of all living things on Earth
3. Body has Three-part: head, thorax, abdomen.
4. Body is metamerically segmented
5. Three pairs of jointed legs (6 legs).
6. Compound eyes which contain several thousand lenses leading to a larger field of vision.
7. They possess two antenna.
8. Symmetry: bilateral
9. Germ layer: triploblastic
10. Grade of organization: organ system grade
11. Coelom: hoemocoel
12. Chitinous (hard) exoskeleton, no bones or a skeleton

13. Respiratory system: by general body surface, by gills, tracheae or book lungs
14. Circulatory system: open type with dorsal heart.
15. Excretion: malpighian tubules or green gland
16. Nervous system: dorsal brain with ventral nerve cord
17. Sexes are separate. Sexually dimorphism is present
18. Fertilization: internal.
19. Development: direct or indirect with larval stages.

Classification of Phylum Arthropoda

Arthropoda is classified into five classes on the basis of body divisions, body appendages, habitat, organs of respiration and modes of excretion.

Class 1 Crustacea (Crusta: shell)

- Habitat: They are mostly aquatic, few are terrestrial and very few are parasitic.
- Head is often fused with thoracic segments to form cephalothorax, covered by carapace.
- Thorax and abdomen have a pair of biramous appendages in each segment.
- Respiration: through the gills or general body surface.
- Excretory organs are modified coelomoducts which may either maxillary glands or antennary glands.
- Examples: *Cancer* (crab), *Palaemon* (Prawn), *Daphnia* (water flea) etc.

Class 2 Myriapoda (Myrios: ten thousand; podos: foot)

- Habitat: Mostly terrestrial.
- Many appendages: Body is long with numerous segments each having one or two pairs of legs.
- Head is distinct with antennae, a pair of eyes and two to three pairs of jaws.
- Excretion: by malpighian tubules.
- Respiration: by trachea.
- Examples: *Julus* (Millipede), *Scolopendra* (Centipede).

Class 3 Insects

(Insectus: divided)

- Habitat: Mostly terrestrial and rarely aquatic
- Body divided into three regions: head, thorax and abdomen.
- Thorax has three segments, each bearing a pair of leg and a pair of wings found on second and third segments.
- Abdomen has 7-11 segments without appendages.
- Respiration: by tracheae, gills etc.
- Excretion: usually by malpighian tubules.
- Examples; *Pieris* (Butterfly), *Periplaneta* (Cockroach), *Tabernus* (Housef ly), Mosquiotes, Ants, etc.

Class 4 Arachnida (Arachne: spider)

- Habitat: mostly terrestrial and rarely aquatic
- Body is usually divided into cephalothorax and abdomen.
- There are four pairs of legs attached to the cephalothorax.
- Respiration: by tracheae or book lungs or gills.
- Excretion: by malpighian tubules or coxal gland or both.
- Examples: *Aramea* (Spider), *Palamnaeus* (Scorpion), *Limulus* (King Crab), etc

Class 5 Onychophora (Onychos: claw; phoros: bearing)

- Habitat: mostly terrestrial
- Small sized arthropods
- Terresrial,primitive,worm like, body is segmented
- Single pair of antenna, eyes and jaws.
- Many unointed clawed legs are present.
- Respiration: by tracheae.
- Excretion: by nephridia
- Examples: *Paripatus*

Phylum Echinodermata: General Characteristics and Classification

General characteristics of Phylum Echinodermata

1. (Echinos: Spines; derma: Skin)

2. Kingdom: Animalia
3. Habitat: These are exclusively marine
4. Grade of organization: organ system grade
5. Germ layer: triploblastic
6. Symmetry: Adults are radially symmetrical while the larvae are bilaterally symmetrical.
7. Coelom: present (coelomate)
8. Body without segmentation
9. The shape of the body is flat, star like, spherical or elongated.
10. Head is absent
11. Presence of tube feet
12. Presence of water vascular system
13. Mouth is present on ventral side while anus is present on dorsal side
14. Respiration: by papule, gills or clocal respiratory tree
15. Nervous system: absent, they are brainless organism.
16. Circulatory system: is reduced, heart is absent
17. Blood has no pigment.
18. Digestive system: complete
19. Excretory system: absent
20. Sexes: mostly dioecious, rarely monocious
21. Reproduction:

- Sexual: by gamatic fusion
- Asexual: regeneration

22. Fertilization: external
23. Development: indirect with characteristic larvae

Classification of phylum Echinodermata

It is divided into 5 classes:

Class 1 Asteroidea: (Aster =Star + eidos = form)

Body is flattened star shaped with five arms

- They possesses tube feet with a sucker
- Presence of calcareous plates and movable spines.
- Respiratory organ: papulae

- Examples: *Asterias* (Star fish), *Astropecten, Zoraster, Oreaster*

Class 2 Ophiuroidea

- Body is flat with pentamerous disc
- They possess a long arm which is sharply demarcated from the central disc.
- They possesses tube feet without sucker
- Anus and intestine are absent
- Respiratory organ: Bursae
- Examples: *Ophiderma, ophiothrix, Astrophyton, Amphuria,* etc

Class 3 Echinoidea

- Body is disc-like hemi-spherical
- They are devoid of arms or free-rays.
- They possesses tube feet with a sucker.
- They possess compact skeleton and movable spines.
- Examples: *Echinus* (Sea urchin), *Cidaris, Arbacia, Echinocardium. Diadema*

Class 4 Holothuroidea

- Body is elongated in the oral-aboral axis and it is like cucumber.
- They have no arms, spines and pedicellariae.
- The tube feet are sucking type which is modified into tentacles and form a circle around mouth.
- Respiratory organ: cloacal respiratory tree
- Examples: *Cucumaria* (Sea cucumber), *Holothuria, Mesothuria,* etc

Class 5 Crinoidea

- Body is star shaped
- Some of the forms were extinct and living forms.
- Arms bifurcated, with two pinnules.
- They have tube feet without suckers
- Examples: *Neometra*, *Antedon, Rhizocrinus*, etc

Hemichordata: Characters and Classification

General Characters of Hemichordata:

1. Solitary and colonial, mostly tubicolous, exclusively marine.

2. Body soft, fragile, vermiform and divisible into proboscis, collar and trunk.

3. Body wall with a single-layered epidermis.

4. Coelom enterocoelous, divisible into protocoel, mesocoel and metacoel.

5. Buccal diverticulum, earlier considered as notochord, present in the proboscis.

6. Digestive tract complete; in the form of straight or U-shaped tube

7. Gill-slits, when present, are paired and one to numerous.

8. Circulatory system simple and well developed; closed type; usually with a contractile heart vesicle and two longitudinal vessels, one dorsal and one ventral, interconnected by lateral vessels and sinuses.

9. Excretion by a single glomerulus situated in the proboscis.

10. Nervous system primitive comprising mainly of an intra-epidermal nerve plexus.

11. Reproduction mostly sexual. Sexes separate or united.Gonads one to several pairs.

12. Fertilisation external. Development mostly indirect through a free swimming tornaria larva. Direct development is also found in some forms.

Classification of Hemichordata:

Class 1. Enteropneusta:

1. Commonly known as **"acorn"** or **"tongue worms."**
2. Solitary and burrowing worm-like marine animals.

3. Body consists of proboscis, collar and trunk; collar without tentaculated arms.

4. Alimentary canal straight; mouth and anus at opposite ends.

5. Numerous pairs of U-shaped gill-slits.

6. Two pairs of hepatic caeca present in the middle of the trunk.

7. Sexes separate; gonads numerous, sac-like.

8. Development with or without tornaria larva.

Examples:
Balanoglossus, Saccoglossus (= Dolichoglossus), Ptychodera.

Class 2. Pterobranchia:
1. Sedentary, solitary or colonial, tubicolous marine animals.

2. Proboscis with ciliated tentacles to produce ciliary feeding currents of water.

3. Collar with two or more tentaculated arms bearing tentacles.

4. One pair of gill-slits or none, never U- shaped.

5. Alimentary canal U-shaped with dorsal anus situated near the mouth at the same end.

6. Sexes separate or united; single or one pair of gonads.

7. Development direct, may or may not include a free swimming larval stage.

8. Asexual reproduction by budding in some.

Examples :
Atubaria, Cephalodiscus, Rhabdopleura.

Reproduction in Protozoa:

Asexual Reproduction in Protozoa:

The mode of reproduction in which there is no union of gametes. In such a case, only one animal can produce new individuals. Protozoa usually reproduces asexually by binary fission and multiple fission.

I. Binary Fission:

The animal divides and two individuals are produced from one:

1. The micronucleus divides into two by a simplified form of mitosis.

2. The macronucleus divides into two by amitosis.

3. The cytoplasm divides into two equal halves by a constriction.

4. The daughter individuals can reconstruct the wanting structures which it does not obtain from the parent. Asymmetrical structures like gullet, peristome of Paramoecim cannot be equally shared by both the daughter individuals.

Binary fission is again of three types:

a. Transverse fission. The animal divides transversely into two. Examples: Amoeba, Paramoecium, etc.

b. Longitudinal fission. The animal splits into two along the long axis of the body. Examples: Euglena, Vorticella, etc.

c. Oblique binary fission. The plane of fission is oblique. Examples: Dinoflagellata, Ceratium, Cochliodinium,. etc.

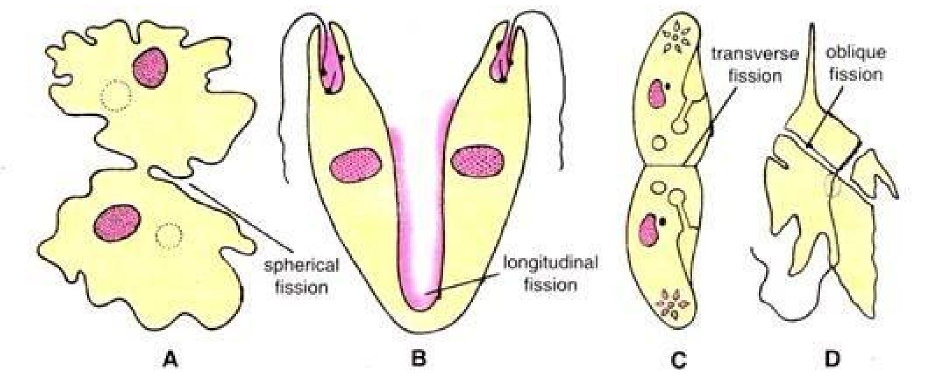
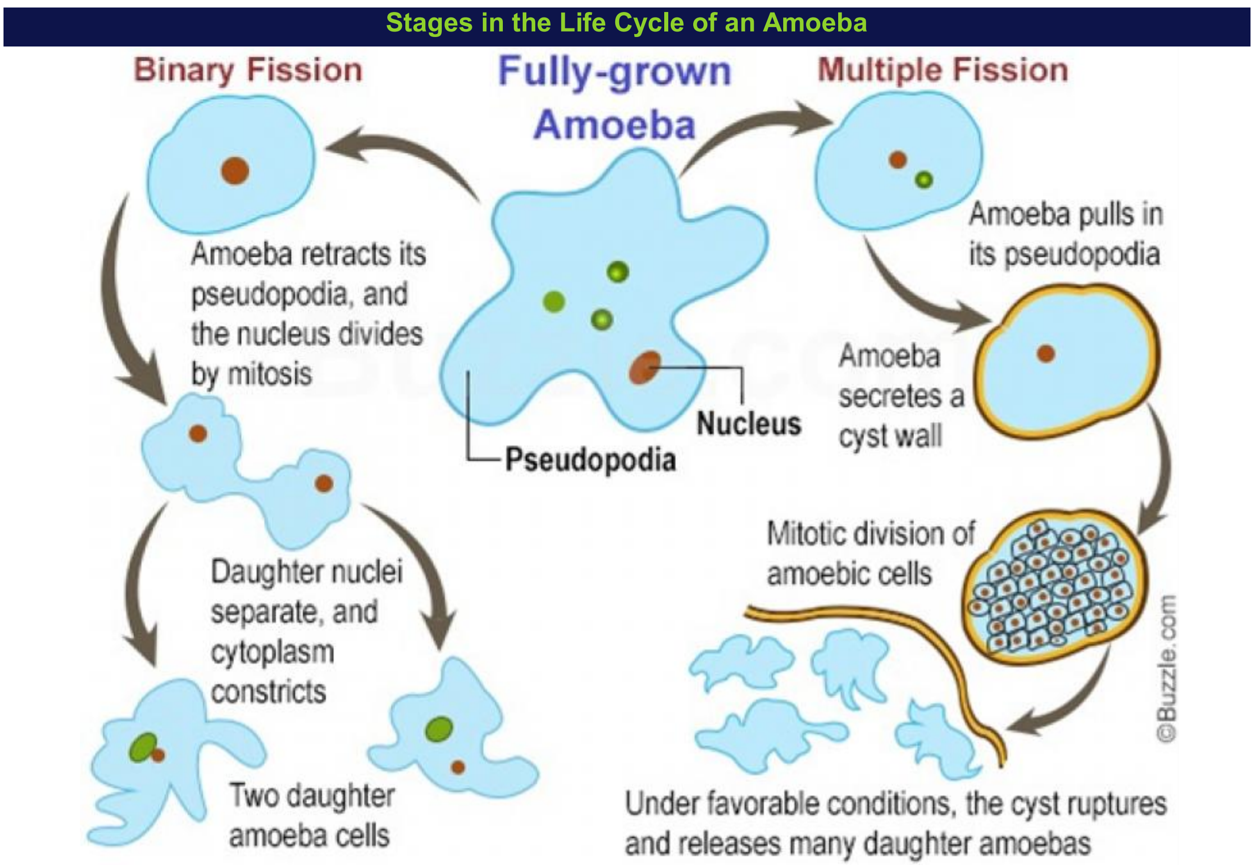


Fig. 23.9. Binary fission in Protozoa. A—*Amoeba* (irregular); B—*Euglena* (longitudinal); C—*Paramecium* (transverse); D—*Ceratium* (oblique).



II. Multiple Fission or Sporulation:

Many individuals are produced from one at a time. Examples: Some Amoebae, Euglena, Polystomella, etc.

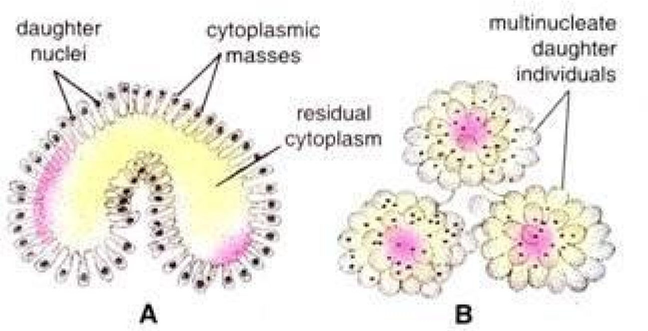


Fig. 23.10. *A*—Multiple fission; B—Plasmotomy.

1. The animal becomes encysted, the nucleus divides repeatedly and a large number of minute daughter nuclei are produced.

2. The cytoplasm fragments and a small bit of it surrounds each daughter nucleus and, thus, many minute animals are formed.

3. Under favourable circumstances the cyst bursts and these small animals come out and grow to the adult stage.

Multiple fission is common in sarcomastigophorans and apicomplexans. The process has been differently named according to the period and time of occurrence.

III. Plasmotomy:

The multinucleate individual divides into many small multinucleate offspring's by simple division of cytoplasm independent of nuclear division. The daughter individuals regain the normal size and the number of nuclei is restored by further nuclear division.

IV. Budding:

New individuals are produced by separation of a portion of the cytoplasm of the parent organism with a daughter nucleus. It may be simple or multiple, exogenous or endogenous. Budding is common in suctorians. Examples: Noctiluca, Tokophrya, etc.

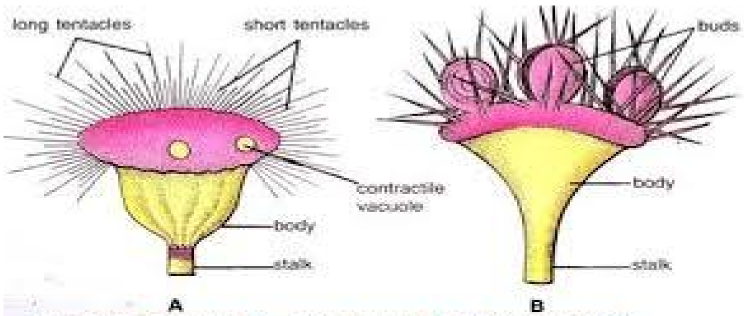
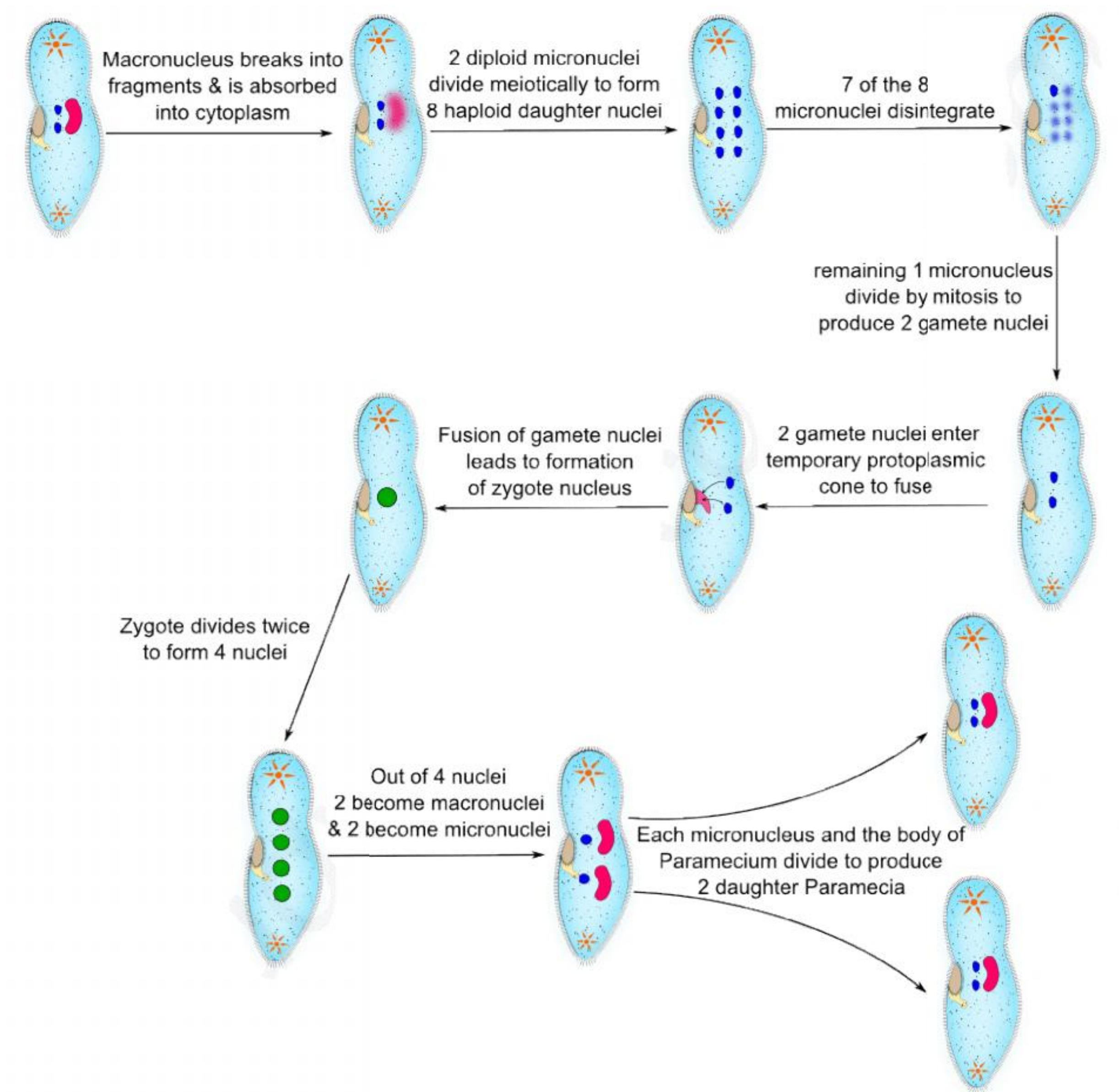


Fig. 22.31. *Ephelota*. A—Entire animal; B—Showing budding.

Sexual Reproduction in Protozoa:

The modes of reproduction in which two gametes unite to form a new individual is known as sexual reproduction. The two units (male and female gametes) from two separate individuals unite by fusion of their cytoplasm, followed by the union of their nuclei. Most protists (protozoa) can continue to live, multiplying asexually for prolonged periods and may undergo sexual reproduction only at irregular intervals.



STEP WISE REPRESENTATION OF AUTOGAMY IN PARAMECIUM AURELIA

Paramoecium aurelia has 1 macronucleus & 2 micronuclei

However, there are many protozoans in which sexual reproduction is of regular occurrence. Sexual reproduction involves meiotic division reducing the chromosomes to haploid number. In majority, reduction division occurs shortly before syngamy. This is called gametic meiosis, in which gametes become haploid.

But in some protozoans reduction division occurs in one of the subsequent divisions after formation of zygote. This is termed as zygotic meiosis, in which only zygote is diploid but rest of the life cycle is haploid. Of different types of sexual reproduction in protozoans syngamy, conjugation, automyxis are important.

I. Syngamy or Sexual Fusion:

Syngamy is the complete and permanent union or fusion of two specialised protozoan individuals or gametes resulting in the formation of a fertilized cell or zygote or oospore. The nuclei of the gametes fuse to form the zygote nucleus or synkaryon. The zygotes develop into adult, either directly or through encystment and fission of various types.

Depending upon the degree of differentiation of the fusing gametes syngamy may be of the following types:

a. Autogamy:

The gametes derived from the same parent cell fuse. Examples: Actinophrys, Actinosphaerium, Paramoecium aurelia, etc.

b. Paedogamy:

The fusing individuals are young. Example: Actinophrys (Fig. 18.15).

c. Hologamy:

The two mature individuals behave as gametes and fuse. Example: Copromonas (18.16).

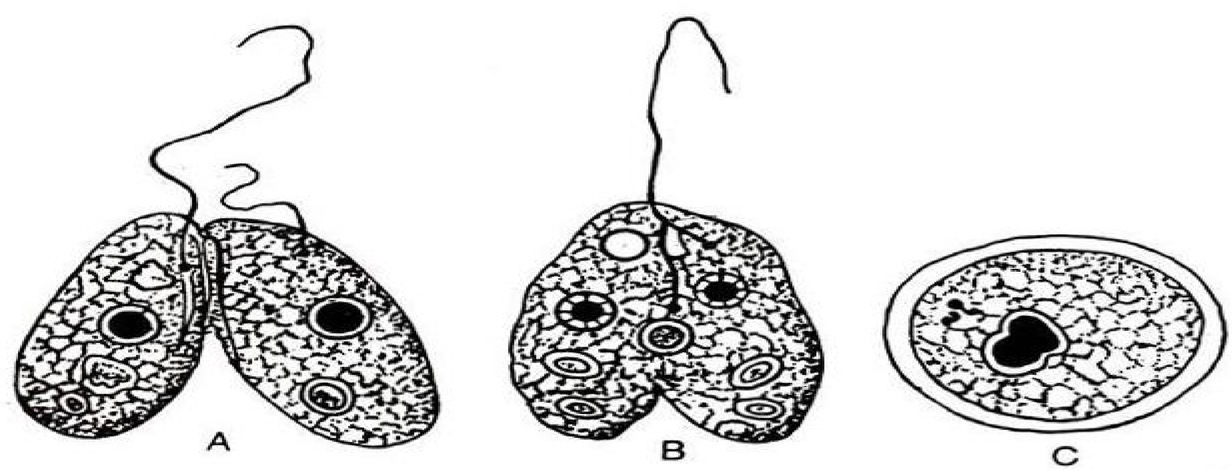


Fig. 18.16. Hologamy in a flagellate capromonas sp. A-B. Fusion of two individuals. C. Encysted zygote

d. Merogamy:

The uniting individuals are smaller than the ordinary vegetative individuals, called merogametes.

e. Isogamy:
Union of the gametes of similar size and shape. The isogametes are produced by multiple or repeated binary fission. Isogamy has been reported in Foraminifera (Elphidium), Phytomonadina (Chlamydomonas, Copromonas) and Gregarinida (Monocystis).

f. Anisogamy:
The two fusing gametes differ in size, shape and behaviour. The gametes are termed as heterogametes or anisogametes and their fusion is known as anisogamy or heterogamy. The formation of morphologically different gametes, is the first indication of sex differentiation in Protozoa.

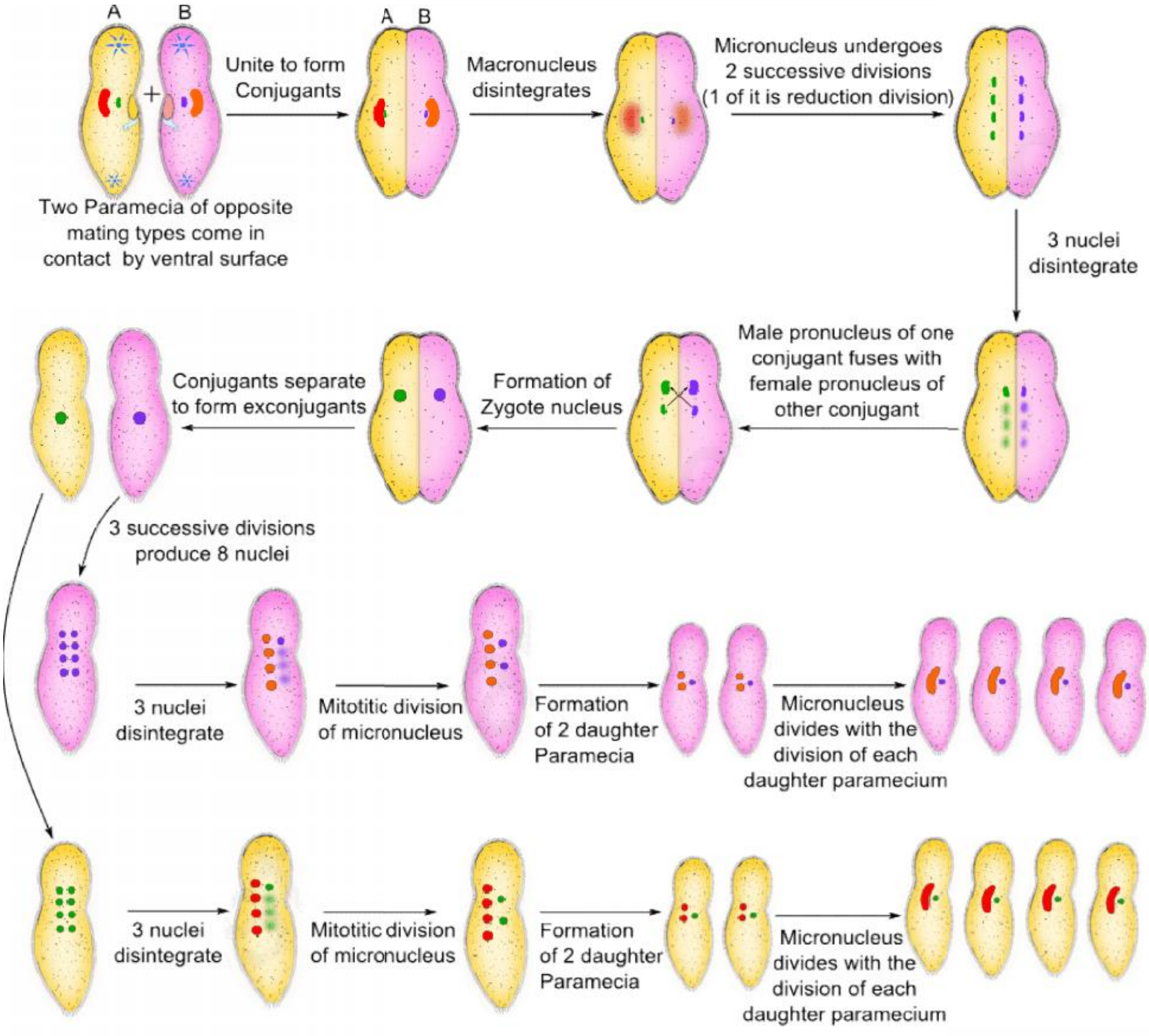
The smaller gametes, the microgametes, or male gametes, are active, motile, generally flagellated and more numerous. They are produced by multiple or repeated fissions.

The fusion of two microgametes is called Micro-gamy. Example: Foraminifera, Arcella, etc. The larger gametes, macrogametes, are immotile, voluminous, and referred to as female gametes. The fusion of two macrogametes is called Macro-gamy. Examples: Plasmodium, Eimeria, Volvox, etc.

The syngamy brings about a combination of two different lines of hereditary characters. It increases the external differences in offspring's. It also renews the vigour which is lost due to repeated binary fissions. The fusion of two nuclei initiates the development of eggs.

II. Conjugation:
The conjugation is the temporary union of two mating types of individuals of the same species to facilitate exchange of nuclear materials. They retain their distinct individuality and separate out after nuclear exchange. The

pairing gametes are known as conjugants. The conjugants may be either isogamous (Paramecium) or anisogamous (Vorticella).



STEP WISE REPRESENTATION OF CONJUGATION PROCESS IN PARAMECIUM

Conjugation is considered to be an episode in reproduction and not a mode of multiplication. In conjugation (i) reorganization of a fresh meganucleus occurs to accelerate the metabolic activities, (ii) rejuvenation and revival of lost vigour, (iii) new nuclear combinations and new hereditary combinations arise.

III. Automixis:

Automixis is the fusion of two gametic nuclei originating by the division of the single nucleus of an individual.

Automixis may be of the following types:

a. Autogamy:

The fusing nuclei come from the same cell as in Paramecium. All the steps in nuclear changes are similar to conjugation but the union occurs between the pronuclei of the same individual.

b. Paedogamy:

The fusion occurs between two nuclei coming from two different cells of a parent. A single organism encysts and then divides into two or more gametocytes. The nuclei of these gametocytes undergo meiosis and the gametes thus produced unite in pairs forming the zygotes. Examples: Actinosphaerium, Actinophrys, myxosporidians, etc.

c. Cytogamy:

In a number of species of Paramoecium the two individuals fuse with their oral surfaces. The nuclear changes occur as in conjugation but no nuclear exchange occurs. The two gametic nuclei in each individual fuse to form synkaryon. Cytogamy is said to be intermediate between conjugation and autogamy.

d. Hemixis:

Other modes of reproduction:

1. Plasmogamy:

Two or more individuals may fuse by their cytoplasm to form a plasmodium and separate out unchanged with their distinct nuclei. This sexual phenomenon is known as Plasmogamy and occurs in certain Rhizopoda and Mycetozoa.

2. Regeneration:

The regeneration and replacement of lost parts among free-living and few parasitic protists is widespread. A proper proportion of cytoplasm and nucleus can regenerate into an entire individual.

3. Parthenogenesis:

The gametes which fail to fertilize start their development parthenogenetically. Examples: Actinophrys, Chlamydomonas, etc.

The Structure and Life Cycle of Entamoeba histolytica :

Entamoeba histolytica is a pathogenic parasite in the intestine of human beings and many other primates. It inhabits the mucous and sub-mucous layers of the large intestine. It feeds mainly on the tissues of the intestinal wall and often produces severe ulcers and abscesses. In chronic cases, it may enter the blood circulation to reach the liver, lung, brain and other organs. It causes a serious and often fatal disease known as amoebic dysentery or amoebiasis. E. histolytica exists in two distinct forms: the magna Trophozoite form and the minuta or precystic form, (fig.9.1).

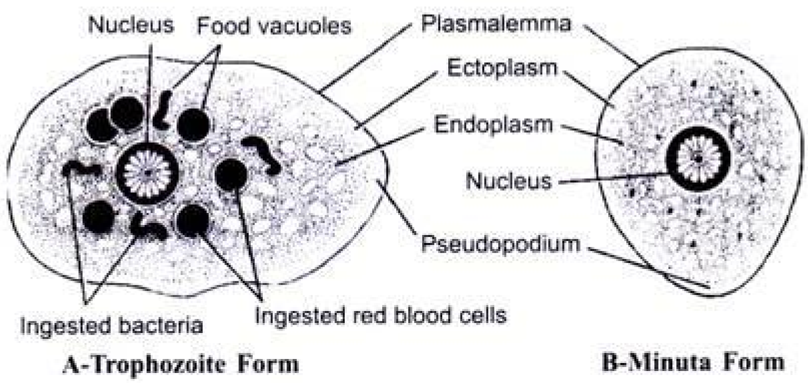


Fig. 9.1 A & B *E. histolytica*

Trophozoites:

The adult trophic form of Entamoeba is known as Trophozoite or Magna. It inhabits anterior part of large intestine, i.e. colon of human beings. It resembles amoeba in structure but differs in parasitic mode of life. Its body is covered by plasma lemma and cytoplasm is differentiated into ectoplasm and endoplasm. There is a single large, broad and blunt pseudopodium formed of ectoplasm. Endoplasm contains single spherical nucleus and food vacuoles. Nucleus has peripheral crown of chromatin blocks and a centrally located nucleolus.

The trophozoites multiply by repeated binary fission in the intestinal wall of host. Some of the daughter entamoebae grow into normal adults while others stop growing. These are distinctly smaller than the normal trophozoites and are called Minuta forms.

Precystic (minuta Form):

It is smaller, spherical and non- pathogenic stage. Normally, it lives in the lumen of the intestine and rarely found in tissues. It undergoes encystations and helps in transmission of parasites from one host to other.

Life cycle:
Entamoeba histolytica is monogenetic, i.e., its life cycle is completed on one host only; the man.

Its life cycle is completed as follows:
Encystment:
In the precystic forms, entamoeba remains only in the intestinal lumen. They undergo encystment but before encystment, the parasites round up, eliminate food vacuoles and accumulate considerable amount of food materials in the form of glycogen and black rod-like chromatoid granules. Each parasite secretes a thin, rounded, resistant, colourless and transparent cyst wall around it.

The cysts of Entamoeba histolytica vary in size. Its cytoplasm is clear and each cyst is mononucleate at this stage. Presence of chromatoid bodies is the characteristic of the cysts of Entamoeba histolytica. They occur either singly or in the multiples of two or more. The nucleus of the cysts divides twice so that each cyst now becomes tetra nucleate (fig. 9.2). At this stage, the cyst is infective to a new host. Encysted forms pass out with the faecal matter of the host.

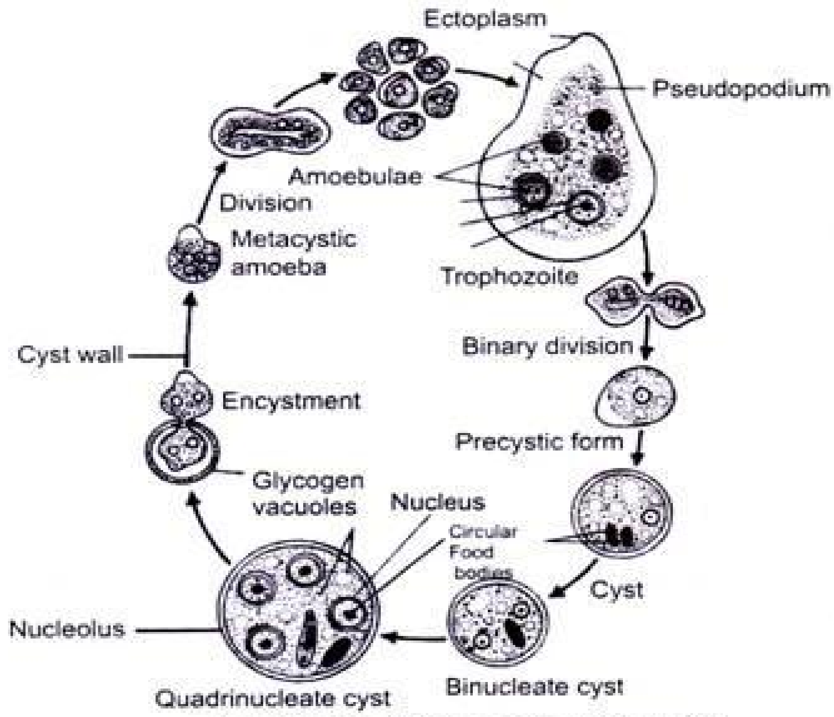


Fig. 9.2 Life Cycle of *E. histolytica*

Transfer to new host:

The infective cysts remain viable for a considerable length of time outside the human intestine, if environmental conditions are favourable. Infection of fresh human host takes place by swallowing the infective cysts with contaminated food and drinks.

Excystment:

The metacystic trophozites feed on the contents of the intestine and grow in size to form the trophozites of the next generation. The trophozoites stay in the lumen of the intestine for a particular period when they may attack the wall of the intestine and start the life cycle again. Entamoeba histolytica causes amoebic dysentery, abscesses in liver, lungs and brain and non-dysenteric infections.

Following measures may be helpful in protecting ourselves against the disease- Amoebiasis :

1. Sanitary disposal of faecal matter

2. Perfect sanitation and protection of water and vegetables from pollution.

3. Washing of hands with antiseptic soap and water before touching the food.

4. Cleanliness in preparing the food.

5. Protection of foods and drinks from houseflies, cockroaches, etc.

6. Raw and improperly washed and cooked vegetables should be avoided.

Treatment:

Dehydrometine an alkaloid compound, Vioform, Diodoquin , Terramycin,Erythromycin, etc. have proved to be effective. Metronidazole is very effective against amoebiasis.

The Structure and Life Cycle of Taenia solium :

Taenia is a digenetic parasite. Man is the primary or definitive host, the secondary host for T.solium is pig. The body is elongated, dorso-ventrally flattened and ribbon-like. It is also called tapeworm as the shape of the body is like a tape. The size of adult worm varies from 3-5 metres i.e., 9-16 feet, but few are recorded to attain a length of about 8 metres. The body is opaque white but may be grey, yellow or creamy. The body of Taenia is modified for parasitic mode of life.

It is distinguished into three parts:

1. Head and scolex

2. Neck

3. Body or strobila.

1. Head or scolex:

The scolex is the anterior- most knob like part of the size of pin head. It is a four- sided, pear-shaped structure distinguished into two parts-

(i) Rostellar part:

Rostellum is the proximal conical part bearing at its base two rows of curved and pointed chitinous hooks. These are about 28 in number and of two different sizes and the smaller hoods alternate with the larger ones. The rostellum is slightly retractile.

(ii) Distal four-sided part

It lies posterior to the rostellum and possesses four cup-shaped suckers. One of them is dorsal, one ventral and two are lateral.

2. Neck:

The scolex is followed by a narrow un-segmented neck region. New segments are budded off from this region by budding. Hence it is also known as the region of proliferation or area of segmentation (fig. 9.12).

3. Strobila:

The rest of the body is known as strobila. It is composed of linear series of 800 to 1,000 sets of reproductive organs or genitalia, each set being contained in a segment. This linear repetition of genital organs is termed as proglottisation and each segment is known as proglottid. Since the segments are budded off from the neck region in an orderly succession, the youngest segments are towards the neck and the oldest segments are posterior most.

Reproductive System:

The reproductive organs are segmentally repeated and each segment carries a complete set of male and female reproductive organs (i.e., hermaphrodite).

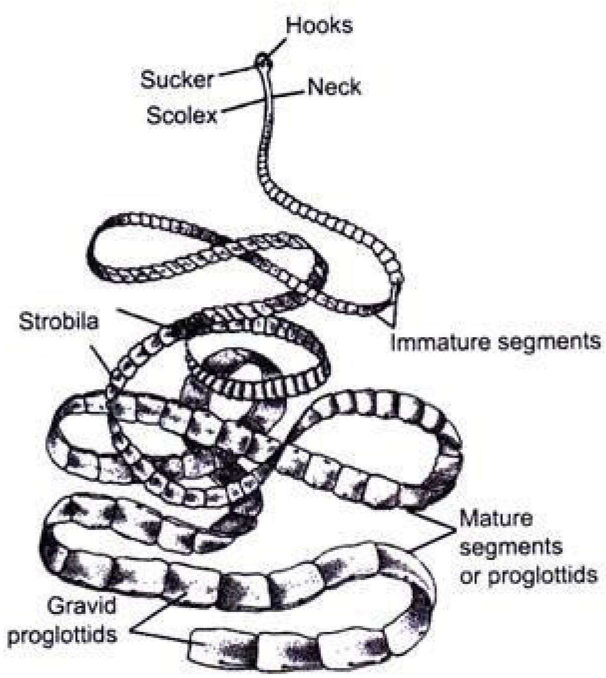


Fig 9.12 *Taenia solium*

Life- History:

The life-history is complicated and digenetic, being completed in two hosts. The primary host is man and the secondary host is pig.

1. Fertilization:

Self-fertilization takes place in Taenia. The cirrus of the segment is inserted into the vagina of the same segment. The sperms received are stored in the seminal receptacle. The eggs are fertilized in the oviduct and get surrounded with yolk and egg-shell in the ootype. The capsulated egg enters the uterus and is collected there. The uterus enlarges in size, gets branched and occupies the whole space. The eggs are very small in size measuring about 40 microns in diameter. These contain a large amount of yolk and each is surrounded by an egg-shell or egg-capsule.

2. Cleavage:
The division in the eggs start, while these are- still inside the uterus. The first cleavage is unequal so that a large vitelline cell and a small embryonic cell is formed. The embryonic cell undergone repeated divisions and a solid ball of cells, the morula is formed. The divisions are unequal so the morula consists of a few larger cells, the macromeres forming an outer or peripheral layer and inner mass of small cells or micromeres.

3. Hexacanth larva:
The micromeres develop into a hexacanth or onchosphere larva.

4. Infection to secondary host:
The development of egg up to the formation of onchosphere takes place inside the uterus of gravid proglottid. The further development is not possible inside the host body. The gravid proglottids detach from the body of the parasite and come out along with the host faeces. These infect the secondary host when pig feeds upon the contaminated faeces.

5. Cysticerus or hydatid larva or bladderworm stage:
The numerous hexacanths are set free in the stomach, where the embryonic membranes of onchospheres is dissolved (fig. 9.14) These bore through the intestinal wall the help of hooks and enter the blood stream or lymph vessels. Travelling through the heart, these enter the muscles of various parts in the body. The usual site where the hexacanths get encysted is the voluntary muscles of tongue, heart, liver and shoulder.

6. Infection of final host:

Further development of the bladder worm takes place only inside the definitive host. Infection of man occurs when inadequately cooked pork infected with bladderworms is eaten. The cysticerci become active in the intestine. The scolex takes a firm hold of intestinal wall of the host. The bladder is thrown off and the neck starts budding off segments an adult tapeworm is formed (fig. 9.15).

The life cycle of *T. solium* is represented graphically below. It consists of six main steps:

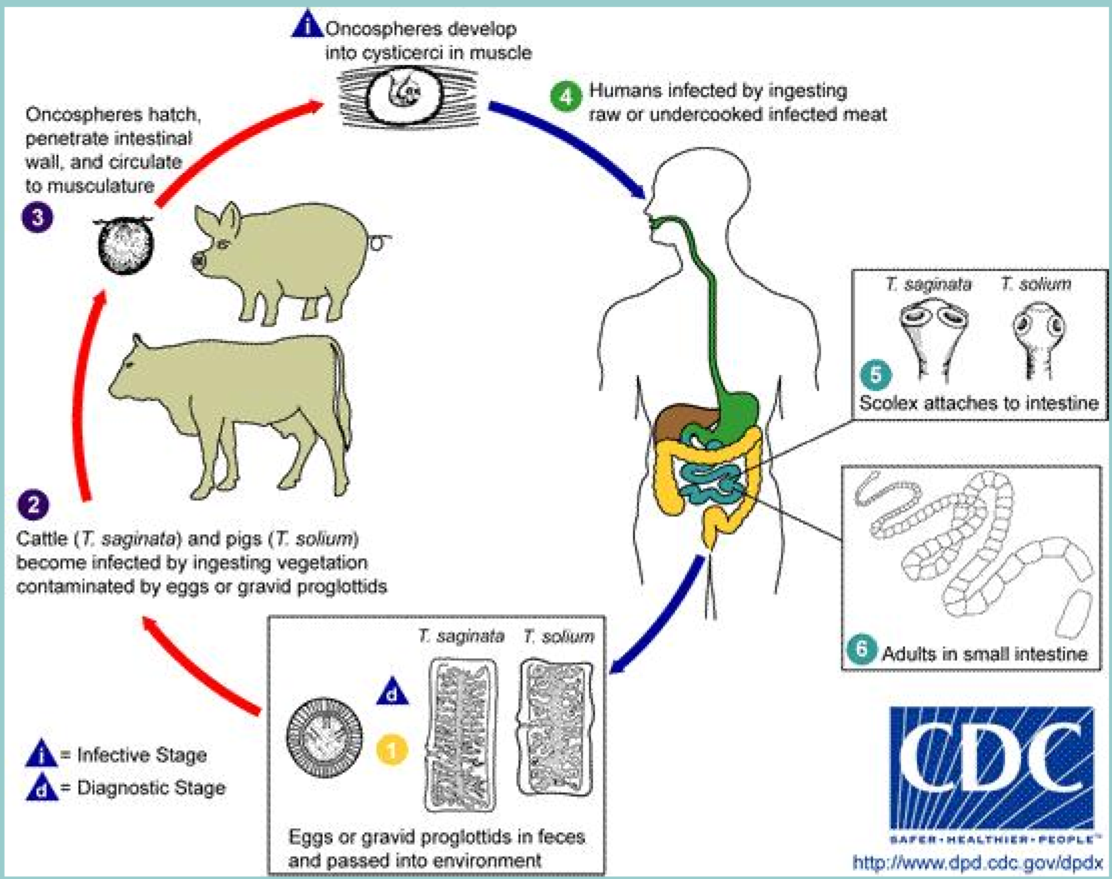


Figure courtesy of the CDC's Division of Parasitic Diseases. [C]

STEP 1. Infected humans (definitive host) excrete the eggs or gravid proglottids in their feces, passing the parasite from the gastrointestinal tract onto nearby vegetation. In egg or gravid proglottid form, *T. solium* is able to remain viable anywhere from days to months. *T. solium* can be diagnosed at this point in the life cycle.

STEP 2. Pigs (intermediate host) acquire infection by eating and digesting the eggs or gravid proglottids along with the parasitized vegetation.

STEP 3. The eggs or gravid proglottids migrate to the pig's intestine and as oncospheres, break through the intestinal wall. Then, via the circulatory system, they embed themselves in the muscles of the pig and develop into cysticerci (the infective form of *T. solium*). Cysticerci have the ability to persist in the muscle for many years.

STEP 4. Humans acquire the infection by eating the undercooked or raw flesh of an infected animal.

STEP 5,6. Cystercerci migrate to the small intestine of the human host and develop into their adult tapeworm form normally within two months. By attaching to the intestinal wall with their scolices (hooked structures), these adult tapeworms may persist for long periods of time, even years.

Taenisis : (Disease)

The infection caused due to this worm is followed by abdominal pain, nausea, anemia,indigestion,diarrhea, eosinophilia etc. the complicated disorders are caused due to the toxins produced by Taenia solium.

Prevention and control :

Infection of tapeworm can be prevented with high level of personal hygiene. The prevention of fecal contamination of pig foods may be helpful in prevention of contamination of these parasites. The Taeniasis can be controlled by the use of Quinacrine hydrochloride and Atabrin.

Water Vascular System in Asterias

The following points highlight the eight different structures of water vascular system in Asterias.

Structure # 1. Madreporite:

The water vascular system starts with the madreporite and gives off a system of vessels traversing the body. The madeporite is a round calcareous plate (Fig. 21.7B) and has an inter-radial disposition on the aboral surface. The madreporite contains furrows which have numerous pores at the bottom. Each pore leads into a pore canal.

The number of pores and pore canals may be about two hundreds. The pore canals unite to form collecting canals which open into a small sac-like ampulla, called madreporic ampulla. The sea water that operates the hydraulic system enters and leaves the water vascular system through the madreporite.

Structure # 2. Stone Canal:

The madreporic ampulla proceeds downwards as an 'S'-shaped cylindrical madreporic or stone canal. The wall of this canal is supported by a number of calcareous rings, hence the name stone canal. From the wall of the stone canal projects a ridge which bifurcates into two lamellae. The lamellae become spirally rolled to occupy a considerable portion of the lumen of the stone canal.

In some species of starfishes, the lumen of the stone canal becomes very much complicated due to extensive development of the lamellae. Most of the pore canals from the madreporite open to the stone canal and the rest open to the axial sinus. The stone canal serves as a pump that drives the circulation of sea water.

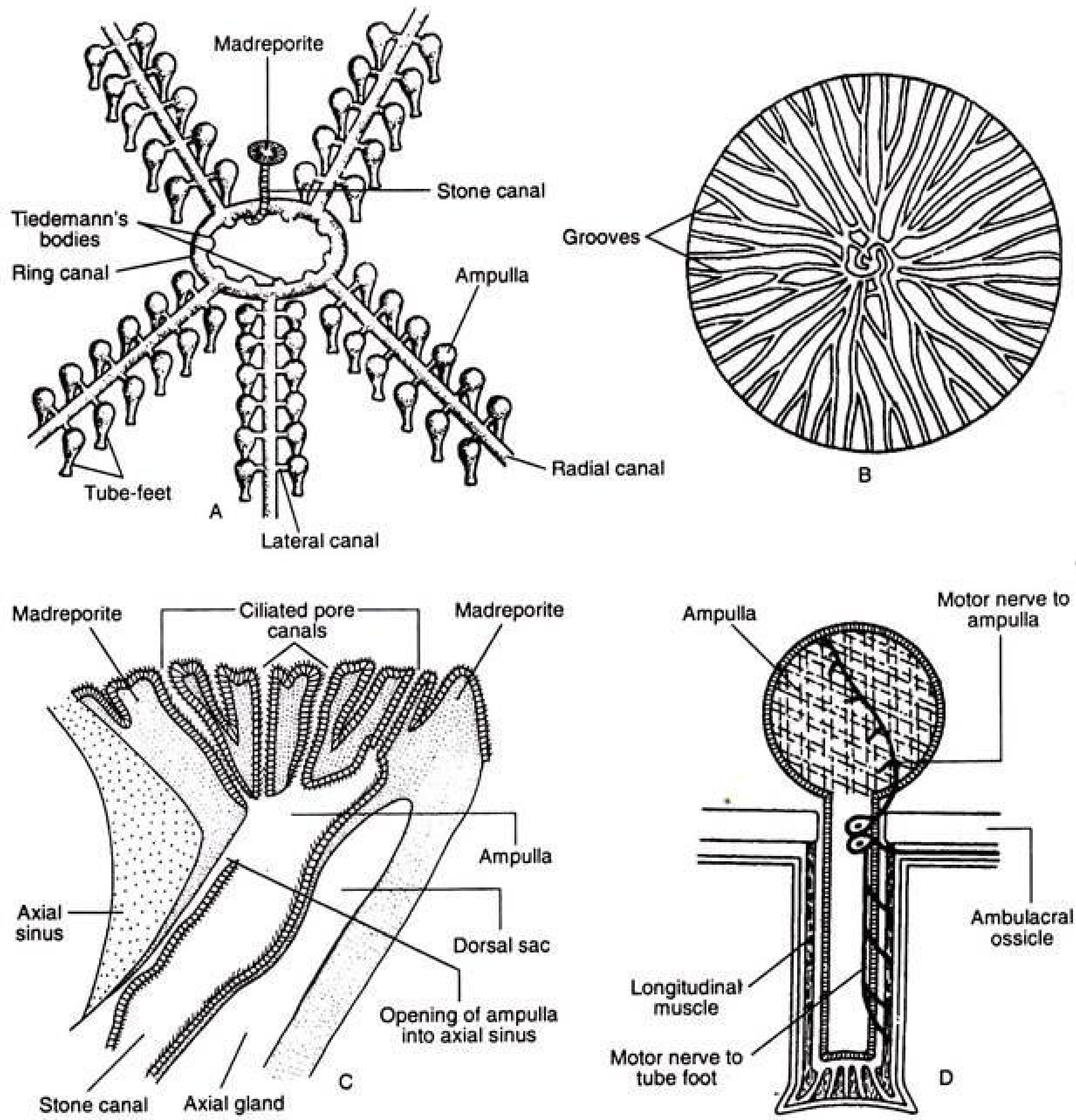


Fig. 21.7: A. Water vascular system in *Asterias*. Note that in *Asterias* the polian vesicles are absent. B. Enlarged view of the madreporite of *Asterias*. C. Diagrammatic view of the vertical section through the madreporite in *Asterias*. D. Diagrammatic sectional view of a tube-foot and its nerve supply in *Asterias*.

Structure # 3. Ring Canal:

The stone canal opens below into a considerably wide pentagonal ring-like canal situated around the mouth.

Structure # 4. Polian Vesicles:

In certain starfishes, there occur on the outer-side of the ring canal pear-shaped sacs, called polian vesicles, which are connected with the ring canal inter-radially. The polian vesicles hang in the perivisceral coelom.

The usual number of polian vesicles is ten, two in each inter-radius. But the numbers vary in different starfishes. In Asterias sp. polian vesicles are wanting as such. The vesicles function as expansion chamber for storage of fluid of water vascular system.

Structure # 5. Tiedmann's Bodies:
The neck of each polian vesicle is provided with a pair of small spherical yellowish glandular bodies attached to the inner wall of the ring canal, called Tiedmann's bodies. As the polian vesicles are absent in Asterias sp., the ring canal gives off inter- radially nine such Tiedmann's bodies. The interrdius which bears stone canal has only one Tiedmann's body.

The significance of these bodies is not properly known, probably helps to filter fluid from the water vascular system into the body cavity. Hyman (1955) regarded this organ as lymphatic glands and probably manufacture the amoebocytes of the water vascular system.

Kowalevsky (1889) first observed that if a sea-star is allowed to live in sea-water containing Indian ink or some vital dye, the colour is accumulated in the epithelial cells lining their lumina. But the absorptive function of the epithelial cells is not yet confirmed.

Structure # 6. Radial Canals:
The ring canal gives off five radial canals along the ambulacral grooves of the arms. The radial canals run up to the tip of the arms and end as the lumen of the terminal tentacle.

Structure # 7. Lateral or Podial Canals:
The radial canal gives out many paired small side branches, called the lateral or podial canals. Each lateral canal is attached to the base of the tube-foot and contains a valve which prevents the back flow of water from the tube-foot to the radial canal. The valve controls the flow of fluid from lateral canal to ampulla and podium (tube-foot).

Structure # 8. Tube-Feet (Podia) and Ampulla:

Each lateral canal, after reaching the ambulacral pore, divides at right angles into two branches. One of the branches is continued used as the lumen of the podium (tube-foot) and the other as the cavity of the ampulla (Figs. 21.7C, 21.8). The ampullae are muscular, rounded, sac-like structures situated at the anterior side of the podia.

Usually one ampulla is present in each tube-foot. In certain starfishes, the ampulla may be bilobed (Astropecten irregularis), with a constriction at the middle. In Asterias sp., the ampullae are simple and undivided. Each podium is a hollow, elastic, tube-like structure which bears at its tip a flattened portion forming a sucker for attachment.

The tube-feet project out- ward on the body surface and lie in the ambulacral groove. Calcareous bodies are often present in the connective tissue layer of the tube-feet particularly at the sucker-like terminations.

The mechanism of podial locomotion operates by the antagonistic musculature of the ampulla and tube-foot and a contained volume of watery fluid. The ampulla contains smooth circular muscle fibres remaining in position vertically, also called ampullary muscles (Fig. 21.8). The tube-foot or podium consists of retractor or longitudinal muscles.

Tube feet helps for locomotion, respiration and capturing the food for animals.