رؤيـة كـليـة الـعـلـوم

التميز في تعليم العلوم الأساسية والبحث العلمي

رسـالـة كـليـة الـعـلـوم

تقديم تعليم مميز في مجالات العلوم الأساسية وإنتاج بحوث علمية تطبيقية للمساهمة فى التنمية المستدامة من خلال إعداد خريجين متميزين طبقا للمعايير الأكاديمية القومية، وتطوير مهارات وقدرات الموارد البشرية، وتوفير خدمات مجتمعية وبيئية تلبي طموحات مجتمع جنوب الوادي، وبناء

رؤية قسم علم الحيوان

خريجون متميزون علميا وبحثيا محليا ودوليا خدمة للمجتمع وتنمية للبيئة.

رسالة قسم علم الحيوان

يسعى قسم علم الحيوان بكلية العلوم من خلال ما يقدمه من برامج تعليمية متطورة وبحث علمى تطبيقى عالمى وبنية اساسية مناسبة الى خريجين متميزين محليا ودوليا فى مجالات علوم البيولوجيا

معلومات المقرر

اســــــــــم المقرر:- تصنيف لافقاريات وحشرات

كـــــــــــود المقرر:- 301ح

الطلاب المستهدفون:- الفرقة االثالثة حيوان– كلية العلوم

متـــــــطلبات سابقة:- لافقاريات 1 – لافقاريات 2

زمـــــــن المحاضرة:- 3 ساعه اسبوعيا لافقاريات + ساعتان حشرات

زمـــــــــن العملى:- ساعاتان اسبوعيا لافقاريات + ساعتان حشرات

النــــــهاية العظمى:-375 درجة

النـــــهاية الصغرى:-225 درجة

طرق تقييم المقرر:-

	اعمال سنة	شفوى	عملى	تحريرى
توزيع لدرجات	%10	%10	%20	%60

The contents of invertebrates

Week	Title
1	General ideas and importance of systematic zoology and study the discrimination bases of animal classification.
2	Study the characters of invertebrate phyla of first year with examples
3	Study the characters of invertebrate phyla of second year with examples.
4	Phylum: Ctenophora
5	Phyla: Mesozoa, Nemertini
6	Pseudocoelomate phyla: Gastrotricha, Rotifera, Nematomorpha,
7	Midterm Exam.
8	Phylum: Acanthocephala, Kinorhyncha
9	Minor Coelomate phyla, (Lophophorate animals) Bryozoa
10	Phylum: Phoronida
11	Phylum: Brachiopoda
12	Pylum: Entoprocta
13	Phylum: Chaetognatha
14	A review of the above

بسم الله الرحمن الرحيم

Systematic Zoology

Classification of invertebrates and insects

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Lecture 1

Introduction

There are approximately 8.7 million species on earth and their • variety is simply astonishing. Besides, no two individuals of any animal-form are exactly alike. Hence, there must be some arrangement to group them in orderly categories to study the animal world. The diversity or differences also signify that organisms are really not so different from one another.
Among 8.7 million species, 6.5 million species live on land and 2.2 • million in oceans and other water bodies. Zoologists expect that only 15% of species are identified to man from the estimated 8.7 million species. Only about 953,434 animal species have been catalogued in the Animal Kingdom.

Animal classification helps to know their characteristics, as well as • their differentiations with other organisms.

The branch of Biology which deals with the identification, • nomenclature and classification of animals is known as taxonomy or systematics. The basis or scheme of classification adopted in animal taxonomy is the same as the one utilized in plants. Modern taxonomy endeavors to synthesize the progress of biology in its all major disciplines and tries to depict the true inter-relationship between animals in evolutionary sequence.

<u>Important Terms and Definition:- Animal Classification: Basis, Principles, Importance of Classification and Rules of Binomial Nomenclature</u> •

•

a.<u>Zoological classification</u>.•
on The term may be ordering the animals into groups
the bases of their relationships of association by similarity "
<u>b-Taxonomy</u>

The term ‘Taxonomy’ (Gr. Taxis-arrangement, nomos-law) was first introduced in 1831 Taxonomy is the theoretical study of classification, including its bases, principles, procedures and rules”.

C-Systematics:

The systematic includes taxonomy, classification and nomenclature. The term is derived from the Latinized Greek word systema. Systematics may be defined as the scientific study of the kinds and diversity of organisms and of any or all relationships among them. In short, systematic is the science of the diversity of organisms

D-Zoological nomenclature:

Is the application of distinctive to each of the groups recognized in any zoological classification.

Binomial Nomenclature**:**

Binomial nomenclature is defined as the present method of naming plants or animals scientifically. This system was first invented by Linnaeus. According to this system, every species of plant or animal is given a name in Latin, in two parts (binomial). Among them, one part is the specific epithet or trivial name which is diagnostic of the species and other part is the generic name signifying the genus. The generic name is written first where first word should be written with capital letter and the specific second with a small letter such as *Panthera tigris*.

Here *Panthera* denotes the generic name while *tigris*, the specific name

Taxonomic Categories

During biological classification, animals are categorized into different groups. These groups are known as taxa (singular taxon). Carolos Linnaeus (1753) described six taxa in animal classification but at present, we use seven main taxa. In the biological classification, the taxonomic hierarchy is the process where various taxonomic categories, groups, and class are arranged into the successive level. In this case, the sequence should be either decreasing or increasing order from kingdom to species or vice versa. Here, each level is known as taxonomic rank or category where rank for the kingdom is high and species is always lowest.

Taxon: Taxon is defined as a general term of taxonomic group irrespective of its rank. It may be noted that the names of taxa above genus are Latin names in plural; the highest unit of classification is the kingdom and the lowest unit is species.

Species: A species may be defined as the smallest unit of classification consisting of identical individuals, young and old, having the same parentage and similar chromosome number that interbreed among themselves

<u>Sub-species</u>: These are phenotypically similar populations of a species which occupy the same geographic area of the range of a species but differs taxonomically from other populations of the species.
<u>Variety</u>: It is a term which is frequently used in classical taxonomy for a heterogenous group of phenomenon like a non-genetic variations of phenotype, domestic breeds, morphs, etc.

A. <u>Taxonomic Hierarchy</u>

1.Kingdom
2.Phylum
3.Class
4.Order
5 .Family
6.Genus
7.Species

B. Species and Sub Species. Species is the lowest rank in the taxonomic hierarchy and it is the basic unit of classification.

<u>Species according to Linnaeus</u>
<u>It adopted by Linnaeus 1758</u>

1-Is a group of organisms which do not differ from one another more than the offspring of a single pair may do.
2-Gradations from one species to a closely related one do not. There is no intermediate form, but sharp distinctive differences between each species and any other.
3-Members of a species can interbreed freely with one another, but not usually with members of another species, if they do, the hybrid offspring are infertile.
4-Usually, the geographical locations inhabited by a particular species, are distinct from those inhabited by most nearly related species.

<u>The type system</u>
It was Linnaeus practice to select a typical specimen of a plant or animal the type or for description and to keep this specimen in his museum as reference specimen.

<u>Taxonomic types</u>

There are two types of taxonomy, artificial and natural. The artificial classification at which animals are grouped according to their place of living (aquatic or terrestrial), type of feeding (herbivorous, carnivorous, omnivorous) and area of living (hot, cold, ice)
While the natural classification at which animals are grouped depending on the degree of relationships among the individuals of each group, these relationships can only obtained by help of other science branches as Comparative anatomy, Physiology, Cytology.

Importance of Animal Classification.

In prehistoric time the man had learned to identify animals to meet their requirements. Now a day`s scientist uses classification systems to help them make sense of the animal world around them. Animal science would be a really crazy place if we did not have a way of organizing animals. Some importance of animal classification mention below:

A classification system is a useful tool which helps to identify the animal taxa on the basis of the interrelationship among different groups of animals.
It helps to know the animal kingdom. In this case, by studying classified animals anyone can gather knowledge about animal kingdom with minimum time and less labor.
The classification systems provide relatively stable, unique and unequivocal names for newly identified animals.

Classification system provides the basic foundations of conservation practice and sustainable management of the world biodiversity.
The animal classification serves as a base for the development of other biological sciences such as bio-geography etc.

Discrimination basis of animal classification

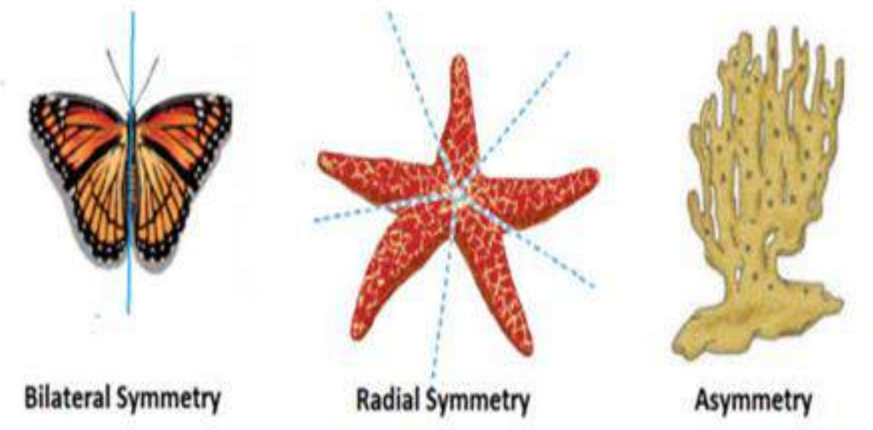
1-Homology and Analogy

Analogous structures are those which perform the same function but they have not the same origin and structure. E.g. the wings of birds and insects. Both of which have the same function, of flight but they are different in structure and embryonic origin. E.g. the gills of fishes and gills of crustaceans have the same function for respiration but they are different in origin and
Homologous structures: (opposed to analogous).

These structures are those have the same embryonic origin and basic structures but they may or may not perform the same function. E.g. wings of birds and bats have the same origin and function, e.g. wings of birds and human arm have the same origin and structure and they are different in the function

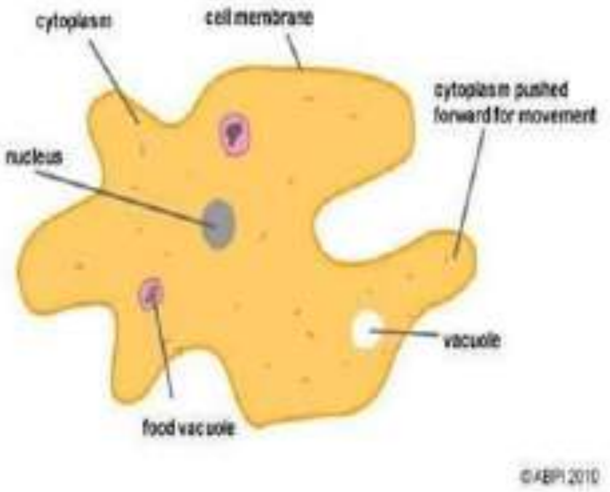
<u>2- Body symmetry</u>
Symmetry refers to the arrangement of parts in relation to planes and centralized axes
(A) Asymmetry animals: Amoeba is an asymmetric organism, no plane can divide it into equal parts. Many of Protista and most of porifera are asymmetrical
(B) Spherical symmetry: it takes the shape of a ball, such a body can divided into similar haves by a cut through center in any direction, e.g. Volvex
(c) Radial symmetry: It is cylindrical in form and may be divided into numbers of similar parts, only around a central longitudinal axis, e.g. Hydra, jelly fish, sea anemones, adult echinoderms

(D) Bilateral symmetry: Animals with bilateral symmetry generally, have their main organs arranged in pairs either side of the sagittal axis which passes from the head to the tail.



<u>3- Cell number</u>

(A) The Protozoa or Unicellular animals: Their body consists of single cell which performs all the functions of life such as *Amoeba*, *Monocystis*, Malarial parasites etc.



(B) The Metazoa: It is a vast group including all the multi-cellular animals. It is grouped or classification as follows:

On the basis of origin of tissue system, the Metazoan is divided as follows:

(1) Parazoa: The body-cells of these multi-cellular animals do not form definite tissue system. The only phylum under Parazoa is <u>Porifera</u>.

Scypha

Spongilla

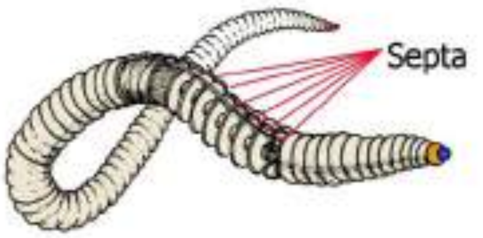
(2) Enterozoa: The body-cells of these multi-cellular animals have formed definite and well-defined tissue system

4- Level of organization:

-The patterns of organization of cells differ in animals in spite of their multi-cellular nature. In animals, the following cellular organizations are seen:

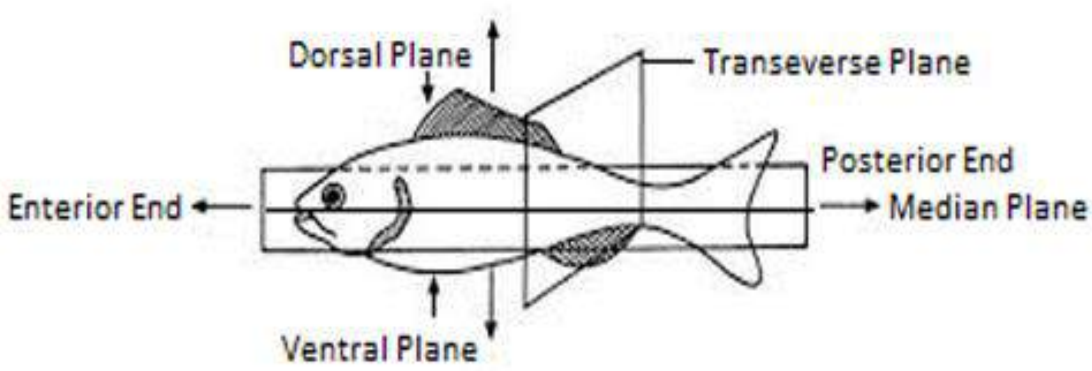
-The cellular level of organization: In these types of animals, the cells of the body create loose aggregates. Example: Sponges.
-Tissue level of organization: In these animals, cells of the animal carrying out a similar function are organized in tissues. Example: Cnidarians.
-Organ system level of organization: In these animals, all the tissues are united together and form organs. Each organ is specialized for specific function.
Example: Animals under phylum Platyhelminthes

5- Metamerism •
The body is externally and internally divided into repeated, linear series of body units are called metameres or somites. Metamerism is also known as the segmentation.
Figure Showing Metamerism or Segmentation



6-Polarity
The polarization of the body parts of an animal on the basis of mouth and head position is known as polarity. The end of the body which bears head is called anterior end and the opposite one is the posterior end. Similarity the end with the mouth is the oral end and an opposite one is the aboral end.

7- Body axes and plane
In bilateral animals, there is a hypothetical line along the body center. This is known as the axis. The axis passes away from the head to tail is called the longitudinal axis and another is the transverse axis that passes transversely in the body. Besides these, there is three planes of the body: median plane, frontal plane, and transverse plane.



8. **<u>Germ Layers</u>**

Germ layers are the collection of cells, formed during animal embryogenesis, found in the gastrula stage. The gastrula may be of two or three layers. These layers of gastrula are called germ layers which play a significant role in the primary classification of animals. According to the basis of the number of germ-layers, animals are of two types:

Diploblastic animals: These are enterozoans with loosely differentiated two layers of tissue cells-outer ectoderm and inner endoderm. They are separated by a non-cellular partition. The diploblastic animals are placed in two phyla: (i) Cnidaria and (ii) Ctenophora

Triploblastic animals: These entoerozoans with three layers of tissue: outer ectoderm, middle mesoderm and inner endoderm.
Example: Platyhelminthes to Chordates'

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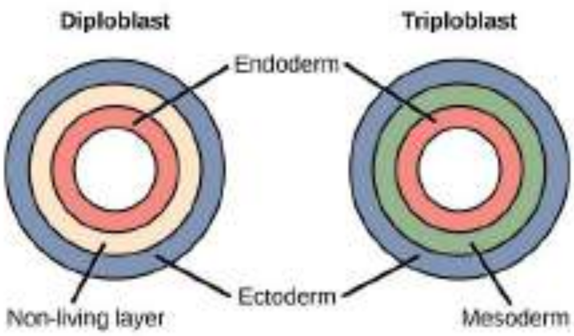
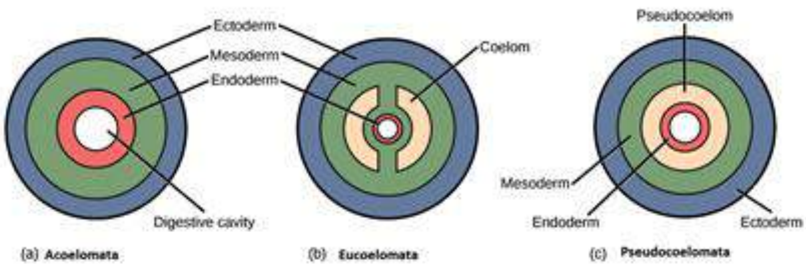


9-Coelom (body cavity):-

The liquid filled cavity between the alimentary canal and body wall of the triploblastic animals is known as a body cavity. The body cavity that is lined by the mesodermal peritoneal membrane is called coelom. According to Hymen (1951), " Coelom is the hollow space between alimentary canal and body wall which is lined by mesodermal peritoneal tissue". The animals are of three categories based on the presence or absence of coelom

(i) Acoelomate animals: In these animals, coelom is absent. The body cavity is filled by mesenchyme and muscles. They are found in phylum Platyhelminthes, Nemertean.
(ii) Pseudocoelomate animals: In these animals, the body cavity is not filled by mesodermal peritoneal tissue. These animals are found in phylum Nematode, Acanthocephalan, Rotifer, Entoprocta.
(iii) Coelomate animals: These are animals having true coelom which is lined by a mesodermal peritoneal membrane and include the phyla like Annelida, Mollusca, Echinodermata, and Chordate.



10-Notochord:-The notochord is a flexible rod-shaped structure •
composed of cells derived from the mesoderm found in the embryo of all higher animals. On the basis of the presence or absence of notochord animals are classified into two groups: Non-chordates: These are animals without a notochord. Example: Phylum Porifera to Echinodermata. Chordates: These are animals with the presence of notochord. Example: Phylum Chordate.

11- The digestive cavity: The digestive system is several forms give indication of taxonomic characters. Parazoa (Porifera)has not digestive cavity at all. Acoelomates have digestive cavity without anus (only mouth) e.g. Hydra, flat worms. Multicellular forms have a complete digestive tract with mouth and anus.

12-Embryonic Development of the Mouth

Eucoelomates can be divided into two groups based on their early embryonic development. protostomes and deuterostomes .

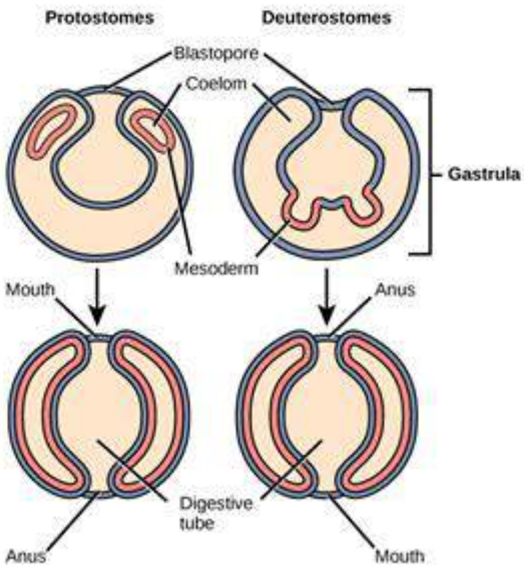
Protostomes include arthropods, mollusks, and annelids.

Deuterostomes include more complex animals such as chordates but also some simple animals such as echinoderms. These two groups are separated based on which opening of the digestive cavity develops first: mouth or anus. The word protostome comes from the Greek word meaning "mouth first," and deuterostome originates from the word meaning "mouth second" (in this case, the anus develops first). The mouth or anus develops from a structure called the blastopore . The **blastopore** is the indentation formed during the initial stages of gastrulation. In later stages, a second opening forms, and these two openings will eventually give rise to the mouth and anus . It has long been believed that the blastopore develops into the mouth of protostomes, with the second opening developing into the anus; the opposite is true for deuterostomes.

Another distinction between protostomes and deuterostomes is the method of coelom formation, beginning from the gastrula stage. The coelom of most protostomes is formed through a process called **schizocoely**, meaning that during development, a solid mass of the mesoderm splits apart and forms the hollow opening of the coelom. Deuterostomes differ in that their coelom forms through a process called **enterocoely**. Here, the mesoderm develops as pouches that are pinched off from the endoderm tissue. These pouches eventually fuse to form the mesoderm, which then gives rise to the coelom.

The earliest distinction between protostomes and deuterostomes is the type of cleavage undergone by the zygote. Protostomes undergo **spiral cleavage**, meaning that the cells of one pole of the embryo are rotated, and thus misaligned, with respect to the cells of the opposite pole. This is due to the oblique angle of the cleavage. Deuterostomes undergo **radial cleavage**, where the cleavage axes are either parallel or perpendicular to the polar axis, resulting in the alignment of the cells between the two poles.

There is a second distinction between the types of cleavage in protostomes and deuterostomes. In addition to spiral cleavage, protostomes also undergo **determinate cleavage**. This means that even at this early stage, the developmental fate of each embryonic cell is already determined. A cell does not have the ability to develop into any cell type. In contrast, deuterostomes undergo **indeterminate cleavage**, in which cells are not yet pre-determined at this early stage to develop into specific cell types. These cells are referred to as undifferentiated cells. This characteristic of deuterostomes is reflected in the existence of familiar embryonic stem cells, which have the ability to develop into any cell type until their fate is programmed at a later developmental stage. •



13- Appendages:

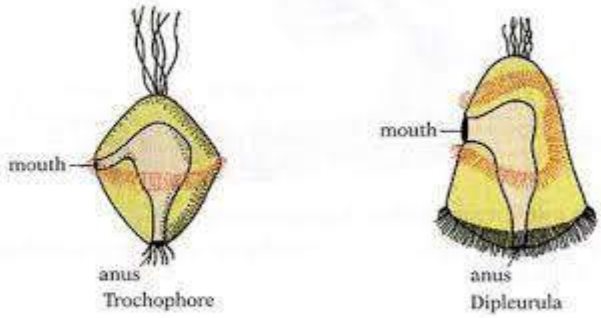
Protruding parts that serve in locomotion, feeding, and other ways are termed appendages; examples are the tentacle of sea anemones, minute setae of earthworms, antennae and legs of arthropods, and the fins, legs, and wings of vertebrates.

14-Skeleton:

Most land dwellers and many aquatic animals have a skeleton for support or protection; it may be internal (frog, man, etc.) or external (coral, crab, insect) and may be of either inorganic or material.

15-Sex:
An animal containing both female and male sex organs in one individual is termed monoecious (also hermaphroditic); members of most higher phyla are dioeciously, each individual being either male or female.

16-Larvae:
The young stages known as larvae often provide important information on relationships not evident in adult animals. Many have features obviously adapted to particular environments such as cilia for swimming. Their basic structure, however, is usually characteristic for each phylum or class. Barnacles and tunicates, for example, were first properly classified by study of their larvae.
Many aquatic invertebrates in the protostome line have a common type of larva- minute, transparent, and free-swimming. Often it is top shaped, and encircled by two lines of cilia that beat so as to suggest a rotating wheel, hence the name trochophore (Gr. Trochos, wheel + phoros, bear). The upper end has a plate with a tuft of cilia and a sense organ. With various modifications this is the early larva of many marine flatworms, nemerteans, mollusks, and some annelids.
Dipleurula is a hypothetical larva of the Echinoderms. It represents the type of basis of all larva forms of the Eleutherozoa, to which the sea-stars, sea-hedgehog, sea-rollers and sand stars belong. The Dipleurula is a bilaterally symmetrical, ciliated echinoderm larva. Dipleurula represents an ancestral form for these primitive deuterostomes.



Lecture 2

Survey of the animal kingdom

Protozoans animals
Some of the characteristics are:

1-Protozoa may be defined as "microscopic acellular animalcules existing singly or in colonies, without tissue and organs, having, one or more nuclei".
2-There are about 50,000 known species of Phylum Protozoa.
3-Protozoans exhibit mainly two forms of life; free-living (aquatic, freshwater, seawater) and parasitic (ectoparasites or endoparasites).
4-They are also commensal in habitat.They are small, usually microscopic, not visualize without a microscope.
5-They are the simplest and primitive of all animals.
6-They have a simple body organization. i.e. with a protoplasmic grade of organization.
7-The body is unicellular (without tissue and organs).
8-They have one or more nuclei which are monomorphic or dimorphic.
9-Body naked or bounded by a pellicle, but in some forms may be covered with shells and often provided with an internal skeleton.
10-They are solitary (existing alone/single) or colonial (individuals are alike and independent).
11-Body shape variables may be spherical, oval, elongated or flattened.
12-Body symmetry either none or bilateral or radial or spherical.
13-Body form usually constant, varied in some, while changing with environment or age in many.
14-Body protoplasm is differentiated into an outer ectoplasm and inner
15-The single-cell body performs all the essential and vital activities, which characterize the animal body; hence only subcellular physiological division of labor.
16-Locomotory organs are fingers like pseudopodia, whip-like flagella, hair-like cilia or none.
endoplasm.one or more nuclei"
17-Nutrition may be holozoic (animal-like), holophytic (plant-like), saprozoic or parasitic.
18-Digestion occurs intracellularly which takes place inside the food vacuoles.
19-Respiration occurs by diffusion through the general body surface.
20-Excretion occurs through the general body surface, but in some forms through a temporary opening in the ectoplasm or through a permanent pore called cytopyge.Contractile vacuoles perform osmoregulation in freshwater forms and also help in removing excretory products.

21-Reproduction asexual (binary or multiple fission, budding, sporulation) or sexual (conjugation (hologamy), game formation (syngamy)).
22-The life cycle often complicated with alternation of asexual and sexual phases (alternation of generation).
23-Encystment commonly occurs to resist unfavorable conditions of food, temperature, and moisture, and also helps in dispersal.
24-The single-celled individual not differentiated into somatoplasm and germplasm; therefore, exempt from natural death which is the price paid for the body.
25-Protozoans exhibit mainly two forms of life; free-living (aquatic, freshwater, seawater) and parasitic (ectoparasites or endoparasites).
26-They are also commensal in habitat.Examples: Euglena, •
Amoeba, Plasmodium, Paramecium, Podophyra, etc.

• <u>Classification of Phylum Protozoa</u>

• Class 1: Mastigophora
Move by one to many flagella.Example: *Euglena*.

Class 2: Sarcodina
Move and capture food by pseudopodia.Example: *Amoeba*.

Class 3: Sporozoa
No locomotory organs.All parasitic.Spore-formation is common.Example: *Plasmodium*.

Class 4: Ciliate
Move by cilia.Example: *Paramecium*.

Phylum Porifera •

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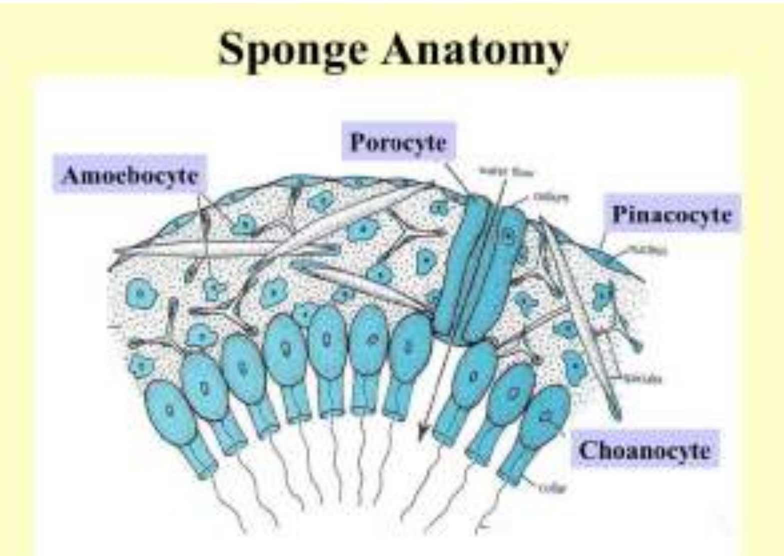


Sponges are sessile, mostly marine, multicellular animals that lack almost all the complex features of higher animals. Rather they are a loose organization of cells that work together to siphon planktonic food, filter it, and distribute energy.

- Sponges often incorporate algal cells in their epidermal tissue.
- The basic body plan of sponges involves two cell layers, an outer epidermis and inner layer made up of flagellated collar cells, separated by a gelatinous matrix, the mesohyl. Body support is provided by a skeletal matrix of spicules. The entire sponge body is covered with small, incurrent pores that bring in water under currents set up by the collar cells' beating flagellae. Food particles captured by the collar cells are transferred throughout the body via wandering amoeboid cells called amoebocytes.

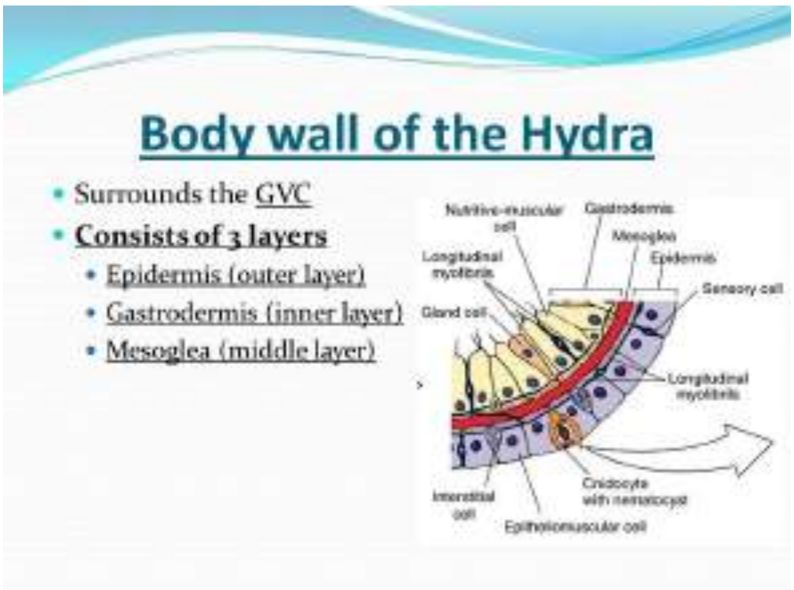
Phylum: CNIDARIA (Coelenterates)

The name Cnidaria comes from the Greek word "cnidos", which means stinging nettle.

Characteristics

- So what characteristics do most (and more typical) cnidarians have in common, and which of these do they share with other animals?
- 1-The symmetry is primarily radial symmetry; although in some it can be modified as biradial or some other form.
- 2-Cnidarians are described as diploblastic (2 layers) and are characterized by the tissue level of organization.
- 3-Cnidarians are essentially made of two cell layers. The outer ectoderm, or epidermis, contains the cnidocysts, the stinging cells that are characteristic of the phylum.
- 4-The inner endoderm, or gastrodermis, lines the gut, which in some cnidarians may be divided up by septa (as in the Anthozoa) or elaborated into branching canals (as in many Scyphozoa). This layer allows extracellular digestion.
- 5-These groups, probably because of their larger size (than Hydrozoa, the third group we will discuss) have become more "impressive" feeders.

- 6-In between epidermis and gastrodermis is the mesoglea or mesenchyme, a layer of jellylike substance which contains scattered cells and collagen fibers.
- 7-Mesoglea is variable from very thick in anemones and most jellyfishes, to quite thin in some of the hydroids.
- 8-The mouth is often, but not always, surrounded by a ring of tentacles.
- 9-Polymorphism in life cycle is common in most species (think adult frog versus tadpole).
- 10-Both polyp and medusa stage are found in many species, but this varies from one group to another.
- 11-In some groups, only the polyp occurs and in other groups the medusa dominates.-
- Medusa is dominant, polyp is reduced.
- 12-The sexes are often separate (dioecious). Sperm are released from mouth of male into the water and are filtered from the water by the female and fertilization is internal.
- 13-Embryos develop into planula larvae in specialized brood pouches in the folds of the mouth lobes. Planulas are ultimately released and attach to overhanging rocks where they develop into polyps (scyphistoma). Scyphistomas bud-off additional polyps which ultimately undergo strobilation, a progressive constriction into a stack of saucer-like medusae (ephyrae) which subsequently separate.
- **Hydrozoa**



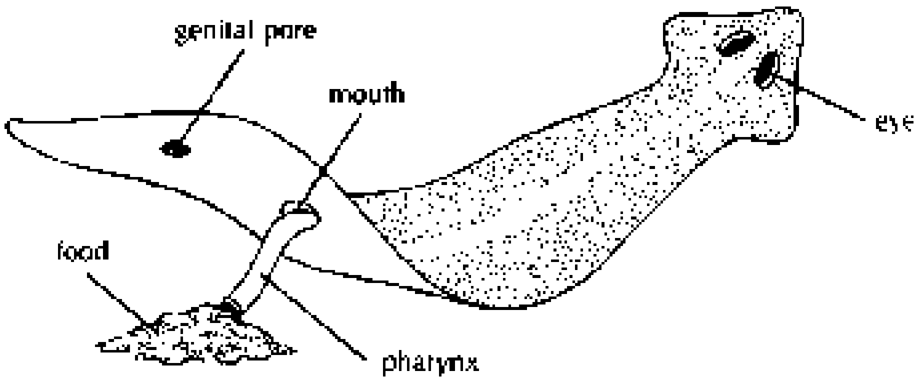
Probably the cnidarian most encounter before college is *Hydra*, more specifically *Hydra littoralis*. It is named after the monster in Greek legend with many heads who grew two more whenever one was cut off. It was finally slain by Hercules who cauterized each neck after severing its head. The regenerative powers of *Hydra* are quite remarkable, a single individual may be cut into many pieces and provided that each piece contains a portion of the two body layers, ectoderm and endoderm, it will develop into a complete animal. **However, this species is an unusual hydrozoan because it only has a polyp stage. There is no medusa stage.** Testes and ovaries simply develop at certain times on the same or different polyp depending on the *Hydra* species of interest.

Acoelomates Phylum Platyhelminthes

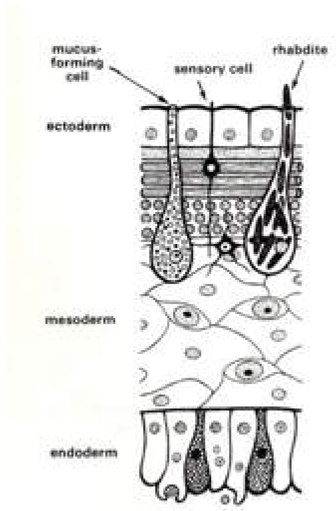
The Flatworms are bilaterally symmetrical, acoelomate animals with a fully developed mesoderm and whose digestive system, if present, consists of a primitive gastrovascular cavity.

Two flatworm classes, **Trematoda and Cestoda**, are entirely parasitic, many of which have complex lifecycles involving more than one host.

Class Turbellaria – Free-living flatworms The vast majority of free-living flatworms are marine, but there are several extremely common freshwater forms. Planaria (= Dugesia), the most well-known freshwater turbellarian, has been used widely to study regeneration and primitive learning. The planarian gastrovascular cavity can be seen in detail in individuals fed carmine-dyed liver. The mouth is at the end of an extendable pharynx, located midway on its ventral side. The pharynx opens into a 3-branched intestine, two branches extend posteriorly and the remaining branch feeds the body’s head end. Planarians have no circulatory system; they rely on diffusion and a thin body to obtain oxygen, distribute food, and possibly excrete nitrogenous waste. Maintaining the appropriate salt balance (and possibly nitrogen exretion) is accomplished by simple pronephridia consisting of branched tubules connecting a number of blind pouches with flagelled flame cells. Flame cells collect fluids from the body and, with flagellar movements, create currents to expell them from the body through nepridiopores.

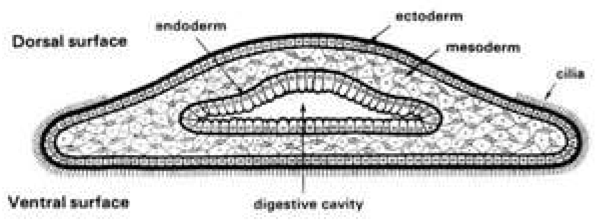


Phylum Platyhelminthes – tissue organization



Triploblastic = 3 tissue layers

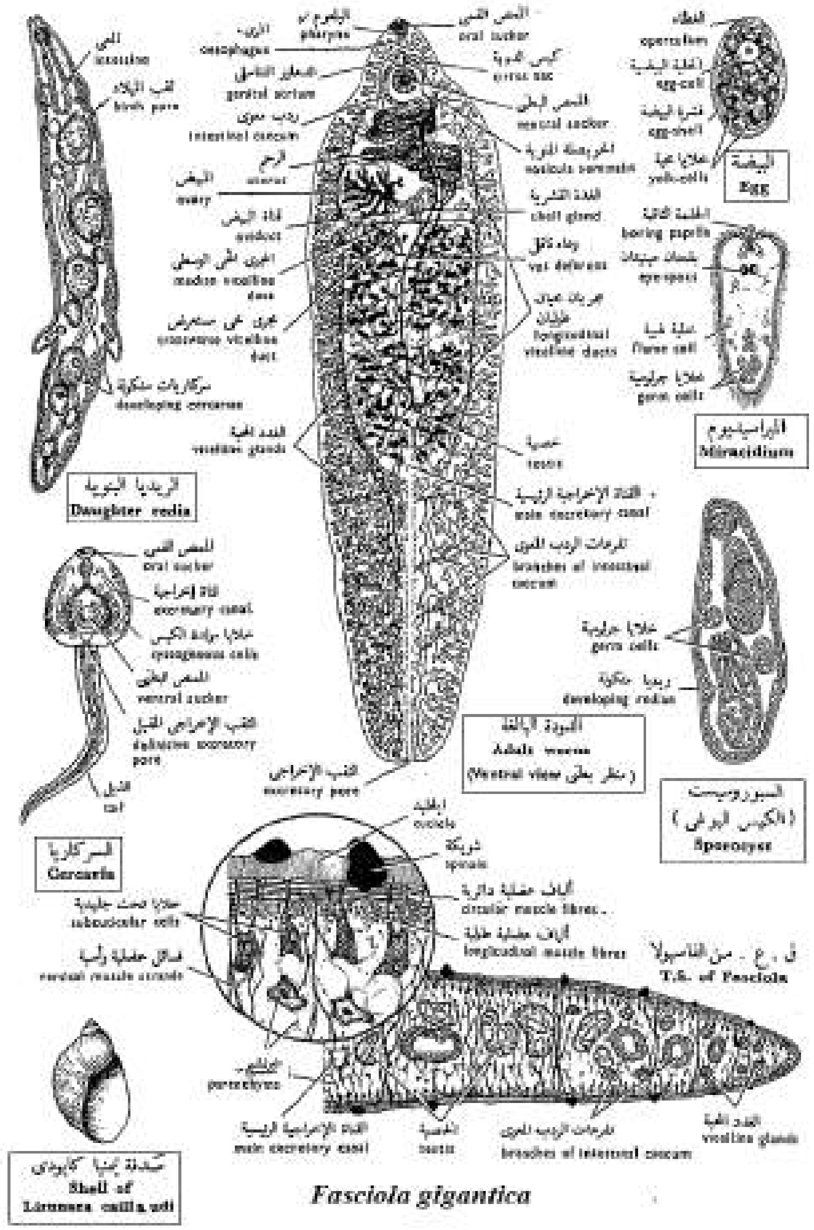
Ectoderm (outer)
Endoderm (inner)
Mesoderm (between)



Cross-section through a planarian.

Class **Trematoda**

- They are entirely parasitic. Many exhibit highly complex lifecycles involving one or more intermediate hosts. Flukes infecting human blood and liver are among the most well-known examples of this class.



Fasciola gigantica

Class **Cestoda** – Tapeworms are the most specialized of the Platyhelminthes; they lack any form of a digestive tract. The anterior-most portion of an adult tapeworm is the scolex. Adapted for adhering to the host, the scolex has suckers and often a rosette of anterior hooks called a rostellum. Behind the scolex is a narrow neck followed by a long strobilus. The strobilus is composed of three to several hundred segments called proglottids, and each mature proglottid contains a complete set of male and female reproductive parts. However, the male portion in each proglittid usually develops much earlier than the female counterpart to prevent self-fertilization one species of trematode

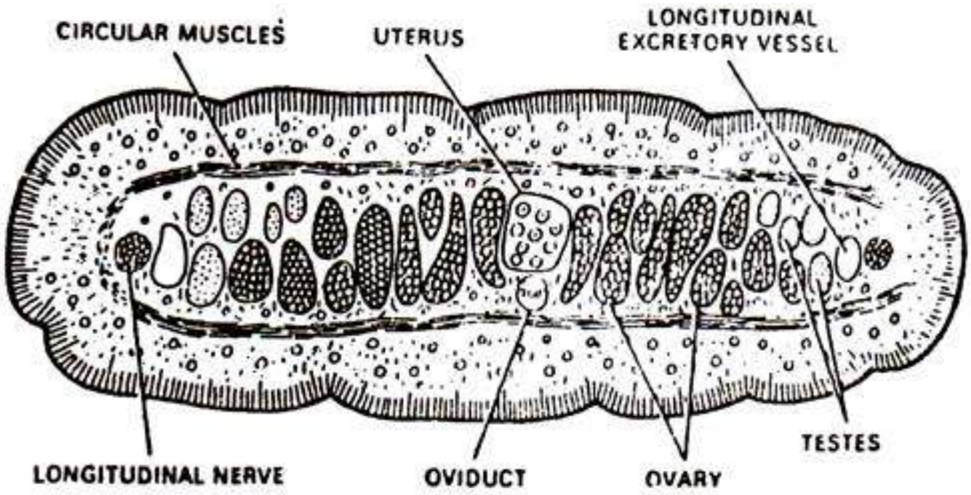
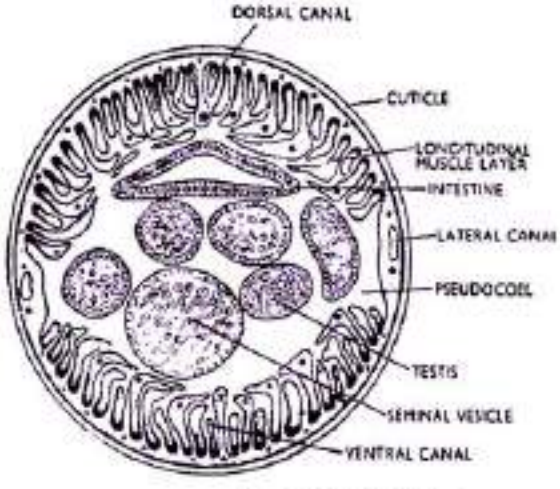


Fig. 116 T.S. TAENIA MATURE PROGLOTTID

Pesudocoelomates •

•

Phylum **Nematoda** – The Roundworms Nematodes are probably the • most numerous and diverse group of animals on earth. Free-living nematodes are found in almost all natural habitats including soils, hot springs, glaciers, deep seas, and high mountain peaks; and a large number of roundworms are parasitic on plants, vertebrates, and other invertebrates.



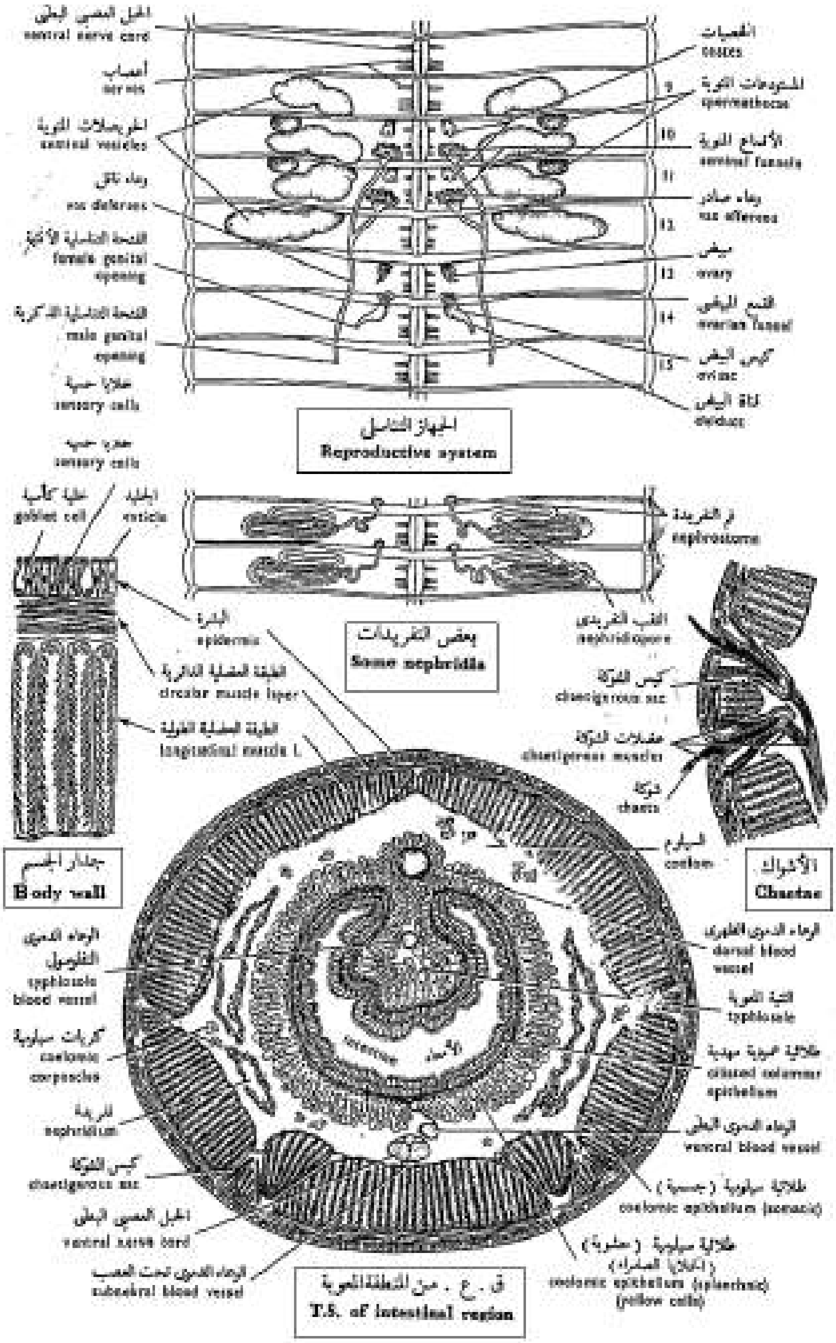
T. S. MALE ASCARIS

Eucoelomate protostomes

Phylum Annelida

The most distinctive feature of annelids is their body is divided by septa into repeated segments in which each segment has parts of the circulatory, excretory, digestive, and nervous systems. Other features of the annelids are: 1) their circulatory system is closed, 2) excretion is by nephridia, 3) they have a complete digestive tract, 4) the nervous system is composed of a pair of anterior dorsal ganglia (the brain) that are connected to two subpharyngeal ganglia by circumpharyngeal their connectives and they have a double, ventral nerve cord, 5) coelom is relatively large, and 6) their cleavage is spiral and determinate. (7)segment has circular and longitudinal muscle layers

Class Oligochaeta Earthworms
Oligochaete means Few setae, which refers to the observation that members of this class possess fewer and more reduced setae than the polychaetes. Oligochaetes are most diverse in soils and freshwater habitats.



Allolobophora caliginosa

Class Polychaeta member of this group with the earthworm

Polychaetes are mostly marine. *Nereis* is one example of this group. It has projections on each segment called **parapodia** that help the worm move through sandy sediments and increase surface area for gas exchange. Protruding from each parapodium are numerous setae.

Class Hirudinea : Leeches
This group is known collectively as the leeches. Some of the members of this class are blood- sucking ectoparasites on vertebrates, but some are predators and a many are detritus feeders. They are typically dorso-ventrally battened and have 32 internal segments (although they often appear to have more externally). Leeches often have both anterior and posterior suckers with the mouth located within the anterior sucker. Some forms mouth evert their pharynx in order to feed and many of

the mouth have sharp teeth used to puncture their hosts skin. Leeches lack setae.

<u>Lecture 3</u>

Phylum Arthropoda

Arthropod Characteristics

The arthropod characteristics are mentioned below:

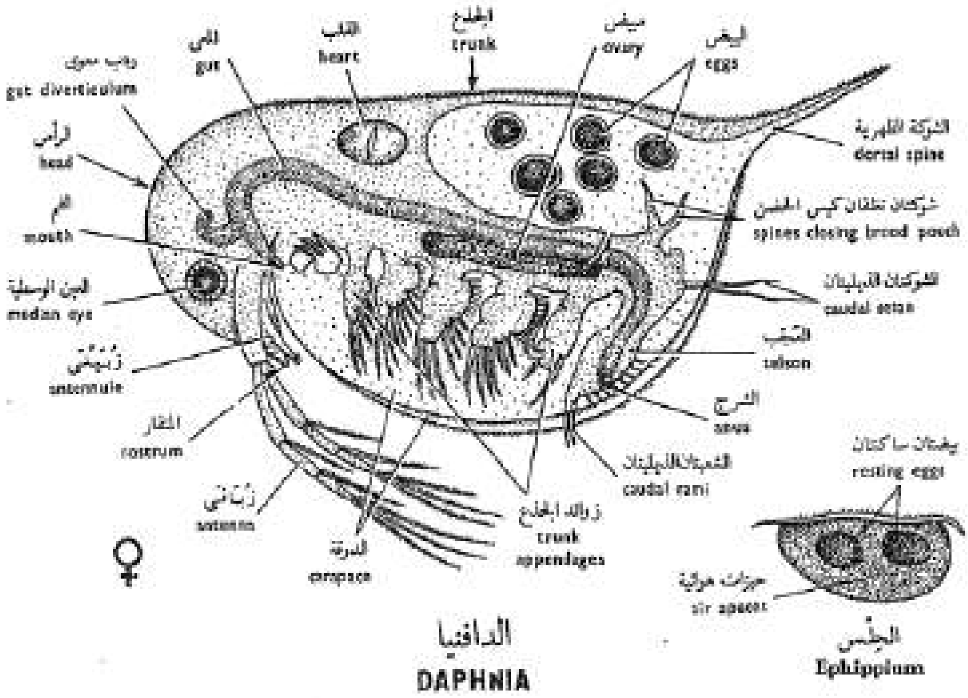
1. The body is triploblastic, segmented, and bilaterally symmetrical.
2. They exhibit organ system level of organization.
3. The body is divided into head, thorax, and abdomen.
4. Their body has jointed appendages which help in locomotion.
5. The coelomic cavity is filled with blood.
6. They have an open circulatory system.
7. The head bears a pair of compound eyes.
8. The exoskeleton is made of chitin.
9. The terrestrial Arthropods excrete through Malpighian tubules while the aquatic ones excrete through green glands or coaxal glands.
10. They are unisexual and fertilization is either external or internal.
11. They have a well-developed digestive system.
12. They respire through the general body surface or trachea.
13. They contain sensory organs like hairs, antennae, simple and compound eyes, auditory organs, and statocysts.

Classification of Phylum Arthropoda

The classification of phylum arthropoda are as follows:

Crustacea

1. They are aquatic, terrestrial, or parasitic.
2. The head is fused with the thorax region known as the cephalothorax.
3. Respiration occurs through gills or general body surface.
4. The body is covered by a single large carapace.
5. They possess two pairs of antennae and five pairs of appendages.
6. They excrete through green glands or antennal glands.
7. They have a pair of compound eyes and gonopores.
8. Development is indirect. Larval stage is present.
9. Eg., *Daphnia*, *Palaemon*



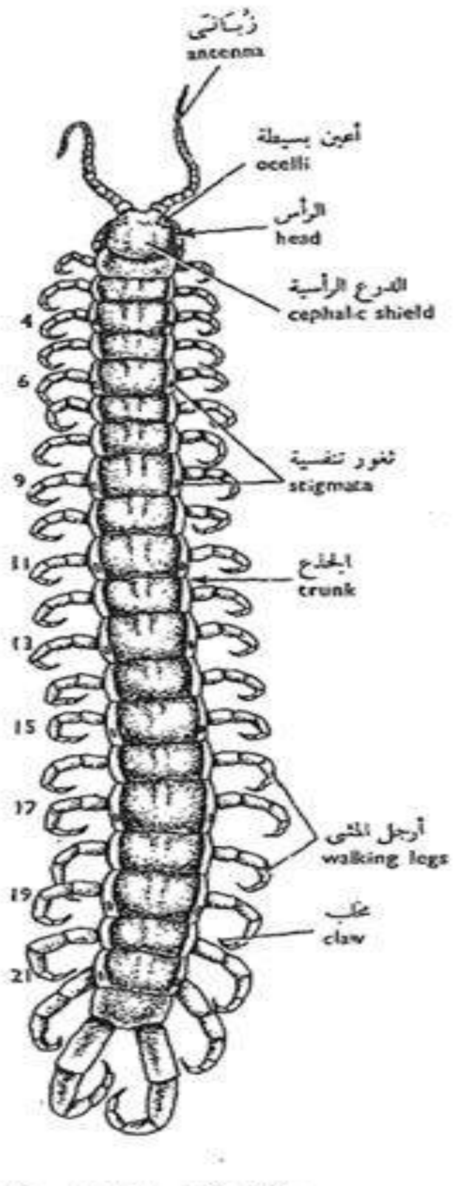
The subphylum Crustacea is divided into six classes-

- Branchiopoda
- Remipedia
- Chephlocarida
- Maxillopoda
- Ostracoda
- Malacostraca

Myriapoda

1. These are mostly terrestrial.
2. The body is elongated with numerous segments.
3. The head is provided with antennae, two pairs of jaws, and a pair of simple eyes.

4. They contain numerous legs.
5. The upper lip of the mouth contains epistome and labrum, and the lower lip contains a pair of maxillae.
6. A pair of mandibles is present inside the mouth.
7. They respire by trachea and excretion occurs by Malpighian tubules.
8. Eg., *Julus*, *Scolopendra*



(Dorsal view منظر ظهري)

The subphylum Myriapoda is divided into the following classes:

- Chilopoda
- Diplopoda
- Pauropoda
- Symphyla

Hexapoda

1. They are mostly terrestrial.
2. The body is differentiated into head, thorax, and abdomen.

3. Head bears a pre-segmental acron.
4. The thorax is divided into three segments.
5. The abdomen has 7-11 segments.
6. They have three pair of appendages.
7. It has a pair of compound eyes
8. They respire through gills and trachea.
9. Malpighian tubules are the excretory organ.
10. Development is indirect, and the larval stage is present.
11. Eg., Tabernus, Mosquitoes, Ants.

Chelicerata

1. They are mostly found on land.
2. The body is differentiated into cephalothorax and abdomen.
3. Antennae are absent.
4. The abdomen is divided into 13 segments.
5. It has four pairs of interior appendages.
6. They respire through trachea or gills.
7. The Malpighian tubules help in excretion.
8. Eg., Aramea, Limulus

The subphylum Chelicerata is divided into the following classes:

- Arachnida
- Merostomata
- Pycnogonida

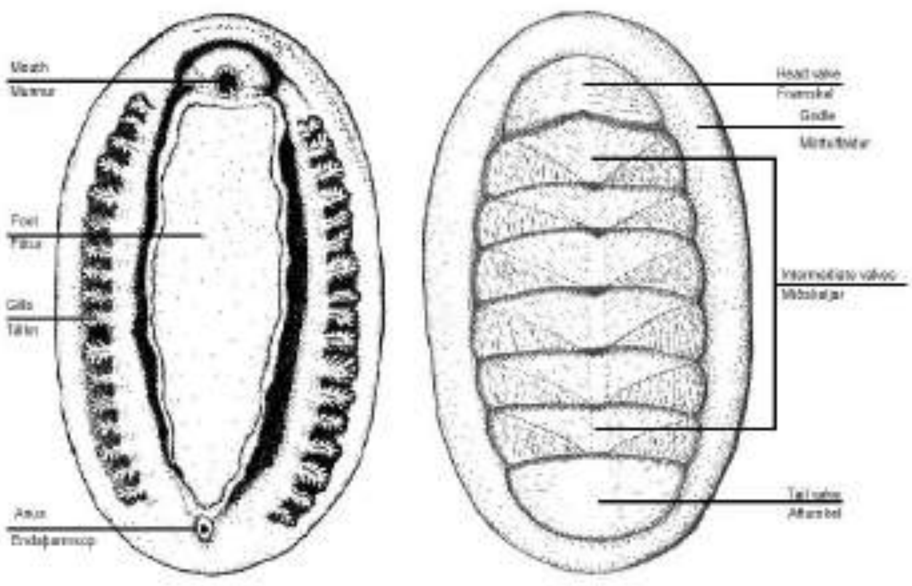
Onychophora

1. These are small-sized, terrestrial arthropods.
2. The body is divided into segments.
3. Excretion occurs through nephridia.
4. They respire through the trachea.
5. Eg., *Paripatus*

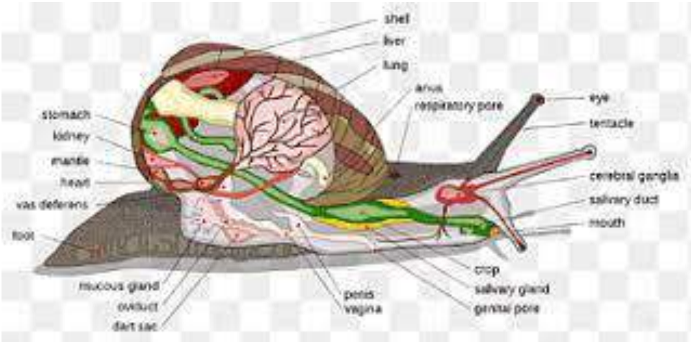
Phylum **Mollusca**:- All mollusks have a mantle, and in many, it is used to secrete a shell and it also encloses a mantle cavity that harbors gills for gas exchange. In addition, they have: 1) a complete digestive tract, 2) an open circulatory system (it is largely closed in the cephalopods) with a heart, 3) a pair of of kidneys involved in nitrogenous waste excretion and osmoregulation, 4) a ventral, muscular foot for locomotion, 5) a reduced coelom , and 6) spiral and determinate cleavage.

Class **Polyplacomorpha** –

- Chitons are well designed for living in intertidal zones and along wave-swept rocky marine shorelines. They have a bilaterally symmetrical, ovoid body that is dorsoventrally flattened and a broad foot by which they are firmly attached to the substrate. Perhaps the most distinctive chitin feature is their shell, which is divided into eight overlapping plates. Their body shape and protective armor allow them to withstand the constant pounding of waves.

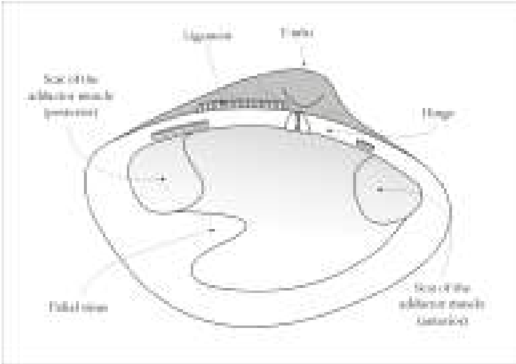


- **Class Gastropoda : Snails, Slugs, and Limpets**



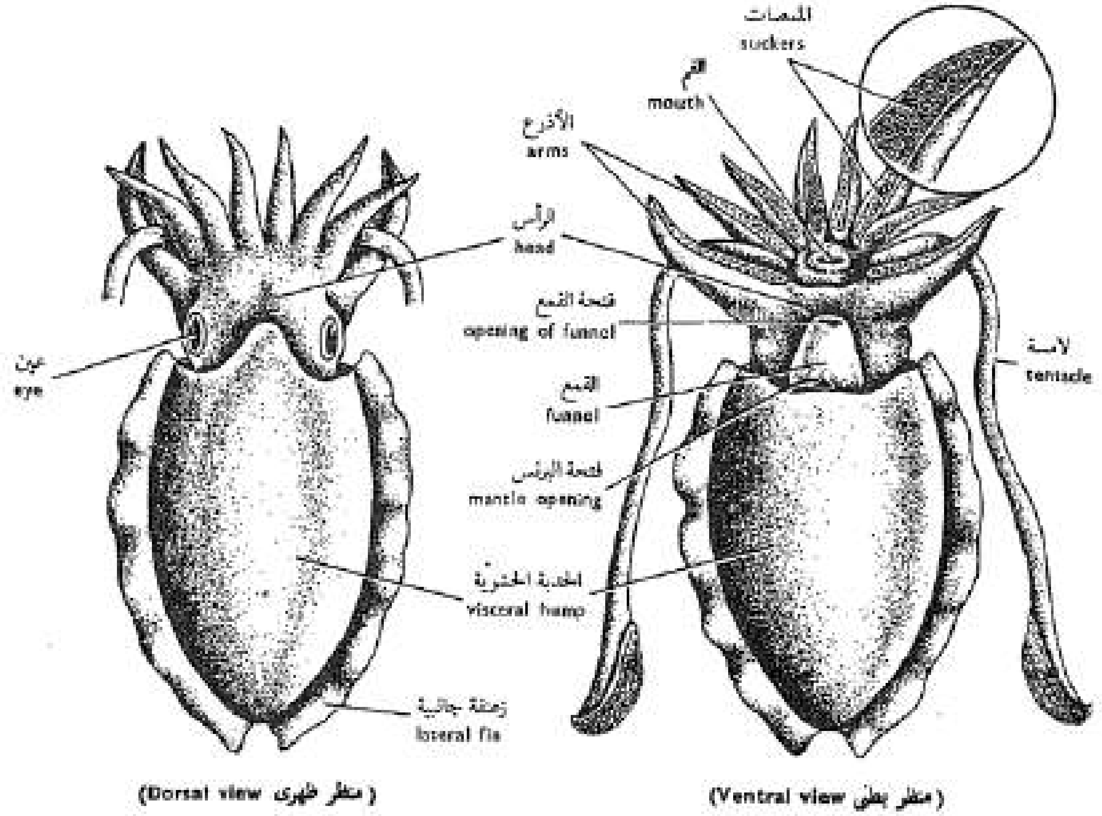
Gastropods represent the largest class of mollusks. They have a ventral foot for locomotion and a single shell, when present. Many gastropods show two separate evolutionary adaptations: body **torsion** and shell **coiling**. Most specimens show torsion that is, their internal organs and mantle have undergone a 180û counter clock wise rotation so that the mantle cavity, gills, anus, and excretory openings are in the body's anterior portion, just behind the head. This means the digestive tract is twisted to form a U-shape and organs originally on the animals left side are now on its right. Most, but not all, gastropods have coiled shells limpets are an example of gastropods without coiled shells, although they do show torsion.

<u>Class Bivalva : Clams, Oysters, and Mussels</u> •
Bivalves have a laterally compressed body and a shell with two •
valves, which are hinged dorsally and open ventrally to
expose the hatchet-shaped foot. Two halves of the mantle join at the •
ventral end to form incurrent and excurrent siphons
Clams burrow anterior-end-Þrst into the sediment there by leaving •
their posterior end exposed to the water column. Water
is pumped in through the incurrent siphon by water currents set up •
resulting from ciliar movements in the gills. Water
enters the mantle cavity, bathes gills with oxygen, and exits through •
the excurrent siphon. Gill cilia Alter out suspended



Class Cephalopoda : Squid, Octopuses, and Nautilus

The term Cephalopod means Head foot, referring to the foot, now modified as tentacles, being attached near the head. Cephalopods are all predacious, feeding primarily on small Ash, crustaceans, and worms. They are visual predators that have well developed eyes comparable to those of vertebrates. All cephalopods, except the *Nautilus* and its fossil relatives, lack a shell; and in most, the mantle is lengthened



- Phylum Echinodermata: Sea Stars, Brittle Stars, and Sand Dollars

The echinoderms are all marine organisms and include brittle stars, sea stars, sea urchins, sand dollars, sea cucumbers, sea lilies, and many extinct forms (e.g., crinoids). They are placed •
among the Deuterostomes which among other things means that they have radial cleavage in the early embryo, that is complete •
and indeterminate developmental characteristics shared with the chordates. The echinoderms are generally •
characterized by having secondary radial symmetry, an endoskeleton of calcareous ossicles, an extensive coelom, complete digestive tract and a poorly developed nervous system. Two unique characters set them apart from all other phyla, namely the water vascular system. Echinoderm larvae closely resemble those of the prochordate *Saccoglossus*, a character that suggests a close relationship between the echinoderms and the chorda

Lecture 4

Phylum: Ctenophora

Characteristics

They are free-swimming, marine, solitary, pelagic animals. No polymorphism and no attached stages were found.

The body is transparent, gelatinous, pear-shaped,
cylindrical, or flat or ribbon-shaped.
They have a biradially symmetrical body along an oral-aboral axis.
They have an external surface with comb-like 8 ciliary plates for locomotion. Hence name as comb jellies.
They have a pair of long, solid, retractile tentacles.
Their body organization is cell- tissue grade.
Their body is acoelomate and diploblastic, with the outer epidermis, inner gastrodermis, middle jelly-like mesoglea with scattered cells, and muscle fibers.
Their digestive system contains the mouth, stomodaeum, complex gastrovascular canals, and 2 aboral anal pores.
They lack nematocysts.
They have special adhesive and sensory cell i.e. colloblasts or lasso cells present in tentacles which helps in food captures.
They lack skeletal, circulatory, respiratory, and excretory organs.
Their nervous system is diffused types and the aboral end bears a sensory organ, called statocyst.
They are monoecious (hermaphrodite); gonads are endodermal situated on walls of digestive canals.
Their development direct with characteristic cydippid larva.
They lack asexual reproduction and alternation of generation.
Regeneration and paedogenesis are common in them.

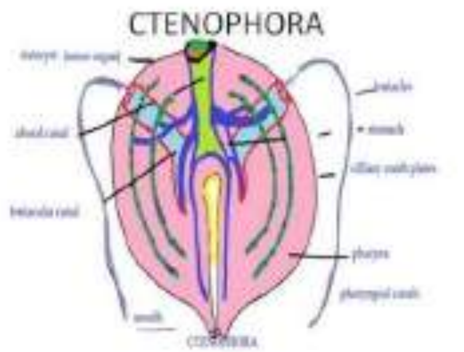
Distinguishing features

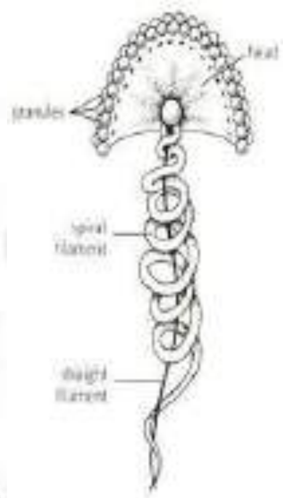
Among animal phyla, the Ctenophores are more complex than sponges, about as complex as cnidarians (jellyfish, sea anemones, etc.), and less complex than bilaterians (which include almost all other animals). Unlike sponges, both ctenophores and cnidarians have: cells bound by inter-cell connections and carpet-like basement membranes; muscles; nervous systems; and some have sensory organs. Ctenophores are distinguished from all other animals by having colloblasts, which are sticky and adhere to prey, although a few ctenophore species lack them

Like sponges and cnidarians, ctenophores have two main layers of cells that sandwich a middle layer of jelly-like material, which is called the mesoglea in cnidarians and ctenophores; more complex animals have three main cell layers and no intermediate jelly-like layer. Hence ctenophores and cnidarians have traditionally been labelled diploblastic, along with sponges. Both ctenophores and cnidarians have a type of muscle that, in more complex animals, arises from the middle cell layer, and as a result some recent text books classify ctenophores as triploblastic, while others still regard them as diploblastic. The comb jellies have more than 80 different cell types, exceeding the numbers from other groups like placozoans, sponges, cnidarians, and some deep-branching bilaterians.

Common features

The Ctenophore phylum has a wide range of body forms, including the flattened, deep-sea platyctenids, in which the adults of most species lack combs, and the coastal beroids, which lack tentacles and prey on other ctenophores by using huge mouths armed with groups of large, stiffened cilia that act as teeth.





The internal cavity forms: a mouth that can usually be closed by muscles; a pharynx ("throat"); a wider area in the center that acts as a stomach; and a system of internal canals. These branch through the mesoglea to the most active parts of the animal: the mouth and pharynx; the roots of the tentacles, if present; all along the underside of each comb row; and four branches around the sensory complex at the far end from the mouth – two of these four branches terminate in anal pores. The inner surface of the cavity is lined with an epithelium, the gastrodermis.

Feeding, excretion and respiration

When prey is swallowed, it is liquefied inthe pharynx by enzymes and by muscular contractions of the pharynx. The resulting slurry is wafted

through the canal system by the beating of the cilia, and digested by the nutritive cells. The ciliary rosettes in the canals may help to transport nutrients to muscles in the mesoglea. The anal pores may eject unwanted small particles, but the most unwanted matter is regurgitated via the mouth.
Little is known about how ctenophores get rid of waste products produced by the cells. The ciliary rosettes in the gastrodermis may help to remove wastes from the mesoglea, and may also help to adjust the animal's buoyancy by pumping water into or out of the mesoglea.

Reproduction and development
Adults of most species can regenerate tissues that are damaged or removed, although only platyctenids reproduce by cloning, splitting off from the edges of their flat bodies fragments that develop into new individuals.
Almost all species are hermaphrodites. Some are simultaneous hermaphrodites, which can produce both eggs and sperm at the same time, while others are sequential hermaphrodites, in which the eggs and sperm mature at different times. The gonads are located in the parts of the internal canal network under the comb rows, eggs and sperm are released via pores in the epidermis. Fertilization is generally external, but platyctenids use internal fertilization and keep the eggs in brood chambers until they hatch. Self-fertilization has occasionally been seen in species of the genus *Mnemiopsis*, and it is thought that most of the hermaphroditic species are self-fertile
Cleavage is determinate(spirle), gastrulation by epiboly or invagination, whereas in cnidarians cleavage by Delamination, ingression or invagination, development of the fertilized eggs is direct; there is no distinctive larval form. In cnidarians there is planula larva. Juveniles of all groups of Ctenophora are generally planktonic, and most species resemble miniature adult cydippids adults, In the genus *Beroe*, the juveniles . have large mouths and, like the adults, lack both tentacles and tentacle sheaths.
In most species the juveniles gradually develop the body forms of their parents.
In some groups, such as the flat, bottom-dwelling platyctenids, the juveniles behave more like true larvae. They live among the plankton and thus occupy a different ecological niche from their parents.only attaining the adult form by a more radical metamorphosis after dropping to the sea-floor.

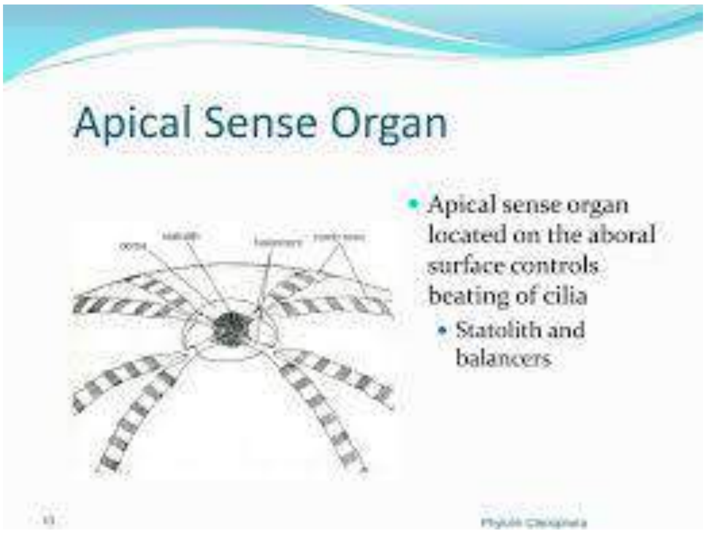
Locomotion

The outer surface bears usually eight comb rows, called swimming-plates, which are used for swimming. The rows are oriented to run from near the mouth (the "oral pole") to the opposite end (the "aboral pole"), and are spaced more or less evenly around the body, although spacing patterns vary by species and in most species the comb rows extend only part of the distance from the aboral pole towards the mouth. The "combs" (also called "ctenes" or "comb plates") run across each row, and each consists of thousands of unusually long cilia. It is uncertain how ctenophores control their buoyancy, but experiments have shown that some species rely on osmotic pressure to adapt to the water of different densities. Their body fluids are normally as concentrated as seawater. If they enter less dense brackish water, the ciliary rosettes in the body cavity may pump this into the mesoglea to increase its bulk and decrease its density, to avoid sinking.

Nervous system and senses

Ctenophores have no brain or central nervous system, but instead have a nerve net (rather like a cobweb) that forms a ring round the mouth and is densest near structures such as the comb rows, pharynx, tentacles (if present) and the sensory complex furthest from the mouth.

The largest single sensory feature is the aboral organ (at the opposite end from the mouth). Its main component is a statocyst, a balance sensor consisting of a statolith, a tiny grain of calcium carbonate, supported on four bundles of cilia, called "balancers", that sense its orientation. The statocyst is protected by a transparent dome made of long, immobile cilia. A ctenophore does not automatically try to keep the statolith resting equally on all the balancers. Instead, its response is determined by the animal's "mood", in other words, the overall state of the nervous system. For example, if a ctenophore with trailing tentacles captures prey, it will often put some comb rows into reverse, spinning the mouth towards the prey.



Colors and bioluminescence
Most ctenophores that live near the surface are mostly colorless and almost transparent. However some deeper-living species are strongly pigmented. The comb rows of most planktonic ctenophores produce a rainbow effect which is not caused by bioluminescence but by the scattering of light as the combs move. Most species are also bioluminescent, but the light is usually blue or green and can only be seen in darkness.

Classification of Ctenophora

- Class 1. Tentaculata

Adults with 2 long aboral tentacles.
In some larva has tentacles, while adults have oral lobes.
Mouth narrow and pharynx small.

- Order 1. Cydippida

Body simple, round, and oval.
Digestive canals terminate blindly; no anal pores.
Tentacles are two long and branched.
Tentacles are retractile into pouches or sheath.
Examples: *Mertensia*, *Pleurobrachia*, *Hormiphora*

- Order 2. Lobata

Body oval, laterally compressed.
Adults with 2 large oral lobes and 4 slender flap-like auricles around the mouth.

Pouched or sheath tentacles in the larva.
Tentacles reduced and without sheath in adults.
Gastrovascular canals are connected by a ring at oral ends.
Examples: *Mnemiopsis*, *Bolinopsis*

- Order 3. Cestida

Body elongated compressed/flat, ribbon-like.
Two main tentacles in the sheath but reduced.
Many small lateral tentacles along the oral edge.
Combs plates in 4 rows but rudimentary.
Examples: *Cestum*, *Velamen*

- Order 4. Platyctenea

Body greatly compressed/flat in the oral-aboral axis.
2 well- developed tentacles with sheath.
Comb plates reduced in adults.
Adapted for creeping.
Examples: *Ctenoplana*, *Coeloplana*

- Order 5. Thalassocalycida

They are found surface waters down up to 2,765 Ms in Atlantic oceans and the Mediterranean Sea.
The body is a bell of Medusa shaped and may be up to 15 cm in diameter.
Mouth slit holds by a central cone-shaped peduncle.
A pair of small tentacles hang from the side of the peduncle.
Com jelly is with its transparent and colorless body. Usually different to see.
They hold the bell wide opens to captures prey i.e. Zooplankton.
Presumably hermaphroditic.
This species has limited swimming ability compared to other comb jellies.
Examples: *Thalassocalyce inconstans*.

- Class 2. Nudu

Body large, conical, and compressed laterally.
Without tentacles and oral lobes.
Wide mouth and large pharynx.
Voracious feeder.

- Order 1. Beroida

No tentacles and oral lobes.
Body large, conical, and laterally compressed.
Mouth large.
Voluminous Stomach.
Examples: *Ber*o

Lecture 5

Mesozoa

Mesozoan, any of approximately 50 species of small, ciliated, multicellular animals that parasitize other marine invertebrates belonging to the phyla Rhombozoa and Orthonectida. These wormlike organisms lack digestive, respiratory, nervous, and excretory systems; their bodies consist of two layers of as few as 20 to 30 cells each. Both sexual and asexual reproduction occur. Their relationship to other phyla is obscure as it is not known whether their simple structure is primitive or, as a result of their parasitic existence, degenerate (*i.e.,* changed gradually into a simpler form). Some authorities, however, have suggested a link with the phylum Platyhelminthes, a group of flatworms.

In both the rhombozoans and the orthonectids, the number and arrangement of cells is relatively constant for any given species. This definitive cell number is attained during embryonic development. Growth, therefore, consists of the enlargement and differentiation of existing cells.

Both groups are very widely distributed wherever appropriate hosts occur in shallow-bottom environments of the sea. They are not found in hosts in open-sea environments, nor have they been found in hosts from tropical coral islands. In many regions, rhombozoans infect entire populations of bottom-dwelling cephalopods, such as squids and octopuses. On the other hand, orthonectids infect only a small percentage of their hosts in a given region.

Orthonectids features:

1. Microscopic and worm-like animals, and the body length rarely exceeds 300 µm.

2. Body without organs and consists of an outer layer of multi-ciliated cells which enclose an inner mass of eggs and sperm cells.

3. In some species the circular and longitudinal muscles are present beneath the epidermis.

4. Parenchymal cells absent but some extracellular matrix present.

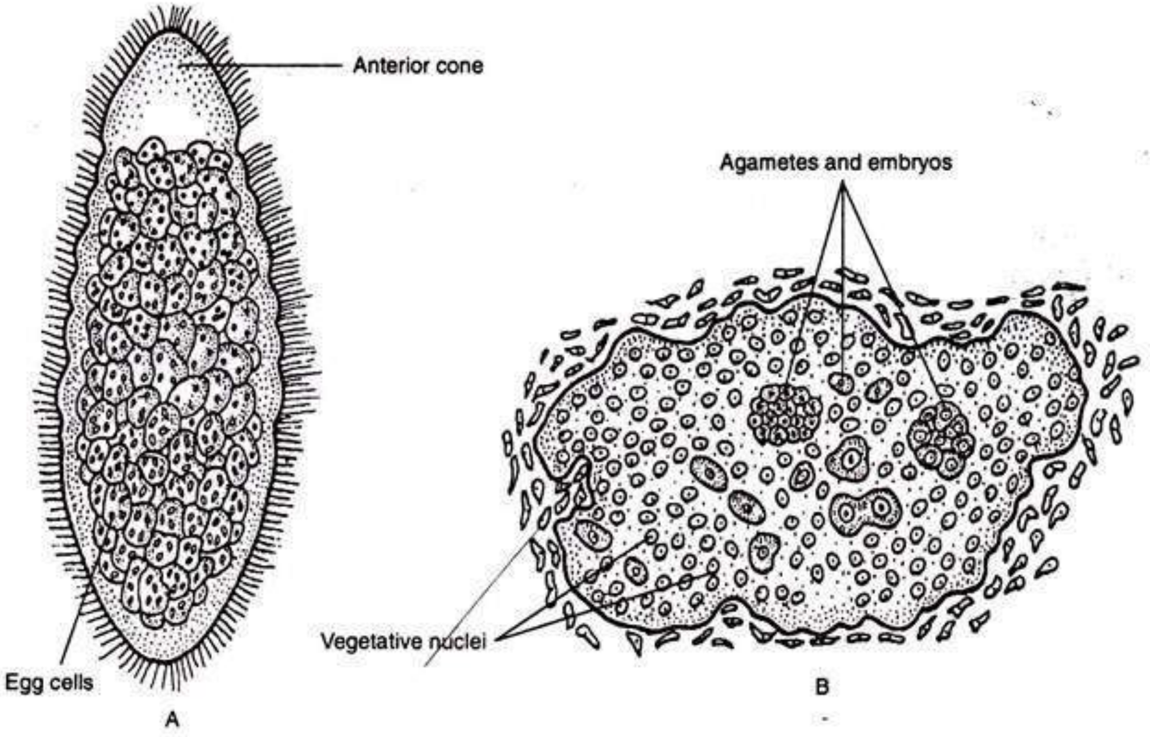
5. Locomotion by cilia.

6. Fertilization takes place outside the host.

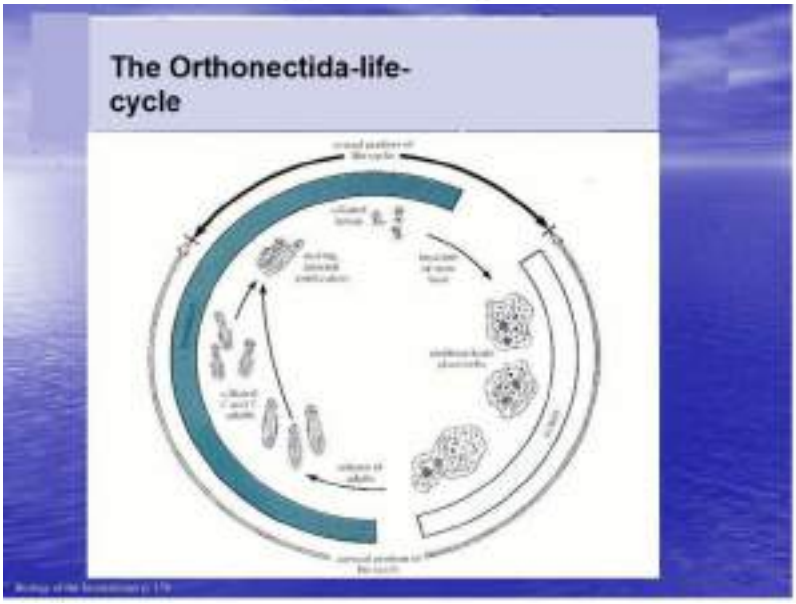
7. Most species show gonochoristic sexuality.

8. Within host tissue the larvae losing their ciliated cells become the form of asymmetrical, multinucleate but syncytial amoeba-like individuals, called Plasmodia. A Plasmodium produces both male and female ciliated adults.

Habitat:
They become parasitized on another marine invertebrates such as turbellarian flatworms, polychaete annelids, nemerteans, bivalve molluscs and echinoderms.



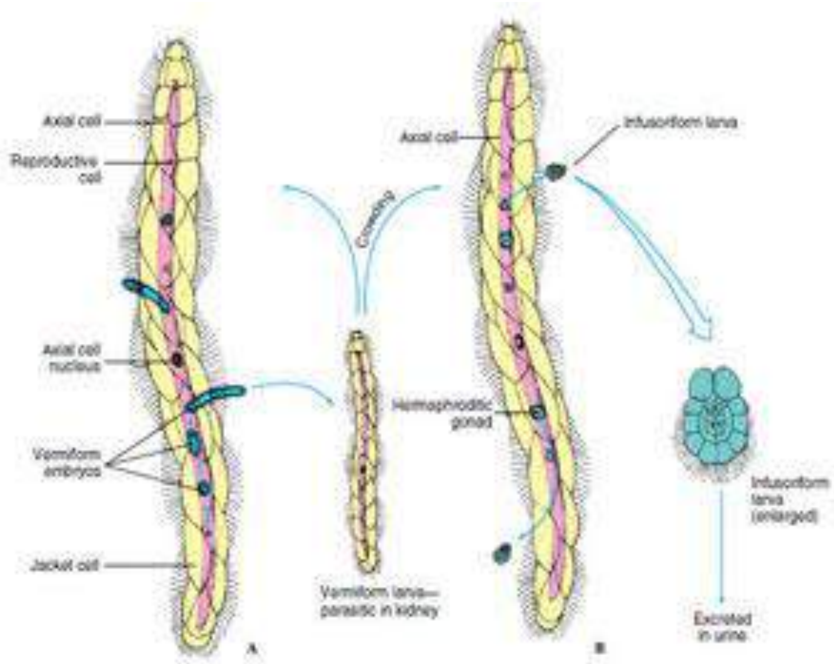
A. Diagram of *Rhopalura granosa* (mature female). B. Male plasmodium *Rhopalura.*



The adults are microscopic wormlike animals, consisting of a single layer of ciliated outer cells surrounding a mass of sex cells. They swim freely within the bodies of their hosts, which include flatworms, polychaete worms, bivalve mollusks, and echinoderms. They are gonochoristic, with separate male and female individuals.

When they are ready to reproduce, the adults leave the host, and sperm from the males penetrate the bodies of the females to achieve internal fertilization. The resulting zygote develops into a ciliated larva that escapes from the mother to seek out new hosts. Once it finds a host, the larva loses its cilia and develops into a syncytial plasmodium larva. This, in turn, breaks up into numerous individual cells that become the next generation of adults.

Rhombozoans features:-



1. Adult dicyemid is called nematogen and about 0.5 to 7 mm long.

2. Body composed of less than 30 cells.

3. Outer body layer composed of 20-30 ciliated cells in number that enclose single to several elongated axial cells which form a central shaft of the animal.

4. Anterior cells help to be attached with the host cells.

5. Within cephalopods the nematogen develops into a sexual stage, called rhombogen.

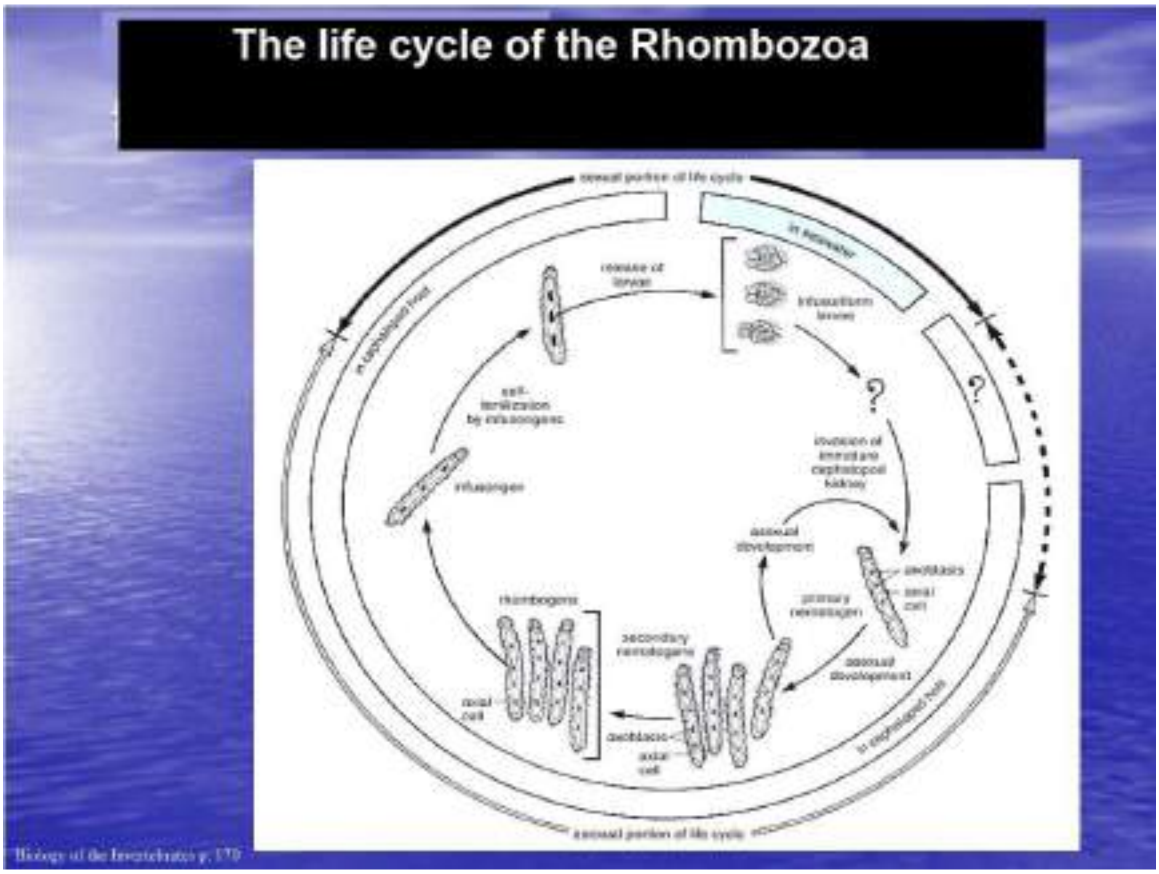
6. Self-fertilization common.

7. After fertilization ciliated infusoriform larva develops from the zygote.

8. Life cycle is not completely known.

Habitat:

They are found in the nephridia of cephalopod molluscs such as cuttle fish and octopuses, and obtain the nourishment from host urine in which they live.

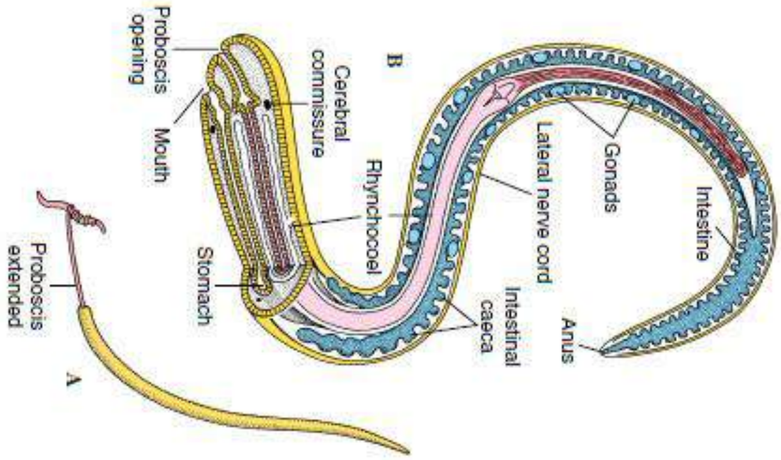


Phylum: Nemertinea

1. General Characters of Nemertean:

Body slender, worm-like, soft, highly contractile, un-segmented, bilaterally symmetrical, triploblastic and acoelomate. The ectoderm is ciliated. Eversible proboscis lying in a sheath on the dorsal side of the gut. The gut is straight, complete with lateral diverticula and terminates in posterior anus. True coelom and respiratory organs are absent, body spaces are filled with gelatinous mesenchyme.

Circulatory system is closed. Paired, excretory tubules provided with flame cells. Nervous system comprises a well differentiated brain from which arises a pair of lateral longitudinal nerves. A pair of ciliated pits are also connected with the brain. Sexes are separate, gonads are simple sac-like structures. Development direct or through a free-swimming pilidium larva. Asexual reproduction by fragmentation.



2-Structure of Nemertean:

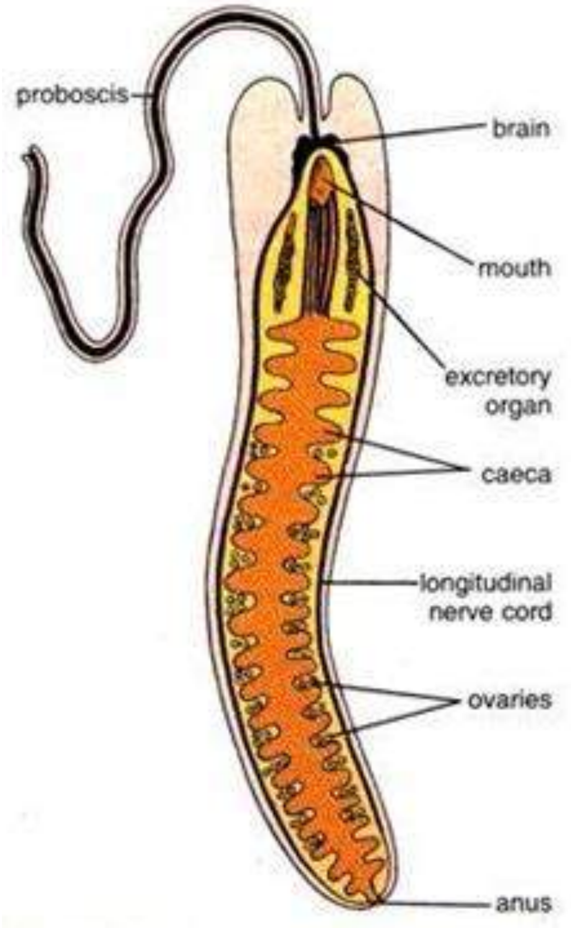
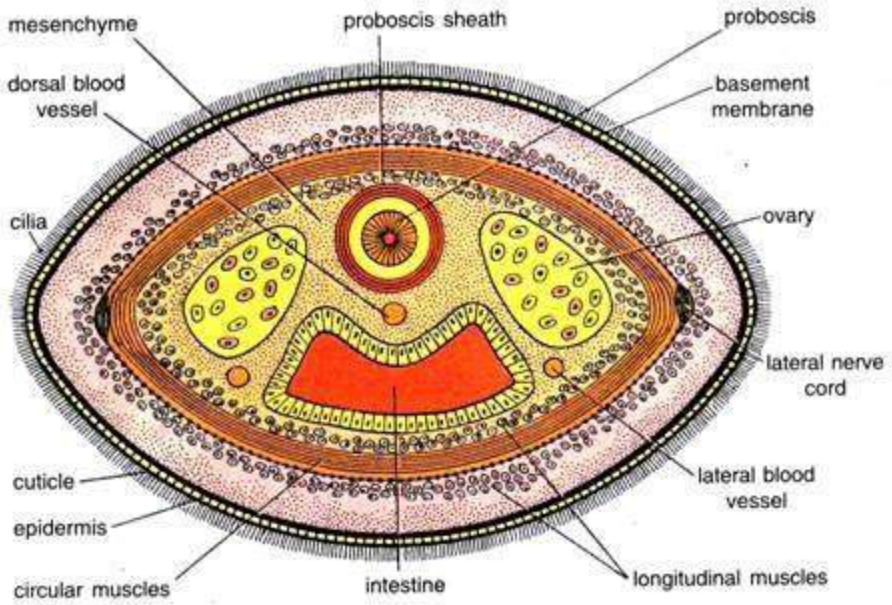


Diagram of a generalised nemertine.

The body is nearly always narrow and elongated, cylindrical or depressed, un-segmented and devoid of appendages. In length they vary from a few millimeters to as much as twenty-seven meters. In some cases, there is a short narrower posterior region or tail. The distinct head is absent.

The entire surface is covered with vibrated cilia and frequently the integument is vividly coloured.
Gland cells of the epidermis secrete a mucous matter, which may serve as a sheath or tube for the animal. The mouth is situated at or near the anterior extremity on the ventral aspect. Near the mouth in front there is an opening through which can be protruded a very long muscular organ, the proboscis. The proboscis is hollow.

3-Body Wall of Nemertean:

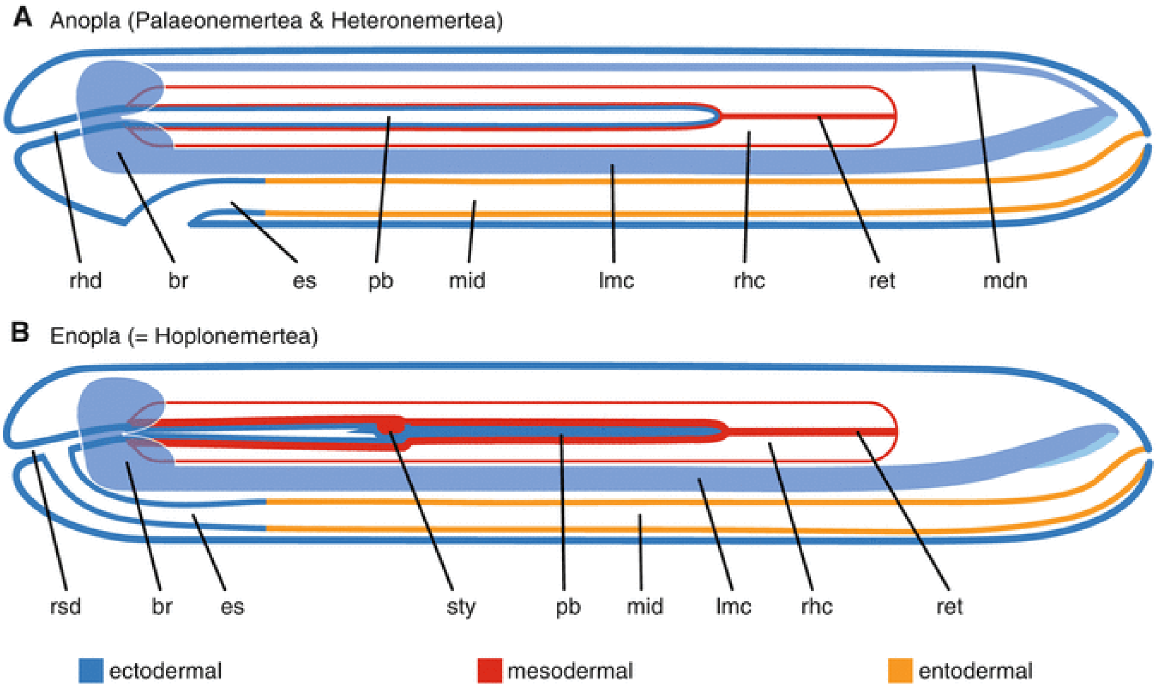


Nemertine. Diagrammatic transverse section.

Body wall consists of epidermis, dermis, circular muscle layer and longitudinal muscle layer.
The outermost layer of the body wall is an epidermis of columnar cells, many of which are ciliated, while others are unicellular glands, some of which are arranged in groups. The unicellular glands secrete mucus with which the surface is usually covered and may form gelatinous tube.
Beneath the epidermis is a basement membrane, very thin in most cases.

Then follows the dermis forming a connective tissue layer. Beneath dermis is a thick muscular layer. In some nemertines there are only two layers of muscle fibres, an outer circular and an inner longitudinal, in the rest a third (longitudinal) layer is superadded. The gland cells are scattered irregularly between the narrower portions of the ciliated columnar epidermal cells.
Besides the unicellular glands many nemertines have cluster of gland cells opening at the surface by a common duct, these are known as the packet glands. The packet glands may be included within epidermis as in paleonemertines or they may sink into the sub-epidermal tissue as in the heteronemertines.

- **4. Proboscis of Nemertine:**



The proboscis is the most characteristic feature of nemertines. It is an elongated, coiled, hollow and muscular organ opening in front and closed behind. It lies within the proboscis sheath and retractile in nature. When retracted it lies within the body in a fluid-filled cavity called rhynchocoel which is completely shut off from the exterior.

The muscular walls of the rhynchocoel form the proboscis sheath. The epithelial cells of the proboscis, in most cases, secrete rods identical with the rhabdites of Turbellaria. The blind end of proboscis is attached to the posterior end of the sheath by a retractor muscle which checks the eversion of the proboscis beyond a certain point, and by means of which also it is retracted.
The part of the proboscis in front of the brain is called rhynchodaeum which opens to the exterior through the proboscis pore. The proboscis

may be armed or unarmed, if armed with styles at the tip. The lining epithelium of the proboscis closely resembles the surface epidermis from which it is derived.

The muscle layer of proboscis and those of the proboscis sheath repeat the body wall musculature. The proboscis is shot out with explosive force through muscular contraction exerting pressure in the fluid of the rhynchocoel. As this is done the proboscis turns inside out (everts) and protrudes. Withdrawal of the proboscis is brought about by retractor muscles.

5. Digestive System of Nemertine:

The mouth is situated ventrally near the anterior tip. The digestive tract is a ciliated tube which extends throughout the length of the body from the mouth to the anus. The first part of the digestive tract is usually a simple tube-oesophagus (stomodaeum) but may be more complicated and divided into various regions, sometimes with paired diverticula. Posteriorly it opens into the intestine.

The intestine may be a simple un-constricted tube or may be only slightly constricted at intervals by the paired gonads. In most cases the constrictions corresponding to the gonads are very deep so that the intestine comes to be provided with two rows of lateral diverticula or caeca which may be branched. The caeca are separated from one another by incomplete transverse septa of dorsoventrally muscular fibres.

The arrangement of the caeca and septa with the alternately arranged gonads bringing about an appearance of imperfect metamerism as observed in some of the Platyhelminthes. The intestine opens to the exterior by an anus at the posterior end of the body. The nemertines feed usually at night on living or dead animals mainly annelids, molluscs, crustaceans and fishes, etc.

6. Circulatory System of Nemertine:

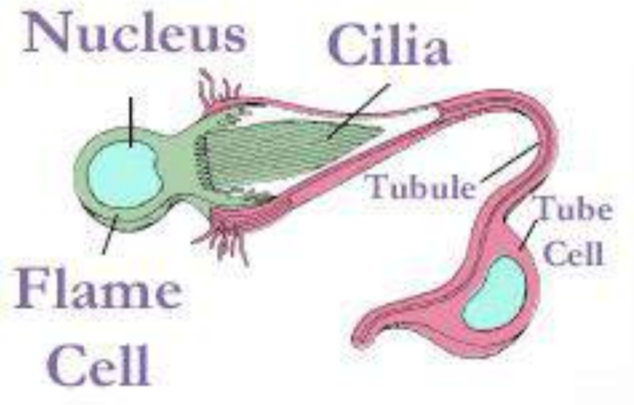
The circulatory system of nemertines is closed type. There are three principal longitudinal trunks a median dorsal and two lateral. The longitudinal trunks lie in the parenchyma, one on each side of the intestine and one just above it. The lateral vessels communicate with each other both anteriorly and posteriorly by spaces lined by only delicate membranes respectively known as cephalic lacuna and anal lacuna.

The longitudinal vessels give off other lateral branches that open into a system of lacunae in the tissues.

The blood is, in most cases, colourless and contains rounded or elliptical, usually colourless corpuscles. In some cases the blood is red because the corpuscles contain haemoglobin. Circulation in nemertines is primitive in several respects. There is no pumping organ or heart. The circulation is brought about by general movement of the body.

7. Excretory System of Nemertine:

The excretory system consists of a pair of longitudinal vessels which give off branches. Each longitudinal vessel opens to the exterior by a nephridiopore on each side. The fine terminal branches of the system are provided with ciliary flames each situated in the midst of a group of cells, not in the interior of a single flame-cell as in most cases in the flatworms.



8. Respiratory System of Nemertine:

There are no special organs of respiration in any of the group. But there is evidence that this function is carried out, in part at least, by taking in and giving out of water through the mouth by the oesophagus. Respiration also takes place by the diffusion of oxygen through the general body surface.

9. Nervous System of Nemertine:

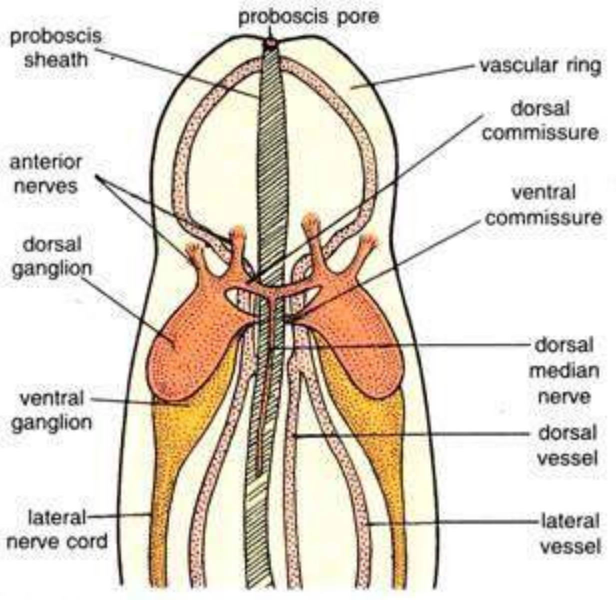


Fig. 53.4. Diagram of the anterior end of a nemertine to show the nervous system in dorsal view.

The nervous system consists of brain. The brain is composed of two pairs of ganglia, dorsal and ventral.

The ganglia of each pair being connected together by commissures, the dorsal situated above and the ventral below. From the brain pass backwards a pair of thick longitudinal nerve cords which run throughout the length of the body. Usually these are lateral in position, sometimes approximated dorsally and sometimes ventrally.

The lateral nerve cords generally meet posteriorly in a commissure usually situated above, but in one genus below, the anus. A third median dorsal nerve of smaller size than the lateral nerve cords extends backwards from the dorsal commissure of the brain. The position of brain and lateral nerve cords, or the system of commissures and nerve branches varies in different groups.

10. Sense Organs of Nemertine:

The sense organs of nemertine consist of sensory nerve cells, sensory pits and eyes. The special organs of the sense are mostly restricted to the anterior part of the body but the sensory nerve cells are found scattered in the epidermis of anterior as well as posterior ends.

The sensory nerve cells are slender-like in appearance, each bearing a hair-like process on the outer side. They are tactile in function. Sensory pits are found all over the body. Eyes are present in majority of nemertines and in the more highly organised species occur in considerable numbers.

Sometimes they are of extremely simple structure, in other cases they are more highly developed, having a spherical refractive body with a cellular vitreous body and a retina consisting of layer of rods enclosed in a sheath of dark pigment. Each rod has a separate nerve branch connected with it. Statocysts containing statoliths have been found in only a few of the nemertines.

11. Reproductive System of Nemertine:

Most nemertines are dioecious but some may be hermaphroditic. The gonads are simple, tubular, sac-like structures, situated in the intervals between the intestinal caeca. The ovary or testis is a sac lined by cells which give rise to ova or spermatozoa; when these are mature each sac opens by means of a narrow duct leading to the dorsal, rarely to the ventral surface, or which it opens by a pore.

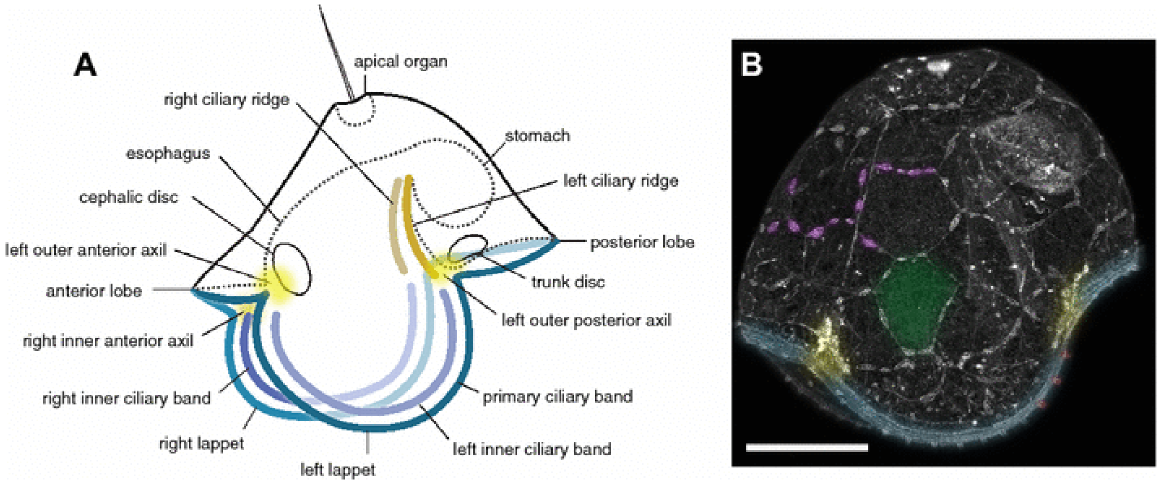
12. Development of Nemertine:

In nemertines the development is of two types:

(i) Direct

(ii) Indirect.

Male and female ribbon worms occur in most species, with annual reproduction typical. Usually eggs and sperm are released separately, and fertilization takes place externally. The fertilized egg develops by a process similar to that of flatworms (phylum Platyhelminthes), annelids (phylum Annelida), and mollusks (phylum Mollusca). Ribbon worms can develop in one of two ways: the most common is the **direct** method, without a larval stage; the other includes a ciliated larval stage, which may be one of two types. One kind, a free-swimming larva of complicated pattern known as the **pilidium**, is more common; the other type, similar to an adult, is called **Desor's** larva. Larvae metamorphose into young ribbon worms after swimming for days or weeks in the plankton. Within the genera *Prostoma* and *Geonemertes,* the species may be either dioecious (*i.e.,* separate male and female animals) or hermaphroditic (*i.e*. male and female reproductive organs in one animal). All ribbon worms have the ability to regenerate lost or damaged parts of their bodies; some species actually break up and form a number of fragments, which then grow into complete individuals. This mechanism provides asexual reproduction.



<u>**Lecture 6**</u>

Aschelminthes

Characters:-

Some of the general characters of phylum Aschelminthes or Nemathelminthes are as follows:

1. Habitat:

Many roundworms live as parasites in plants and animals. They cause serious agricultural, veterinary and human health problems. Round worms are also free living and occur in fresh water, sea water and soil.

2. Body Form:

They are called round worms because they appear circular in cross section. They are un-segmented.

3. Body wall:

It consists of firm, non living resistant cuticle, syncytial epidermis (a continuous layer of cytoplasm with scattered nuclei) and muscle layer.

4. Body cavity:

The body cavity is called pseudocoel or pseudocoelom as it devel-ops from the blastocoel of the embryo. Pseudocoel is filled with pseudocoelomic fluid.

5. Digestive Tract:

Alimentary canal is complete with muscular pharynx.

6. Skeletal, respiratory and circulatory systems are absent:

Pseudocoelomic fluid present in the pseudocoelom maintains body shape and forms hydro skeleton. Gas-eous exchange in aerobic respiration occurs by diffusion through the body surface. The pseudocoelomic fluid transports materials.

7. Excretory System:

The excretory system consists of gland cells, or of canals or of both. In *Ascaris*, 'H' shaped excretory system of canals and complicated "giant cell" called "renette cell" is present. Ammonia is main excretory matter. However, *Ascaris* also excretes urea.

8. Nervous System:

It consists of a circumpharyngeal ring that gives rise to nerves forwards as well backwards.

9. Sense Organs:

(i) Papillae (raised structures) occur on the lips, on the sides of anterior end in both male and female and in front and behind the cloacal aperture. All papillae are tactile in function,

(ii) Amphids (pits) are present on the lips and are chemoreceptors.

(iii) Phasmids are unicellular glands located upon lateral sides of the posterior end and are glandulosensory in nature.

10. Sexes:

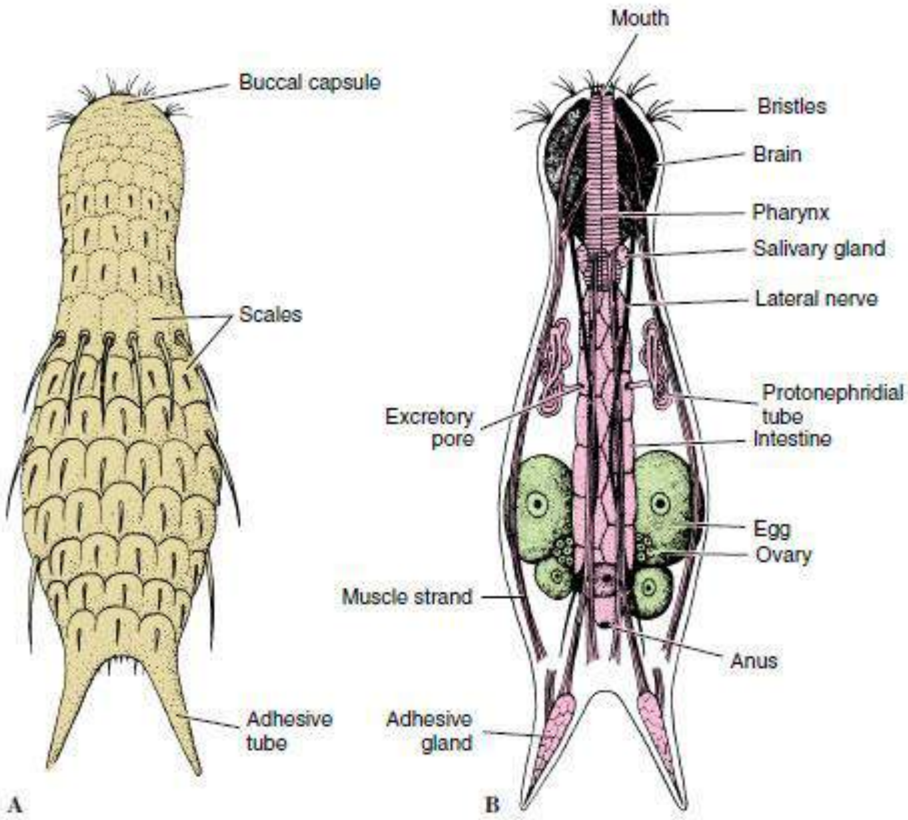
Sexes are separating (dioecious). Generally they show sexual dimorphism; often females are longer than males. Fertilization is internal. There is no asexual reproduction.

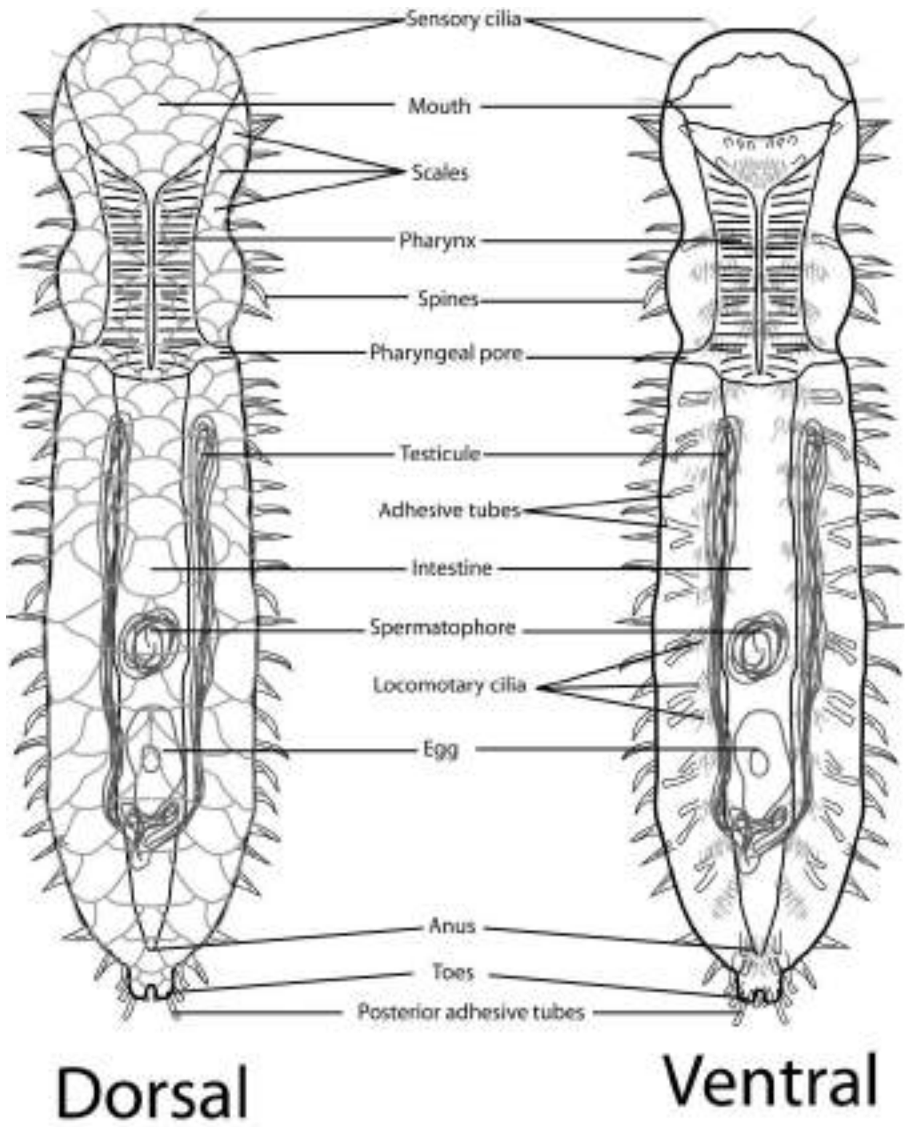
11. Development:

Development may be direct or indirect. During indirect development a larva is present. Filariform larva is present in *Ancylostoma* (hook worm), microfilaria larva is found in *Wuchereria* (filarial worm) and Rhabditiform larva is present in *Ascaris* and *Enterobius* (pin worm).

Phylum: Gastrotrich

A hairy back worms


Buccal capsule
Scales
Adhesive tube
A
Mouth
Bristles
Brain
Pharynx
Salivary gland
Lateral nerve
Protonephridial tube
Excretory pore
Intestine
Egg
Ovary
Muscle strand
Anus
Adhesive gland
B



Gastrotrich, any of about 500 species of the phylum Gastrotricha, a group of microscopic aquatic invertebrates that live in the spaces between sand grains and soil particles and on the outer coverings of aquatic plants and animals. They occur in salt water and freshwater and also on sandy seashores.

The gastrotrich body, which ranges in size from 0.1 to 1.5 millimetres (0.004 to 0.06 inch), is covered by a cuticle that is often scaly and spiny. The head is swollen and lobelike. Adhesive tubules are used for anchorage. Cilia—especially on the head and on the ventral, or bottom, surface—are used for locomotion.

The body wall consists of a cuticle, an epidermis is syncytial and longitudinal and circular bands of muscle fibres. In some primitive species, each epidermal cell has a single cilium. The whole ventral surface of the animal may be ciliated or the cilia may be arranged in rows, patches or transverse bands. The cuticle is locally thickened in some gastrotrichs and forms scales, hooks and spines. There is no coelom (body cavity) and the interior of the animal is filled with poorly differentiated connective tissue. In the macrodasyidans, Y-shaped cells, each containing a vacuole, surround the gut and may function as a hydrostatic skeleton.

Feeding & Digestion

The mouth is at the anterior end and opens into an elongated muscular pharynx with a triangular or Y-shaped lumen, lined by myoepithelial cells. The pharynx opens into a cylindrical intestine, which is lined with glandular and digestive cells. The anus is located on the ventral surface close to the posterior of the body. In some species, there are pores in the pharynx opening to the ventral surface; these contain valves and may allow egestion of any excess water swallowed while feeding. Gastrotriches feed in algae, protozoa, bacteria and detritus

Excretion

In the chaetonotidans, the excretory system consists of a single pair of protonephridia, which open through separate pores on the lateral underside of the animal, usually in the midsection of the body. In the macrodasyidans, there are several pairs of these opening along the side of the body. Nitrogenous waste is probably excreted through the body wall, as part of respiration, and the protonephridia are believed to function mainly in osmoregulation. **Unusually**, the protonephridia do not take the form of flame cells, but, instead, the excretory cells has 1 flagellum enclosed in cylinder of cytoplasmic rods (flame cell has many cilia). These cells, termed *cyrtocytes*, connect to a single outlet cell which passes the excreted material into the protonephridial duct. As is typical for such small animals, there are no respiratory or circulatory organs. The nervous system is relatively simple. The brain consists of two ganglia, one on either side of the pharynx, connected by a commissure. From these lead a pair of nerve cords which run along either side of the body beside the longitudinal muscle bands. The primary sensory organs are the bristles and ciliated tufts of the body surface which function as mechanoreceptors. There are also ciliated pits on the head, simple ciliary photoreceptors and fleshy appendages which act as chemoreceptors.

Reproduction and lifespan

Gastrotrich reproduction and reproductive behaviour has been little studied. primitive gastrotrichs are simultaneous hermaphrodites, possessing both male and female sex organs. There is generally a single pair of gonads, the anterior portion of which contains sperm-producing cells and the posterior portion producing ova. The sperm is sometimes packaged in spermatophores and is released through male gonopores that open, often temporarily, on the underside of the animal, roughly two-thirds of the way along the body. A copulatory organ on the tail collects the sperm and transfers it to the partner's seminal receptacle through the female gonopore. Details of the process and the behaviour involved vary with the species, and there is a range of different accessory reproductive organs. During copulation, the "male" individual uses his copulatory organ to transfer sperm to his partner's gonopore and fertilization is internal. The fertilized eggs are released by rupture of the body wall which afterwards repairs itself.

Fertilized eggs can produce two kinds of eggs:

Thin- walled for immediate reproduction

Thick-walled egg for dormancy

Resistant stage------can survive for years

Direct development: no larval stage

Juveniles mature in a few days after hatching. As is the case in most protostomes, development of the embryo is determinate, with each cell destined to become a specific part of the animal's body. Many species of chaetotonid gastrotrichs reproduce entirely by parthenogenesis. In these species, the male portions of the reproductive system are degenerate and non-functional, or, in many cases, entirely absent.

Classification

Macrodasyida

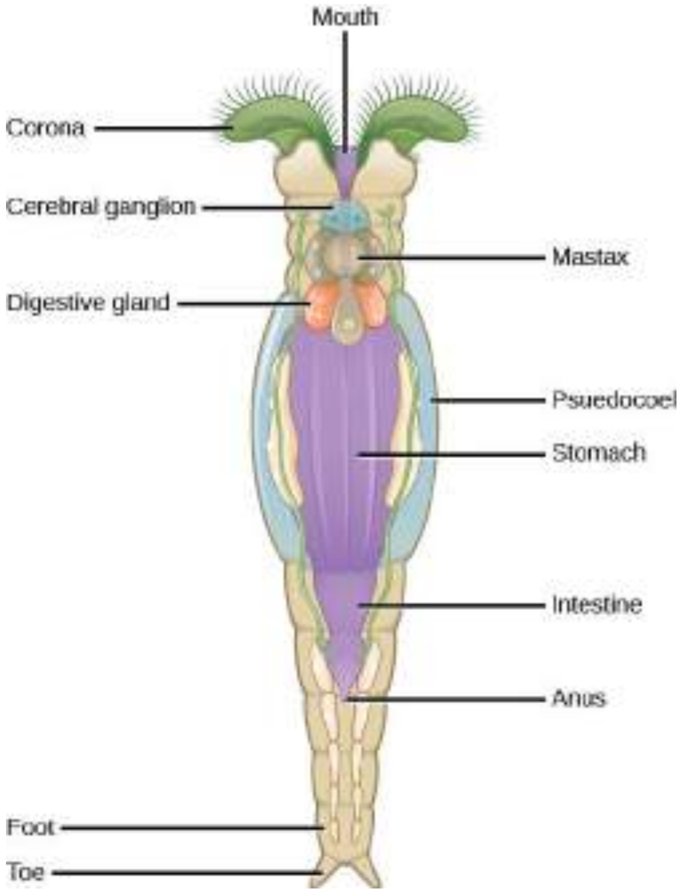
Is an order of gastrotrichs. Members of this order are somewhat worm-like in form, and not more than 1 to 1.5 mm in length. Macrodasyids are almost in entirely marine and live in the sediment in marine or brackish water, but two species have been discovered in freshwater. They can be distinguished from other gastrotrichs by the presence of two pores on either side of the pharynx, that allow excess water to be expelled during feeding. The body is dorsally flattened and there are tubular adhesive glands at both ends and on the lateral surfaces. These animals are detritivores and are hermaphrodites.

The **Chaetonotida**

is an order of gastrotrichs. They generally have a tenpin or bottle-like shape.

Chaetonotids inhabit both freshwater and marine environments. They can be distinguished from other gastrotrichs by the absence of pores in the pharynx, and by the presence of adhesive glands at the posterior end of the animal only. Most freshwater species are parthenogenetic. The smooth or complex cuticle has a variable number of adhesive tubes, and the pharyngeal lumen of Chaetonotids is Y-shaped. A valve may be present at the junction of the pharynx and midgut. The epidermis in most organisms in this order is partly syncytial.

- Phylum: Rotifera



The **rotifers** (/ˈroʊtɪfərz/, from Latin *rota* "wheel" and *-fer* "bearing"), commonly called **wheel animals** or **wheel animalcules**, make up a phylum (**Rotifera** /roʊˈtɪfərə/) of microscopic and near-microscopic pseudocoelomate animals.

Most rotifers are around 0.1–0.5 mm long (although their size can range from 50 µm to over 2 mm), and are common in freshwater environments throughout the world with a few saltwater species. Some rotifers are free swimming and truly planktonic, others move by inchworming along a substrate, and some are sessile, living inside tubes or gelatinous holdfasts that are attached to a substrate. About 25 species are colonial (e.g., *Sinantherina semibullata*), either sessile or planktonic. Rotifers are an important part of the freshwater zooplankton, being a major food source and with many species also contributing to the decomposition of soil organic matter. Most species of the rotifers are cosmopolitan.

Anatomy

- Rotifers have bilateral symmetry and a variety of different shapes. The body of a rotifer is divided into a head, trunk, and foot, and is typically somewhat cylindrical. There is a well-developed cuticle, which may be thick and rigid, giving the animal a box-like shape, or flexible, giving the animal a worm-like shape; such rotifers are respectively called *loricate* and *illoricate*. Rigid cuticles are often composed of multiple plates, and may bear spines, ridges, or other ornamentation. Their cuticle is non chitinous and is formed from sclerotized proteins.
- The most distinctive feature of rotifers is the presence of a ciliated structure, called the *corona*, on the head. In the more

primitive species, this forms a simple ring of cilia around the mouth from which an additional band of cilia stretches over the back of the head. In the great majority of rotifers, however, this has evolved into a more complex structure.

- The trunk forms the major part of the body, and encloses most of the internal organs. The foot projects from the rear of the trunk, and is usually much narrower, giving the appearance of a tail. The cuticle over the foot often forms rings, making it appear segmented. Many rotifers can retract the foot partially or wholly into the trunk. The foot ends in from one to four toes, which, in sessile and crawling species, contain adhesive glands to attach the animal to the substratum. In many free-swimming species, the foot as a whole is reduced in size, and may even be absent.

- **Digestive system**

- The coronal cilia create a current that sweeps food into the mouth. The mouth opens into a characteristic chewing pharynx (called the *mastax*), sometimes via a ciliated tube, and sometimes directly. The pharynx has a powerful muscular wall and contains tiny, calcified, jaw-like structures called *trophi*, which are the only fossilizable parts of a rotifer. The shape of the trophi varies between different species, depending partly on the nature of their diet. In suspension feeders, the trophi are covered in grinding ridges, while in more actively carnivorous species, they may be shaped like forceps to help bite into prey. In some ectoparasitic rotifers, the mastax is adapted to grip onto the host, although, in others, the foot performs this function instead.

- Behind the mastax lies an oesophagus, which opens into a stomach where most of the digestion and absorption occurs. The stomach opens into a short intestine that terminates in a cloaca on the posterior dorsal surface of the animal. Up to seven salivary glands are present in some species, emptying to the mouth in front of the oesophagus, while the stomach is associated with two gastric glands that produce digestive enzymes.
- A pair of protonephridia open into a bladder that drains into the cloaca. These organs expel water from the body, helping to maintain osmotic balance.

- Feeding

- Rotifers eat particulate organic detritus, dead bacteria, algae, and protozoans. They eat particles up to 10 micrometres in size. Like crustaceans, rotifers contribute to nutrient recycling. For this reason, they are used in fish tanks to help clean the water, to prevent clouds of waste matter. Rotifers affect the species composition of algae in ecosystems through their choice in grazing. Rotifers may be in competition with cladocera and copepods for planktonic food sources.
- **Nervous system**

- Rotifers have a small brain, located just above the mastax, from which a number of nerves extend throughout the body. The number of nerves varies among species.
- The nervous system comprises about 25% of the roughly 1,000 cells in a rotifer.

- Rotifers typically possess one or two pairs of short antennae and up to five eyes. The eyes are simple in structure, sometimes with just a single photoreceptor cell. In addition, the bristles of the corona are sensitive to touch, and there are also a pair of tiny sensory pits lined by cilia in the head region.
- Reproduction and life cycle
  Rotifers are dioecious and reproduce sexually or parthenogenetically. They are sexually dimorphic, with the females always being larger than the males. In some species, this is relatively mild, but in others the female may be up to ten times the size of the male. In parthenogenetic species, males may be present only at certain times of the year, or absent altogether.
- The female reproductive system consists of one or two ovaries, each with a *vitellarium* gland that supplies the eggs with yolk. Together, each ovary and vitellarium form a single syncitial structure in the anterior part of the animal, opening through an oviduct into the cloaca.
- Males do not usually have a functional digestive system, and are therefore short-lived, often being sexually fertile at birth.
- Fertilization is internal. The male either inserts his penis into the female's cloaca or uses it to penetrate her skin, injecting the sperm into the body cavity. The egg secretes a shell, and is attached either to the substratum, nearby plants, or the female's own body. A few species, such as members of the *Rotaria*, are ovoviviparous, retaining the eggs inside their body until they hatch.
- Most species hatch as miniature versions of the adult. Sessile species, however, are born as free-swimming larvae, which closely resemble the adults of related free-swimming species. Females grow rapidly, reaching their adult size within a few days, while males typically do not grow in size at all.

- **Resting eggs**

- Resting eggs enclose an embryo encysted in a three layered shell that protects it from external stressors. They are able to remain dormant for several decades and can resist adverse periods (e.g., pond desiccation or presence of antagonists). When favorable conditions return and after an obligatory period of diapause which varies among species, resting eggs hatch releasing diploid amictic females that enter into the asexual phase of the life cycle.

Phylum: Nematomorpha

horsehair worms (Also: Gordian worms)

Characteristics of Nematomorpha:

1. Bilaterally symmetrical, and vermiform.
2. Body has more than two cell layers, tissues and organs.
3. Body monomeric with a pseudocoelomic cavity.
4. Body possesses a through gut which is normally non-functional.
5. Body possesses in a cuticle and longitudinal muscles.
6. Has a intra-epidermal nervous system with an anterior nerve ring.
7. Has no circulatory system (no blood system)

8. Reproduction normally sexual and gonochoristic.
9. Adults non-feeding, larvae endoparasitic.

10-Aquatic or moist soils, mostly fresh-water.

Introduction to the Nematomorpha

The nematomorpha (Horsehair Worms) are relatively long, thin worms (1-3 mm diametre and 10-100 cm length). They are a smallish phylum, with about 361 known species.

They are called Horsehair Worms because they used to be found in horse watering troughs and they look like the hairs from a horses tail. Thus, before the advent of modern science, it was believed they arose spontaneously from the hairs from horse tails that fell into the water.

The nematomorpha have a second common name, Gordian Worms. They derived this name from the mating habits of certain species who mate in a tangled bundle that to some people resembled the fabled Gordian Knot of Greek mythology.

They are most probably closely related to the nematodes and like them they move by muscularly induced, undulating waves passing along the body.

All known species are parasites and use arthropods as their primary host. Usually an insect in the majority of species, however the few marine species use crustaceans as their primary host. All known, bar a single species from North America, *Gordius terrestris*, whose biology was only described in 2021, Gordian Worms require water to live in as adults, which is the free-living and reproductive stage.

As many of their hosts are terrestrial they have evolved the ability to force their hosts to seek out aquatic environments when they are ready to leave the host. The host usually dies after the emergence of the adult which is why it is common to find the hosts appearing as if drowned in water bodies containing adult Nematomorpha.

The adults may not feed, and do not they live long. Their only function in the life of the species is reproduction.

One of the unique features of Horse Hair Worms is their ability to escape the body of a predator that eats their host. Nematomorpha larva have been observed exiting the body of predators such as fish and frogs through various orifices; gills, mouth or nose. This ability is unknown in any other parasite and presumably is facilitated by the fact that their natural habitat is the digestive tract of their host.

Anatomy

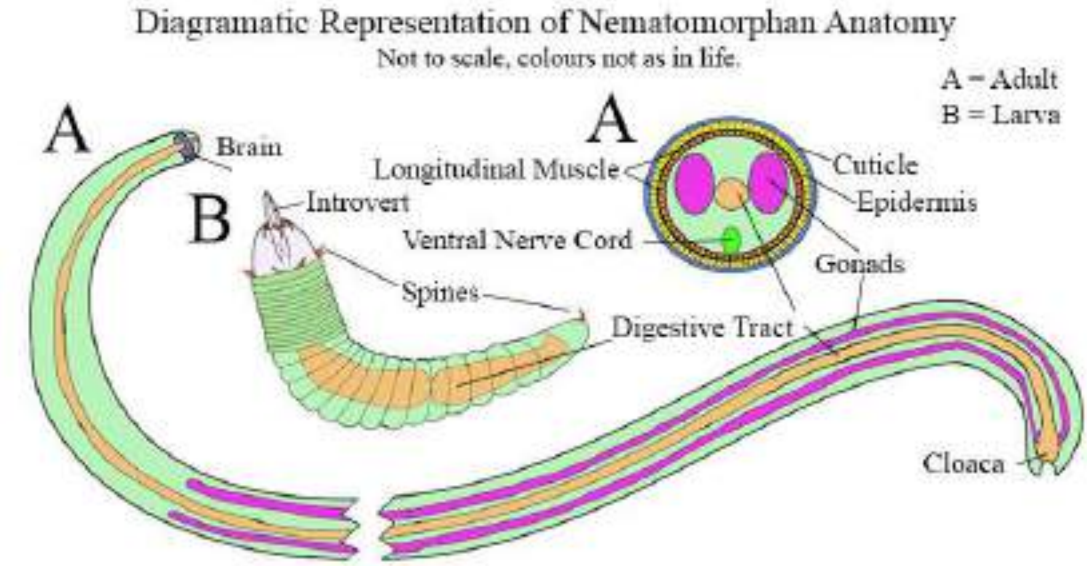
As adults the Nematomorpha are long and thin. Their body is circular in cross-section and unsegmented. They have no known respiratory, excretory or circulatory systems. Seen undissected it is difficult to know which end is the front and which the tail as they lack any distinctive head morphology. The posterior end may posses two small lobes.

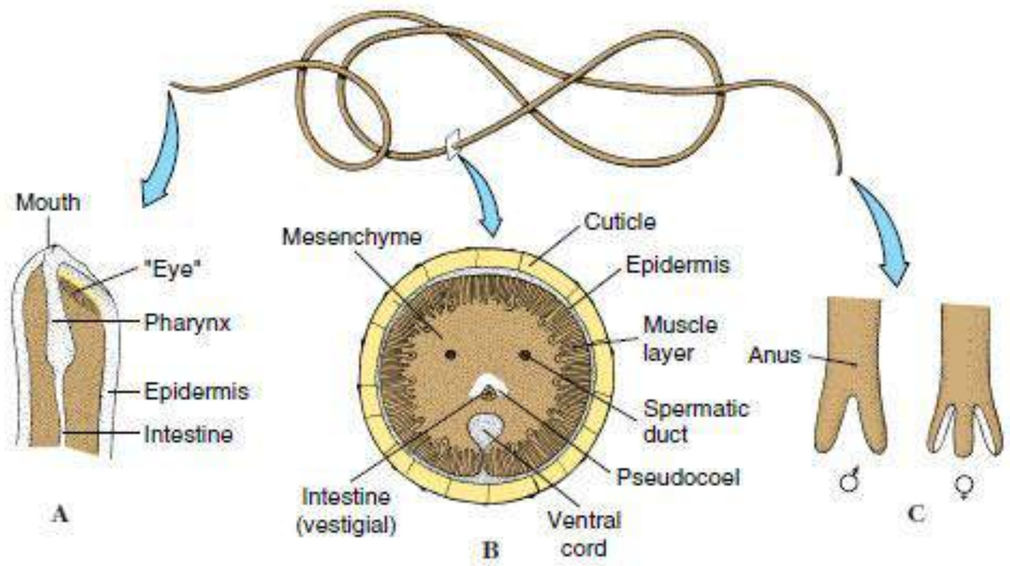
Their body is covered externally by a cuticle that is secreted by the epidermis. Immediately beneath the epidermis is a layer of longitudinal muscles. Like nematodes, nematomorphs have no circular muscle. The cuticle of the larval form is thin, only a single layer of cells. When the larva becomes an adult the cuticle become thicker and multilayered.

Internally the space between the digestive tract and the muscles of the epidermis is packed with a mix of mesenchyme and more fibrous collagen cells. Nematomorpha are dioecious and gonorchoristic, meaning adults are either male or female and only this one gender. The reproductive organs are long and thin as might be expected, extending the length of the gut in the body. Near the posterior end of the gut there exists a cloaca.

The nervous system of most Nematomorpha consists of a anterior brain, a single ventral nerve cord (plus an additional dorsal cord in *Nectonema spp.*), and a basilateral nerve net. The brain is a circumpharyngeal mass of nervous tissue, meaning it exist as a ring around the pharynx.

The mouth may be open or closed in adults, and the digestive tract may be reduced or blocked at the pharynx. Even in juveniles the digestive tract is simple and it is probable that most nutrition is absorbed across the cuticle rather than taken in through the mouth.





Life Cycles

Nematomorphs are parasites of arthropods as juveniles, though not necessarily aquatic ones. Commonly parasitized groups include, but are not to limited beetles, cockroaches, mantids, orthopterans and crustaceans.

Most known Nematomorpha have a two stage life cycle with primary host and a paratenic host. The primary host is the one in which the animal feeds and grows. A single species of Horse Hair Worm may use more than one species of arthropod as its definitive or primary host. However species that use more than one species as primary host tend to be adapted to a single genus of family.

The paratenic host serves as an intermediary, carrying the microscopic larva around until such times as it is eaten by a primary host. No development occurs within the paratenic host. Paratenic hosts are usually species that live in aquatic environments and include fish, Trematodes and insects with aquatic larva such as Mayflies, Caddisflies, Stoneflies. and True Flies such as Chironomids. It is not yet known whether the paratenic host is an absolute requirement for species using terrestrial arthopods

The larva may hatch in the water and then enter the host, or be eaten by the host. Either way the next stage is for the larva, which looks more like a Kinorhynchan than a true worm, to burrow into the host flesh and encyst itself. The larva will awaken and leave the cyst when the host is eaten. If the predator is not a suitable primary host the larva can encyst itself again.

The larvae have a better developed digestive system than the adults, but it is likely they derive most of their nutrition from nutrients absorbed through their body wall. While it was once believed that adult Nematomorpha did not feed at all, it is now accepted, that in at least some species adults may also absorb nutrients.

Development of the nematomorpha larvae can takes from a few weeks to several months and there can be several generations per year. It is believed that the mature larvae somehow manipulate their non-aquatic hosts into seeking out water – though how this is accomplished is unknown. The nematomorpha do not require the water they breed in to be deep, free flowing or permanent. Areas of very wet ground are used by some species.

Most species inhabit freshwater and there is one marine genus which parasitizes crabs. In some species, individuals that mature in autumn form cysts on grass near to water and wait until spring before continuing their lives.

Reproduction in the Nematomorpha

Females are normally sedentary and are searched for by the more active males. Males can tract down females using scent. Once a male has found a female it will curl itself around the female and deposit a spermatophore near the females cloaca. The sperm then swim into the female's seminal receptacle, from where they can later fertilize her eggs. The female deposits her eggs in long strings, all stuck together and tangled around aquatic plants, or as a mass on some substrate such as a submerged rock.

The eggs take from 15 to 80 days to hatch. The larvae are free swimming and look like the Kinorhyncha, with scalid spines around their heads and a set of oral stylets (that can be everted or retracted into the body cavity) and not at all like their parents.

Once they have found a suitable primary host the larva begin to absorb nutrients and grow, rapidly becoming more worm-like.

Taxonomy of the Nematomorpha

The taxonomy and classification of the Nematomorpha is an on going study. To date 361 species have been discovered but it is likely the final total will be quite a bit higher than this as 90+ species have been added to the total in the last 30 years including new species from India, Mexico and Taiwan in in 2020. In terms of overall classification they are usually linked with the Nematoda, but also possibly with the Platyhelminthes. As very few genetic analyses have been done yet the final position of the Nematomorpha in the tree of life is still to be determined.

Phylum: Nematomorpha

- **Class Gordioida**
    - Order Gordioidea
        - Family Chordodiae (16 genera and 259 species)
            - Genus Gordius • 88 living spp.
            -

- **Class Nectonematoida**
    - Order Nectonematoidea
        - Family Nectonemidae (1 genus and 5 species)
            - Genus Nectonema • 5 living

Lecture 7

Midterm Exam.

Lecture 8

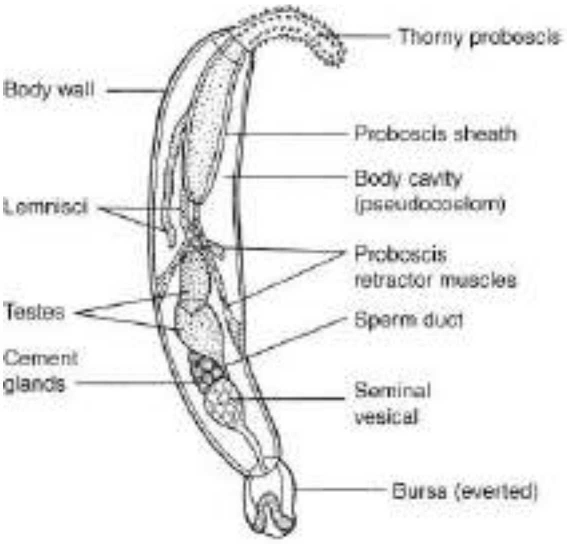
Phylum: Acanthocephala

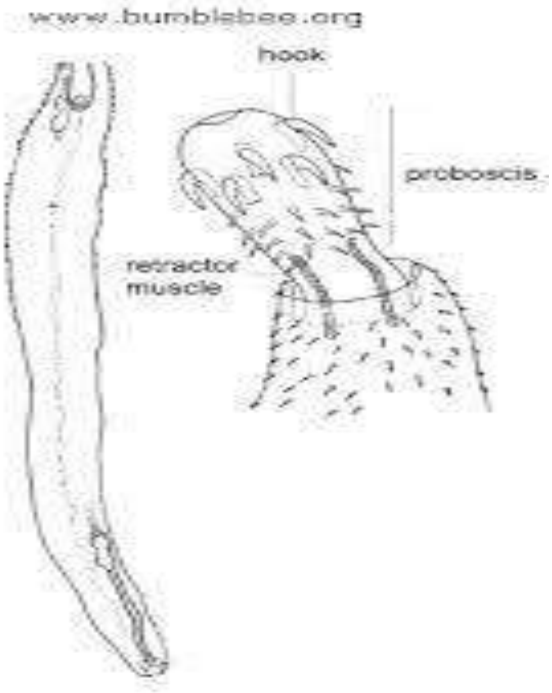
Spiny-headed worm

Spiny-headed worm, also called **acanthocephalan**, any animal of the invertebrate phylum Acanthocephala. A proboscis, or snout, which bears hooks, gives the group its name. There are about 1,150 recorded species, all of which parasitize vertebrates (usually fish) as adults and arthropods (usually insects or crustaceans) as juveniles. The adults are usually less than 1 cm (0.4 inch) long, but some reach lengths of 50 cm (about 20 inches) or more. Spiny-headed worms are found throughout the world.

Form and function.

The body of a spiny-headed worm is divided into a proboscis and an elongated cylindrical trunk. The proboscis, which usually bears backward-pointing hooks, can be withdrawn into the trunk, which may also bear hooks or spines. Usually white, spiny-headed worms may occasionally be yellow, orange, or red in colour. The internal anatomy is simple; there is no gut, and the bulk of the trunk is occupied by a proboscis receptacle and the muscles used to retract it. Passing backward from the base of this receptacle are structures known as ligament sacs. One of these sacs in the male encloses two testes and a number of cement glands. The female has two sacs that do not necessarily persist after she matures. Externally the male possesses an eversible copulatory bursa, the female a simple vagina.





Natural history.

Spiny-headed worms occur in both male and female forms, and mating occurs in the intestines of their vertebrate hosts. The fertilized eggs are excreted with the feces of the host. No further development occurs until the shelled embryos are eaten by an arthropod, which serves as a necessary intermediate host. After its release in the arthropod gut, the larva, called an acanthor, bores through the gut wall into the arthropod's blood cavity (hemocoel), becomes encapsulated there, and develops into a new stage called an acanthella. The acanthella, a miniature version of the adult, withdraws its armed proboscis before entering a resting stage during which it is known as a cystacanth. Once again, no further development occurs unless the cystacanth is ingested by its definitive host, a vertebrate. If ingested, the young spiny-headed worm emerges inside the vertebrate's intestine, uses its proboscis to bore into the gut wall, and matures there.

If an inappropriate host swallows a cystacanth, the cystacanth may bore through the gut wall into the body cavity, where it encysts and remains infective until the accidental host is eaten; then the cystacanth emerges again in its new host. This behaviour, incorporated into the life cycles of some spiny-headed worms, may provide the only means for completing the life cycle if the definitive host does not feed directly on the intermediate host. Although they are usually fish parasites, spiny-headed worms also parasitize amphibians, reptiles, birds, and mammals. Humans are only rarely infected and then accidentally. Because they do little damage to their hosts, spiny-headed worms are of no economic importance.

Classification.

The affinities of the spiny-headed worms are uncertain. Some morphological features, such as the fine details of the epidermis, and an increasing amount of molecular evidence suggest that acanthocephalans are closely related to rotifers, possibly having evolved from a rotifer ancestor.

Phylum: Kinorhyncha

Characteristics of Kinorhyncha:

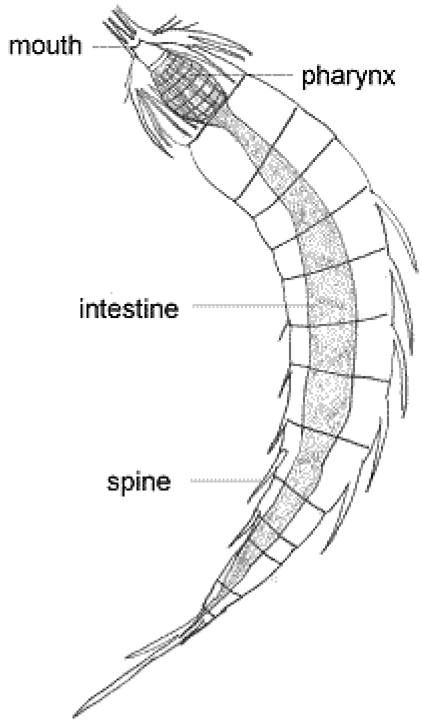
1. Bilaterally symmetrical, and vermiform.
2. Body has more than two cell layers, tissues and organs.
3. Body cavity is pseudocoelomate.
4. Body possesses a through gut with an anus.
5. Body possesses in a cuticle and longitudinal muscles.
6. Has a nervous system with an anterior nerve ring and a double nerve chord.
7. Has no circulatory system (no blood system)
8. Reproduction normally sexual and gonochoristic.
9. Feed on diatoms and organic detritus.

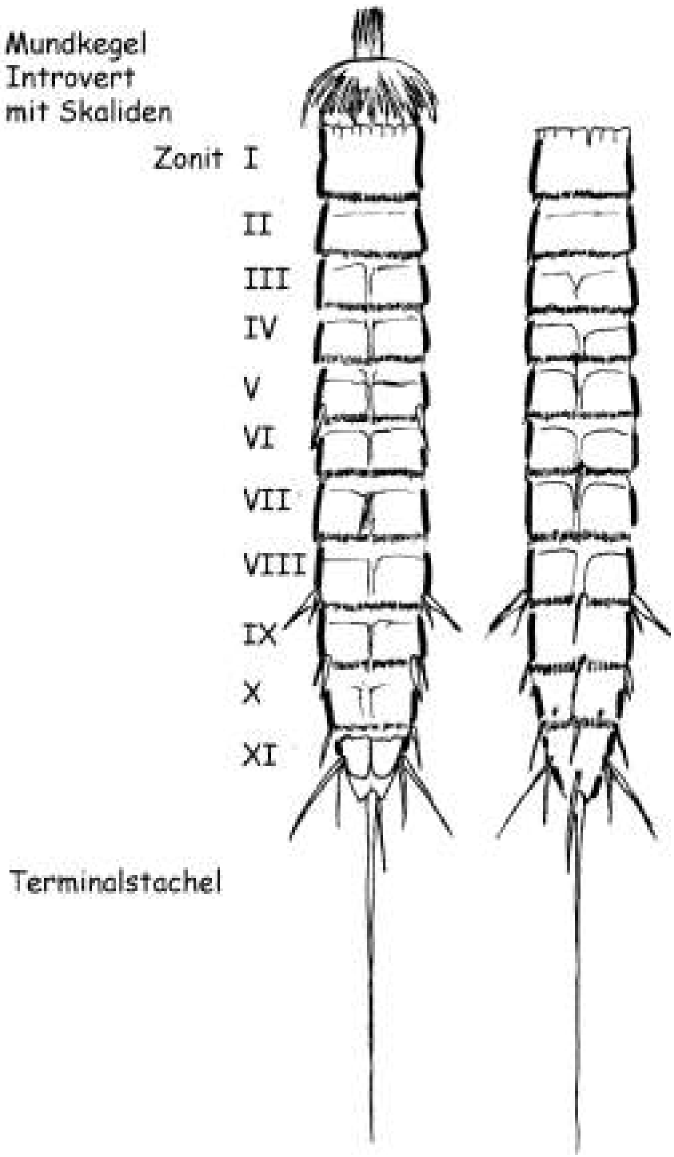
10. All live in marine environments.

Introduction to the Kinorhyncha

The Kinorhyncha are a smallish class (100 species) of marine worms that was until recently considered to be a phylum.

They are recognized by the 5 or 6 rings of recurved spines on their heads and the segmented appearance of their bodies. The segmented nature of their bodies is a reflection of the rings of cuticular plates that surround the body. It is not homologous with the segmentation of Annelid worms or Arthropods.

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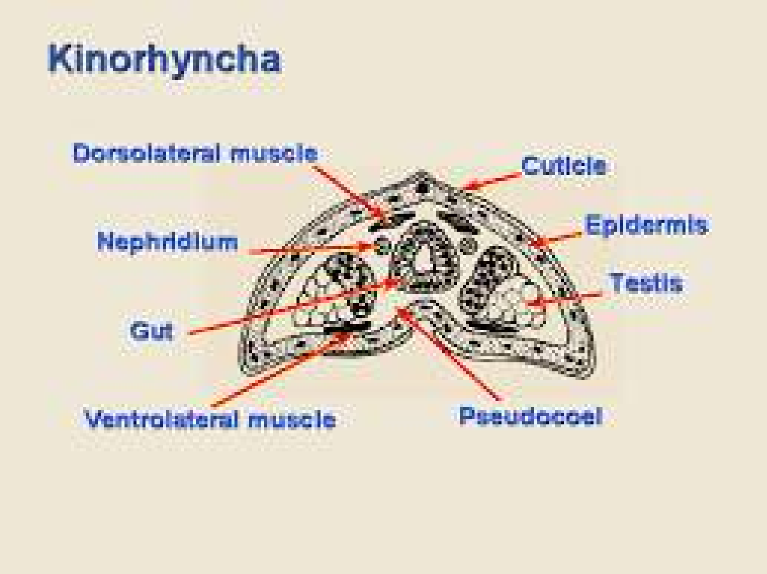


Kinorhyncha are not a very specious phyla, with only about 188 species currently known to science and a number of un-named species awaiting classification. They live in marine sediments ranging from coastal, to depths of up to 5,000 meters – and have been found in all the world's seas and oceans.

They can not swim and move by pushing their heads forward into the mud, extending their scalids then retracting the head into the body. Because the head is held in place by the spines, this has the effect of dragging the body forward. The spines can then be closed and the head pushed forward once more. They feed on diatoms and other organic matter they find in the mud.

The Biology of the Kinorhyncha

The Kinorhynchan body is comprised of a head, a neck and a trunk. The trunk has 11 segments or zonites. The head and the neck each constitute a zonite on their own meaning the adult animal has 13 segments or zonites. Each zonite has a single dorsal plate (tergite) and two ventral plates (sternites).

The head, which bears recurved spines or scalids and can be retracted into the trunk, and is therefore called an 'introvert'. The head also bears an oral cone or mouth, surrounded by more spines called stylets. These oral stylets are anteriorly directed (point backwards). There are nine outer stylets and three to four rings of inner stylets, each inner ring possesses 5 stylets. Behind these can be seen five to seven rings of posteriorly directed scalids. These are sensory, and or, locomotive spines. Each ring may have between 540 and 1,860 scalids. The neck is the second zonite and is made of up to 16 placids (plates), which can fold over the head when it is retracted.

The gut passes straight along the body and there is an anus at the posterior (tail) end of the body. Metabolic excretion and water balance are performed by a pair of protonephridia in the 10th zonite. Wastes are eliminated through a duct opening through the 11th zonite called a nephridiopore.

Kinorhynchans have a reasonably well-developed nervous system, composed of a nerve ring or brain which encircles the anterior (front) end of the pharynx, a double nerve cord (which runs down the ventral side of the body) and various other nerves and ganglia.

Reproduction in the Kinorhyncha

The Kinorhyncha are dioecious and gonorchoristic, meaning they have the two sexes separate, though to us they often look the same. In both males and females the gonads are paired. The gonads are situated towards the posterior end of the body and the gonopore can be found between the 12th and 13th zonites.

Very little is known of their reproduction. The eggs are fertilized by a spermatophore attached to the female's cuticle. As best we know between three and six eggs are laid at one time. The female encloses each egg in a capsule. The development is direct and the larvae that hatch out with 11 segments, the last two segments are acquired after several moults. The hatched larvae are free living and go through at least 6 moults of their cuticle before they reach maturity.

No kinorhyncha fossils have yet been found.

Lecture 9

The Lophophorates

Lophophore is derived from the Greek *lophos* (crest, tuft) and *-phore*, -*phoros* (bearing), a derivative of *phérein* (φέρειν) (to bear); thus crest-bearing.

3 phyla that had an *apparent* synapomorphy lophophore, a

horseshoe-shaped ring ofciliated tentacles surrounding mouth, used in filter feeding.

Lophophorate characteristis

Body divided in 3 parts, each with its own coelomic space:

Anterior **Coelomic space**

Protocoel

Mesocoel

Metacoel

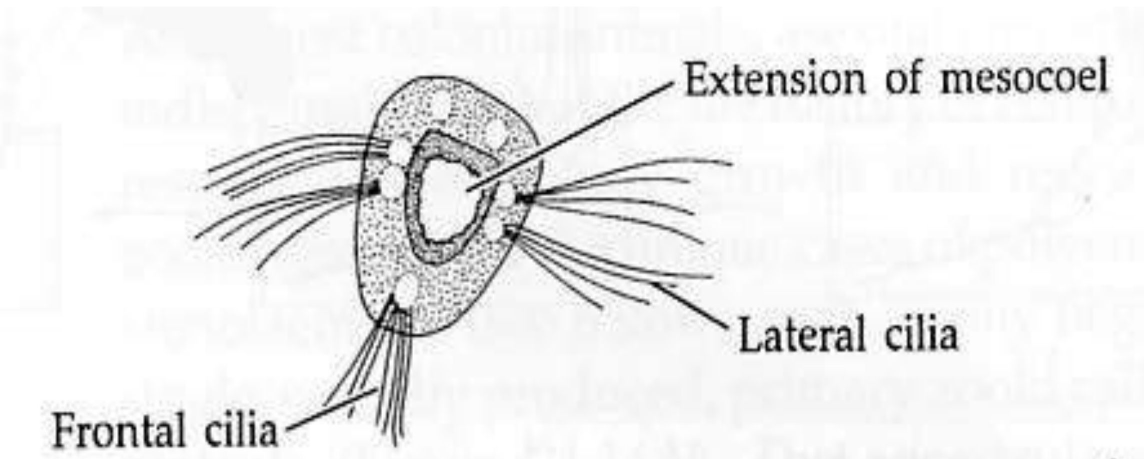
Posterior

This 3-part body/coelom structure is typical of deuterostomes.

Lophophore Function

Cilia on lophophore tentacles generate a feeding current

- cilia catch particles, bounce them back and forth to mouth

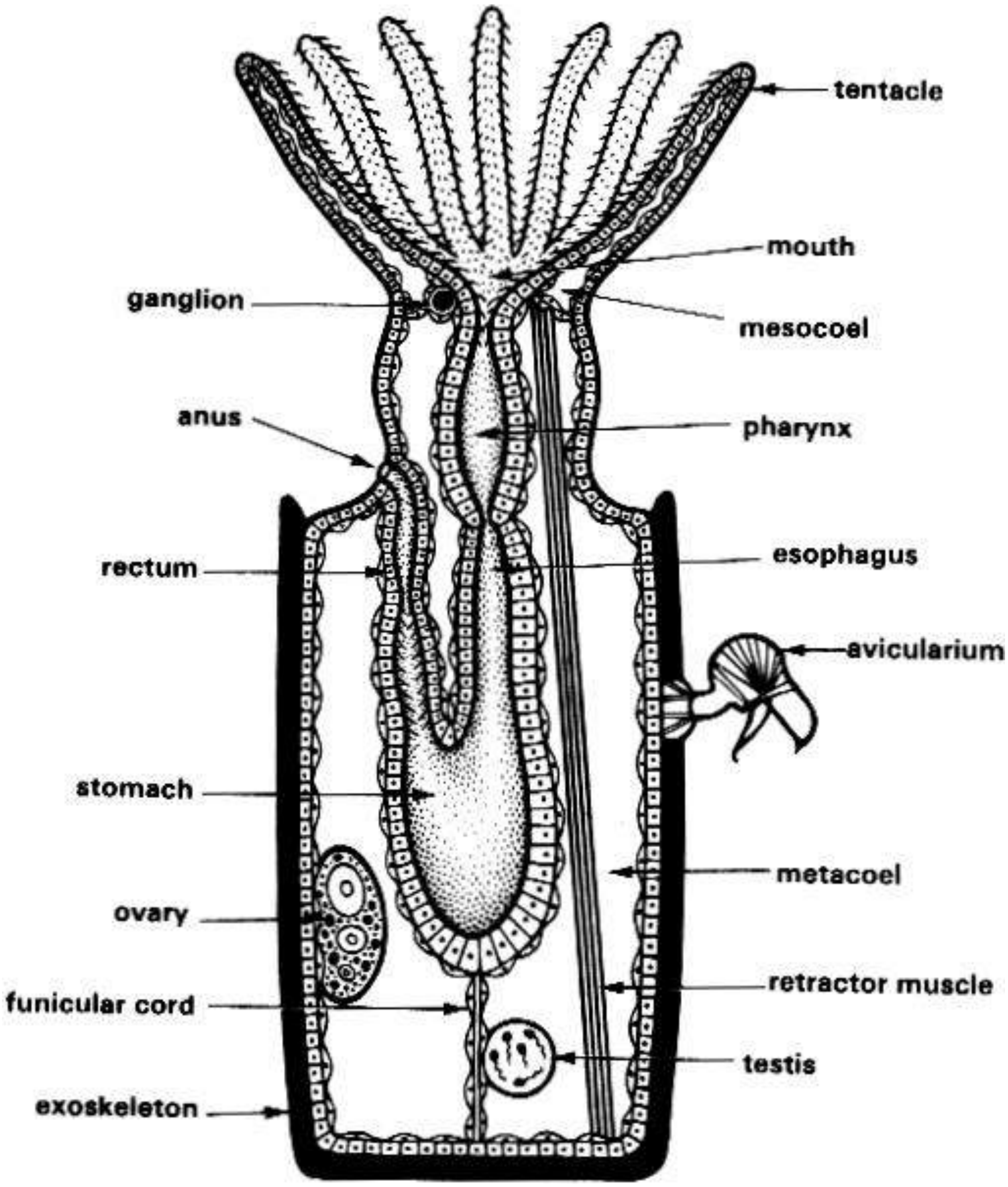


Each tentacle has one row of frontal cilia and two rows of lateral cilia. In addition to possessing a lophophore, nearly every member of these phyla is sessile has a reduced head, secretes a protective covering, and except for some brachiopods, possesses a U- shaped digestive tract.

Lophophorate phyla

- **Phoronida** (tube-dwelling marine worms) - unitaryorganism, tube dwelling with lophophore at upper end of body, only marine
- **Brachiopoda** (marine bivalves, mainly Paleozoic butsome modern) –modular (colonial), zooids, polypide, marine and freshwater (statoblast)
- **Bryozoa** (=**Ectoprocta,** marine and freshwater, colonial)-unitary organisms, bivalved-shell is chitinand calcium phosphate, dorsal/ventral-most prominent in the Paleozoic--inarticulate, articulate

Phylum: Bryozoa



moss animal invertebrate

moss animal, also called **bryozoan**, any member of the phylum Bryozoa (also called Polyzoa or Ectoprocta), in which there are about 5,000 extant species. Another 15,000 species are known only from fossils. As with brachiopods and phoronids, bryozoans possess a peculiar ring of ciliated tentacles, called a lophophore, for collecting food particles suspended in the water. The bryozoans are a widely distributed, aquatic, invertebrate group of animals whose members form colonies composed of numerous connected units called zooids (hence the term Polyzoa, which means “many animals”). Individual zooids are usually no more than one millimeter (0.04 inch) long, although colonies of some species can exceed 0.5 meter (about 20 inches) in diameter. Until the mid-18th century, bryozoans, like corals, were regarded as plants; hence the name, which means “moss animals.” Seventy-five years later, the bryozoans were distinguished from the cnidarians, and the characteristic structure of the zooid was first described.

Bryozoans are separated into three classes: Phylactolaemata (freshwater dwelling); Stenolaemata (marine); and Gymnolaemata (mostly marine).

General features

Distribution and abundance

Bryozoan colonies are found in both fresh and salt waters, most commonly as growths or crusts on other objects. Freshwater bryozoans live among vegetation in clear, quiet, or slowly flowing water. Marine species range from the shore to the ocean depths but are most plentiful in the shallow waters of the continental shelf. They cover seaweeds, form crusts on stones and shells, hang from boulders, or rise from the seabed. Bryozoans readily colonize submerged surfaces, including the hulls of ships and the insides of water pipes. A few types of bryozoans form non-attached populations on sandy seabeds.

The zooid walls, which constitute the most permanent portion of the colony, generally are calcareous (i.e., impregnated with calcium carbonate), giving bryozoans a fossil record that dates from the Ordovician onward (i.e., from about 500 million years ago).

Size range and diversity of structure

Although the component zooids rarely exceed one millimeter in length, bryozoan colonies—formed of numerous asexually budded zooids—vary greatly in size.

The colonies, diverse and complex in structure, are composed of individual modules, or zooids, and each zooid effectively is a complete animal. In all bryozoan colonies, however, the zooids remain interconnected and may exchange nutrients and other substances through interconnecting cables or minute pores in their body walls. A bryozoan colony usually has many zooids, which may be of one type or of types that differ both functionally and structurally. All zooids in a colony arise by asexual budding from the first zooid to form. Zooids capable of feeding have a ring of slender tentacles at one end of the body. Cilia (hairlike projections) that propel tiny particles of food toward the zooid mouth are found on this ring, and the whole feeding organ is called a lophophore. The mouth opens into a digestive tract that is divided into several regions and terminates at an anus, which is outside (but near) the tentacles (hence the name Ectoprocta, meaning "outside anus"). If zooids are disturbed, they withdraw their tentacles inside the body cavity. Only if the zooids have transparent walls, such as in the gymnolaemates *Bowerbankia* and *Membranipora*, is the digestive tract visible. The internal living parts of each zooid—i.e., the nervous and muscular systems, the tentacles, and the digestive tract—are called the polypide.

Zooids

Although zooid appearance and structure vary considerably from class to class, all conform to a basic plan. Zooids are rarely longer than one millimeter; the most primitive are cylindrical, suggesting that the bryozoan ancestor was probably wormlike. The skeleton is external, ranging from a thin, cuticular cover to a thick, calcified layer. The tentacles, collectively termed the lophophore, are raised above the zooid on a slender extension of the body wall (the tentacle sheath, or introvert). When not spread for feeding, the tentacles are withdrawn into the coelom in a movement that involves the inrolling of the tentacle sheath as the mouth and tentacles are pulled down within by the action of paired retractor muscles. Eversion of the tentacle sheath and tentacles is effected by raising the hydrostatic pressure of the body fluid. Phylactolaemates have a muscular and contractile body wall for this purpose; in gymnolaemates the wall is nonmuscular but in whole or in part flexible, so that it can be pulled inward by the body musculature associated with it (parietal muscles). In most extant bryozoans the zooids are not cylindrical but flat, with rigid side walls. The upward-facing or frontal wall either remains flexible or has concealed below its calcified surface a membranous cavity, the ascus (sac), which can be inflated with seawater, thereby compressing the body fluid. At the free end of a cylindrical zooid or near the distal end of a flat zooid is an opening known as the orifice, through which the tentacle sheath and tentacles emerge; in cheilostome gymnolaemates the orifice has a closable lid, the operculum. Stenolaemate zooids are different, and the walls have the form of a slender calcareous tube, no part of which can be inflected to evert the tentacles; instead, body fluid is forced from one part of the zooid to another by muscles.

Food and feeding

Bryozoans feed on minute planktonic particles that are captured by the ciliated lophophore tentacles (from eight to about 30), which, in marine species, spread as a funnel with the mouth at its vertex. The beating of long lateral cilia draws water into the top of the funnel and propels it out between the tentacles. Particles are projected toward the mouth, and those that would leave the funnel between the tentacles appear to be flicked back into it by a reversal of the ciliary beat. Shorter cilia on the inner face of the tentacles carry food particles toward the mouth without the involvement of mucus; from there they are sucked into the pharynx. Diatom shell valves are separated or broken in the gizzard, when present. Digestion and absorption occur in the stomach, and indigestible remains are compacted by rotation and expelled as fecal pellets. Freshwater bryozoans have more tentacles, which are disposed in a crescent shape, the ends of which project behind the mouth.

The digestive canal forms a deep loop; the pharynx descends to the stomach, the anterior part of which forms a gizzard in some genera, such as the gymnolaemate *Bowerbankia*; the rectum rises from the stomach, and the anus is situated just outside the lophophore.

Respiratory, circulatory, and excretory systems are absent.

The nervous system of bryozoans consists of a small ganglion (brain) positioned between the mouth and the anus that supplies nerves to the zooidal organs. In some bryozoans there is also a colonial network that unites the zooids through the interzooidal pores. A stimulus that causes the lophophore to withdraw in a zooid.

In bryozoans. The reproductive organs (ovary, testes) are sited on the lining of the body wall or on the funiculus, a cord of tissue that links the stomach to the lining of the body wall and distributes nutrients throughout the colony. The polypide degenerates periodically during the lifetime of a zooid, and a compact mass, called a brown body, frequently remains in its place. A new polypide soon differentiates from living cells of the cystid.

Zooid polymorphism exists among the cheilostome colonies, and the operculum seems to have been significant in the evolution of the specialized zooids of this order. The avicularium type of zooid has a small body and a rudimentary polypide; the operculum, however, is proportionally larger, has strong adductor (closing) muscles, and has become, in effect, a jaw. Avicularia are found among normal zooids but usually are smaller and attached to normal zooids, as in the gymnolaemate *Schizoporella*. In the gymnolaemate *Bugula* the avicularia are movable on short stalks and closely resemble miniature birds' heads—hence the name avicularium. Another specialized form of zooid is the vibraculum, in which the operculum has become a whiplike seta (i.e., hairlike projection). The functions of avicularia and vibracula are not clearly known, but both types of zooids may help to keep the colony free from particles and epizoites (i.e., organisms that attach to the surface of the colony but do not parasitize it).

Natural history

Reproduction and life cycle

Many animals, bryozoans included, have a life cycle that incorporates phases of asexual and sexual reproduction. Asexual reproduction, in which no gametes (sex cells) participate, produces genetically identical progeny (clones), which separate in larger animals (e.g., sea anemones). In bryozoans, the progeny, called zooids, are produced by an asexual process called budding and almost invariably remain in intimate contact to form a colony. As the colony continues to enlarge by budding, the zooids become sexually mature, producing eggs and spermatozoa. Sexual reproduction, by the production and subsequent fusion of gametes, generates the genetic variability necessary for a species to adapt to changing conditions. Fertilized eggs develop into swimming larvae.

Budding

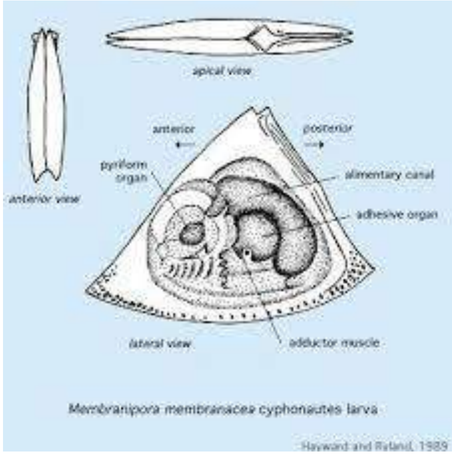
The colony formed by asexual budding originates from either a primary zooid (the ancestrula) or a statoblast. The ancestrula is formed by the metamorphosis of a sexually produced larva. New zooids bud from the ancestrula to produce colonies of definite shape and growth habit. .

Reproduction

Mature gymnolaemate and phylactolaemate zooids are generally hermaphroditic (i.e., both male and female reproductive organs in the same zooid); small gonads are attached in clusters to the membrane that lines the body wall or the polypide. In a few species the individual zooids are of one sex only. In these circumstances, female zooids are usually larger (e.g., the cheilostome *Reptadeonella*), male zooids may be simpler (e.g., the cheilostome *Hippoporidra*), or female and male reproductive zooids each may be distinguishable from ordinary feeding zooids (e.g., the cheilostome *Celleporella*). Among living stenolaemates most zooids contain only testes (male gonads). The few female zooids enlarge to form spacious brood chambers, which are called gonozooids. During development, a young embryo squeezes off groups of cells that form secondary embryos; these in turn may form tertiary embryos. In this way, many larvae can develop in a single brood chamber.

Among the phylactolaemates, the fertilized egg develops in an internal embryo sac; a larva, which already contains the first polypide, is formed there, then liberated. Phylactolaemates also produce statoblasts, which develop on the funiculus, a cord of tissue that links the stomach to the lining of the body wall. As it grows, each statoblast is surrounded by a hard protective case that may also include an air-filled float and slender, hooked spines. Statoblasts usually develop in late summer and are liberated as the colony disintegrates with the approach of winter. Statoblasts survive dry and freezing conditions and can initiate a new colony when favourable climatic conditions recur.

In gymnolaemates one oocyte at a time usually enlarges and bursts from the ovary into the coelom. The oocyte then is fertilized and transferred to a brood chamber. This may be an undifferentiated part of a zooid; usually among the cheilostomes, however, each reproducing zooid develops a special globular or hooded ooecium in which the embryo grows. In most cheilostomes the egg at transfer has sufficient yolk to nourish its developing embryo, The ciliated larvae, spherical and often about $^{1}/_{4}$ millimetre in diameter, are liberated when fully developed and may swim first toward the light and thus away from the parent colony; later, however, the larvae avoid light as they seek a place in which to attach and metamorphose. Metamorphosis of larvae to adults occurs within a few hours after larvae are liberated.



Ecology

Freshwater bryozoans

Freshwater bryozoans live mainly on leaves, stems, and tree roots in shallow water. Before drinking water was filtered, they regularly polluted water supply pipes. Though not uncommon, freshwater bryozoans are inconspicuous in pools, lakes, or gently flowing rivers, especially in slightly alkaline water.

Marine bryozoans

The most familiar marine bryozoans are those that inhabit shores, though they occur in greater numbers below tidemarks. Colonies also occur on the ocean bed, even at great depths, but the frequently muddy bottom of the oceanic abyss is an unfavourable habitat. A few species tolerate hypersaline or brackish waters. The predominantly marine Gymnolaemata has a few freshwater representatives; e.g., *Paludicella*.

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Classification

- **PHYLUM BRYOZOA**
  Sedentary, aquatic invertebrates; form colonies of zooids by budding; each zooid with circular or crescentic lophophore surrounding a mouth from which slender, ciliated tentacles arise; anterior part of body forms an introvert within which the lophophore can be withdrawn; alimentary canal deeply looped; anus opens

near mouth but outside lophophore; excretory organs and a blood vascular system absent; each zooid secretes a rigid or gelatinous wall to support colony; about 5,000 extant species.

- **Class Phylactolaemata**
  Zooids basically cylindrical, with a crescentic lophophore and an epistome (hollow flap overhanging mouth); body wall non-calcareous, muscular, used for everting the lophophore; coelom continuous between zooids; new zooids arise by replication of polypides; special dormant buds (statoblasts) are produced; zooids monomorphic; exclusively freshwater; cosmopolitan; apparently primitive, but with no certain fossil record; about 12 genera, 50 species.

- **Class Stenolaemata**
  Fossil except for some Cyclostomata; zooids cylindrical; body wall calcified, without muscle fibres; not used for everting the lophophore; zooids separated by septa; new zooids produced by division of septa; limited polymorphism; marine; Ordovician to present; about 20 families, 900 species.
    - **Order Cyclostomata**
      Orifice of zooid circular; lophophore circular; no epistome; zooids interconnected by open pores; sexual reproduction involves polyembryony, usually in special reproductive zooids; all seas; Ordovician to present; about 250 genera.
    - **Order Cystoporata**
      Zooid skeletons long and tubular, interconnected by pores and containing diaphragms (transverse partitions); cystopores (not pores but supporting structures between the zooid skeletons) present; Ordovician to Permian; about 80 genera.
    - **Order Trepostomata**
      Colonies generally massive, composed of long tubular zooid skeletons with lamellate calcification; without interzooidal pores; orifices polygonal; sometimes with numerous diaphragms, zooid walls thin proximally, thicker distally; Ordovician to Permian; about 100 genera.
    - **Order Cryptostomata**
      Colonies mostly with foliaceous or reticulate fronds or with branching stems; zooid skeletons tubular, shorter than in trepostomes; without pores; with diaphragms; proximal portions thin walled, distal portions funnellike and separated by extensive calcification; Ordovician to Triassic; about 130 genera.

- **Class Gymnolaemata**
  Zooids cylindrical or squat, with a circular lophophore; no epistome; body wall sometimes calcified; nonmuscular; eversion of lophophore dependent on deformation of body wall by extrinsic muscles; zooids separated by septa or duplex walls; pores in walls plugged with tissue; new zooids produced behind growing points by formation of transverse septa; zooids polymorphic; mainly marine; all seas; Jurassic to present, but presumed to have been established at least by the Ordovician; about 3,000 species.
  - **Order Ctenostomata**
    Zooids cylindrical to flat; walls not calcified; orifice terminal or nearly so, often closed by a pleated collar; no ooecia or avicularia; Jurassic to present, but presumed older; about 20 families, 250 species.
  - **Order Cheilostomata**
    Zooids generally shaped like a flat box, walls calcified; orifice frontal, closed by a hinged operculum; specialized zooids commonly present; embryos often developing in ooecia (brood chambers); Upper Jurassic to present; about 70 families, 2,750 species.

Lecture 10

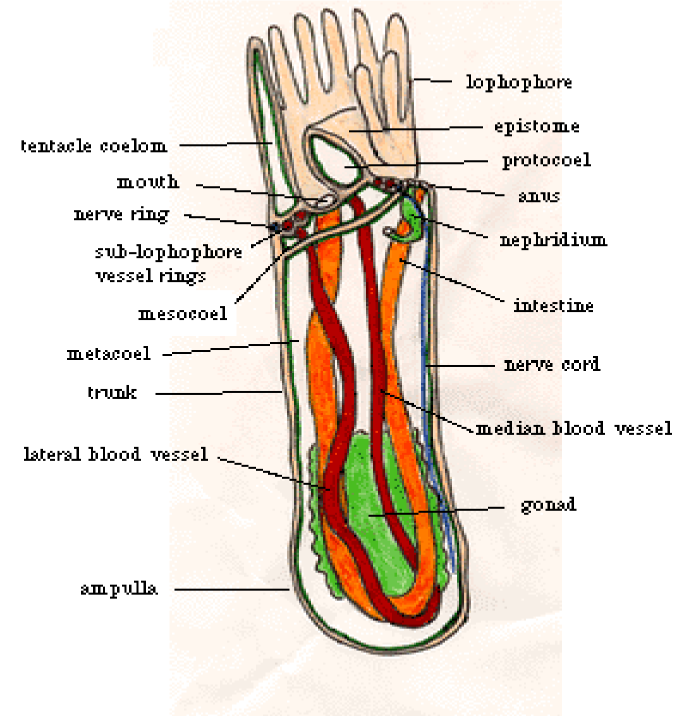
Phoronida

Phoronids (scientific name **Phoronida**, sometimes called **horseshoe worms**) are a small phylum of marine animals that filter-feed with a lophophore (a "crown" of tentacles), and build upright tubes of chitin to support and protect their soft bodies. They live in most of the oceans and seas, including the Arctic Ocean but excluding the Antarctic Ocean, and between the intertidal zone and about

400 meters down. Most adult phoronids are 2 cm long and about 1.5 mm wide, although the largest are 50 cm long.

The name of the group comes from its type genus: *Phoronis*.

Body structure



Anatomy of an adult phoronid

Most adult phoronids are 2 to 20 cm long and about 1.5 mm wide, although the largest are 50 cm long. Their skins have no cuticle but secrete rigid tubes of chitin, similar to the material used in arthropods' exoskeletons, and sometimes reinforced with sediment particles and other debris. Most species' tubes are erect, but those of *Phoronis vancouverensis* are horizontal and tangled. Phoronids can move within their tubes but never leave them. The bottom end of the body is an ampulla (a flask-like swelling in a tube-like structure , which anchors the animal in the tube and enables it to retract its body when threatened, reducing the body to 20 percent of its maximum length. Longitudinal muscles retract the body very quickly, while circular muscles slowly extend the body by compressing the internal fluid.

For feeding and respiration each phoronid has at the top end a lophophore, a "crown" of tentacles with which the animal filter-feeds. In small species the "crown" is a simple circle, in medium-size species it is bent into the shape of a horseshoe with tentacles on the outer and inner sides, and in the largest species the ends of the horseshoe wind into complex spirals. These more elaborate shapes increase the area available for feeding and respiration. The tentacles are hollow, held upright by fluid pressure, and can be moved individually by muscles.

The mouth is inside the base of the crown of tentacles but to one side. The gut runs from the mouth to one side of the stomach, in the bottom of the ampulla. The intestine runs from the stomach, up the other side of the body, and exits at the anus, outside and a little below the crown of tentacles. The gut and intestine are both supported by two mesenteries (partitions that run the length of the body) connected to the body wall, and another mesentery connects the gut to the intestine.

The body is divided into coeloms, compartments lined with mesothelium. The main body cavity, under the crown of tentacles, is called the metacoelom, and the tentacles and their base share the mesocoelom. Above the mouth is the epistome, a hollow lid which can close the mouth. The cavity in the epistome is sometimes called the protocoelom.

The tube comprises a three-layered organic inner cylinder, and an agglutinated external layer.

Feeding, circulation and excretion

When the lophophore is extended, cilia (little hairs) on the sides of the tentacles draw water down between the tentacles and out at the base of the lophophore. Shorter cilia on the inner sides of the tentacles flick food particles into a groove in a circle under and just inside the tentacles, and cilia in the groove push the particles into the mouth. Phoronids direct their lophophores into the water current, and quickly reorient to maximize the food-catching area when currents change. Their diet includes algae, diatoms, flagellates, peridinians, small invertebrate larvae, and detritus. Unwanted material can be excluded by closing the epistome (lid above the mouth) or be rejected by the tentacles, whose cilia can switch into reverse. The gut uses cilia and muscles to move food towards the stomach and secretes enzymes that digest some of the food, but the stomach digests the majority of the food. Phoronids also absorb amino acids (the building blocks of proteins through their skins, mainly in summer. Solid wastes are moved up the intestine and out through the anus, which is outside and slightly below the lophophore.

A blood vessel starts from the peritoneum (the membrane that loosely encloses the stomach), with blind capillaries supplying the stomach. The blood vessel leads up the middle of the body to a circular vessel at the base of the lophophore, and from there a single blind vessel runs up each tentacle. A pair of blood vessels near the body wall lead downward from the lophophore ring, and in most species these are combined into one a little below the lophophore ring. The downward vessel(s) leads back to the peritoneum, and also to blind branches throughout the body. There is no heart, but muscles in the major vessels contract in waves to move the blood. Unlike many animals that live in tubes, phoronids do not ventilate their trunks with oxygenated water, but rely on respiration by the lophophore, which extends above hypoxic sediments. The blood has heamocytes containing heamoglobin, which unusual in such small animals and seems to be an adaptation to anoxic and hypoxic environments. The blood of *Phoronis architecta* carries as much oxygen per cm^3 as that of most vertebrates; the blood's volume in cm^3 per gm of body weight is twice that of a human.

Podocytes on the walls of the blood vessels perform first-stage filtration of soluble wastes into the main coelom's fluid.

Two metanephridia, each with a funnel-like intake, filter the fluid a second time, returning any useful products to the coelom and dumping the remaining wastes through a pair of nephridiopores beside the anus.

Nervous system and movement

There is a nervous center between the mouth and anus, and a nerve ring at the base of the lophophore. The ring supplies nerves to the tentacles and, just under the skin, to the body-wall muscles. *Phoronis ovalis* has two nerve trunks under the skin, whereas other species have one. The trunk(s) have giant axons (nerves that transmit signals very fast) which co-ordinate the retraction of the body when danger threatens.

Except for retracting the body into the tube, phoronids have limited and slow movement: partial emerging from the tube; bending the body when extended; and the lophophore's flicking of food into the mouth.

Reproduction and lifecycle

Only *Phoronis ovalis* naturally builds colonies by budding or by splitting into top and bottom sections which then grow into full bodies. In experiments, other species have split successfully, but only when both parts have enough gonadal (reproductive) tissue. All phoronids breed sexually from spring to autumn. Some species are hermaphroditic (have both male and female reproductive organs) but cross-fertilize (fertilize the eggs of other members]), while others are dioecious (have separate sexes]). The gametes (sperms and ova]) are produced in the swollen gonads, around the stomach. The gametes swim through the metacoelom to the metanephridia. Sperm exit by the nephridiopores and some are captured by the lophophores of individuals of the same species. Species that lay small fertilized eggs release them into the water as plankton, while species with larger eggs brood them either in the body's tube or stuck in the center of the lophophore by adhesive. The brooded eggs are released to feed on plankton when they develop into larvae.

Development of the eggs is a mixture of deuterostome and protostome characteristics. Early divisions of the egg are holoblastic (the cells divide completely) and radial (they gradually form a stack of circles). The process is regulative (the fate of each cell depends on interaction with other cells, not on a rigid program in each cell), and experiments that divided early embryos produced complete larvae. Mesoderm is formed from mesenchyme originating from the archenteron. The coelom is formed by schizocoely, and the blastopore (a dent in the embryo) becomes the mouth.

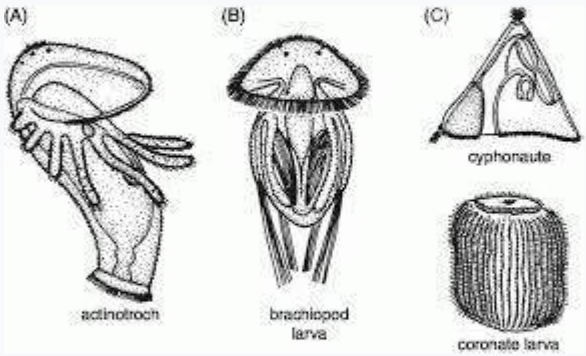


Photo of an actinotroch larva

The slug-like larva of *Phoronis ovalis* swims for about 4 days, creeps on the seabed for 3 to 4 days, then bores into a carbonate floor. Nothing is known about three species. The remaining species develop free-swimming actinotroch larvae, which feed on plankton. The actinotroch is an upright cylinder with the anus at the bottom and fringed with cilia. At the top is a lobe or hood, under which are: a ganglion, connected to a patch of cilia outside the apex of the hood; a pair of protonephridia (smaller and simpler than the metanephridia in the adult); the mouth; and feeding tentacles that encircle the mouth. After swimming for about 20 days, the actinotroch settles on the seabed and undergoes a catastrophic metamorphosis (radical change) in 30 minutes: the hood and larval tentacles are absorbed and the adult lophophore is created around the mouth, and both now point upward; the gut develops a U-bend so that the anus is just under and outside the lophophore. Finally the adult phoronid builds a tube.

Phoronids live for about one year.

Ecology

A dense colony of phoronids

Phoronids live in all the oceans and seas including the Arctic and excepting the Antarctic Ocean, and appear between the intertidal zone and about 400 meters down. Some occur separately, in vertical tubes embedded in soft sediment such as sand, mud, or fine gravel. Others form tangled masses of many individuals buried in or encrusting rocks and shells. In some habitats populations of phoronids reach tens of thousands of individuals per square meter. The actinotroch larvae are familiar among plankton, and sometimes account for a significant proportion of the zooplankton biomass.

Phoronis australis bores into the wall of the tube of a ceriantheid anemone, *Ceriantheomorphe brasiliensis*, and uses this as a foundation for building its own tube. One cerianthid can house up to 100 phoronids. In this unequal relationship, the anemone experiences no significant benefits nor harm, while the phoronid benefits from: a foundation for its tube; food (both animals are filter-feeders); and protection, as the cerianthid withdraws into its tube when danger threatens, and this alerts the phoronid to retract into its own tube. Although predators of phoronids are not well known, they include fish, gastropods (snails), and nematodes (tiny roundworms). *Phoronopsis viridis*, which reaches densities of 26,500 per square meter on tidal flats in California (USA), is unpalatable to many epibenthic predators, including fish and crabs. The unpalatability is strongest in the top section, including the lophophore, which is exposed to predators when phoronids feed. When the lophophores were removed in an experiment, the phoronids were more palatable, but this effect reduced over 12 days as the lophophores regenerated. These broadly effective defenses, which appear unusual among invertebrates inhabiting soft sediment, may be important in allowing *Phoronopsis viridis* to reach high densities.

Lecture 11

Phylum: Brachiopod

Brachiopods (/ˈbrækioʊˌpɒd/), phylum **Brachiopoda**, are a phylum of trochozoan animals that have hard "valves" (shells) on the upper and lower surfaces, unlike the left and right arrangement in bivalve molluscs. Brachiopod valves are hinged at the rear end, while the front can be opened for feeding or closed for protection. Two major categories are traditionally recognized, **articulate** and **inarticulate** brachiopods. The word "articulate" is used to describe the tooth-and-groove structures of the valve-hinge which is present in the articulate group, and absent from the inarticulate group. This is the leading diagnostic skeletal feature, by which the two main groups can be readily distinguished as fossils. Articulate brachiopods have toothed hinges and simple, vertically-oriented opening and closing muscles. Conversely, inarticulate brachiopods have weak, untoothed hinges and a more complex system of vertical and oblique (diagonal) muscles used to keep the two valves aligned. In many brachiopods, a stalk-like pedicle projects from an opening near the hinge of one of the valves, known as the pedicle or ventral valve. The pedicle, when present, keeps the animal anchored to the seabed but clear of sediment which would obstruct the opening.

Brachiopod lifespans range from three to over thirty years.
Ripe gametes (ova or sperm) float from the gonads into the main coelom and then exit into the mantle cavity. The larvae of inarticulate brachiopods are miniature adults, with lophophores that enable the larvae to feed and swim for months until the animals become heavy enough to settle to the seabed. The planktonic larvae of articulate species do not resemble the adults, but rather look like blobs with yolk sacs, and remain among the plankton for only a few days before leaving the water column upon metamorphosing.

Anatomy

Shell structure and function

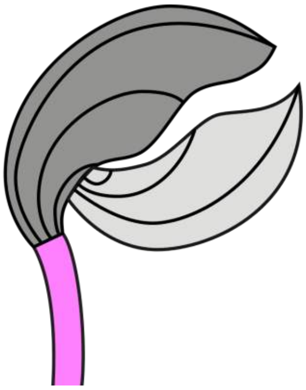
Modern brachiopods range from 1 to 100 millimetres (0.039 to 3.937 in) long, and most species are about 10 to 30 millimetres (0.39 to 1.18 in). *Magellania venosa* is the largest extant species. The largest brachiopods known – *Gigantoproductus* and *Titanaria*, reaching 30 to 38 centimetres (12 to 15 in) in width – occurred in the upper part of the

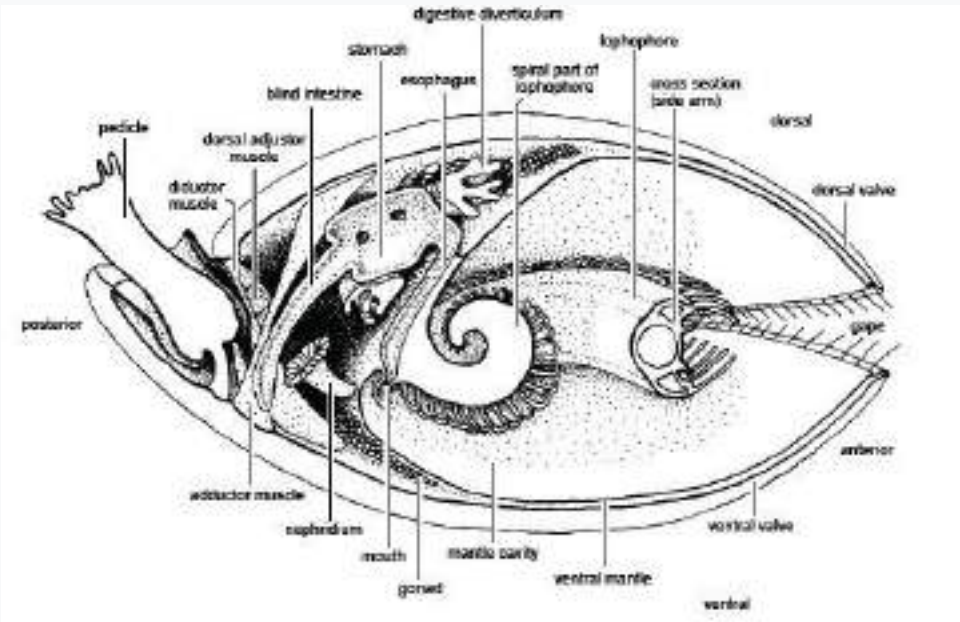
Lower Carboniferous. Brachiopods have two valves (shell sections), which cover the dorsal (top) and ventral (bottom) surface of the animal, unlike bivalve molluscs whose shells cover the lateral surfaces (sides). The valves are unequal in size and structure, with each having its own symmetrical form rather than the two being mirror images of each other.

The brachial valve is usually smaller and bears brachia ("arms") on its inner surface. These brachia are the origin of the phylum's name, and support the lophophore, used for feeding and respiration. The pedicle valve is usually larger, and it's near the hinge it has an opening for the stalk-like pedicle through which most brachiopods attach themselves to the substrate. (R. C. Moore, 1952) the brachial and pedicle valves are often called the dorsal and ventral valves, respectively, but some paleontologists regard the terms "dorsal" and "ventral" as irrelevant since they believe that the "ventral" valve was formed by a folding of the upper surface under the body. The ventral ("lower") valve actually lies above the dorsal ("upper") valve when most brachiopods are oriented in life position. In many living articulate brachiopod species, both valves are convex, the surfaces often bearing growth lines and/or other ornamentation. However, inarticulate lingulids, which burrow into the seabed, have valves that are smoother, flatter and of similar size and shape. (R. C. Moore, 1952)

Articulate ("jointed") brachiopods have a tooth and socket arrangement by which the pedicle and brachial valves hinge, locking the valves against lateral displacement. Inarticulate brachiopods have no matching teeth and sockets; their valves are held together only by muscles. (R. C. Moore, 1952)

All brachiopods have adductor muscles that are set on the inside of the pedicle valve and which close the valves by pulling on the part of the brachial valve ahead of the hinge. These muscles have both "quick" fibers that close the valves in emergencies and "catch" fibers that are slower but can keep the valves closed for long periods. Articulate brachiopods open the valves by means of abductor muscles, also known as diductors, which lie further to the rear and pull on the part of the brachial valve behind the hinge. Inarticulate brachiopods use a different opening mechanism, in which muscles reduce the length of the coelom (main body cavity) and make it bulge outwards, pushing the valves apart. Both classes open the valves to an angle of about 10°. The more complex set of muscles employed by inarticulate brachiopods can also operate the valves as scissors, a mechanism that lingulids use to burrow.





The inarticulate species *Lingula anatina*, showing the long pedicle, flattened shells and prominent chaetae around the front edge of the shells

Each valve consists of three layers, an outer periostracum made of organic compounds and two biomineralized layers. Articulate brachiopods have an outermost periostracum made of proteins, a "primary layer" of calcite (a form of calcium carbonate) under that, and innermost a mixture of proteins and calcite.[9] Inarticulate brachiopod shells have a similar sequence of layers, but their composition is different from that of articulated brachiopods and also varies among the classes of inarticulate brachiopods.

Mantle

Brachiopods, as with molluscs, have an epithelial mantle which secretes and lines the shell, and encloses the internal organs. The brachiopod body occupies only about one-third of the internal space inside the shell, nearest the hinge. The rest of the space is lined with the mantle lobes, extensions that enclose a water-filled space in which sits the lophophore. The coelom (body cavity) extends into each lobe as a network of canals, which carry nutrients to the edges of the mantle.

Relatively new cells in a groove on the edges of the mantle secrete material that extends the periostracum. These cells are gradually displaced to the underside of the mantle by more recent cells in the groove, and switch to secreting the mineralized material of the shell valves. In other words, on the edge of the valve the periostracum is extended first, and then reinforced by extension of the mineralized layers under the periostracum. In most species the edge of the mantle also bears movable bristles, often called chaetae or setae, that may help defend the animals and may act as sensors. In some brachiopods groups of chaetae help to channel the flow of water into and out of the mantle cavity.

In most brachiopods, diverticula (hollow extensions) of the mantle penetrate through the mineralized layers of the valves into the periostraca. The function of these diverticula is uncertain and it is suggested that they may be storage chambers for chemicals such as glycogen, may secrete repellents to deter organisms that stick to the shell or may help in respiration. Experiments show that a brachiopod's oxygen consumption drops if petroleum jelly is smeared on the shell, clogging the diverticula.

Lophophore

Paired lophophores of *Terebratalia transversa*, a modern brachiopod in the order Terebratulida.

Like bryozoans and phoronids, brachiopods have a lophophore, a crown of tentacles whose cilia (fine hairs) create a water current that enables them to filter food particles out of the water. However a bryozoan or phoronid lophophore is a ring of tentacles mounted on a single, retracted stalk, while the basic form of the brachiopod lophophore is U-shaped, forming the brachia ("arms") from which the phylum gets its name. Brachiopod lophophores are non-retractable and occupy up to two-thirds of the internal space, in the front most area where the valves gape when opened. To provide enough filtering capacity in this restricted space, lophophores of larger brachiopods are folded in moderately to very complex shapes—loops and coils are common, and some species' lophophores contort into a shape resembling a hand with the fingers splayed. In all species the lophophore is supported by cartilage and by a hydrostatic skeleton (in other words, by the pressure of its internal fluid), and the fluid extends into the tentacles. Some articulate brachiopods also have a brachidium, a calcareous support for the lophophore attached to the inside of the brachial valve, which have led to an extremely reduced lophophoral muscles and the reduction of some brachial nerves.

The tentacles bear cilia (fine mobile hairs) on their edges and along the center. The beating of the outer cilia drives a water current from the tips of the tentacles to their bases, where it exits. Food particles that collide with the tentacles are trapped by mucus, and the cilia down the middle drive this mixture to the base of the tentacles. A brachial groove runs round the bases of the tentacles, and its own cilia pass food along the groove towards the mouth. The method used by brachiopods is known as "upstream collecting", as food particles are captured as they enter the field of cilia that creates the feeding current. This method is used by the related phoronids and bryozoans, and also by pterobranchs. Entoprocts use a similar-looking crown of tentacles, but it is solid and the flow runs from bases to tips, forming a "downstream collecting" system that catches food particles as they are about to exit.

Pedicle and other attachments

A lingulid in its burrow, in "up" and retracted positions

Most modern species attach to hard surfaces by means of a cylindrical pedicle ("stalk"), an extension of the body wall. This has a chitinous cuticle (non-cellular "skin") and protrudes through an opening in the hinge. However, some genera have no pedicle, such as the inarticulate *Crania* and the articulate *Lacazella;* they cement the rear of the "pedicle" (ventral) valve to a surface so that the front is slightly inclined up away from the surface. In these brachiopods, the ventral valve lacks a pedicle opening. In a few articulate genera such as *Neothyris* and *Anakinetica*, the pedicles wither as the adults grow and finally lie loosely on the surface. In these genera the shells are thickened and shaped so that the opening of the gaping valves is kept free of the sediment.

Pedicles of inarticulate species are extensions of the main coelom, which houses the internal organs. A layer of longitudinal muscles lines the epidermis of the pedicle. Members of the order Lingulida have long pedicles, which they use to burrow into soft substrates, to raise the shell to the opening of the burrow to feed, and to retract the shell when disturbed. A lingulid moves its body up and down the top two-thirds of the burrow, while the remaining third is occupied only by the pedicle, with a bulb on the end that builds a "concrete" anchor. However, the pedicles of the order Discinida are short and attach to hard surfaces.

The pedicle of articulate brachiopods has no coelom, and its homology is unclear. It is constructed from a different part of the larval body, and has a compact core composed of connective tissue. Muscles at the rear of the body can straighten, bend or even rotate the pedicle. The far end of the pedicle generally has rootlike extensions or short papillae ("bumps"), which attach to hard surfaces. However, articulate brachiopods of the genus *Chlidonophora* use a branched pedicle to anchor in sediment. The pedicle emerges from the pedicle valve, either through a notch in the hinge or, in species where the pedicle valve is longer than the brachial, from a hole where the pedicle valve doubles back to touch the brachial valve. Some species stand with the front end upwards, while others lie horizontal with the pedicle valve uppermost.

Some early brachiopods – for example strophomenates, kutorginates and obolellates – do not attach using their pedicle, but with an entirely different structure known as the "pedicle sheath", which has no relationship to the pedicle. This structure arises from the umbo of the pedicle valve, at the centre of the earliest (metamorphic) shell at the location of the protegulum. It is sometimes associated with a fringing plate, the colleplax.

Feeding and excretion

A fossil of *Spiriferina rostrata* with visible brachidium (lophophore support)

The water flow enters the lophophore from the sides of the open valves and exits at the front of the animal. In lingulids the entrance and exit channels are formed by groups of chaetae that function as funnels. In other brachiopods the entry and exit channels are organized by the shape of the lophophore. The lophophore captures food particles, especially phytoplankton (tiny photosynthetic organisms), and deliver them to the mouth via the brachial grooves along the bases of the tentacles. The mouth is a tiny slit at the base of the lophophore. Food passes through the mouth, muscular pharynx ("throat") and oesophagus ("gullet"), all of which are lined with cilia and cells that secrete mucus and digestive enzymes. The stomach wall has branched ceca ("pouches") where food is digested, mainly within the cells.

Nutrients are transported throughout the coelom, including the mantle lobes, by cilia. The wastes produced by metabolism are broken into ammonia, which is eliminated by diffusion through the mantle and lophophore. Brachiopods have metanephridia, used by many phyla to excrete ammonia and other dissolved wastes. However, brachiopods have no sign of the podocytes, which perform the first phase of excretion in this process, and brachiopod metanephridia appear to be used only to emit sperm and ova.

The majority of food consumed by brachiopods is digestible, with very little solid waste produced. The cilia of the lophophore can change direction to eject isolated particles of indigestible matter. If the animal encounters larger lumps of undesired matter, the cilia lining the entry channels pause and the tentacles in contact with the lumps move apart to form large gaps and then slowly use their cilia to dump the lumps onto the lining of the mantle. This has its own cilia, which wash the lumps out through the opening between the valves. If the lophophore is clogged, the adductors snap the valves sharply, which creates a "sneeze" that clears the obstructions. In some inarticulate brachiopods the digestive tract is U-shaped and ends with an anus that eliminates solids from the front of the body wall. Other inarticulate brachiopods and all articulate brachiopods have a curved gut that ends blindly, with no anus. These animals bundle solid waste with mucus and periodically "sneeze" it out, using sharp contractions of the gut muscles.

Circulation and respiration

The lophophore and mantle are the only surfaces that absorb oxygen and eliminate carbon dioxide. Oxygen seems to be distributed by the fluid of the coelom, which is circulated through the mantle and driven either by contractions of the lining of the coelom or by beating of its cilia. In some species oxygen is partly carried by the respiratory pigment hemerythrin, which is transported in coelomocyte cells. The maximum oxygen consumption of brachiopods is low, and their minimum requirement is not measurable.

Brachiopods also have colorless blood, circulated by a muscular heart lying in the dorsal part of the body above the stomach. The blood passes through vessels that extend to the front and back of the body, and branch to organs including the lophophore at the front and the gut, muscles, gonads and nephridia at the rear. The blood circulation seems not to be completely closed, and the coelomic fluid and blood must mix to a degree. The main function of the blood may be to deliver nutrients.

Nervous system and senses

The "brain" of adult articulates consists of two ganglia, one above and the other below the oesophagus. Adult inarticulates have only the lower ganglion. From the ganglia and the commissures where they join, nerves run to the lophophore, the mantle lobes and the muscles that operate the valves. The edge of the mantle has probably the greatest concentration of sensors. Although not directly connected to sensory neurons, the mantle's chaetae probably send tactile signals to receptors in the epidermis of the mantle. Many brachiopods close their valves if shadows appear above them, but the cells responsible for this are unknown. Some brachiopods have statocysts, which detect changes in the animals' position.

Reproduction and life cycle

Lifespans range from 3 to over 30 years. Adults of most species are of one sex throughout their lives. The gonads are masses of developing gametes (ova or sperm), and most species have four gonads, two in each valve. Those of articulates lie in the channels of the mantle lobes, while those of inarticulates lie near the gut. Ripe gametes float into the main coelom and then exit into the mantle cavity via the metanephridia, which open on either side of the mouth. Most species release both ova and sperm into the water, but females of some species keep the embryos in brood chambers until the larvae hatch.

The cell division in the embryo is radial (cells form in stacks of rings directly above each other), holoblastic (cells are separate, although adjoining) and regulative (the type of tissue into which a cell develops is controlled by interactions between adjacent cells, rather than rigidly within each cell). While some animals develop the mouth and anus by deepening the blastopore, a "dent" in the surface of the early embryo, the blastopore of brachiopods closes up, and their mouth and anus develop from new openings.

The larvae of lingulids swim as plankton for months and are like miniature adults, with valves, mantle lobes, a pedicle that coils in the mantle cavity, and a small lophophore, which is used for both feeding and swimming. The larvae of craniids have no pedicle or shell. As the shell becomes heavier, the juvenile sinks to the bottom and becomes a sessile adult. The larvae of articulate species live only on yolk, and remain among the plankton for only a few days. This type of larva has a ciliated front most lobe that becomes the body and lophophore, a rear lobe that becomes the pedicle, and a mantle like a skirt, with the hem towards the rear. On metamorphosing into an adult, the pedicle attaches to a surface, the front lobe develops the lophophore and other organs, and the mantle rolls up over the front lobe and starts to secrete the shell. In cold seas, brachiopod growth is seasonal and the animals often lose weight in winter. These variations in growth often form growth lines in the shells. Members of some genera have survived for a year in aquaria without food.

Taxonomy

Classification was defined in 1869; two further approaches were established in the 1990s:

- In the "traditional" classification, brachiopods are divided into the Articulata and Inarticulata. The Articulata have toothed hinges between the valves, while the hinges of the Inarticulata are held together only by muscles.
- A classification devised in the 1990s, based on the materials of which the shells are based, united the Craniida and the "articulate" brachiopods in the Calciata, which have calcite shells.

Lecture 12

Phylum: Entoprocta

Entoprocta /ɛntoʊˈprɒktə/ (lit. 'inside rectum/anus'), or **Kamptozoa** /kæm(p)təˈzoʊə/, is a phylum of mostly sessile aquatic animals, ranging from 0.1 to 7 millimetres (0.004 to 0.3 in) long. Mature individuals are goblet-shaped, on relatively long stalks. They have a "crown" of solid tentacles whose cilia generate water currents that draw food particles towards the mouth, and both the mouth and anus lie inside the "crown". The superficially similar Bryozoa (Ectoprocta) have the anus outside a "crown" of hollow tentacles. Most families of entoprocts are colonial, and all but 2 of the 150 species are marine. A few solitary species can move slowly.

Some species eject unfertilized ova into the water, while others keep their ova in brood chambers until they hatch, and some of these species use placenta-like organs to nourish the developing eggs. After hatching, the larvae swim for a short time and then settle on a surface. There they metamorphose, and the larval gut rotates by up to 180°, so that the mouth and anus face upwards. Both colonial and solitary species also reproduce by cloning — solitary species grow clones in the space between the tentacles and then release them when developed, while colonial ones produce new members from the stalks or from corridor-like stolons.

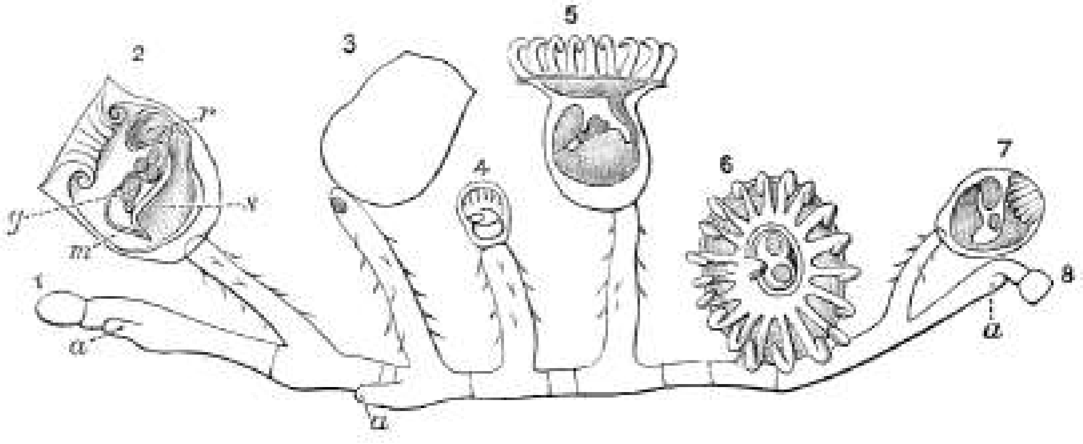
Fossils of entoprocts are very rare, and the earliest specimens that have been identified with confidence date from the Late Jurassic. Most studies from 1996 onwards have regarded entoprocts as members of the Trochozoa, which also includes molluscs and annelids. However, a study in 2008 concluded that entoprocts are closely related to bryozoans.

Most species are colonial, and their members are known as "zooids", since they are not fully independent animals. Zooids are typically 1 millimetre (0.039 in) long but range from 0.1 to 7 millimetres (0.004 to 0.3 in) long.

Distinguishing features

Entoprocts are superficially like bryozoans (ectoprocts), as both groups have a "crown" of tentacles whose cilia generate water currents that draw food particles towards the mouth. However, they have different feeding mechanisms and internal anatomy, and ectoprocts undergo a metamorphosis from larva to adult that destroys most of the larval tissues; their colonies also have a founder zooid which is different from its "daughters".

Zooids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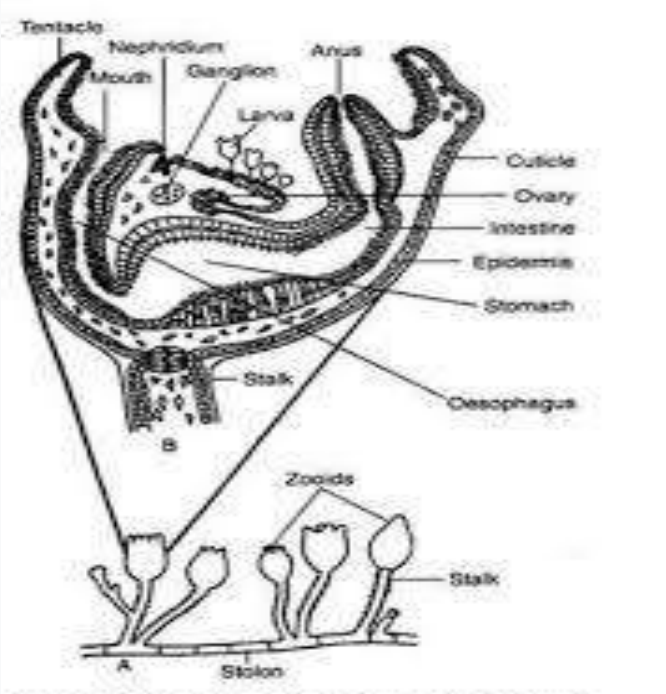


Fig. 14.34: Structures of *Pedicellina*. A. Part of a colony. B. Enlarged sectional view (saggital section) of a calyx.

Pedicellina cernua

The body of a mature entoproct zooid has a goblet-like structure with a calyx mounted on a relatively long stalk that attaches to a surface. The rim of the calyx bears a "crown" of 8 to 30 solid tentacles, which are extensions of the body wall. The base of the "crown" of tentacles is surrounded by a membrane that partially covers the tentacles when they retract. The mouth and anus lie on opposite sides of the atrium (space enclosed by the "crown" of tentacles), and both can be closed by sphincter muscles. The gut is U-shaped, curving down towards the base of the calyx, where it broadens to form the stomach. This is lined with a membrane consisting of a single layer of cells, each of which has multiple cilia.

The stalks of colonial species arise from shared attachment plates or from a network of stolons, tubes that run across a surface.] In solitary species, the stalk ends in a muscular sucker, or a flexible foot, or is cemented to a surface. The stalk is muscular and produces a characteristic nodding motion. In some species it is segmented. Some solitary species can move, either by creeping on the muscular foot or by somersaulting.

The body wall consists of the epidermis and an external cuticle, which consists mainly of criss-cross collagen fibers. The epidermis contains only a single layer of cells, each of which bears multiple cilia ("hairs") and microvilli (tiny "pleats") that penetrate through the cuticle. The stolons and stalks of colonial species have thicker cuticles, stiffened with chitin.

There is no coelom (internal fluid-filled cavity lined with peritoneum) and the other internal organs are embedded in connective tissue that lies between the stomach and the base of the "crown" of tentacles.
The nervous system runs through the connective tissue and just below the epidermis, and is controlled by a pair of ganglia. Nerves run from these to the calyx, tentacles and stalk, and to sense organs in all these areas.

Feeding, digestion, excretion, circulation and respiration

A band of cells, each with multiple cilia, runs along the sides of the tentacles, connecting each tentacle to its neighbors, except that there is a gap in the band nearest the anus. A separate band of cilia grows along a groove that runs close to the inner side of the base of the "crown", with a narrow extension up the inner surface of each tentacle. The cilia on the sides of the tentacles create a current that flows into the "crown" at the bases of the tentacles and exits above the center of the "crown". These cilia pass food particles to the cilia on the inner surface of the tentacles, and the inner cilia produce a downward current that drives particles into and around the groove, and then to the mouth.

Entoprocts generally use one or both of: ciliary sieving, in which one band of cilia creates the feeding current and another traps food particles (the "sieve"); and downstream collecting, in which food particles are trapped as they are about to exit past them. In entoprocts, downstream collecting is carried out by the same bands of cilia that generate the current; trochozoan larvae also use downstream collecting, but use a separate set of cilia to trap food particles.

In addition, glands in the tentacles secrete sticky threads that capture large particles. A non-colonial species reported from around the Antarctic Peninsula in 1993 has cells that superficially resemble the cnidocytes of cnidaria, and fire sticky threads. These unusual cells lie around the mouth, and may provide an additional means of capturing prey.

The stomach and intestine are lined with microvilli, which are thought to absorb nutrients. The anus, which opens inside the "crown", ejects solid wastes into the outgoing current after the tentacles have filtered food out of the water; in some families it is raised on a cone above the level of the groove that conducts food to the mouth. Most species have a pair of protonephridia which extract soluble wastes from the internal fluids and eliminate them through pores near the mouth. However, the freshwater species *Urnatella gracilis* has multiple nephridia in the calyx and stalk.[4]

The zooids absorb oxygen and emit carbon dioxide by diffusion, which works well for small animals.

Reproduction and life cycle

Most species are simultaneous hermaphrodites, but some switch from male to female as they mature, while individuals of some species remain of the same sex all their lives. Individuals have one or two pairs of gonads, placed between the atrium and stomach, and opening into a single gonopore in the atrium. The eggs are thought to be fertilized in the ovaries. Most species release eggs that hatch into planktonic larvae, but a few brood their eggs in the gonopore. Those that brood small eggs nourish them by a placenta-like organ, while larvae of species with larger eggs live on stored yolk. The development of the fertilized egg into a larva follows a typical spiralian pattern: the cells divide by spiral cleavage, and mesoderm develops from a specific cell labelled "4d" in the early embryo. There is no coelom at any stage.

In some species the larva is a trochophore which is planktonic and feeds on floating food particles by using the two bands of cilia round its "equator" to sweep food into the mouth, which uses more cilia to drive them into the stomach, which uses further cilia to expel undigested remains through the anus. In some species of the genera *Loxosomella* and *Loxosoma*, the larva produces one or two buds that separate and form new individuals, while the trochophore disintegrates. However, most produce a larva with sensory tufts at the top and front, a pair of pigment-cup ocelli ("little eyes"), a pair of protonephridia, and a large, cilia-bearing foot at the bottom.] After settling, the foot and frontal tuft attach to the surface. Larvae of most species undergo a complex metamorphosis, and the internal organs may rotate by up to 180°, so that the mouth and anus both point upwards.

All species can produce clones by budding. Colonial species produce new zooids from the stolon or from the stalks, and can form large colonies in this way. In solitary species, clones form on the floor of the atrium, and are released when their organs are developed.

Ecology

Distribution and habitats

All species are sessile. While the great majority are marine, two species live in freshwater: *Loxosomatoides sirindhornae*, reported in 2004 in central Thailand, and *Urnatella gracilis*, found in all the continents except Antarctica. Colonial species are found in all the oceans, living on rocks, shells, algae and underwater buildings. The solitary species, which are marine, live on other animals that feed by producing water currents, such as sponges, ectoprocts and sessile annelids The majority of species live no deeper than 50 meters, but a few species are found in the deep ocean.

Comparison of similar phyla

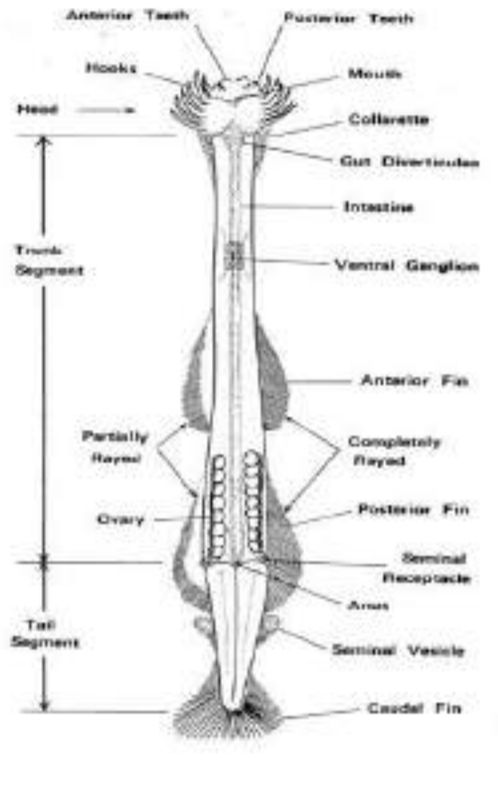
Summary of distinguishing features				
Feature	**Phoronids**	**Brachiopods**	**Bryozoans**	**Entoprocts**
Tentacles hollow	Yes	Yes	Yes	No
Protection and support	Erect tube of chitin	Shell with two valves	Various, including chitin, mineralized skeletons, plant-like shapes, and a mass of gelatinous material	None
Feeding flow	Top to bottom	In through sides of shell, out through front	Top to bottom	Bottom to top

Anus	Outside ring of tentacles	In the mantle, or none and solid waste is ejected out of the mouth[11]	Outside ring of tentacles	Inside ring of tentacles
Colonial	One species	No	All but one genus	Most species colonial
Coelom	Yes	Yes	Yes	No

Lecture 13

Phylum: Chaetognatha

Chaetognatha Etymology: From the Greek *Chaite* for long hair, and *gnathos* for jaw.



Chaetognatha Species Count: There are 132 recognized species of Arrow Worms

Characteristics of Chaetognatha:

1. Bilaterally symmetrical and vermiform.
2. Body has more than two cell layers, tissues and organs.
3. Body cavity is a coelom divided into compartments.
4. Body possesses a through gut with a non-terminal anus.
5. Body divided into three sections, a head, a trunk and a tail.
6. Nervous system is a circum-pharangeal ganglionated ring.
7. Has a no circulatory system or gaseous exchange organs.
8. Possesses no excretory system – *contentious*.
9. Reproduction normally sexual and hermaphroditic.
10. Feed on smaller marine zooplankton and phytoplankton in the water.
11. All live marine environments.

Introduction to the Chaetognatha

The Chaetognatha are commonly called Arrow Worms because of their general shape and the speed with which they attack their prey.

Chaetognathans are a small, though unusual group of animals, which do not appear to be to closely related to any other phyla. The Chaetognatha have been around for a long time. There are fossils from both the middle and early Cambrian.

They are found in all marine environments, often in very large numbers, sometimes representing 10% of the zooplankton (Giribet et al 2020). They are an important aspect of the zooplankton fauna and as predators play an important role in nutrient flow.

Physically they are small, ranging from 2mm to 120 mm in length. They have long thin, cyclindrical bodies with lateral, horizontally projecting fins and a dorsoventrally flattened tail. Otherwise they are characterized by the possession of two sets of grasping spines at the mouth. Arrow worms are usually basically colourless and range from transparent to translucent.

Chaetognathan Biology

Head of Sagitta sp.

All arrow worms are marine, and most species are planktonic, living in the open ocean. A small percentage of the known species are benthic, preferring the sea bottom, and *Spadella cephaloptera* can be found in rock pools on many European coastlines adhering to seaweed (algae) where it exists as an ambush predator. Many species are associated with particular water currents in the oceans. For instance, the edges of the Florida Current on the continental shelf of North Carolina can be detected by the presence of absence of *Sagitta bipunctata*.

Like many other members of the planktonic world, some chaetognaths migrate up and down in the water column. They come to the surface to feed at night then retire to deeper waters as the sun rises. Unlike other planktonic organisms, some chaetognaths migrate annually – living in the surface waters during the winter but retiring to deeper waters in summer.

Arrow worms are small to very small animals and the ratio between surface area and volume for their bodies is quite large. This means that gas exchange and excretion of wastes can be occur by diffusion across the general body surface. Therefore Chaetognathans possess no specialized respiratory or excretory organs (but note – it is considered possible by some researchers that the sperm ducts may serve a secondary purpose as metanephridia), and they lack a blood circulatory system. Within the coelom the coelomic fluid is moved by cilia allowing for the internal distribution of both nutrients and wastes.

Feeding Ecology of Chaetognathans

The planktonic species occur in large numbers in warmer oceans where they are voracious predators on other species of plankton particularly as copepods. They may in fact be the primary predator in many planktonic environments. Larger species may reach 10cm (4 inches) or more in length and are known to attack small fish. They have a series of movable spines on their head which they use to grasp and hold their prey while it is eaten.

All Chaetognathans were considered to be purely carnivorous until recently. However, over the last twenty years a body of evidence has been collected which shows that some Arrow Worms are definitively omnivorous, eating phytoplankton as well as zooplankton i.e. *Eukrohnia hamata*.

While the curved grasping spines of arrow worms are present, possess another weapon to help them capture their prey. This weapon is a tetrodotoxin venom, a powerful neurotoxin that paralyzes their prey. All the arrow worms so far tested have been found to have this toxin which it is believed is secreted by bacteria located in the papillae of the vestibular ridges adjacent to the mouth.

Once captured food items pass from the mouth to the muscular pharynx which propels them on into the digestive tract. The digestive tract is a simple intestine that runs straight along the body to the anus which is found at the posterior end of the trunk, thus i front of the tail. Digestion of the food is extracellular and mostly occurs in the part of the intestine further from the mouth.

Anatomy of the Chaetognatha

Basic Body Plan

The basic Chaetognathan body plan is a long thin body divided into three sections. These three body sections are called the head, trunk and tail. Internally each body section is separated from the next by transverse septa. Septa also divide the trunk longitudinally into four compartments. The head compartment is called a ‘protocoel’ and the four longitudinal compartments of the trunk are called paired ‘mesocoels’ and ‘metacoels,

The outside of the body is covered by a layered epidermis that is three to five cells thick. This epidermis is missing on the ventral surface of the head, where it is replaced by a cuticle and on the inner surface of the hood. The cuticle extends to the dorsal and lateral surfaces of the head where it forms a protective mask. There is no cuticle on any other part of the Chaetognathan body. Although the trunk (and therefore the fins) and the tail lack cuticle, the inner epidermal cells of these areas contain numerous microscopic skeletal fibers called ‘tonofilaments’.

Across the body of a Chaetognath there are dispersed collections sensory cilia that allow the animal to be highly sensitive to vibrations from any direction. One of the more distinctive aspects of Arrow Worm morphology is their possess of lateral fins and a post anal tail. Both of these are supported by rays (except in the genus *Bathybelos*). The fins and tail are comprised of two layers of epidermis with an extracellular matrix between them. The visible fin rays are built up from intracellular filaments. The fins are not muscular, but supply floatation and stability. The tail is moved by the flexing of the trunk and supplies forward momentum.

Most Chaetognathans have one pair of fins, but some, such as *Adhesisagitta hispida* and *Sagitta elegans* possess two pairs of fins. The size, shape and placement of the fins along the trunk varies considerably between species. , passed the trunk/tail septum, giving the animal a long-necked appearance.

Anatomy of the Head

The head area of the average Arrow Worm is dominated by the paired sets of large grasping spines they use to catch their prey. These spines vary in number from 4 to 14 on each side of the head. They are made of α-chitin and are separate from the much smaller teeth.

The mouth itself is situated ventrally in a depression called the 'vestibule'. On either side of the mouth, inside of the spines are one or two sets of teeth that are also used to grasp and devour prey items. From the mouth food passes into a muscular pharynx that crosses the head/trunk septum.

Also on either side of the mouth and posterior to the teeth are the vestibular ridges and the vestibular pits, one ridge and one pit on either sides. The pits are believed to be the site of undefined sensory organs, while the ridges have papillae that contain the bacteria that produce the tetrodotoxin chaetognathans use to subdue their prey. The control mechanism for the release of the tetrodotoxin is not yet understood..

Chaetognathans have two compound eyes situated on the top of the head, each made up of 5 ocelli. It is doubtful if they can see very much, but they can certainly detect changes in light intensity and movement. The individual ocelli point in different directions allowing the animal a wide field of view. In fact at least two of the ocelli point downwards, meaning the animal is able to see below itself by looking through its own transparent body.

Finally, at approximately the junction of the head and the trunk is an unusual structure called the 'ciliary loop' or the 'corona ciliata'. This loop is made up of two rings of ciliated cells. While visually obvious under the microscope the true nature, or function of this organ is still unknown.

Internal Anatomy of the Trunk (Nerves and Muscles)

Underneath the epidermis lie well developed longitudinal muscles the structure of which is that of transversely striated muscles, which is also found in insect asynchronous flight muscles. This makes up about 80% of the animals musculature. The rest of the animals muscles are also unusual in structure in that they are made up of two different, and not normally related, types of sarcomere, The longitudinal muscles are separated from the coelomic fluid by a peritoneum.

Chaetognathans have unique neuromuscular innervations in that they lack the specialized junctions present in most phyla. This means the presynapses are separated
from the underlying muscles by a thick extracellular matrix through which the chemical transmitter must pass.

Chaetognatha have a well developed nervous system. This nervous system begins with a well developed central ganglion located in the head above the pharynx. Several other paired sets of smaller ganglia are closely associated with this central ganglion. These small ganglia are connected by nerves to the various muscles and sensory organs of the head.

Within the epidermis of the trunk lies another large ganglion called the 'ventral' or 'subenteric' ganglion. This ventral ganglion and the central ganglion are connected by a pair of circumenteric nerves. About twelve pairs of nerves extend from this ventral ganglion to different parts of the body to form a subepidermal nerve plexus (network) The ventral ganglion is in control of swimming.

Reproduction in the Chaetognatha

All known Chaetognatha are hermaphrodites, meaning they possess both male and female sex organs. The female organs, the ovaries, are located in the hind part of the trunk, while the male sexual organs, the testis, are located in the tail. The sperm mature before the ova (eggs) which may help avoid self fertilization to some extent. However self fertilization is known to occur.

The ovaries are connected to the outside by a pair of oviducts that pass down along the sides of the body to a pair of gonopores located laterally just before the trunk/tail septum.

The sperm are expelled from the testis as spermatogonia (cells in which mitosis occurs to produce sperm). These spermatogonia collect in the tail coelom where they generate to sperm. The mature sperm are collect by ciliated funnels which connect to the sperm ducts. From the spermducts they are collected in the seminal vesicles which open to the external world. While waiting in the seminal vesicles the sperm form aggregations sometimes referred to as sperm balls, and some times as spermatophores. There is some argument as to whether they are true spermatophores because an enclosing membrane has not been identified.

Reproduction begins with a courtship dance in the benthic forms. This dance facilitates species and intent recognition. After the dance the adults align their bodies and exchange sperm balls. On contact with the partners body the sperm balls deaggregate and the individual sperm find their way to the partners gonopores and from their to the oviducts where they can fertilize the mature ova. In the benthic *Spadella cephaloptera*, pairs of Chaetognaths may lie beside each other head to tail such that they fertilize each other.

The development of the embryos is direct (there is no larval form) and very quick, sometimes as short as a day. Most females release the fertilized ova into the water, where they may float and become part of the zooplankton, or sink to the bottom. Some deep water species such as Eukrohnia are known to form temporary gelatinous pouches near the tail to hold the developing embryos. What emerges from the ova is a miniature Chaetognathan.

Chaetognathan Taxonomy

The phylum Chaetognatha is divided into one class, two orders, nine families and 26 genera.The relationship of the Chaetognathans to the rest of the invertebrate phyla has been contentious for decades. The unique characteristics of the phylum, and its lack of obvious morphological similarities to any other phyla have made it difficult for scientist to assign it a definite place in the tree of life. Recent phylogenetic research, such as that done by Marlétaz et al., 2019, and Vinther and Parry, 2019 now places the Chaetognatha amongst the

Gnathifera. The Gnathifera is a taxonomic clade that includes three other phyla as well as the Chaetognatha, namely; Gnathostomulida, Micrognathozoa and Rotifera.

Phylum Chaetognatha • 132 identified species.

Lecture 14

A review of all that was previously studied

General questions about the course

Multiple Choice Questions

1- Blind sac body plan is shown by

(a) Roundworm. (b) Annelida.

(c) Coelenterata. (d) Arthropoda.

2- Level of organization in hydra and jelly fishs is

(a) Cellular leve.l (b) Acellular level.

(c) Tissue. (d) Organ –system.

3- Mollusks all have a

(a) A tough muscular foot for creeping and digging.

(b) Stinging cells called cnidoblasts.

(c) Gills or lungs. (d) Both a and c.

4- Deuterostomic organisms occur in

(a) Echinodermata. (b) Mollusca.

(c) Arthropoda. (d) Annelida.

5-A **zooid** of ectoprocta is known as:

(a) A complete individual.
(b) A group of asexually produced and physically unified components.
(c) A reproductive structure. (d) A feeding structure.

6- Choanoflagellate (choanocyte) cells of sponges:

(a) pump water with an individual flagellum.
(b) filter food particles via a sieve of microvilli surrounding the flagellum.
(c) produce sperm and sometimes eggs during reproduction.
(d) (a) and (b) but not (c).

7-A nematocyst:

(a) is an intracellular organelle that aids in prey capture and defense in cnidarians
(b) may be fired only once.
(c) is just another name for a cnidocyte.
(d) (a) and (c) but not (b).

8-Ctenophores:

(a) are mainly pelagic and have a well-developed gelatinous middle layer.
(b) are the largest metazoans to swim using cilia.

(c) have larger cilia in their comb rows than any other living metazoan.
(d) All of the above.

9- Unlike most protostomes, deuterostomes exhibit:

(a) radial, indeterminate cleavage.
(b) a mouth that does not derive from the larval blastopore.
(c) coelom formation by schizocoely.
(d) (a) and (b) but not (c).

10-Platyhelminthes is considered a primitive phylum in the Protostomia because:

(a) a coelom is lacking.
(b) an anus is lacking.
(c) a nervous system is lacking.
(d) (a) and (b) but not (c).

11- The cuticle of many aschelminth taxa:
(a) is a layer of non-living material that lies outside the epidermis.
(b) may be composed of chitin or collagen.
(c) does not need to be molted in taxa where it is quite thin.
(d) All above.

Eutely:

(a) Occurs in at least two different Platyhelminthes phyla.

(b) Refers to the situation where adult of a species are formed from a fixed number of cells.
(c) Refers to the situation where adult of a species regulate their osmotic balance hydrostatically.
(d) (a) and (b) but not (c).

13- The Porifera, Cnidaria and Platyhelminthes all:
(a) lack a coelom.
(b) lack an anus.
(c) lack a mesoderm layer.
(d) (a) and (b) but not (c).

14- Both protonephridia and metanephridia:
(a) are multicellular excretory systems associated with a coelom.
(b) depend on cilia or flagella to transport wastes outside the body.
(c) possess a distinct, flagellated 'terminal cell' or 'flame cell'.
(d) All of the above.

True / False Question

1**-** unisexual reproduction; females produce young without fertilization, asexually → parthenogenesis.

True

False

2- Have two of the three embryonic tissue layers (ecto and endo) → Diploblastic.

True

False

3- Shells are dorsal/ventral not lateral like mollusks

Marine habitat

Attached by pedicel (fleshy stalk foot)-→ Phylum Brachiopod

True False

4- horseshoe worms; two parallel ridges curved into horseshoe shape

-live on substrate (bottom dweller)

-Secrete Chitin tubes to live in

-marine → Phylum Phoronida

True False

5- feeding structures bearing ciliated tentacles (ectoprocta) → Rhabdites

True False

6- Brachiopods are most common in warm fresh water.

True False

7-Nermetea shape is → dorso-ventrally flattened

True False

8- Most nemerteans use their epidermal cilia to glide over the substratum on a trail of slime, some of which is secreted by cephalic glands on the head. Larger species use musculature waves to crawl over surfaces. Burrowing nemerteans often have extremely muscular body walls. → Body Wall, Locomotion and Extensibility

True False

9- Mouth, buccal cavity, esophagus, stomach, intestinal diverticula, rectum, anus → Describe the closed circulatory system of Nemertean.

True False

10- The proboscis is stored in the RHYNCOCOEL → What distinguishes Enopla?

True False

11- Ctenophora symmetry → Diploblastic

True False

12**-** The nitrogenous waste in mollusks is removed by Flame cells.

True False

13- The mesoglea is cellular and it contains amoebocytes and muscle cells. → Describe the larval forms of Ctenophores.

True False

14- Ctenophorans have a complete digestive system. There are three openings: one mouth and two anuses. The digestive system branches extensively to distribute nutrients through the body → Describe the nervous system of p. Ctenophora.

True False

15- What is the skeleton of arthropods made of ? → Chitin (ecdysis)

True False

16- Digestion in arthropod → Complete

True False

17**-** Two layers: inner fibrous layer and outer, homogenous layer → Cuticle of nematomorpha

True False

1-Write on each of the following:-

- Distinctive features of Brachiopoda.
- General characters of *Pleurobrachia* sp.
- Definitive characters of Nemertea.

2- Write notes on each of the following:-

- The history of scientific taxonomy and the efforts of authors in this field.
- Colloblast – Nematoblast.
- Body wall of Nematoda.

3-Describe each of the following:-

- Definitive characters of Coelenterate.
- The mesozoans animals.
- The general characters of phylum Echinodermata.

INSECT TAXONOMY

WHAT IS TAXONOMY ?

Taxonomy is a greek word derived from 2 words :

Taxis : means arrangment

Nomos : means law

Taxonomy can also defined:

1- The science, laws, or principles of classification

2- The classification of organisms in an ordered system that indicates natural relationships

3- Division into ordered groups

Carl linneous the first one put a system of taxonomy according to physical features :

He also put the system of bionomial nomenclуture of each organism

Recently Organisms are classified into 4 kingdoms :

Protista , Fungi , Plantae , Animalia

Kingdom : Animalia

Phylum : Arthropoda

Class : Insecta

(Hexapoda)

Insects are the biggest class of Arthropods

They are the most diverse group of animals on the earth

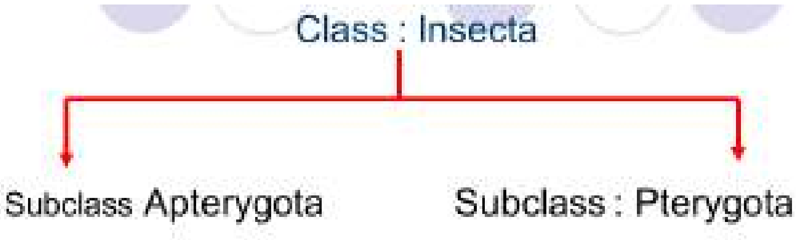
Have approximately million described species

Represent more than half of all known living organisms

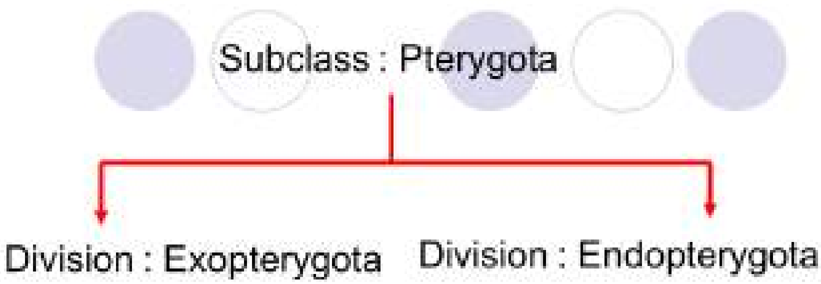
Insects found in nearly all environments on the plant

Have economical harmful and beneficial species for human

General Classification of Class : Insecta



Subclass : Apterygota



Exopterygota : Incomplete metamorphosis wings develop externally

Endopterygota : Complete metamorphosis wings rudiments develop internally

Exopterygota

Ephemeroptera , Odonata , Isoptera , Dermaptera , Blattodea (Dictyoptera) , Orthoptera, Plecoptera , Embioptera , Hemiptera , Psocoptera , Thysanoptera , Siphunculata, Zoraptera ,Mallophaga

Endopterygota

Diptera , Lepidoptera , Siphonaptera, Mecoptera , Trichoptera , Hymenoptera , Coleoptera

, Neuroptera , Strepsiptera

Subclass : Apterygota

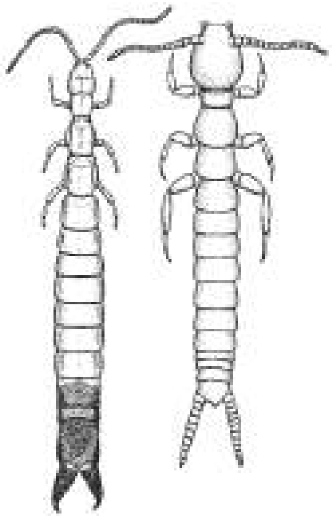
Order :Diplura

The Diplura are a group of primitive arthropods usually included in the class Insecta

The Diplura are world wide distribution with about 1000 described species a signed to 8 families

The name Diplura is derived from the presence of paired caudal appendages

General Chracters of order diplura



1- Shape : Slender elongated body

2- Size : Small (Less than 5mm)

3- Body is divided into :

a) Head : eyes : absent

antenna : many segmented

mouth parts : chewing (inside head)

b) Thorax : wingless

legs : well developed

2 pairs of spiracles on the thorax

c) Abdomen : 10 segments

has a pair of caudal cerci which

may be segmented (Campodeidae)

or one segmented (Japygidae)

4- Metamorphosis : not marked

the young and adult differ chiefly in size and sexual maturity

5- Habitat : under leaves , stones or in soil

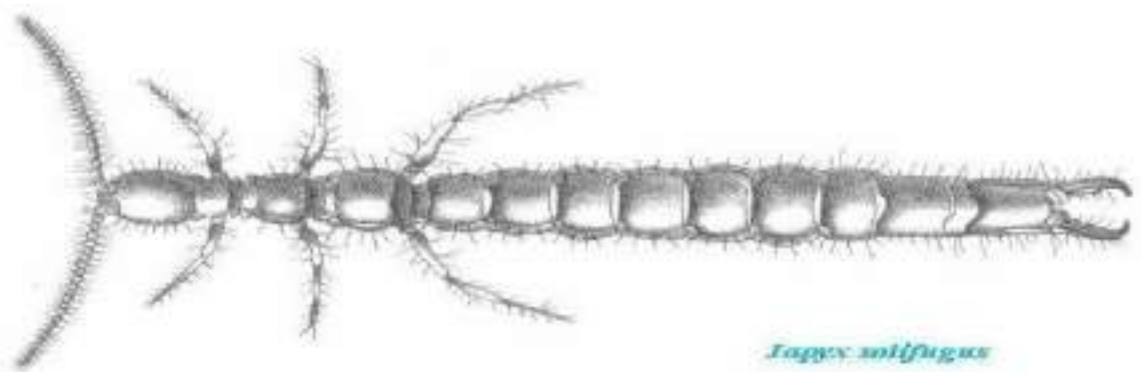
6- Feeding : many species may be predators

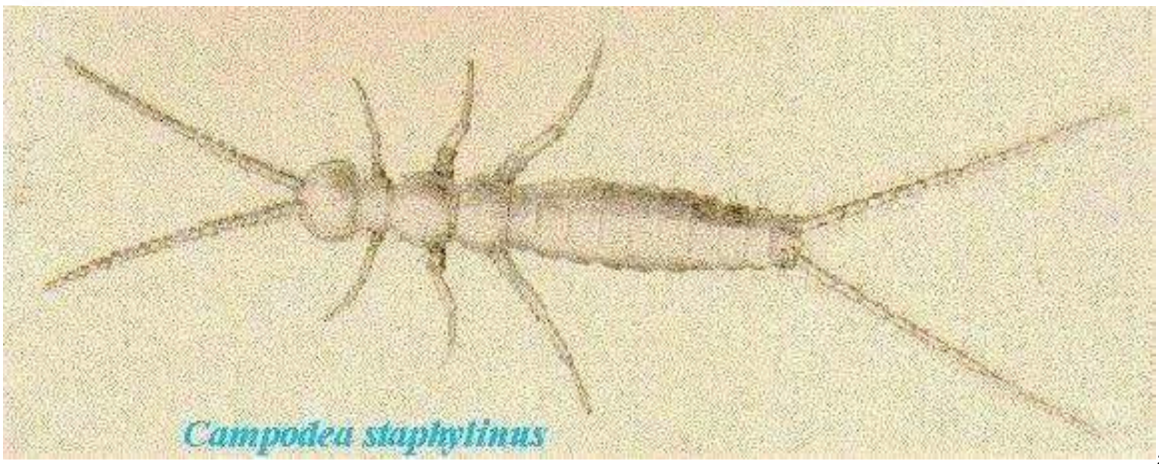
food is other Diplura , mites , Collembola fly and beetle larvae ,roots of living plants

7- Biology :

- Male deposit sperm bundles in the soil
- Female pick up these sperm bundles and become fertilized
- Eggs may be deposit randomly and in clusters or at end of a filamentous stalk
- The prelarva hatch in 7-16 days (donot feed and move little)
- The prelarva molts in about 2 days to immature fully mobile and feed on whatever food source available
- After 2nd molt the immature form possesses the major setae
- During 4th – 5th molt the individual becomes sexually mature
- Diplura continue to molt during their lives adding and regenerating damaged appendages

8- Examples :


Japyx solifugus


Campodea staphylinus

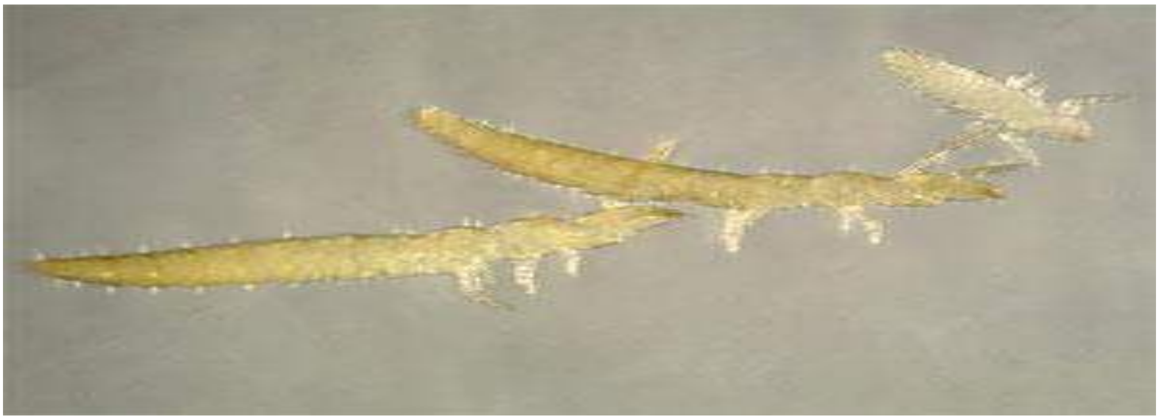
,,,

Order : Protura

(Proturans)

600 speices have been described asigned to 8 families

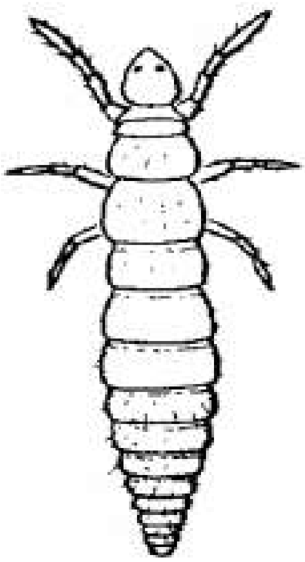
Members of order Protura are pale to white arthropods that live in the soil and ground litter debris, because of these characteristics , the group was not discovered and recognized until 1907 , long after almost all the other insect orders had been described and classified by F.Silvestri and A. Berlese



General Characters of Order : Protura

1- Shape : Slender

3- Body is divided into :



a) Head : cone shaped

eyes : absent

antenna : absent

mouthparts ; chewing , well developed

Inside head

b) Thorax : wingless

3 similar pairs of thoracic legs

the 1st pair serve as tactile organs

c) Abdomen : 12 segments

1st 3 abdominal segments with paired

styli

2- Size : Small (1.5 mm)

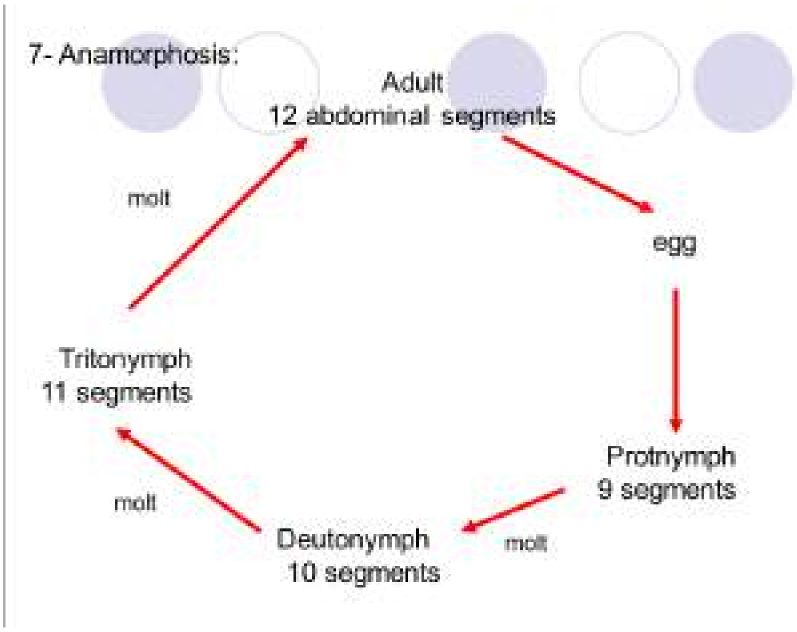
4- Metamorphosis :

Nymphs are similar to adults in general appearance -

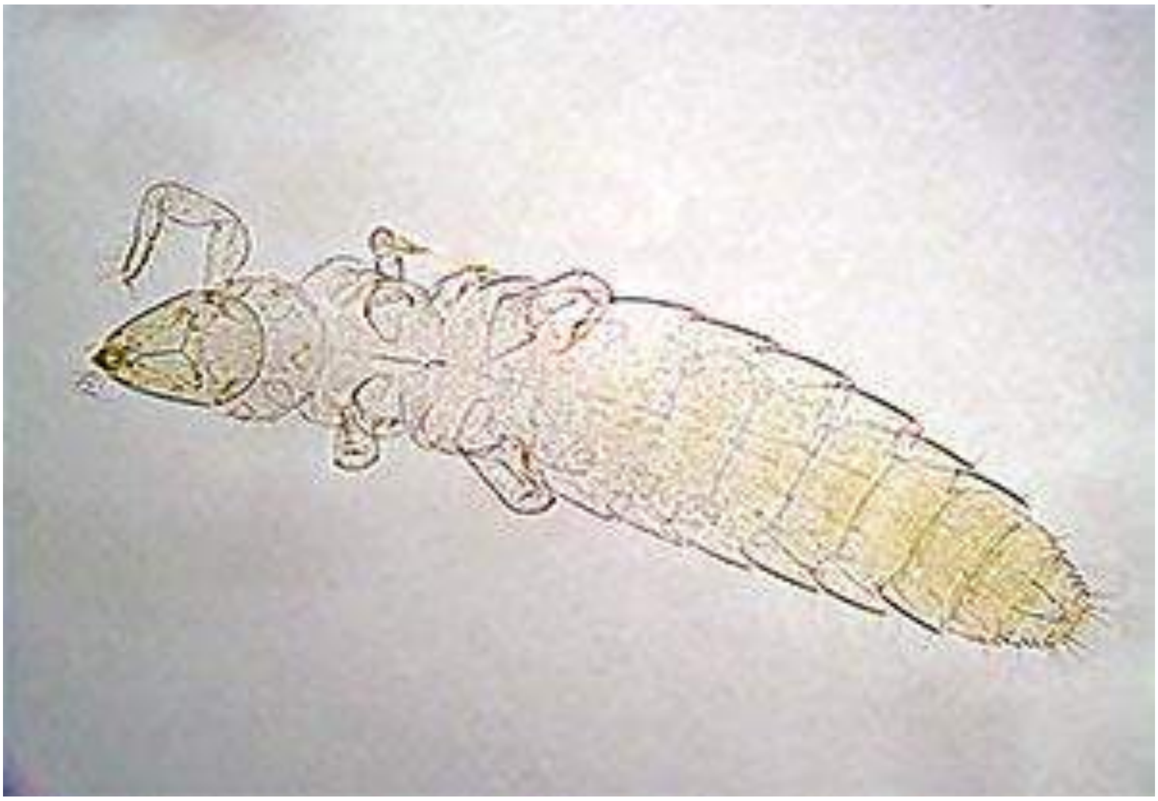
In development they exhibit anamorphosis , that is adding segments to the body at each molt

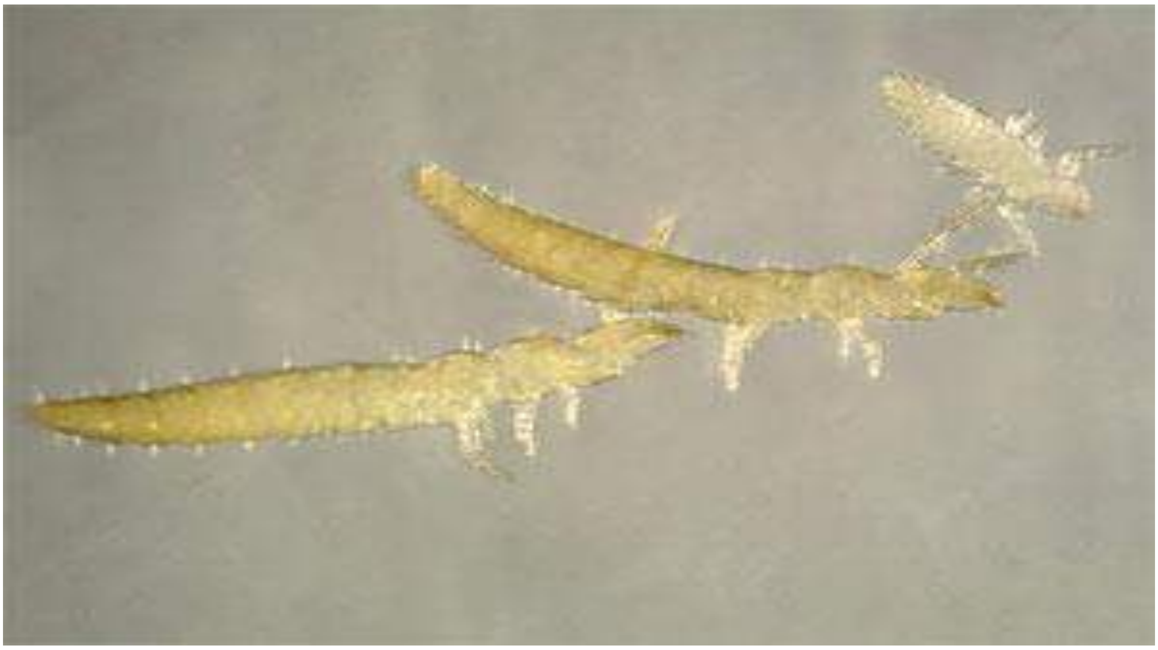
5- Habitat : humus , soil damp situation , old leaf mold along wood edges

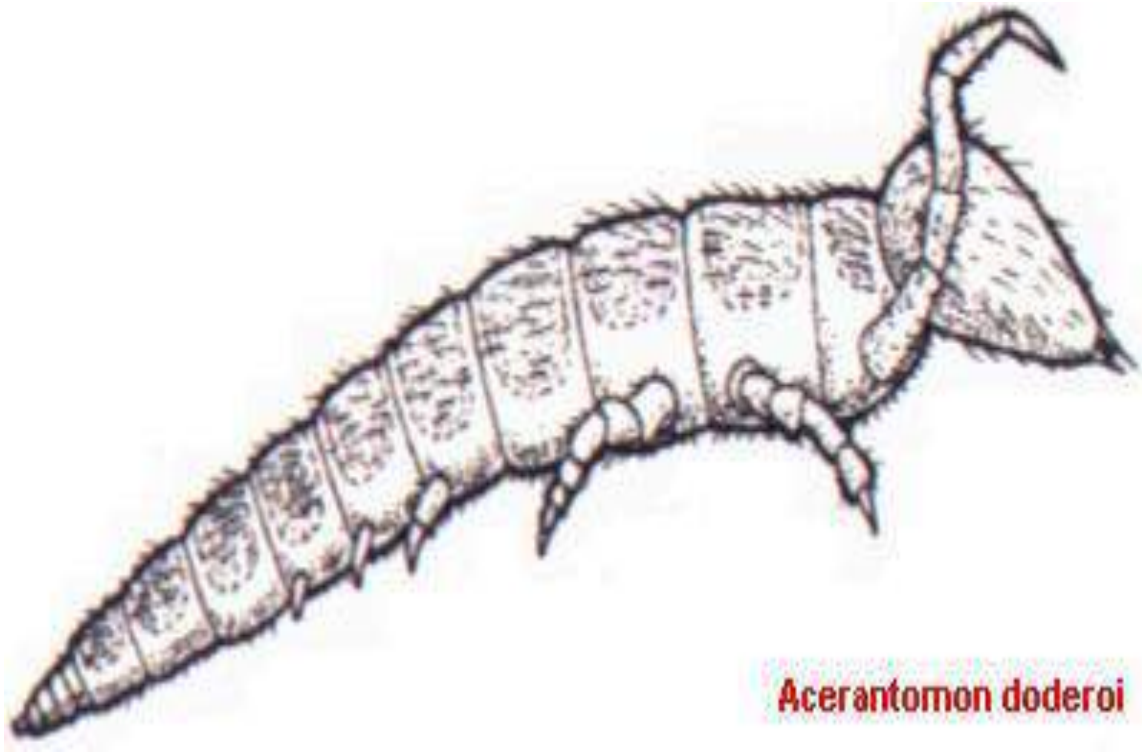
6- Feeding : both nymphs and adults feed on decayed organic matter



8 – Examples :






Acerantomon doderoi

Order : Collembola

(Springtails , Snow fleas)

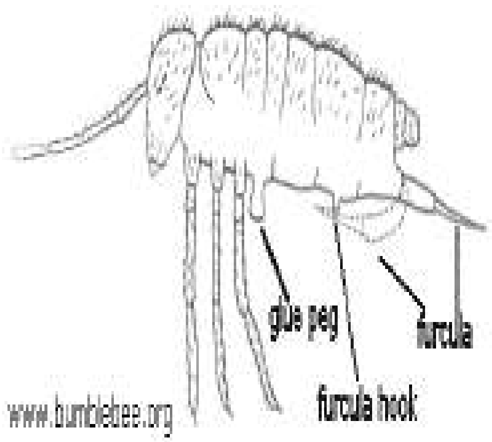
Collembola comprise one of the most wide spread terrestrial arthropods

They are found everywhere in all habitats except the open oceans and deep areas of large lakes

General characters of Order : Collembola

1- Size : minute to medium small (0.5 -10 mm)

2- Body is divided into :



Head : eyes : present or absent

antenna : present

mouthparts : chewing

can retract

may have stylet-like

Thorax : wingless

legs : well developed

Abdomen : 6 or fewer abdominal segments

1st seg.has tubular structure(collophore)

4th seg has a ventral jumping organ or furcula

button or tenaculum when not in use

Furcula move down and back abliing insect for jumping

3 – Metamorphosis : absent

both sexes usually similar and without

definite genitalia

4 – habitat : found abundantly in many types of moist situations , including deep leaf mold , damp soil , rotten wood , edges of ponds , fleshy fungi

5- Feeding : feed on fungi (mushrooms) , bacteria and decaying vegetation, some are carnivores , others are herbivores

a number are fluid feeders

6- Biology :

Fertilization is internal

The sperm is produced in a packet

These packets are produced randomly and fertilization

occurs by accidental contact of the female with the packet of sperm

Both male and female occur in most species but parthenogenesis is common

Collembola continue to molt after reaching sexual maturity reach 52 time

7- Examples :

Class : Insecta

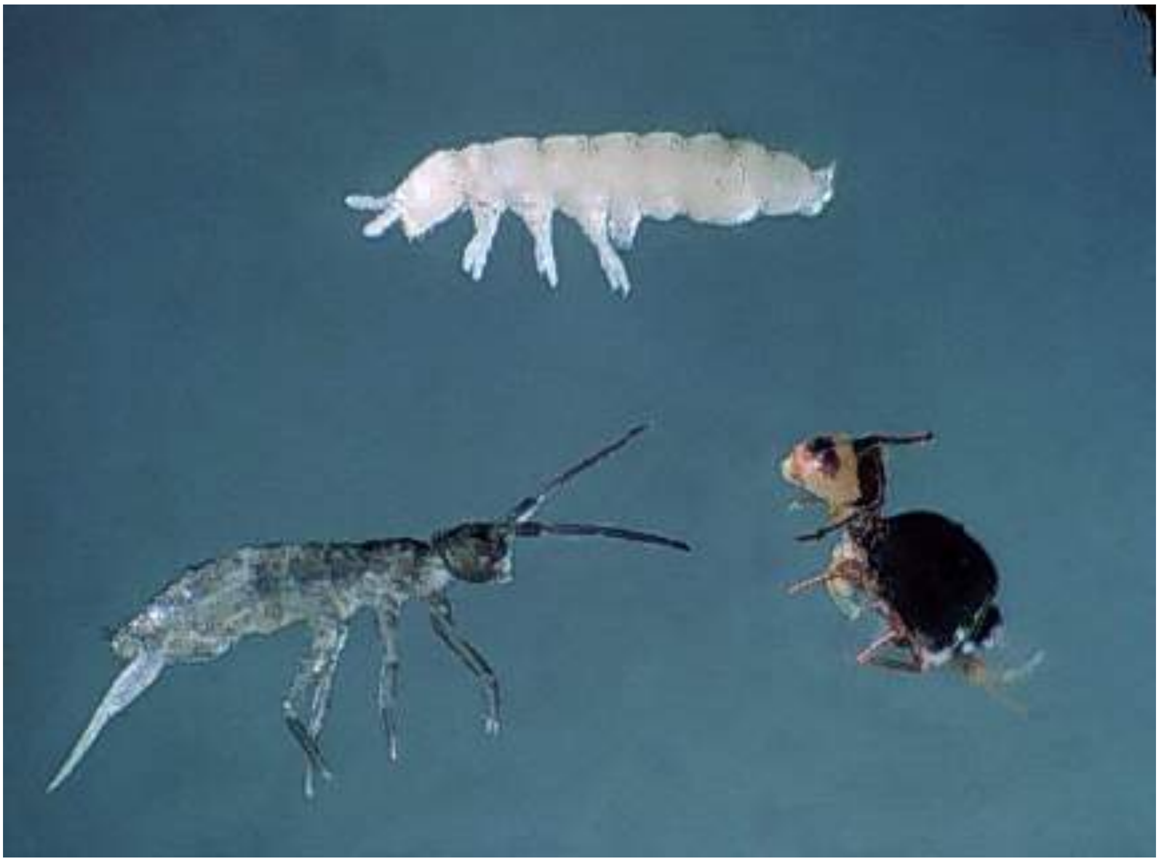
Subclass :Apterygota

Order : Collembola

Suborder : Arthropleona

Family : Onychiuridae

e.g. : *Tetrotodophora bielanensis*



Order : Thysanura

(Silverfish , Firebrats)

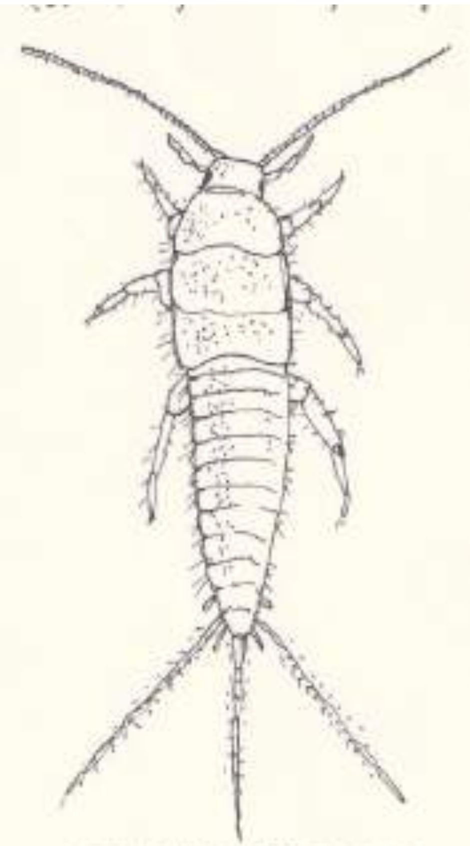
General characters of Order : Thysanura

1- Shape : Flattened wider body

styliform appendages

2- Size : Small to medium size (5-30 mm)

3- Body is divided into :



Lepismatidae (Thysanura)

Head : eyes : absent or small

antenna : multisegmented

Thorax : wingless

legs : well developed

Abdomen :11 segments

has long cerci and along caudal filament

4- Economic status :

Silverfish *Lepisma saccharina* ,

firebrats *Thermobia domestica* feed commonly on starch.

They cause considerable damage to books and clothing by chewing off the starch or glue

5- Biology :

-Eggs are laid singly in cracks

-The young grow slowly , maturing in 3-24 months , and

have a large and indefinite number of molts

-Molting continue after adulthood is reached

6- Examples :

Thermobia domestica

Lepisma saccharina

Thermobia domestica

Subclass: Pterygota

Division : Exopterygota

Order : *Ephemeroptera*

(Mayflies; Cadisflies)

Classification of Order: Ephemeroptera
Order : Ephemeroptera (mayflies)

Suborder : Furcatergalia
Infraorder : Scapphodonta
Family : Ephemeridae
Genus : Ephemera
Genus : Hexagenia
Genus : Litobrancha
Genus : Pentagenia

(Ephemeroptera from Greek, *ephemeros* = short-lived; *pteron* = wing)
General Chracters of order:Ephemeroptera

1-shape : Slender insects with soft body.
2-size : small to medium sized insects with an average wingspan up to 15 mm
3-Body is divided into :
a) Head : Short, fine antennae.
Compound eyes large, usually Covering most of the head.
Vestigial mouthparts.

b)Thorax : 2 pair of membranous wings, Hindwings much smaller than the forewings.

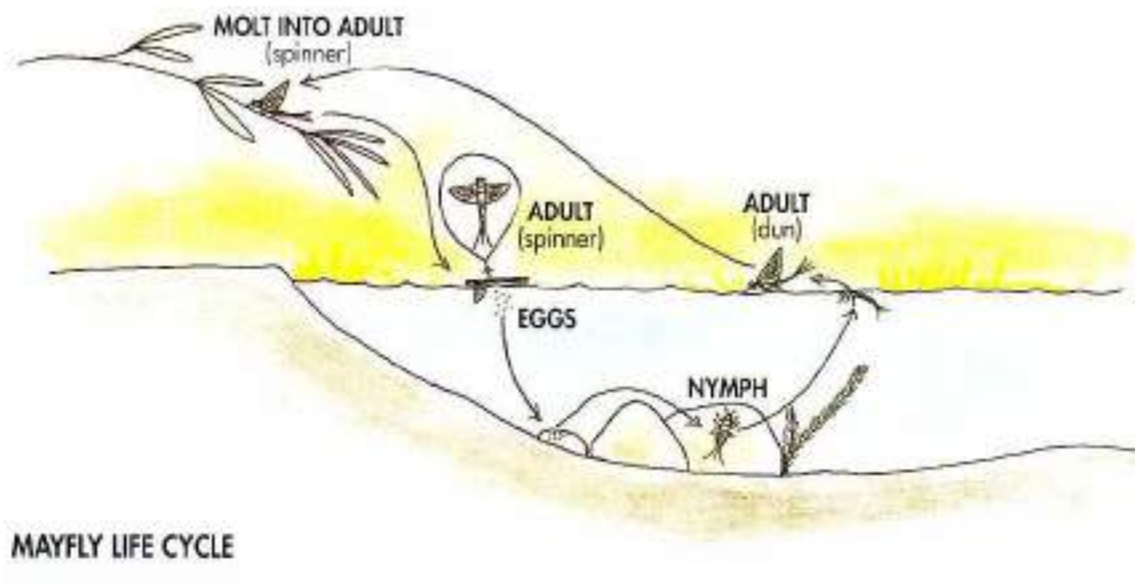
front wings large, triangular. hind wing smaller, fan-shaped.
Front legs long and often held out in front body.

c) Abdomen : Abdomen slender, bearing two (or sometimes three) long terminal filaments **.**

4 -Metamorphosis : gradual metamorphosis. Mating occurs during flight and large swarms of mayflies close to the fresh water. Eggs are laid on the water surface. Upon hatching the nymphs live on the bottom. Development can

take from several months up to a year and can involve from 20 to 50 molts depending on the species .

Mayfly nymphs are aquatic and have a similar body shape to the adults but lack wings. The nymphs have gills along the sides of their abdomen, which look similar to fine leaves.



8 – Examples :

Ephemera *Hexagenia*

Mayfly nymph

Order : *Odonata*

(Dragonflies and Damselflies)

This scientific name is derived from a Greek word, *odon*, meaning " tooth," possibly referring to the teeth on the mandibles or tusk-like shape of the insect's abdomen.

Classification of Order:Odonata

The majority of odonata belong to two suborders, the Anisoptera (Dragon flies) and Zygoptera (Damsel flies).

Order : Odonata (dragonflies and damselflies)
Suborder : Anisoptera (dragonflies)
Family : Libellulidae
Genus : *Crocothemis*
Species :*Crocothemis erythraea*
Suborder :Zygoptera (damselflies)
Family :Coenagrionidae
Genus :*Ischnura*
Species :*Ischnura senegalensis*

General Characters of order : Odonata

1-shape : this insects have beautiful colors.
2-size : medium to large.
3-Body is divided into :
a) Head : very mobile hypognathous head.
Short filiform antenna.
Mandibulate (chewing) mouth parts.
Large compound eyes, 3 ocelli.
b)Thorax : Short and compact.
Two pairs of nearly similar net-veined wings with pterostigmata. In the hindwing, the inner margine is broader than the outer margine.
Short walking legs.

c) Abdomen : Elongated, slender with 10 segments.

One segmented cerci work as catch organ in male.

Male capulatory organs on second abdominal sternites (ventral side).

Female genitalia on the last abdominal segment.

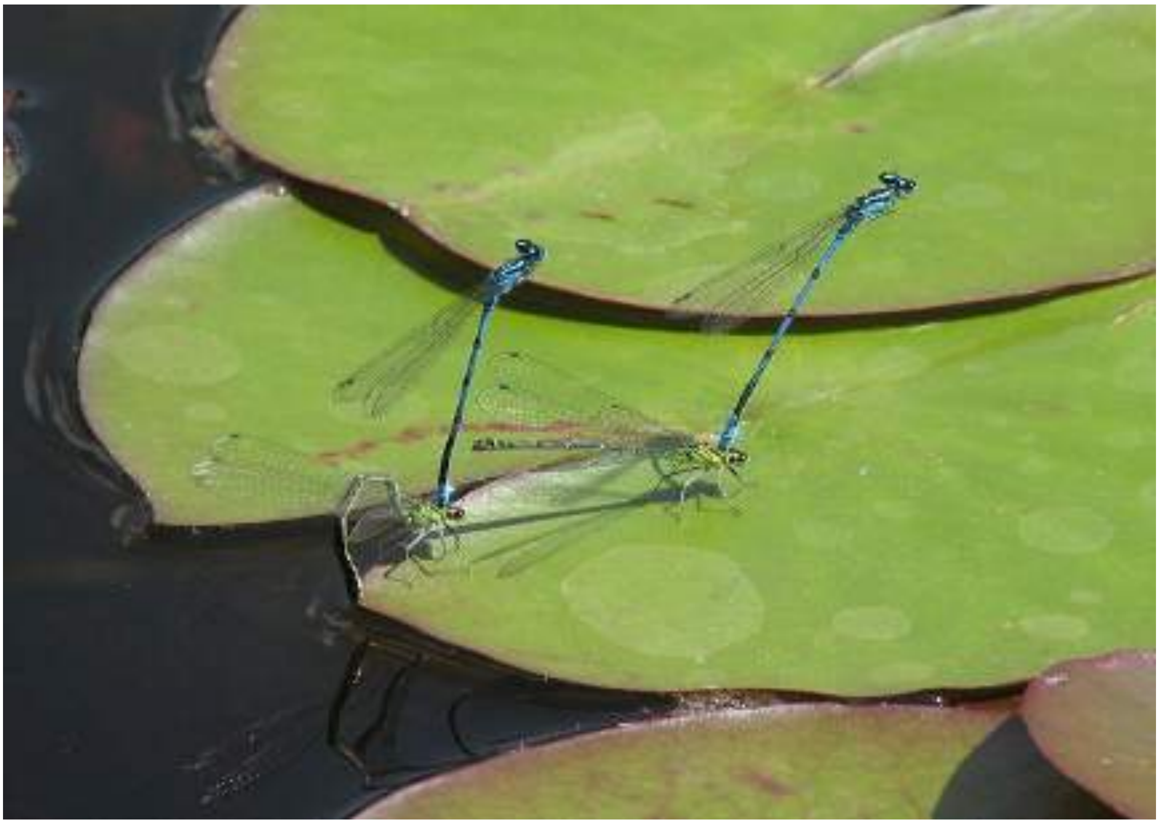
4- Metamorphosis : Incomplete metamorphosis.

Eggs are laid in water or on vegetation near water or wet places, and hatch to produce pronymphs.

They then develop into instars with approximately

9-14molts

that are) in most species) voracious predators on other aquatic organisms , including small fishes.These insects later transform into reproductive adults



couples damselfly two of flight Ovipositing

5- habitat :Dragonflies and damselflies range from the arctic to the tropics and are even found in desert regions where water is present. Immature dragonflies and damselflies, called naiads, live in water and often have preferences for a specific kind of aquatic habitat, some preferring streams and others ponds or lakes.
6- Feeding :Adult dragonflies and damselflies catch and eat insects while they are flying, including flies, wasps, moths, and beetles.

Naiads are voracious predators and feed mostly on other insects in water, but they also can be cannibals by feeding on other naiads of their own species. Some large naiads have been known to feed on small fish.

7-Differences between the Anisoptera and the Zygoptera

Anisoptera	Zygoptera
1-Strong fliers. 2-large and robust at all stages. 3-Hindwings broader at base, held horizontally at rest. 4-Eyes not projecting from sides of head. 5-Most females with reduced or vestigial ovipositors. 6-Nymphs robust, with rectal gills. 7-Eggs usually laid at water surface or on surfaces of aquatic plants.	1-weak fliers. 2-small and delicate at all stages. 3-Wings of equal size,narrow at base, held vertically at rest. 4-Eyes bulbous and prominent. 5-Females with well developed ovipositors. 6-Nymphs slender, with paddle-like caudal gills. 7-Eggs inserted into stems of aquatic plants.

Dragon fly nymph

Damsel fly nymph

8 – Examples :

Dragon fly

Damsel fly

Ischnura

Ischnura senegalensis

Ischnura senegalensis

Ischnura senegalensis

Order :Mantodea

Mantids

Mantids

Mantodea or mantids is an order of predatory insects which contains approximately 2,200 species in 9 families world wide in temperate and tropical habitats

The common name of the order is “ praying mantises” because of the typical “ prayer form “

1- Size :Large

2- Body is divided into :

a- Head : flexible, bearing :

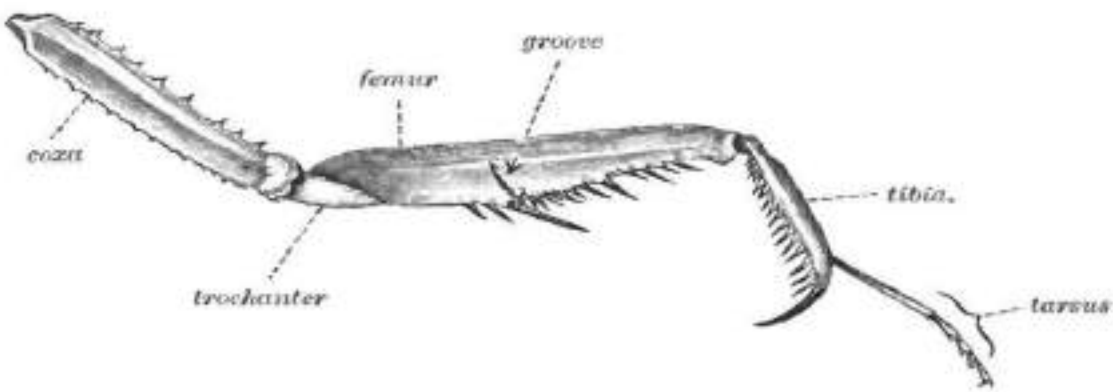
Eyes: compound

Mouthparts : chewing

b- Thorax : with

Elongated flexible prothorax   Seizing prey legs

c- Abdomen : Flattened



Leg of a Mantis.

Food:

Mantids are predaceous , typically feeding on insects and other arthropods

Large mantids have also been known to prey on small birds , lizards and amphipians

Life cycle

1- Mantises carry out incomplete metamorphosis

2- Generally molting 7 or more times to reach maturity

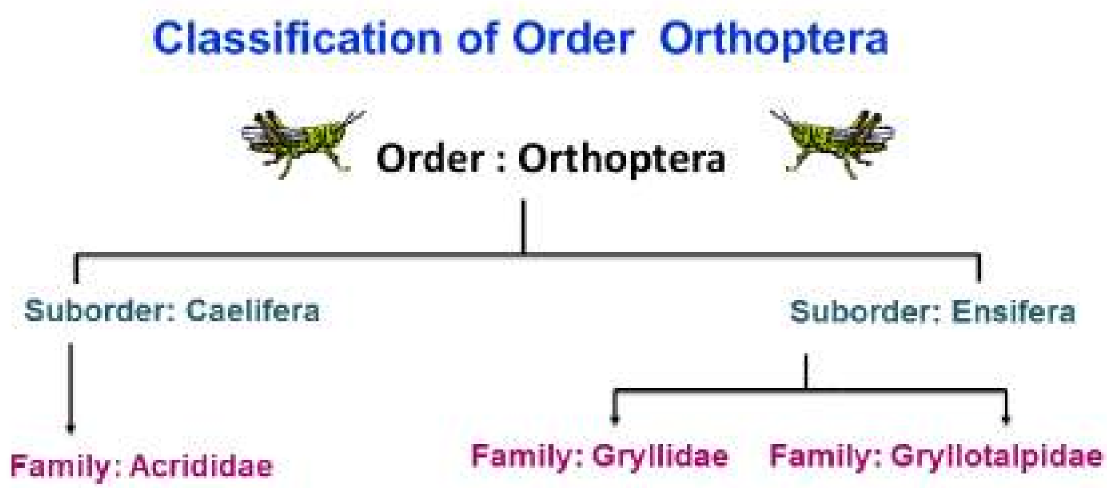
3- Eggs are laid during autumn in an ootheca (egg sac) which hatch in the spring

Examples:


Sphadromantis viridus

Order: Orthoptera

(Grasshoppers, crickets, and katydids)



Scientific Classification

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Subclass: Pterygota

Division: Exopterygota

order: Orthoptera

General Characters of Order Orthoptera

- The **Orthoptera** (from the Greek, *orthos* = "straight" and, *pteron* = "wing")
- There are about 20 000 known species distributed around the world
- Including the grasshoppers, crickets and locusts.
- Many insects in this order produce sound (known as a "stridulation") by rubbing their wings against each other or their legs.
- The tympanum or ear is located in the front tibia in crickets, mole crickets, and katydids.

These organisms use vibrations to locate other individuals.

1- Size: Varies from less than 5mm to some cm. of the world's largest insects

2- Body is divided into:

- **Head:**

Eyes: large compound eyes and 3 ocelli (may present or absent).

Antenna: Length vary with species(sometimes filamentous, setaceous or multiarticulate)

Mouth parts: Mandibulated

- **Thorax:**

Prothorax: Large and covered by shield-like pronotum

Mesothorax: Small

Metathorax: Large

Wings: Two pairs of wings; the forewings or tegmina are narrower than hind wings and hardened at the base. They are held overlapping the abdomen at rest. The hind wings are membranous and held folded fan-like under the forewings when at rest.

Legs: Walking legs with saltorial hind legs are elongated for jumping.

Abdomen: about 8-9 segments and the three terminal abdominal segments are reduced. There is short unsegmented cerci. The female usually has well developed ovipositor.

3- Metamorphosis: They undergo incomplete (gradual) metamorphosis (having nymphs that look like small adults and no pupa).

Most grasshoppers lay their eggs in the ground or on vegetation. The eggs hatch and the young nymphs resemble adults but lack wings and at this stage are often called *hoppers*. Through successive molts the nymphs develop wings until their final molt into a mature adult with fully developed wings.

The number of molts varies between species; growth is also very variable and may take a few weeks to some months depending on food availability and weather conditions.

4- Habitat: The Orthoptera can be found in most habitats, as well as the more familiar species found in Grassland and Forest, Sea-shores, Bogs and Marshes, Camel Crickets are naturally cave dwellers, the Desert Locust *Schistocerca gregaria* lives in Desert and Semi-Desert, while the Mole-cricket (Gryllotalpa gryllotalpa) lives under ground. Many species are arboreal (live in trees).

Though some species are very cosmopolitan, others can be quite specific in the habitat requirements i.e. the Ant Cricket is only found in ant nests.

5- Feeding: Leaves, flowers, bark, and seeds, but many species are exclusively predatory, feeding on other insects, snails or even small vertebrates such as snakes and lizards. Some are also considered pests by commercial crop growers.

Grasshopppers mating

Instars of Grasshoppers: from the newly-hatched nymph to the fully-winged adult.

6- Economic Importance:

Orthoptera is generally regarded as a dominant group in most terrestrial habitats.

They are one of the largest and most important groups of plant-feeding insects. As they feed on all types of plants and often cause serious economic damage. Swarms of grasshoppers (locusts) regularly appear in parts of Africa, Asia, and North America and destroy crops over wide land areas. Several species of field crickets are reared commercially as fish bait.

Differences Between Suborder Caelifera and Suborder Ensifera

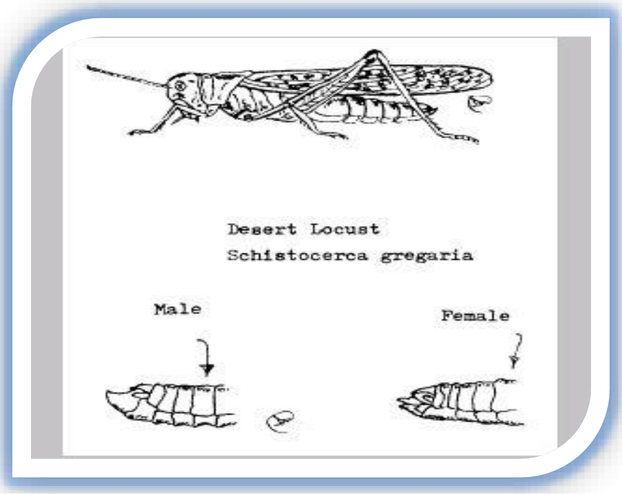
Characters	Suborder Caelifera *(Short-horned grasshoppers)*	Suborder Ensifera *(Long-horned grasshopper)*
Living	**Diurnal**	**Nocturnal**
Antennae	**Short**	**Longer than the body**
Eyes	**Sharp & Large eyes**	**Small eyes**
Hearing	**Strong hearing**	**Weak hearing**
Legs	**Hind legs modified into jumping legs**	**Fore legs modified into digging legs**
Tarsi	**Three segmented tarsi**	
Ovipositor	**Short**	**Long or vestigeal**

Characters	Suborder Caelifera *(Short-horned grasshoppers)*	Suborder Ensifera *(Long-horned grasshopper)*

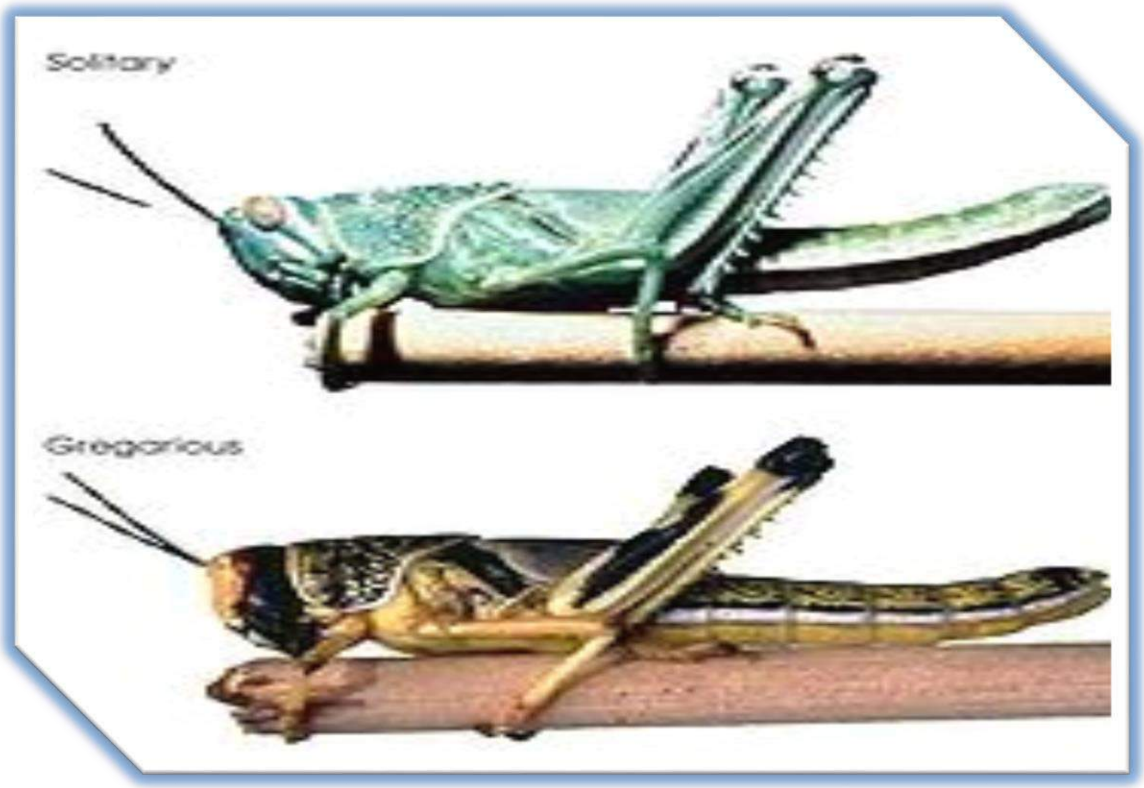
Auditory organ	Located on the tergum of the 1st abdominal segment under the fore wing	Located on the tibia of the fore legs
Stridulatory organs	The sound produced from the projections on the inner side of the femur of the hind legs which is rubbed against the hardness radial vein on the fore wing.	The sound produced as the following: A- The fore wings are moved backward and foreword laterally. B- The scraper of the left wing is rubbed against the file of the right wing.
Characters	Suborder Caelifera (Short-horned grasshoppers)	Suborder Ensifera (Long-horned grasshopper)
Family	Acrididae	Gryllidae
	e.g.: Schistocerca gregaria	e.g.: Gryllus bimaculatus
	e.g.: Locusta donica	e.g.: Gryllus domisticus
	e.g.: Anacridium aegyptium	Gryllotalpide
	e.g.: Tryxalis nasuta	e.g.: Gryllotalpa africana

Examples

Compound eyes in Desert Locust — *Schistocerca gregaria*

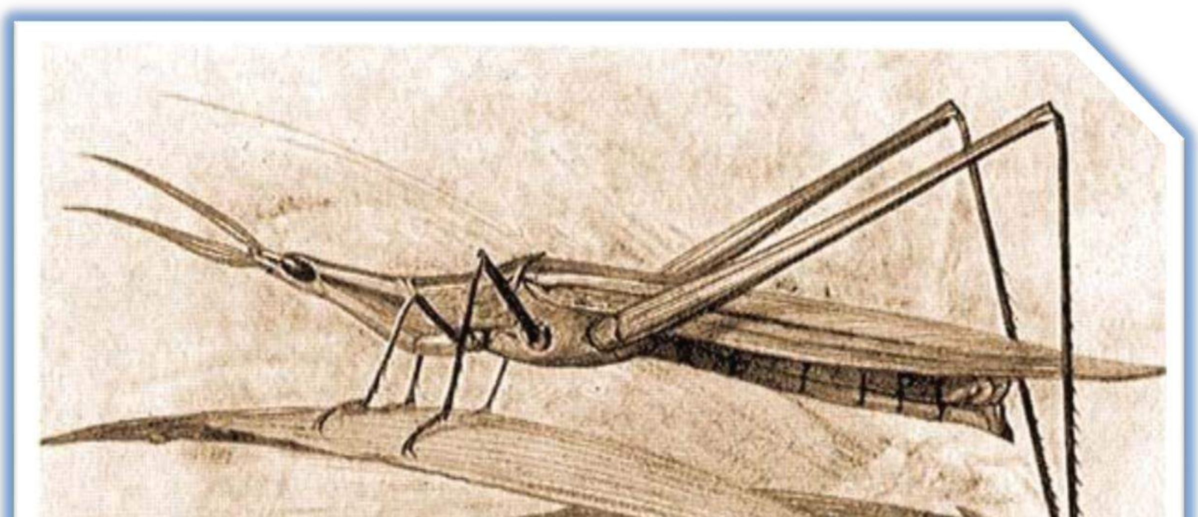


Desert Locust



Solitary (top) and gregarious (bottom) desert locust nymphs

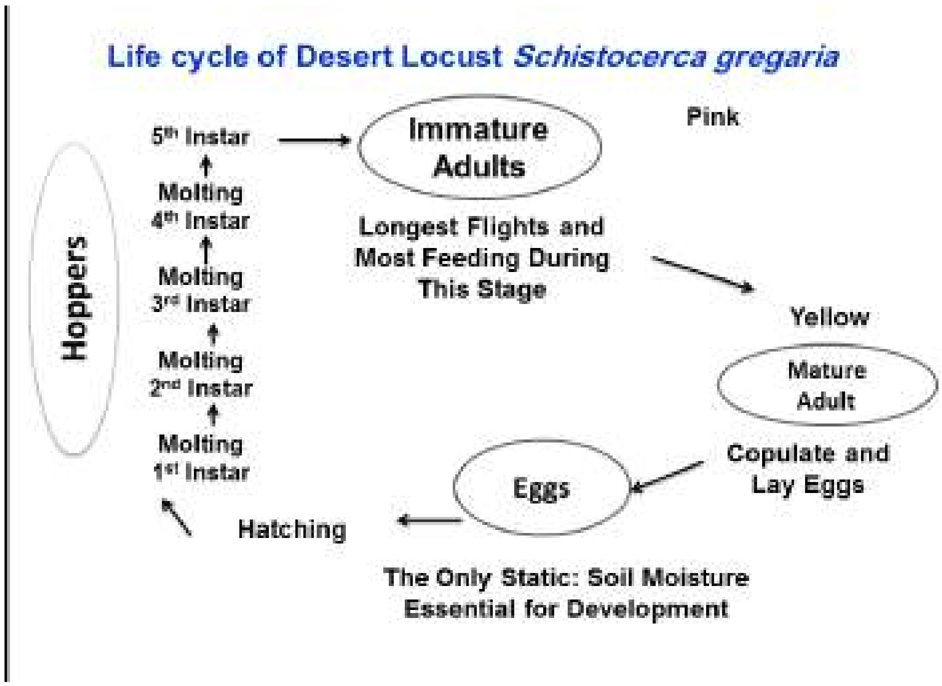
Anacridium aegyptium

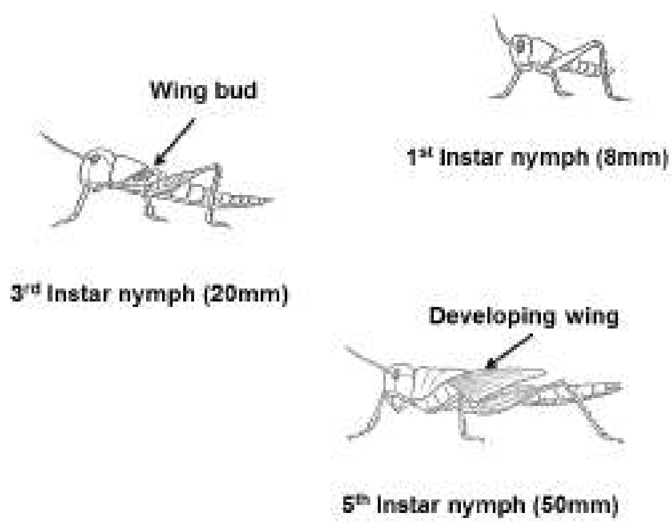


Tryxalis nosuta

Common Field Cricket, *Gryllus domesticus*

Gryllus bimaculatus


Life cycle of Desert Locust *Schistocerca gregaria*
Hoppers
5th Instar
Molting
4th Instar
Molting
3rd Instar
Molting
2nd Instar
Molting
1st Instar
Hatching
Immature Adults
Pink
Longest Flights and Most Feeding During This Stage
Yellow
Mature Adult
Copulate and Lay Eggs
Eggs
The Only Static: Soil Moisture Essential for Development


Wing bud
1st instar nymph (8mm)
3rd instar nymph (20mm)
Developing wing
5th instar nymph (50mm)

Order: Dermaptera
(Earwig)

Scientific Classification

Kingdom:	**Animalia**
Phylum:	**Arthropoda**
Class:	**Insecta**
Subclass:	**Pterygota**
Division:	**Exopterygota**
Order:	**Dermaptera**

General Characters of Order Dermaptera

Dermaptera = "skin wings" Refers to the leathery texture of the forewings. The name earwig comes from a superstition that the insects would enter the ears of a sleeping person and tunnel into the brain.

1- Size: 6-35 mm long

2- Shape: Earwigs have slender, flattened bodies.

3- Color: Adults are pale-brown to reddish-black in color.

4- Body: Is divided into :

A- Head:

Antennae: bead-like antennae

Mouth Parts: Chewing mouth parts.
B- Thorax: The front wings are short and meet in a straight-line down the back. The hind wings are membranous and folded underneath the front wings.

C- Abdomen: Adult males have 10 abdominal segments, while the females have 8 segments.

Both the males and females have large, pincers (cerci) that stick out from the back of the abdomen (the pincers are one segment). The pincers are used in defense for protection against predators or to capture prey.

5- Metamorphosis:
Simple metamorphosis with visible changes including increasing antennal segments and progressive wing development until sexual maturity. The mother cares for the eggs and nymphs.

6- Habitat:

Earwigs tend to hide under debris during the day, but feed on plants, organic matter, and smaller insects at night.

7- Feeding:

Plants, organic matter, other small insects.

8- Life Cycle:
Earwigs hibernate in the soil as adults during the winter. In spring, adult females lay 30 to 55 eggs in the soil. The females nurture and protect the eggs and young (maternal care), which is uncommon for insects. The eggs hatch into young nymphs. Earwigs have four to five nymphal stages before

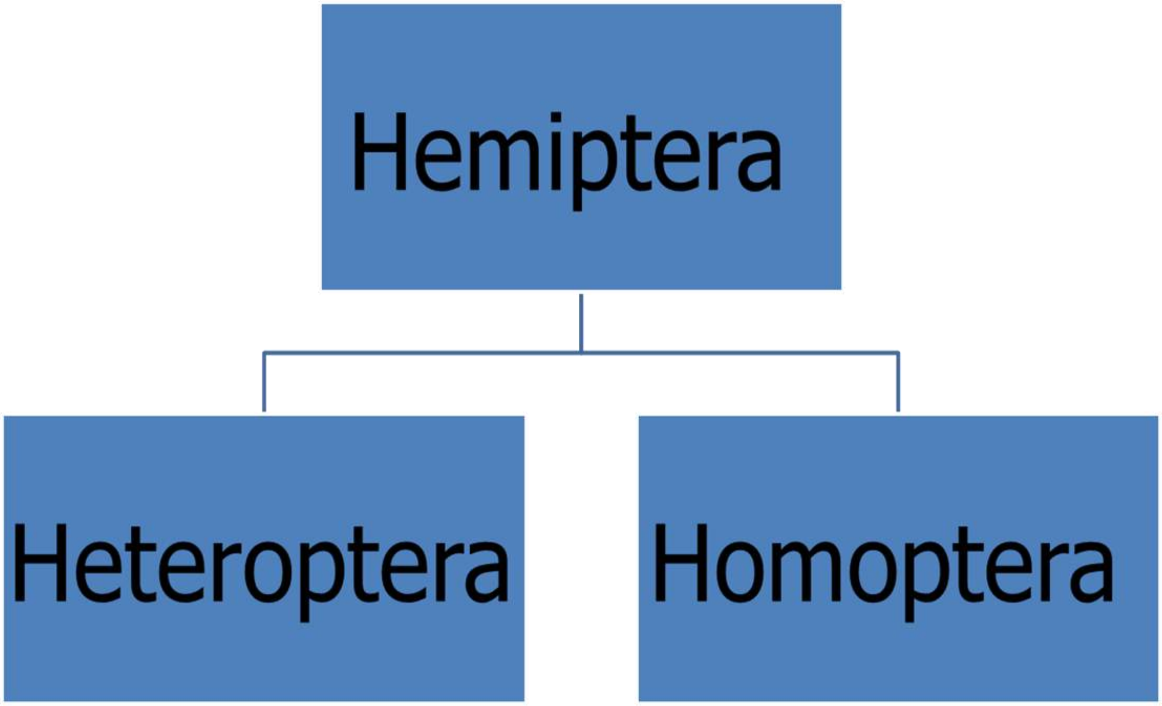
becoming adults. Earwigs are nocturnal, hiding during the daytime and active at night. They tend to prefer moist environments. During the day, they usually inhabit dark confined or shaded areas such as under plants, debris, stones, organic mulch, tree bark, and flower pots. They are less likely to be found in exposed sunny areas.

9- Economic Importance:

Earwigs are not a major pest; however they do feed on flowers and can be a nuisance inside homes.

Labidura reparia

Order :Hemiptera



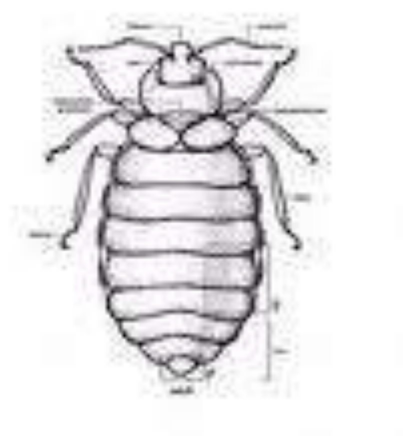
Suborder: Heteroptera
Family : Belostomatidae

- Antenna short to long, filiform or setaceous
- Compound eyes large, ocelli present or absent
- Mouth parts: piercing and sucking
- Thorax: prothorax large, distinct ,mesothorax represented dorsally by scutellum. forewings large than hind wings ,flexed flat over abdomen
- Legs: Walking, in some species predatory
- Abdomen with anterior1-2segment reduced or absent, posterior1-2 segment reduced

Cerci absent

e.g.: Lethocerius niloticus

- Family: Cimicidae
- *Cimex lectularius*
- mandible and maxilla become specialized as two channeled
- Piercing to delivering saliva, and talking up food injection of saliva
- Is the major factor in transmission of pathogens?
- In predatory species saliva is highly toxic enabling large prey
- Reproduction bisexually



- Most hemiptera hemimetabolous,nymphs differ from adults in such details,such as number of antennal segments
- presence of ocelli
- wings development
- Reproduction bisexually ,oviposition on plant tissue or on soil
- basal portion of fore
- Wings thickned, rostrum arising interiorly on the head

- *Nezara veridula*
- Bentatomidae
- Heteroptera
- Hemiptera

Homoptera

wings uniformly membranous

rostrum arising near

posterior margin of the head

e.g.:Aphis faba

e.g.:Aphis gossypyii

Family: Aphididae

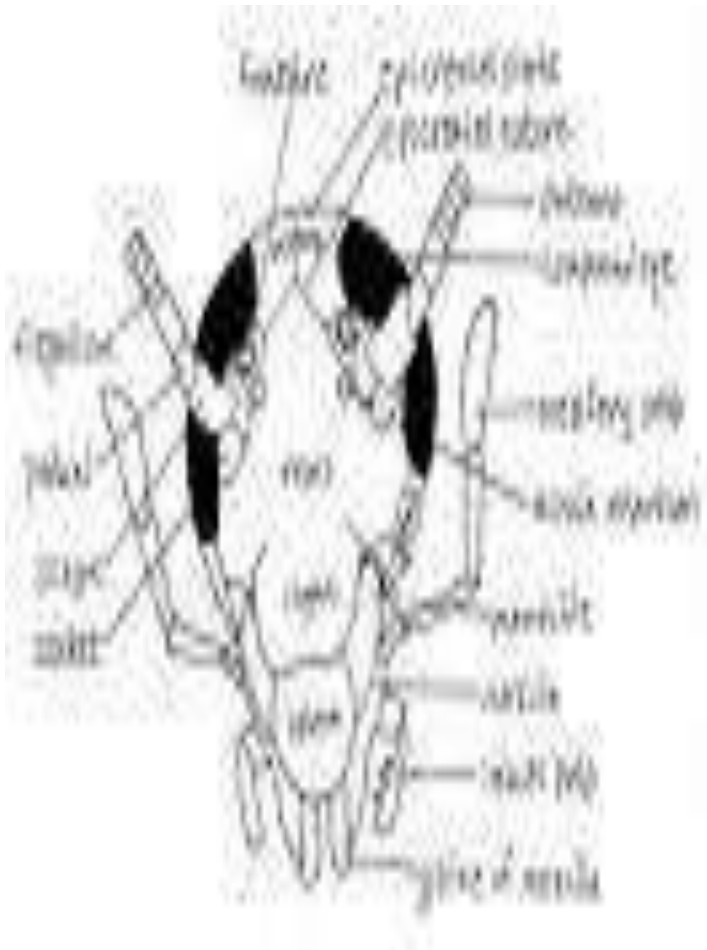
Order: Blattodeae(Dictyoptera)

- About 30 species of cockroaches are cosmopolitan inhabitants of man dwellings , placing them among most familiar insects to non-entomologist yet they must considered potential medical importance because large number of pathogenic micro-organisms isolated from their bodies.

- Cockroaches have been important subject for investigation of hormonal control of insect growth , development , study insecticidal mode of action and insecticide resistance , cockroaches adults are long lived , some species surviving 4-years under experimental conditions

General characters

- Flattend broad body ,mouthparts mandibulate, compound eyes large , with 2-ocelli
- Antenna :very long ,multiarticulat
- Thorax :prothorax large ,mobile , with shield-like notum
- Meso and meta thorax smaller than prothorax



- Wings : fore wings scelerotized hind wings membranous
- Legs :coxae long , tarsi 5-segments ,abdomen 10-segments
- Tergit 10 bearing cerci tergit 5-6 bearing scentgland.
- Order:Dyctyoptera(Blattodeae)

  Family : Blattidae

  e. g:*Periplaneta amricana*

  e.g :Blattela germanica

  e. g: Polyphaga aegyptiaca


5
6
5m
7

Order : Isoptera

Termite-White ant

The name Isoptera, derived from the Greek "iso" meaning equal and "ptera" meaning wings, refers to the similar size, shape, and venation of the four wings.

General characteristics

1- Social insects living in large communities, with several different forms or castes, reproductive ('kings' and queens'),non reproductive (soldiers and workers). 2- All are soft-bodied and generally pale in color, with biting mouthparts. The soldiers have a large head - in some species with large, powerful jaws - in others with a pointed rostrum from which a poisonous, repellent liquid can be ejected.

3-The reproductive castes have two pairs of similar long, narrow wings, but these are soon shed once they start nesting. Other castes are wingless. The wingless forms have rudimentary eyes or none at all.

4- Abdominal cerci always very short.

5- Metamorphosis simple. All castes are long-lived. A king and queen may live together in their colony for many years - up to 50 years has been quoted for some species - and individual soldiers and workers may live up to four or five years.

Termite castes

Termite queen with its workers

Life History & Ecology:

The termites are another group of insects that appear to be closely related to cockroaches. This conclusion is based on behavioral and ecological similarities between termites and wood roaches (members of the family Cryptocercidae). These cockroaches live in fallen timber on the forest floor, feeding on wood fibers which are then digested by symbiotic microorganisms within their digestive systems. They live in small family groups where each female provides care for her young offspring. Termites and wood roaches are thought to be close relatives because they both occupy similar habitats, share the same type of food resources, have the same intestinal symbionts, and provide care for their offspring.

Termites are the only hemimetabolous insects that exhibit true social behavior. They build large communal nests that house an entire colony. Each nest contains adult reproductives (one queen and one king) plus hundreds or thousands of immatures that serve as workers and soldiers. Like cockroaches and mantids, the termites are most abundant in tropical and subtropical climates.

Distribution:

Extremely common in tropical and subtropical climates. Generally less abundant in temperate regions.

	North America	Worldwide
Number of Families	4	7
Number of Species	44	~2300

Classification:

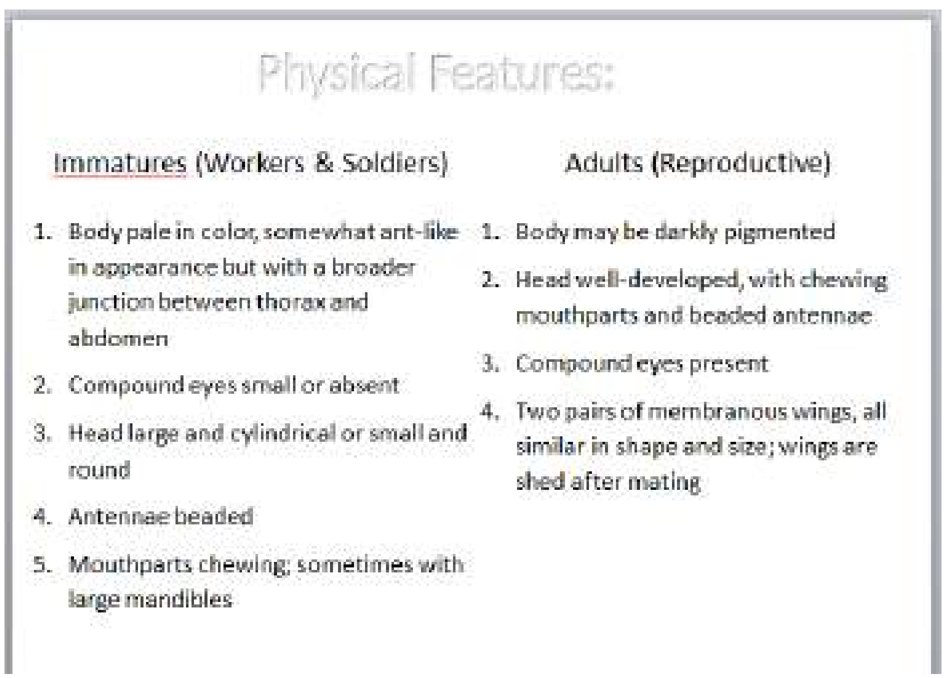
Hemimetabola

incomplete development (egg, nymph, adult)

Major Families :

- **Rhinotermitidae** (Subterranean termites) -- These insects build nests in the soil and generally infest wood that is in contact with the ground. This family includes the most destructive species found in the United States: the eastern subterranean termite (*Reticulitermes flavipes*), the western subterranean termite (*R. hesperus*), and the Formosan subterranean termite (*Coptotermes formosanus*).

- **Hodotermitidae** (Rottenwood termites) -- Generally found inhabiting moist wood. Contact with the soil is not a requirement. This family includes the Pacific dampwood termite, *Zootermopsis angusticollis*.
- **Kalotermitidae** (Drywood and dampwood termites) -- These insects nest in the wood itself and do not require contact with the soil. Pest species include the western drywood termite (*Incisitermes minor*) and the forest tree termite (*Neotermes connexus*).
- **Termitidae** -- This is the largest family of termites worldwide, but all of the North American species are relatively minor in importance.



Life Cycle of termites

1. Winged reproductive ('alates') emerge from the nest entrance, surrounded by workers trying to protect them from predators.

2. The alate female flies some distance from the nest, then settles on the ground, tips her abdomen in the air and releases a sex pheromone into the air, its dispersal aided by beating of the wings.

3. A male locates the advertising female, settles beside her, they recognize each other, brake off their wings and then scuttle off together to find a suitable nest site.

4. After finding a nest site, the male ('king') mates with the female ('queen') and the queen starts laying eggs. The colony steadily grows, in many species a large mound is formed and eventually it reaches a size where they have sufficient resources to produce reproductive and repeat the cycle.

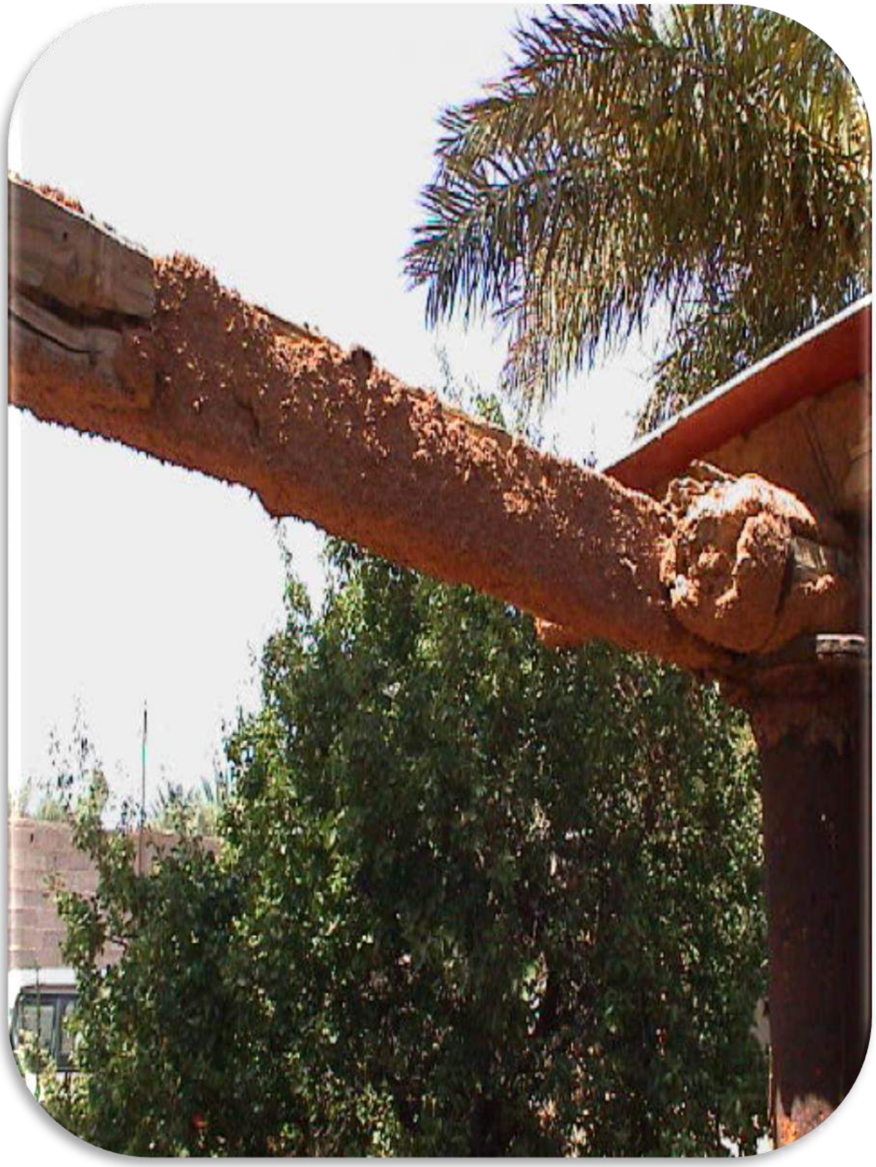
Economic Importance**:**

Termites are an important part of the community of decomposers. They are abundant in tropical and subtropical environments where they help break down and recycle up to one third of the annual production of dead wood. Termites become economic pests when their appetite for wood and wood products extends to human homes, building materials, forests, and other commercial products. In the United States alone, annual losses due to termite infestations are estimated at more than 800 million dollars.

Termite attacking dry wood (Damages)

Termite attacking books

Aljouf



Termite attacking Mango trunks

Order Neuroptera

- The Neuroptera

comprise a small but highly variable order of predominately predatory insects ,which display mixture of premative and specialized feature ,Neuroptera are occur in all parts of the world but many families show restricted distribution e.g Ithonidae are restricted to north America ,Polystoechotidae to north America and south America

General characters of Neuroptera

Adult

They are soft-bodied in generalized body Plan.

Mouth parts are adapted for chewing with large mandible and maxilla.

Compound eyes large widely separated.

Antenna usually filiform or moniliform

Thoracic segments semi-equal with free

mobile pro-thorax

They have two pairs of membranous wings ,which are similar in size and held

roof-like over abdomen at rest wing occur in several families

Cerci absent

Larva

All Neuropteran larvae are predatory With clearly defined head capsule

Mandible and maxillae are elongate, slender,modefied for sucking

Thoracic segments bearing walking

Legs with 1-segmented tarsus

Cerci absent

- Pupa

Excreta ,detaches ,enclosed in silken cocoon

- Family Chrysopidae

Body and wings usually green ,larva and adult are predatory , wing coupling occur by bristle like frenulum on the base of hind wings

e. g. *Chrysopa vulgaris*

Family Mermeleontidae

Antenna about as long as head and thorax gradually thickened

Legs of larvae adapted for digging

Larva construct conical pitfalls ,in dry soil, or sand and buried at the bottom with open jaws

E g : *Creoleon africanus*

- Family Mantispidae

In which fore legs are raptorial

Larva are specialized parasitoid on

Spider egg mass ,or immature stages of Vespidae wasps

Order: Hymenoptera

Ants, Wasps, Bees, Sawflies, Horntails

Scientific Classification

Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Insecta
Subclass:	Pterygota
Superorder:	Endopterygota
Order:	Hymenoptera

The name Hymenoptera is derived from the Greek words "*hymen*" meaning membrane and "*ptera*" meaning wings. It is also a reference to Hymeno, the Greek god of marriage. The name is appropriate not only for the membranous nature of the wings, but also for the manner in which they are "joined together as one" by the hamuli. The Hymenoptera with over 130 000 named species are a contender for the second largest order of insects in the world, the Beetles (Coleoptera) boast the greatest number of species.

Within the Hymenoptera are the Aculeates or stinging insects, these are all the Bees ants and wasps as well as a few smaller groups such as the Ruby Tailed Wasps and the Velvet Ants. Within the Aculeates are the 'social insects' an indistinct group comprising all the Ants (Formicoidae) and many of the Bees (Apoidea) and Wasps (Vespoidea) and (Sphecoidea) these are perhaps the most commonly seen insects after the True Flies (Diptera).

General Characters

Size

Most are of moderate size, but they range in size from miniscule (less than a millimeter) to 50 mm. Arnett gives a range of 0.2-115 mm, but typically 2-30 mm.

Identification

1- Two pairs of wings, with forewings usually larger than hindwings, but some groups (such as ants) wingless in most life stages, Wings have few cross-veins, these are angled to form closed cells

2- Antennae typically with 10 or more segments. Often 13 segments in male, 12 in female, but sometimes as few as 3 or up to 60 segments. Antennae longer than head, but usually not highly elongated (longer than head and thorax combined). Highly elongated in some parasitic groups.

3- Chewing mouthparts, but some groups have a "tongue" used for lapping up fluids, such as nectar

4- Females have prominent ovipositor, modified in some groups to be a "stinger", used to paralyze prey and in defense

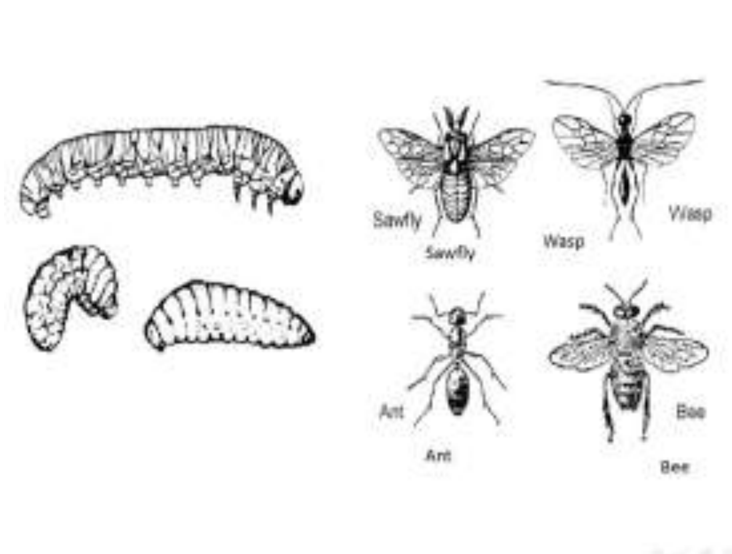
5- Complete metamorphosis

6- Several groups highly social (eusocial), with separate reproductive and worker castes.

The Hymenoptera is divided into two suborders:

- **Symphyta** (sawflies and horntails) have a broad junction between thorax and abdomen (have no discernible waist).
- **Apocrita** (ants, bees, and wasps) have a narrow junction between the thorax and abdomen (have a distinct waist).

Immatures	Adults
1. **Sawflies:** Eruciform (caterpillar-like); well developed head capsule; chewing mouthparts; fleshy abdominal prolegs	1. Chewing mouthparts - except in bees where maxillae and labium form a proboscis for collecting nectar.
2. **Bees and wasps:** Grub-like; well developed head; chewing mouthparts; legless and eyeless	2. Compound eyes well developed.
3. **Parasitic wasps:** Body form highly reduced; lacking head, eyes or appendages	3. Tarsi usually 5-segmented.
	4. Triangular stigma in front wings.
	5. Hind wings smaller than front wings, linked together by small hooks (hamuli).
	6. Narrow junction (wasp waist) between thorax and abdomen - except in sawflies and horntails.



Habitat

Hymenopterans are found in nearly all terrestrial habitats throughout Australia and may occur in soil, leaf litter and a range of vegetation types, especially flowers. Some species are often observed drinking at the edges of water or gathering mud that is used to construct nests, often in man-made environments.

Feeding

Hymenopterans feed on a wide range of foods depending on the species. Adult wasps mostly feed on nectar and honeydew and can often be seen at flowers. Some species are predators or parasites and spend their time searching out invertebrate hosts to lay their eggs on these hosts.

The feeding habits of adult ants vary and may range from specialist to generalist predators, scavengers and omnivores, to seedeaters, fungus feeders or honeydew feeders.

Life Cycle

Complete metamorphosis (holometabolus). Life cycle has egg, larva, pupa, and adult. Some larvae (such as sawflies) are caterpillar-like, most are grub-like, lacking legs. Males usually develop from unfertilized eggs in this order, a feature of their biology which likely contributed to the evolution of sociality independently in several groups.

In many groups, young are provisioned by the adults, however in many groups the larvae are parasitoids (predatory parasites) of other insects. Larvae of sawflies feed on plants, and these are believed to be a basal group, linking hymenoptera with related orders, such as Lepidoptera. Predatory, provisioning, and parasitoid life-styles are believed to have evolved in groups descended from plant-feeding (as larvae) hymenoptera.

Remarks

Ordinarily, Hymenoptera stings will only cause local pain and swelling. However, some individuals may be allergic to Hymenoptera stings. An allergic reaction to Hymenoptera stings occurs once the victim becomes sensitized to the venom from a previous sting. The allergic reaction is caused by the immune system, which has now been over sensitized to the venom and releases histamines into the blood stream.

Economic Importance

Although some species are regarded as pests (e.g., sawflies, gall wasps, and some ants), most members of the Hymenoptera are extremely beneficial, either as natural enemies of insect pests (parasitic wasps) or as pollinators of flowering plants (bees and wasps).

Classification of order Hymenoptera

1-suborder: Symyphyta

Junction between thorax and abdomen is broader

Family: Cephidae (Stem sawflies)

e. g: *Cephus tabidus*

Sawflies: Larvae feed on foliage or burrow into plant tissues.

2-Suborder:Apocrita

Junction between thorax and abdomen is waist

Family:Ichneumonidae

e. g: *Pimpla robarator*

parasitoids of other holometabolous insects (or spiders)
ovipositor is long , the color of the body and legs is red , while the head and antenna is black.

Family :**Vespidae** (potter wasps) -- prey on caterpillars
- Social Wasps: True social insects. Paper-like nests are tended by sterile female workers.

Vespidae -- yellowjackets, hornets, paper wasps
e. g: *Vespa orientalis*
e. g *: Euminus (Delta) maxillosa*
Family : Apidae
Subfamily: Apinae
e. g : *Apis mellifica (mellifera)*
Subfamily : Xylocopinae

e. g: *Xylocopa aestuans*

Family: Evanidae
e. g: *Evania appendigaster*
beneficial insects because parasite on egg sac of cockroaches .

Ants: True social insects.   Wingless

- **Family : Formicidae (** Ants)

e. g: *Cataglyphus bicolor*
e. g: *Componotus maculatus aegyptiacus*
many types of ants are danger home pests and agricultural field and feed on food plant materials


U F Ent Dep, James L Cas

Vespa orientalis

The Social Bees = Apidae.

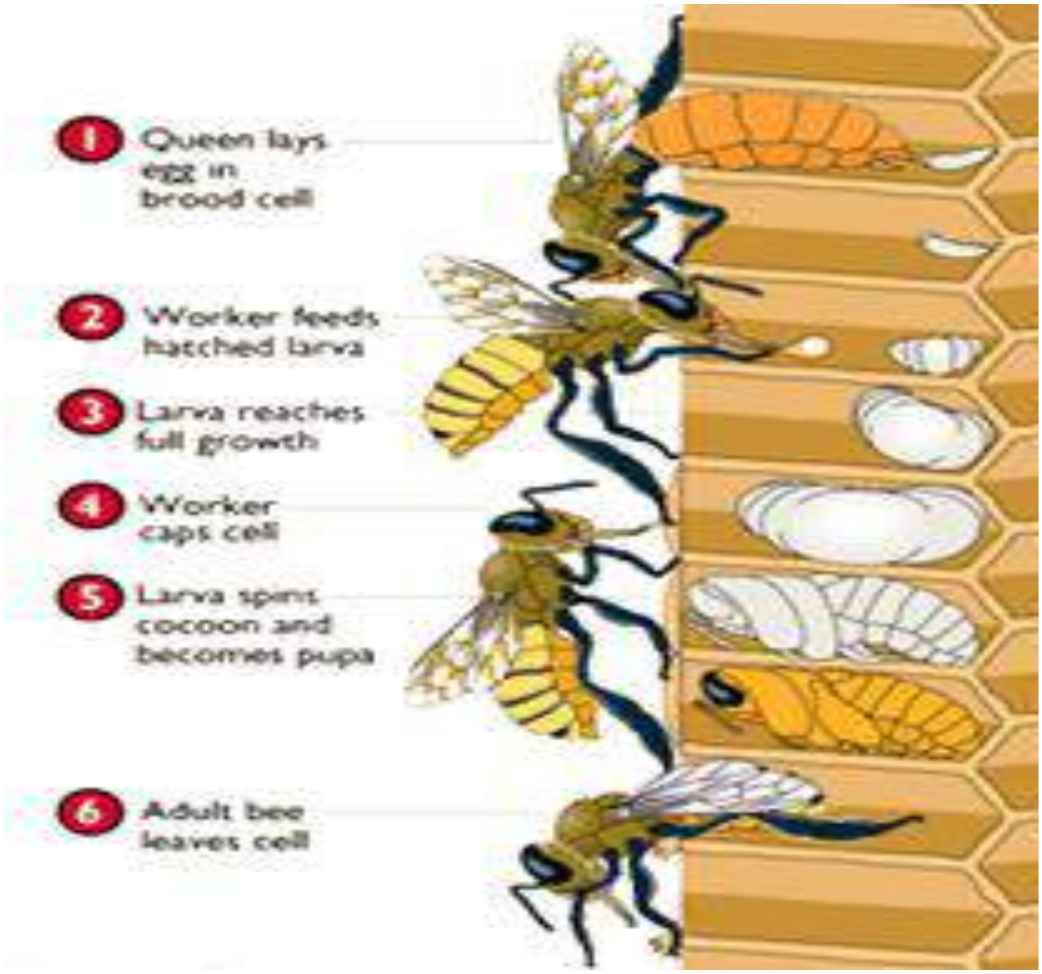
Not all the Apidae are social insects

Honey Bees have a long history of association with man. 9 000 years ago gathering wild honey was already such an important part of mankind's activities that he was painting scenes about it on the walls of his caves, a few thousand years later people in China and Egypt were keeping bees in hives made out of wicker baskets, nowadays thousands of pages of literature are devoted to Honey Bees and their culture every year. Recently a subspecies of *Apis mellifera, A.mellifera scutellata* has become infamous as Africanised Honey Bee. Honey Bees however are not the only social bees, both the Bumble Bees (Bombinae) and the mostly South American Stingless Bees (Meliponinae) are also social.

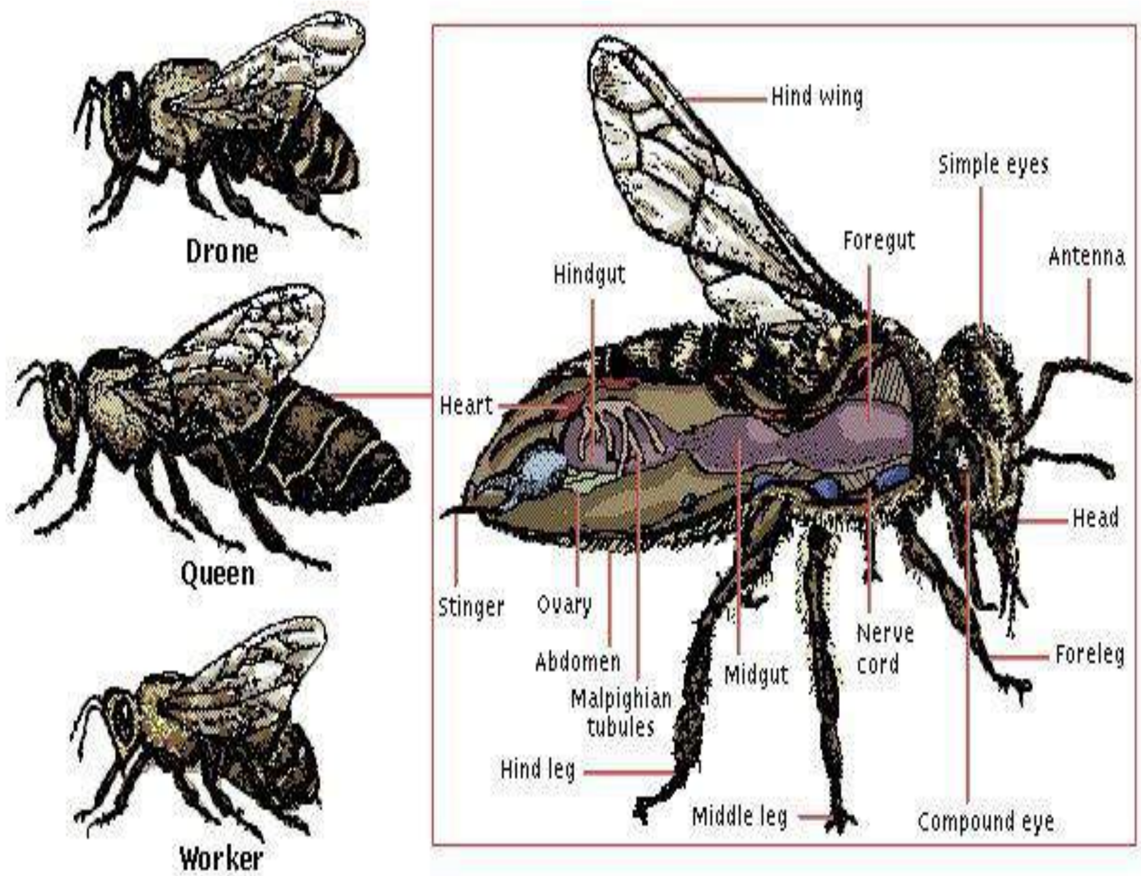
Bumble bee

The Honey Bee is a social insect. A small hive may contain 20,000 bees. These bees are divided into three castes: queen, drone, and worker. There is usually only one queen in the colony. She is the only fertile female in the hive, and her job is to lay eggs. The drone is a male bee. His only job is to mate with the queen. There can be up to 500 drones in the hive. The rest of the bees are workers. They are actually infertile females. The workers have lots of tasks to perform, such as feeding the queen, cleaning the hive, tending to the young and defending the hive from invaders. The worker is equipped with a stinger and a venom pouch (The ovipositor is modified into a stinger). When used, the stinger is ripped out of the workers body and left in the invaders. The worker bee soon dies from the rupture.

Honey Bees are not likely to sting unless they are provoked. If a hive gets overcrowded, it happens that the queen leaves the hive with some of her workers to start a new colony somewhere else. This is called “swarming”. The mother queen leaves a daughter queen behind, to take over the old colony.



Honey bee develop



Drone
Queen
Worker
Hind wing
Simple eyes
Foregut
Antenna
Hindgut
Heart
Head
Stinger
Ovary
Abdomen
Malpighian
tubules
Midgut
Nerve
cord
Foreleg
Hind leg
Middle leg
Compound eye

A naturally built queen cell for a honey bee queen

Honey bee queen

The drone of the honey bee

Bee pupae

The pupae of western honey bee drones. After passing through their larval stage within cells of the honeycomb, they continue there

until they develop into their adult form. Due to the protection this provides, the pupae do not need to be surrounded by a chrysalis or other shell, but instead have their legs and proboscis free.

Honey bee worker

Order: ***Diptera***

True Flies / Mosquitoes / Midges

The name Diptera, derived from the Greek words "di" meaning two and "ptera" meaning wings, refers to the fact that true flies have only a single pair of wings.

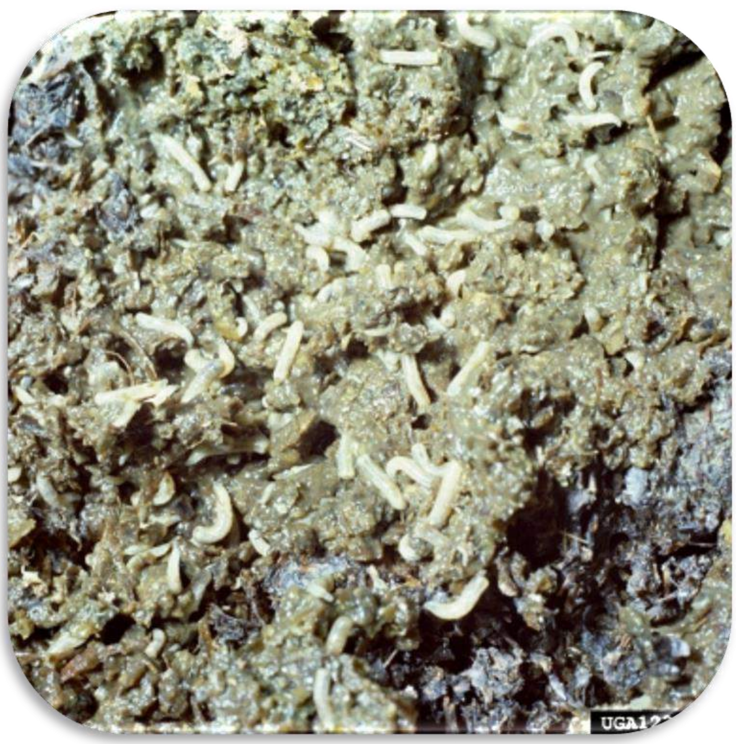
General characteristics

1. Flies are well adapted for aerial movement, and typically have short bodies.
2. Flies have a mobile head with a distinct neck and have large compound eyes on the sides of the head, with three small ocelli on the top, and antennae, either long or short.
3. Mouthparts of sucking type. Often adapted to absorb liquids, sometimes piercing.
4. Only 1 pair of wings (on mesothorax). Hind wings are reduced to halters used for balance during flight.
5. Complete metamorphosis.
6. Larvae are called maggots. Legless, wormlike larvae, often with a reduced head. Many larvae live in water. In plant feeding species the larvae often live within the plant tissues, leaf miners, stem or root borers.

Life History & Ecology:

The order Diptera includes all true flies. These insects are distinctive because their hind wings are reduced to small, club-shaped structures called halteres -- only the membranous front wings serve as aerodynamic surfaces. The halteres vibrate during flight and work much like a gyroscope to help the insect maintain balance.

All Dipteran larvae are legless. They live in aquatic (fresh water), semi-aquatic, or moist terrestrial environments. They are commonly found in the soil, in plant or animal tissues, and in carrion or dung. Some species are herbivores, but most feed on dead organic matter or parasitize other animals, especially vertebrates, molluscs, and other arthropods. In the more primitive families (suborder Nematocera), fly larvae have well-developed head capsules with mandibulate mouthparts. These structures are reduced or absent in the more advanced suborders (Brachycera and Cyclorrhapha) where the larvae have worm-like bodies and only a pair of mouth hooks for feeding.

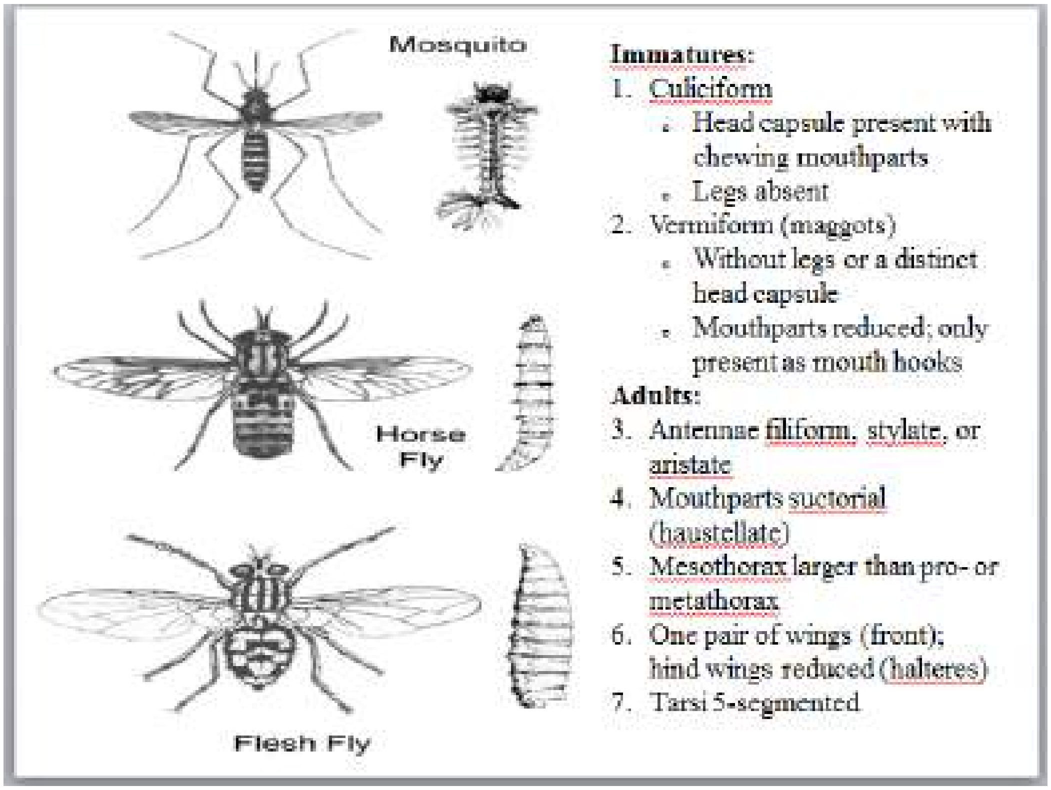


Larva(e) of house fly


UGA1316086

Fruit fly maggots found feeding on mango

Adult flies live in a wide range of habitats and display enormous variation in appearance and life style. In many families, the proboscis (rostrum) is adapted for sponging and/or lapping. These flies survive on honeydew, nectar, or the exudates of various plants and animals (dead or a live). In other families, the proboscis is adapted for cutting or piercing the tissues of a host. Some of these flies are predators of other arthropods (e.g., robber flies), but most of them are external parasites (e.g., mosquitoes and deer flies) that feed on the blood of their vertebrate hosts, including humans and most wild and domestic animals.



Classification

Holometabola

complete development (egg, larva, pupa, adult)

The Diptera have been divided into three suborders:

- Nematocera (flies with multisegmented antennae)
- Brachycera (flies with stylate antennae)
- Cyclorrhapha (flies with aristate antennae)

In some newer classifications, Brachycera includes the Cyclorrhapha.

There are two generally accepted suborders of Diptera. The Nematocera are usually recognized by their elongated bodies and feathery antennae as represented by mosquitoes and crane flies. The Brachycera tend to have a more roundly proportioned body and very short antennae.

1. Suborder Nematocera (77 families, 35 of them extinct) – long antennae, pronotum distinct from mesonotum. In Nematocera, larvae are either eucephalic or hemicephalic and often aquatic.

2. Suborder Brachycera (141 families, 8 of them extinct) – short antennae, the pupa is inside a puparium formed from the last larval skin. Brachycera are generally robust flies with larvae having reduced mouthparts.

Major Families

Biting flies: In most cases, only the adult females take blood meals.

1. **Culicidae** (mosquitoes) -- may spread malaria, yellow fever, filariasis, and other diseases.

2. **Tabanidae** (horse flies / deer flies) -- may spread trypanosomiasis, and other diseases.

3. **Simulidae** (black flies) -- may spread leucocytozoon infections of poultry.

4. **Psychodidae** (moth flies) -- may spread leishmaniasis, sand fly fever, and other diseases.

5. **Ceratopogonidae** -- small but vicious biters that have been linked to the spread of several roundworm, protozoan, and viral pathogens in humans and other animals.

6. **Muscidae** (House flies) -- these are among the most cosmopolitan of all insects. Some species have biting mouthparts, others are scavengers. Diseases such as dysentery, cholera, and yaws may be transmitted on their feet and mouthparts.

Herbivores: larvae feed on plant tissues.

1. **Cecidomyiidae** (gall midges) -- some induce the formation of plant galls; others are scavengers, predators, or parasites.

2. **Tephritidae** (fruit flies) -- many species are agricultural pests; such as the apple maggot,

3. **Agromyzidae** -- most larvae are leaf miners, some are stem and seed borers. Several species are agricultural pests.

4. **Anthomyiidae** -- many species are root or seed maggots.

Scavengers: larvae feed in dung, carrion, garbage, or other organic matter.

1. **Drosophilidae** (fruit flies) -- feed on decaying fruit.

2. **Tipulidae** (crane flies) -- larvae live in soil or mud.

3. **Calliphoridae** (blow flies) -- larvae feed on garbage and carrion; includes the screwworm.

4. **Sarcophagidae** (flesh flies) -- larvae typically feed on carrion. Some species may cause human myiasis.

Predators: adults and/or larvae attack other insects as prey.

1. **Asilidae** (robber flies) -- general predators of other insects.

2. **Bombyliidae** (bee flies) -- predatory larvae; adult bee mimics.

3. **Empididae** (dance flies) -- adults are predatory.

4. **Syrphidae** (flower flies) -- some larvae are aphid predators; most adults mimic bees or wasps.

Parasites: larvae are parasites or parasitoids of other animals.

1. **Tachinidae** -- parasitoids of other insects. Several species are important biocontrol agents.

2. **Sciomyzidae** (marsh flies) -- larvae parasitize slugs and snails.

3. **Oestridae** (boat flies / warble flies) -- larvae are endoparasites of mammals, including humans.

4. **Hippoboscidae** (louse flies) -- adults are blood-feeding ectoparasites of birds and mammals.

Muscoid fly

Hexapoda (including Insect) > Diptera > Muscidae

horse fly

Hexapoda (including Insecta) > Diptera > Tabanidae

Syrphid fly, *Eristalinus aeneus*

Hexapoda (including Insecta) > Diptera > Syrphidae

Syrphid fly, *Arctophila superbiens*

Hexapoda (including Insecta) > Diptera > Syrphidae

snipe fly

Rhagionidae , *Chrysopilus spp.*

mosquito

Culicidae , *Anopheles spp.*

Tabanid flies

Hexapoda (including Insecta) > Diptera > Tabanidae

guava fruit fly

Diptera > Tephritidae , *Bactrocera correcta*

Life Cycle

The female lays her eggs as close to the food source as possible, and development is generally rapid, allowing the larva to consume as much food as possible in a short period of time before transforming into the adult. In extreme cases, the eggs hatch immediately after being laid, while a few flies are ovoviviparous, with the larva hatching inside the mother.

The pupae take various forms, and in some cases develop inside a silk cocoon. After emerging from the pupa, the adult fly rarely lives more than a few weeks, and serves mainly to reproduce and to disperse in search of new food sources.

Life Stages of the stable fly, *Stomoxys calcitrans*

Life Stages of the house fly

Economic Importance

The Diptera probably have a greater economic impact on humans than any other group of insects. Some flies are pests of agricultural plants, others transmit diseases to humans and domestic animals. On the other hand, many flies are beneficial -- particularly those that pollinate flowering plants, assist in the decomposition of organic matter, or serve as biocontrol agents of insect pests.

Order :*Siphonaptera*

Fleas

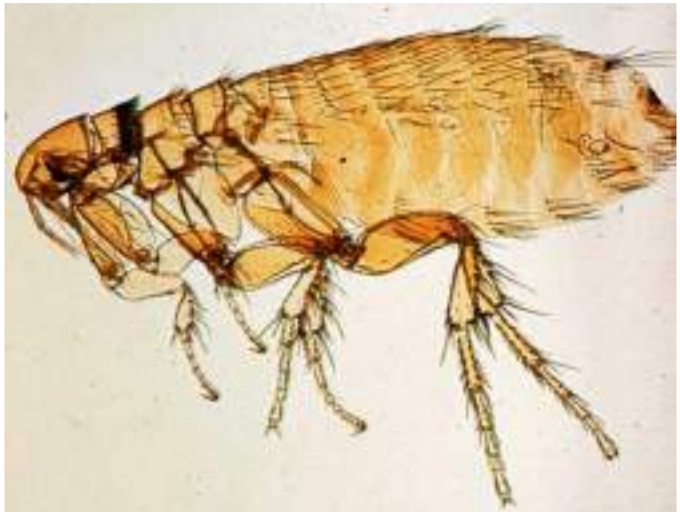
SIPHONAPTERA: from the Greek "siphon" (hollow tube) + "a" (without) + "pteron" (wing); fleas are wingless and have tube-like mouthparts for sucking blood.

General characteristics

1. Fleas are small, wingless insects ranging in size from approximately 1-10 millimetres in length depending on the species.

2. Laterally compressed bodies .
3. Piercing-sucking mouthparts .
4. Enlarged hind legs adapted for jumping .
5. Strong tarsal claws adapted for holding onto their hosts.
6. Small antennae which tuck away into special groves in the head .
7. row of large bristles often present on head and/or thorax (called genal and pronotal combs)

cat,dog flea



Oriental rat flea

Life History & Ecology:

all fleas are blood-sucking external parasites. Most species feed on mammals, although a few (less than 10%) live on birds. Only adult fleas inhabit the host's body and feed on its blood. They are active insects with a hard exoskeleton, strong hind legs adapted for jumping, and a laterally flattened body that can move easily within the host's fur or feathers. Unlike lice, most fleas spend a considerable amount of time away from their host. Adults may live for a year or more and can survive for weeks or months without a blood meal

Flea larvae are worm-like (vermiform) in shape with a sparse covering of bristles. They rarely live on the body of their host. Instead, they are usually found in its nest or bedding where they feed as scavengers on organic debris (including adult feces). After a larval period that includes two molts, fleas pupate within a thin silken cocoon. Under favorable conditions, the life cycle can be completed in less than a month.

Distribution:

Commonly associated with mammals
The greatest diversity occurs in temperate zones throughout the world.

	North America	Worldwide
Number of Families	٧	١٦
Number of Species	٣٢٥	٢,٣٨٠

Physical Features:

Immatures	Adults
Body vermiform (maggot-like), sparsely covered with hairs Head reduced, eyeless, mouthparts mandibulate	Body bilaterally flattened Mouthparts suctorial (haustellate) Large bristles (ctenidia) often present on head or thorax (genal and pronotal combs) Hind femur enlarged, adapted for jumping

Classification:

Holometabola
complete development)) egg, larva, pupa, adult

Major Families in the Order:

- Pulicidae – common fleas
- Ceratophyllidae – bird and rodent fleas
- Ischnopsyllidae – bat fleas

- Rhopalopsyllidae – marsupial fleas

Families and Genera of Interest:

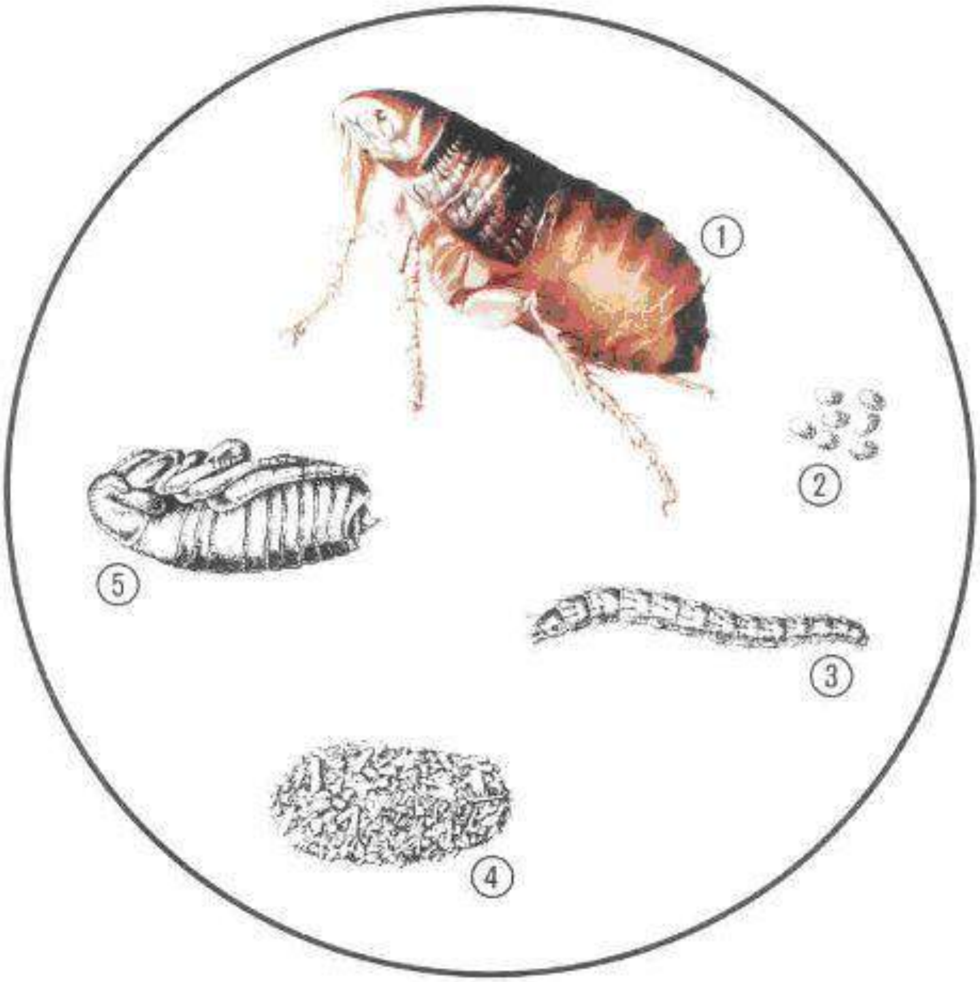
- Cat fleas, Ctenocephalides felis, are the most common fleas found on dogs (and cats, of course).
- Rodent fleas are best known as vectors of the Black Death, aka Bubonic Plague, which wiped out much of the world's population during the Middle Ages.
- Female sand fleas (Tunga penetrans) take up residence under people's toenails.

Common Name	**Scientific Name**

Cat Flea	***Ctenocephalides felis (Bouche)***
Dog Flea	***Ctenocephalides canis (Curtis)***
Northern Rat Flea	***Nosopsyllus fasciatus (Bosc)***
Oriental Rat Flea	***Xenopsylla cheopis (Rothschild)***
Rabbit Flea	***Cediopsylla simplex (Baker)***
Sand flea	***Tunga penetrans***
Human Flea	***Pulex irrttans***

Life Cycle

Fleas mate on their host animal and lay their eggs either onto the animal where they fall to the nest or directly in the nest. The small larvae hatch from the eggs and do not begin to feed on blood like that of their parents but consume the dead skin and dust from the host animal. The larvae develop through 3 instars and when fully grown spin a silken cocoon and pupate in the nest of the host. The vibrations of a host often trigger the emergence of the adult flea from the pupal case, enabling it to immediately find a host and begin feeding. The complete life cycle may take from several weeks to many months depending on the species.



Economic Importance

In addition to their irritating bites, fleas may also transmit pathogens that cause disease in humans and other animals. Cat and dog fleas, for example, are intermediate hosts for a tapeworm (Dipylidium caninum) that infects dogs, cats, and humans. Rabbit fleas spread a myxomatosis virus within rabbit populations, and the oriental rat flea is the primary vector of Yersinia (=Pasturella) pestis, the bacterial pathogen for bubonic plague.

Examples

human flea

cat,dog flea

Oriental rat flea

Northern rat flea

sand flea

flea larvae

Order : Lepidoptera

Butterflies, skippers, and moths

Lepidoptera means "scale wing", from Greek: lepis-"scale" + ptera - "wing“. refers to the flattened hairs (scales) that cover the body and wings of most adults.

General characteristics

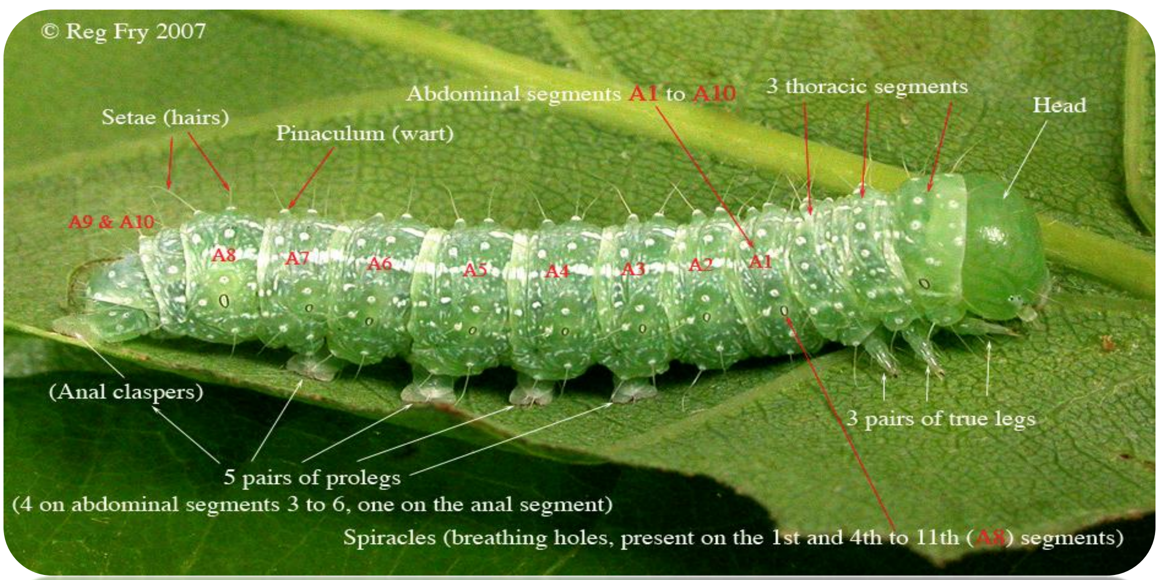
1. pairs of membranous wings that are covered in tiny scales . A few moths are wingless .
2. Large compound eyes .
3. One ocelli present above each eye .

4. Antennae present. Antennae are long and slender in female moths and generally feathery in male moths. Butterflies have clubbed antennae .

5. Mouthparts are formed into a sucking tube known as a haustellum .

Life History & Ecology

Lepidoptera (moths and butterflies) is the second largest order in the class Insecta. Nearly all lepidopteran larvae are called caterpillars. They have a well-developed head with chewing mouthparts. In addition to three pairs of legs on the thorax, they have two to eight pairs of fleshy abdominal prolegs that are structurally different from the thoracic legs. Most lepidopteran larvae are herbivores; some species eat foliage, some burrow into stems or roots, and some are leaf-miners.



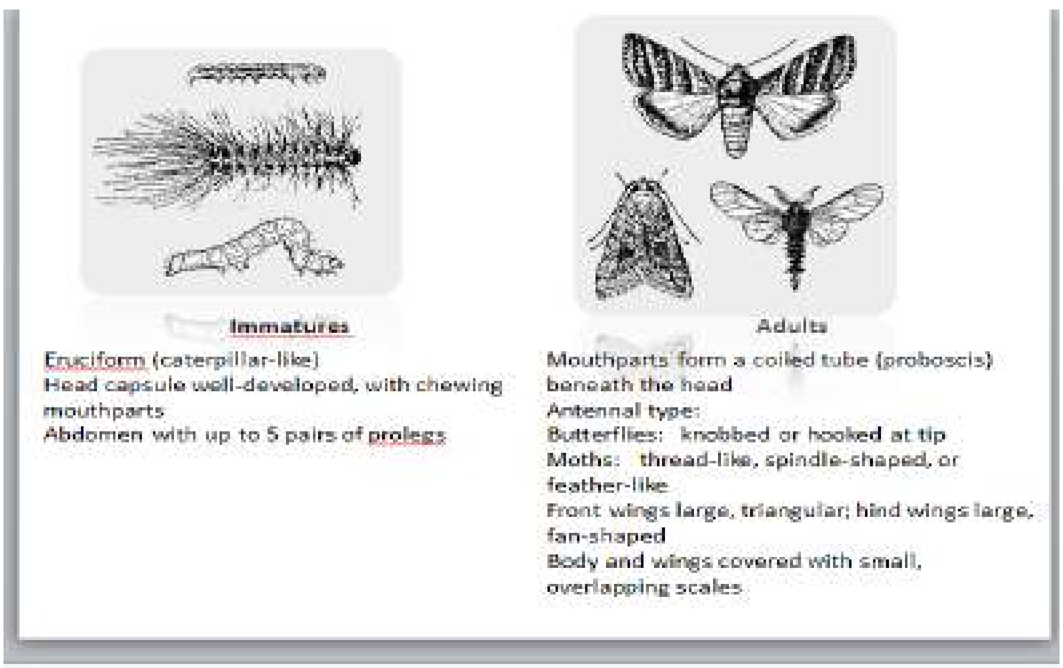
Adults are distinctive for their large wings (relative to body size) which are covered with minute overlapping scales. Lepidopteran wing scales often produce distinctive color patterns that play an important role in courtship and intraspecific recognition.

In all other lepidopteran families, the mouthparts are vestigal or form a tubular proboscis that lies coiled like a watch spring beneath the head.   This proboscis is derived from portions of the maxillae.   It uncoils by hydrostatic pressure and acts as a siphon tube for sipping liquid nutrients, such as nectar, from flowers and other substrates.

Acronicta oblinita (smeared dagger moth)

A Painted Arachnis (Arachnis picta), showing scales and hair

From a taxonomic standpoint, the distinction between moths and butterflies is largely artificial -- some moths are more similar to butterflies than to other moths. As a rule, butterflies are diurnal, brightly colored, and have knobs or hooks at the tip of the antennae. At rest, the wings are held vertically over the body. In contrast, most (but not all) moths are nocturnal. They are typically drab in appearance, and have thread-like, spindle-like, or comb-like antennae. At rest, their wings are held horizontally against the substrate, folded flat over the back, or curled around the body.



Classification

Holometabola

complete development (egg, larva, pupa ,adult)

Butterflies:

1- Superfamily Papillionoidea

Nymphalidae (brushfooted butterflies) -- front legs reduced in size. This is the largest butterfly family; it includes the fritillaries, admirals, emperors, and tortoiseshells.

Danaidae (milkweed butterflies) -- adults are reddish-orange with black and white markings. Larvae feed on various species of milkweed. Includes the monarch (*Danaus plexippus*).

Monarch

Pieridae (whites and sulfurs) -- adults are predominantly white or yellow with black markings. The imported cabbageworm (*Pieris rapae*) is a pest throughout the world.

Western White

Dog Face

Papillionidae (swallowtails) -- hind wings have a tail-like extension. The tiger swallowtail (*Papilio glaucus*) is a cosmopolitan species.

Lycaenidae (blues, coppers, and hairstreaks) -- small butterflies with fluted hind wings. Some species are extinct or nearing extinction, others are very common.

American Copper

Spring Azure

2- Superfamily Hesperoidea (skippers)

Hesperiidae (skippers) -- antennal club is hooked at the tip. The silverspotted skipper, *Epargyreus clarus*, is a common species.


Hobomok Skipper


White Striped Longtail

Moths:

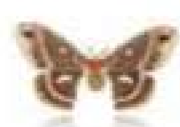
1- Superfamily Bombycoidea

Lasiocampidae (lappet moths) -- larvae feed on the leaves of trees and some spin large webs or tents on the foliage. Pests include the eastern tent caterpillar (*Malacosoma americana*) and the forest tent caterpillar (*M. disstria*).


Small Tolype

Saturniidae (giant silk moths) --- large, colorful moths. Larvae feed on a wide range of trees and shrubs. Well-known species include the cecropia moth (*Hyalophora cecropia*) and the luna moth (*Actias luna*).


Luna Moth


Cecropia Moth

2- Superfamily Noctuoidea

Arctiidae (tiger moths) -- distinctive adults, usually white with black, red, yellow, or orange markings. Many larvae are covered with long hairs (woollybears). Includes the fall webworm (*Hyphantria cunea*).


Scarlet Bodied Wasp Moth


Giant Leopard Moth


Great Tiger Moth


Faithful Beauty


Isabella Moth

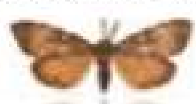
Noctuidae (loopers, owlet moths, and underwings) -- this is the largest family in the Lepidoptera. Larvae are leaf feeders and stem borers. Many species are pests, including the fall armyworm (*Spodoptera frugiperda*), the black cutworm (*Agrotis ipsilon*), and the cabbage looper (*Trichoplusia ni*).


lia Underwing


The Herald


White Underwing

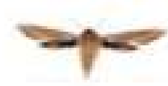
Lymantriidae (tussock moths) -- larvae are characterized by tufts of hair along the body. Adults do not feed. Pests include the gypsy moth (*Lymantria dispar*) and the browntail moth (*Euproctis chrysorrhoea*).


Gypsy Moth

3- Superfamily Sphingoidea

Sphingidae (hawk moths) -- medium to large adults with long proboscis for collecting nectar. Larvae are frequently called hornworms. Pests include the tobacco hornworm (*Manduca sexta*) and tomato hornworm (*M. quinquemaculata*).


Rustic Sphinx


Tersa Sphinx

4- Superfamily Pyraloidea

Pyralidae (snout moths) -- second largest family of Lepidoptera. Pests include the European corn borer (*Ostrinia nubilalis*), the Indianmeal moth (*Plodia interpunctella*), and the greater wax moth (*Galleria mellonella*).


Grape Leaffolder Moth

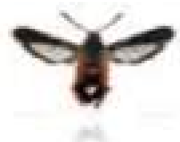
5- Superfamily Geometridea

Geometridae -- third largest family of Lepidoptera. Larvae are often called inchworms or spanworms. Includes the winter moth (*Operophtera brumata*) and the fall cankerworm (*Alsophila pometaria*).

Kent's Geometer

6- Superfamily Sesioidea

Sesiidae (clearwing moths) -- diurnally active adults mimic wasps. Many pests of fruit and vegetable crops, including the peachtree borer (*Synanthedon exitiosa*) and squash vine borer (*Melittia cucurbitae*).

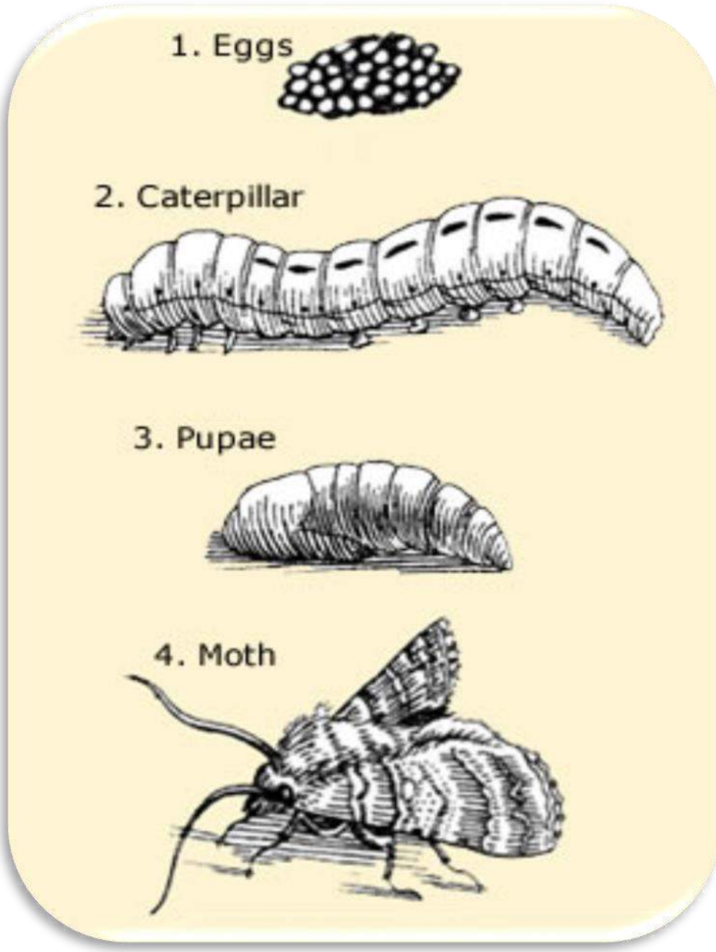


Hornet Clearwing

Life Cycle

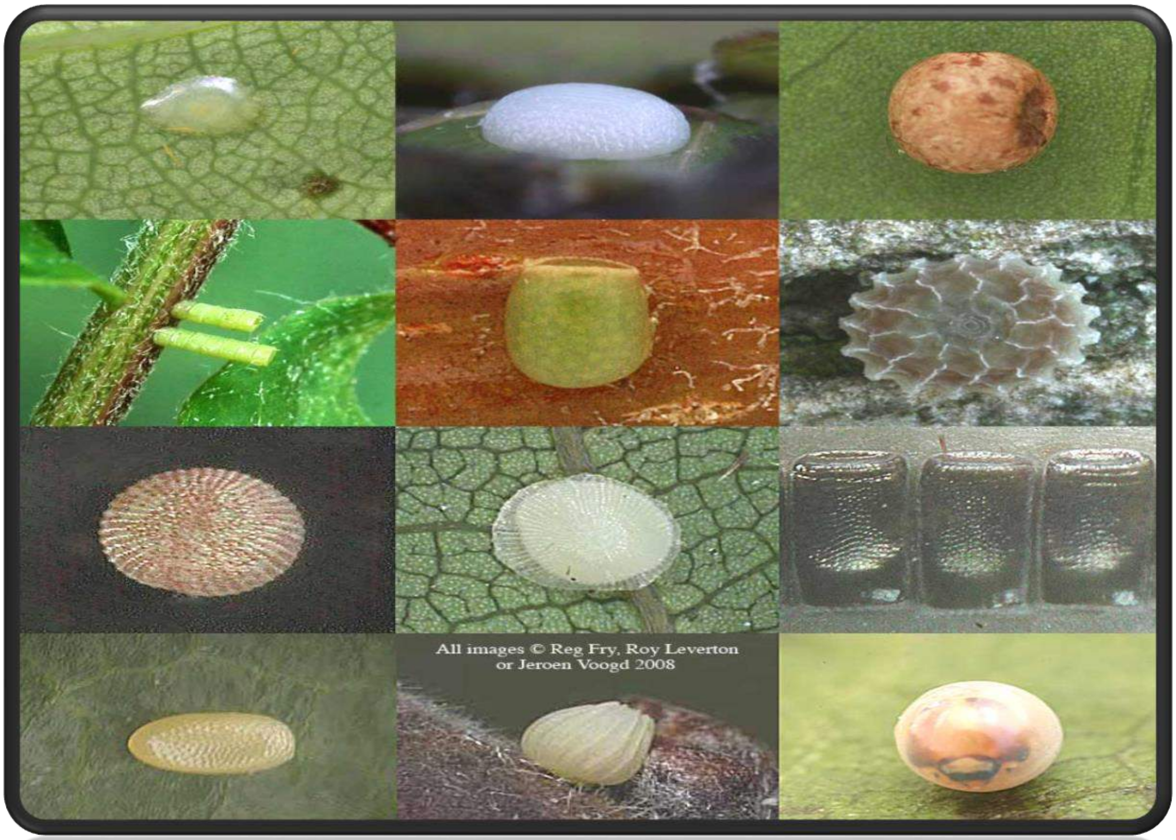
Moths and butterflies undergo a complete life cycle that includes four stages: egg, caterpillar (larvae), pupae and adult. The eggs are usually laid on or close to the caterpillar's food plant either singularly or in groups. A female may lay only a few eggs or tens of thousands depending on the species, but several hundred is reasonably typical. After hatching caterpillars usually develop through 4 to 7 instars over a period of a few weeks up to a few months depending on the species, before pupating .

When ready to pupate caterpillars generally find a sheltered site to spin their cocoons. Some may pupate attached to vegetation, others in the soil or leaf litter or inside the wood they have been tunneling in. Many moths and butterflies have one or two generations each year while others may breed continuously. Other species such as the large wood-boring Cossidae may take up to five years to develop.



Examples of the eggs of twelve butterfly species are shown below

Examples of the eggs of twelve moth species are shown below



Examples of caterpillar (larvae)


Least Black Arches © Reg Fry 2006

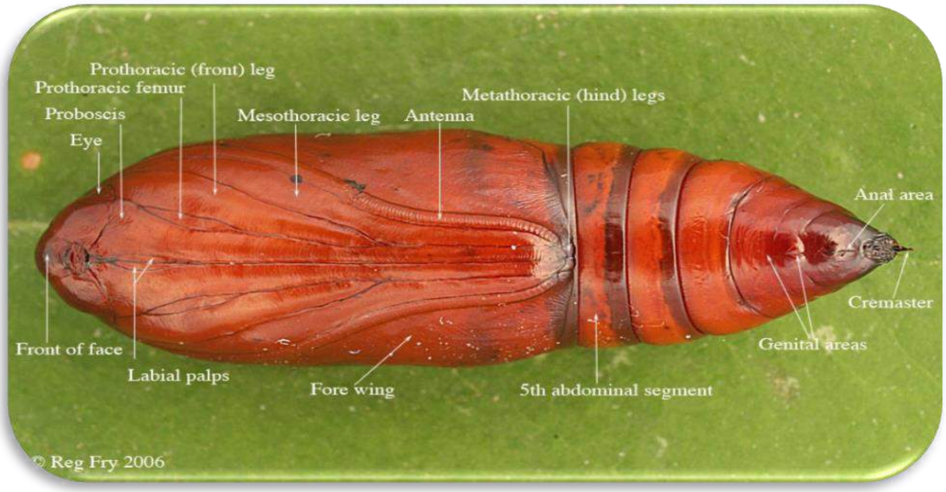

Pale Brindled Beauty © Reg Fry 2006
Orange Underwing © Jeroen Voogd 2006
March Moth © Jeroen Voogd 2006
Light Emerald © Mark Boddington 2006
Scalloped Hazel © Reg Fry


© Mark Boddington 2007


Tiny hooks

Tiger Swallowtail

THE CHRYSALIS OR PUPA AND EXAMPLES OF COCOONS


Prothoracic (front) leg
Prothoracic femur
Proboscis
Eye
Mesothoracic leg
Antenna
Metathoracic (hind) legs
Anal area
Cremaster
Genital areas
Front of face
Labial palps
Fore wing
5th abdominal segment
© Reg Fry 2006

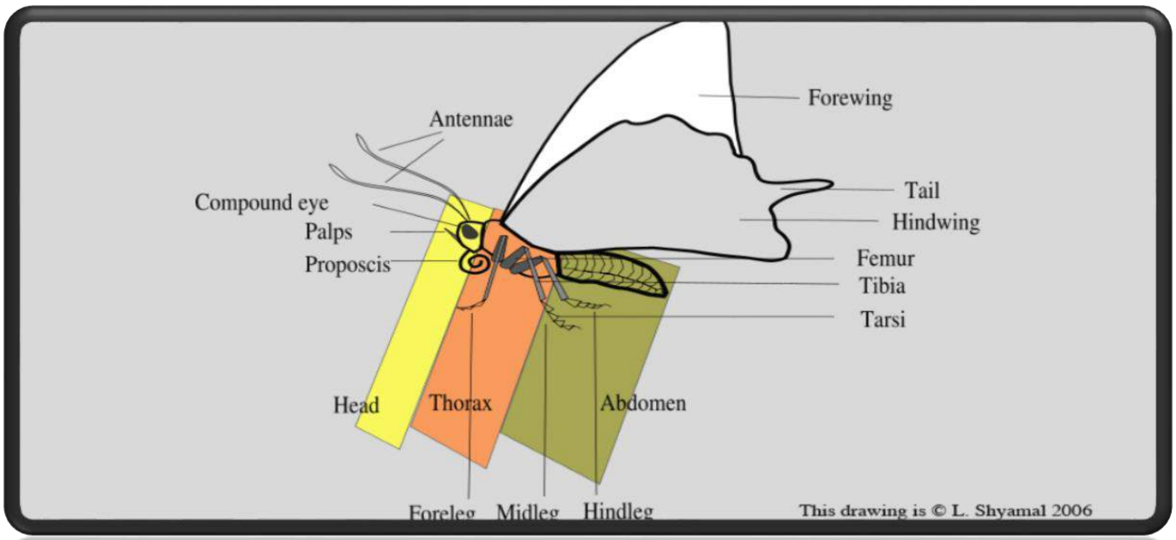

© Reg Fry 2007

Spice Bush Swallowtail


Vertical escape hatch


Fibres making a trap-door
Neck of the cocoon
© Reg Fry

THE ADULT BUTTERFLY OR MOTH



sylvia Parthenos ,The Clipper
(Limenitidinae :Nymphalidae :Papilionoidea)

Junonia villida calybe

(meadow argus butterfly)

California Sister (Adelpha bredowii)

Luna Moth (Actias luna)

Asterocampa celtis

Actias luna; Luna Moth

Economic Importance

Although many Lepidoptera are valued for their beauty, and a few are useful in commerce (e.g., the silkworm, Bombyx mori), the larvae of these insects are probably more destructive to agricultural crops and forest trees than any other group of insects.

Order Coleoptera

- Beetles are insects with the largest number of known species, constituting about 25% of all known life forms, about 40% of all described insects are beetles
- The name Coleoptera are derived from Greek words (coleo=sheath ,and pteron =wings)

Coleoptera habitats

- Beetles can be found in all habitats , but are not known to occur in polar regions , or in the sea they interact with their ecosystem in several ways, they feed mainly on plants or fungi break down animals and plant debris , and eat other invertebrates ,certain species are well known as agricultural pest such boll weevil.

- And red flour beetles , while other species are important controls of agriculture pest like beetles of family Coccinellidae") ladybirds "or "ladybugs ("consume aphids ,scale insects ,thrips ,and other plant-sucking insects that damage crops.

Feeding

-

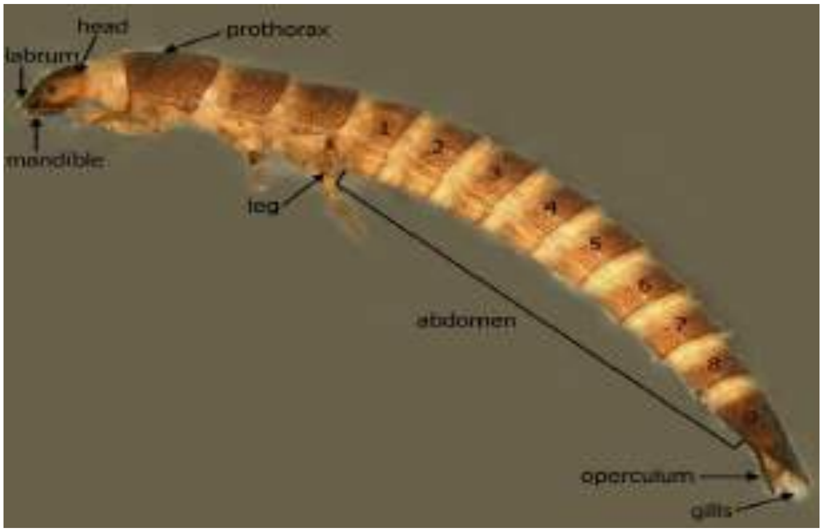
herbivores ,scavengers or predators ,Beetles are generally although some adult beetles do not feed at all. The greatest numbers are plant feeders in one form or another, such as nectar feeders (some Buprestidae), foliage eaters (Chrysomelidae), seed-eaters (many Curculionidae) or timber (Cerambycidae) or bark borers (Scolytidae). Others may feed on rotting wood (Lucanidae), carrion (Silphidae), dung (some Scarabaeidae), fungi or leaf litter. Some species are also predators (Carabidae) of other invertebrates. The feeding habits between larvae and adults may be the same or can vary. For example some beetle species are predatory when in the larval stage and plant-feeders when adults.

Life cycle

Beetles have a complete life cycle and development may take anywhere from a few weeks to several years. Eggs are usually laid on or near the food source such as in the soil or on a host plant, depending on the species. The number of eggs laid will depend on the species and may range from one or two up to hundreds. After hatching the larvae develop through a series of growth stages known as instars (usually 3 to 5) before pupating into adults.

Scarbidae form larva

Weir form larva .family(staphylinidae)



Family Cicindelidae

- The **tiger beetles** are a large group of beetles known for their aggressive predatory habits and running speed. The fastest species of tiger beetle can run at a speed of 9 km/h (5.6 mph), which, relative to its body length,

Family :**Cicindelidae**

Cicindela ***melancholica***

Family Carabidae

- common habitats are under the bark of trees, under logs, or among rocks or sand by the edge of ponds rivers. Most species are carnivorous and actively hunt for any invertebrate prey they can overpower. Some will run swiftly to catch their prey ;tiger beetles) Cicindelinae) can sustain speeds of 8 km/h (5 mph) – in relation to their body length they are among the very fastest land animals on Earth. Unlike most Carabidae which are nocturnal ,the tiger beetles are active diurnal hunters and often brightly coloured; they have large eyes and hunt by sight.

- Calosoma Ground Beetle
- *Calosoma semilaeve*

Family dytiscidae

- Its beetle adapted to living in water, it rise to water surface to take atmospheric air into their tracheal system , many water beetles take carry an air bubble between their abdomens and wings , and prevents water from getting into spiracles ,they have fringed ,hairy hind legs adapted for swimming

Cybister tripunctatus

Family elateridae

- Click beetles can be large and colorful (e.g. *Agrypnus notodonta*), but most are small to medium-sized (<2 cm) and dull. The adults are typically nocturnal and phytophagous, but rarely of economic importance. In hot weather, they may enter people's houses at night if entries or windows are left opened but are not a pest. Click beetle larvae, called **wireworms**, are usually saprophagous, but some species are serious

agricultural pests, and other species are predators of other insect larvae.

Family Curculionidae

- They are usually smaller than 6mm and herbivorous, many weevil damaging to crops. The grain weevil damaging the stored grains. boll weevil attacks cotton crops it lays their eggs in the cotton bolls , and the larvae eat their way out

Family Scarabidae

- The beetle of this family are medium to large size occasionally with bright colors . They have distinctive lamellate antennae. Witch open like small fan. and they can close it as compact club . Beetles of other families may have similar antennae but they can not fore legs adapted for digging . And most of them are active flyers

Scarabaeus sacer

Family Cocccinellidae

The member of this family has bright colors With black head, legs ,and antennae , with black spots on their wings' a few species considered as pests ,but majority are useful insects ,as they feed on aphid , or scale insects ,

- Most of this family over winter as adults
- Aggregation on the south sides of larg objects such as trees ,houses .
- Dispersin in responding to the increasing in day length in the spring

Family Staphylinidae

- Rove beetles are a large family of Coleoptera primarily distinguished by their short elytra ,that leave more than half of their abdomens exposed.
- Staphylinidae regarded as second largest
- family of Coleoptera after Curculionidae

- الحشرة الرواغةRover Beetle

(Paederus alfierii)

- Rove beetles are known from every type of habitat that beetles occur , and their diets include just about everything except the living tissues of higher plants .Most rove beetles are predators of insects and other kinds of invertebrates, living in forest leaf litter and similar kinds of decaying plant matter. They are also commonly found under stones, and around freshwater margins

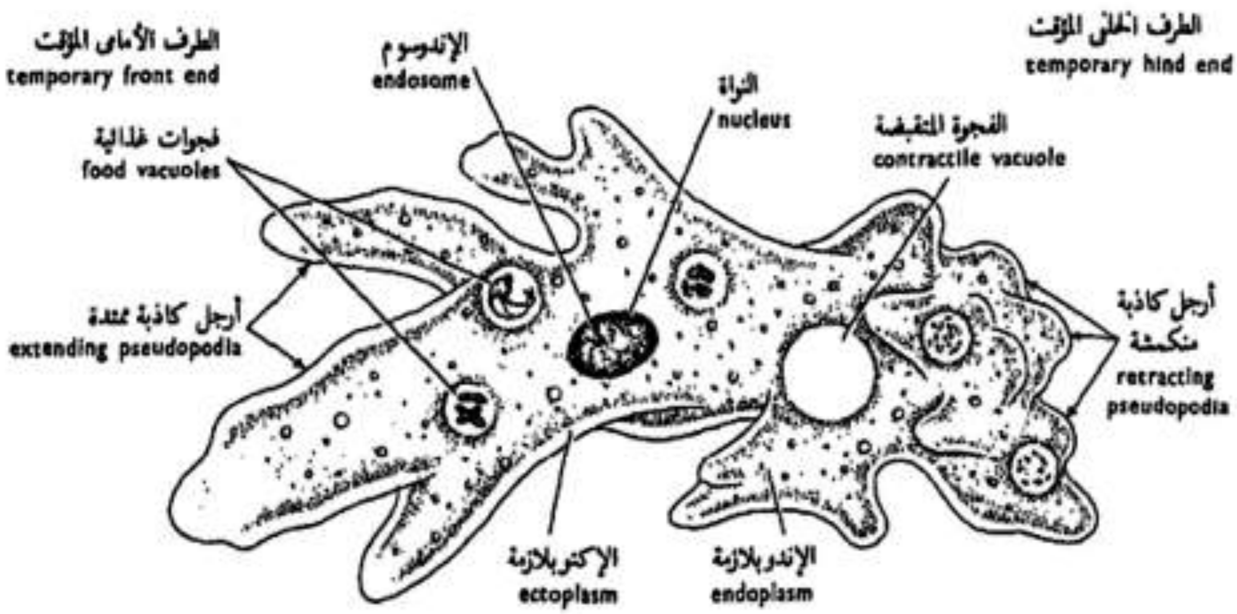
توزيع الدروس العملية

م	اليوم	التاريخ	موضوع المحاضرة
1			مقدمة للمقرر العملى- طريقة العمل فى المعمل- طرق تقييم العملى مملكة الطلائعيات- تحت مملكة الاوليات دراسة عملية - الاميبا- - يوجلينا- تريبانوسوما- براميسيوم
2			الالياف الاسفنجية من اسفنج الحمام – الهيدرا – الالسينيوم
3			الفاشيولا – (القوقع- الريديا –- السركاريا – ق. ع. فى الفاشيولا.
4			التنيا- (الشـــكل العام- الرأس – ق. ع. فى قطعة ناضـــجة للتنيا – القطعة الناضجة –القطعة المثقلة.
5			الاسكارس (الذكر+ الأنثى+ ق. ع. فى ذكر الأسكاارس + ق. ع. فى انثى الأسكارس- الأنكلستوما (ذكر وانثى)
6			دودة الأرض+ العلق الطبى+ ق. ع. فى دودة الأرض+ ق. ع. فى العلق الطبى.
7			امتحان عملى.
8			
9			الجمبرى+ الدافنيا + الأرتيميا.
10			السيكلوبس + البالانس + الميسس الجمارس + ام 44 + العقرب
11			

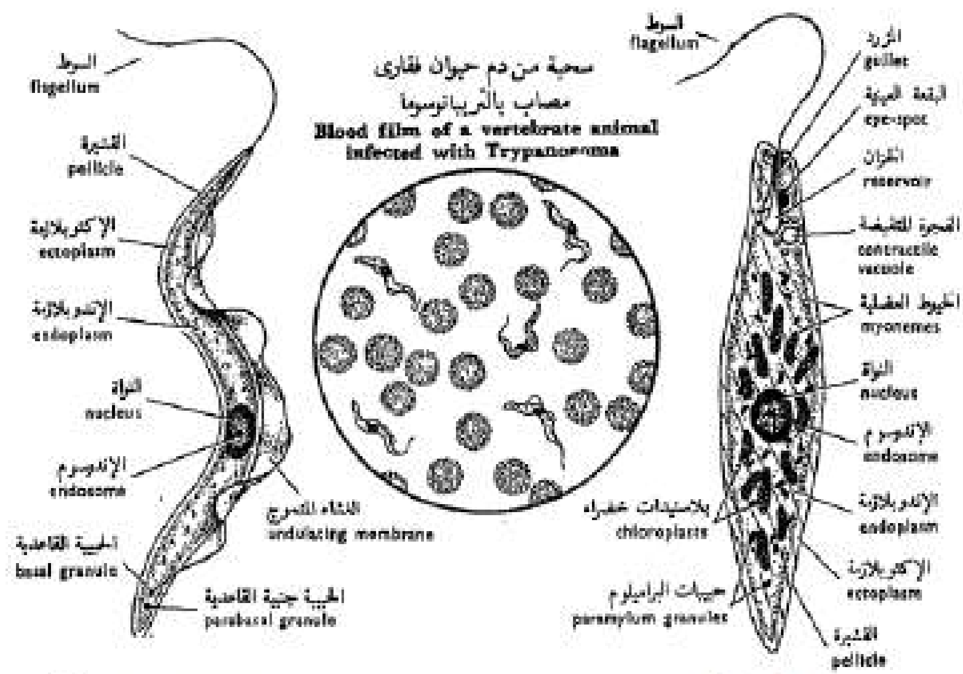
12			الكيتون + السيبيا + الأخطبوط
13			نجم البحر + خيار البحر
14			قنفذ البحر
			مراجعة عامة و مناقشة حول المقرر

7

Kingdom: Protista	**مملكة الطلائعيات**
Subkingdom: Protozoa	**تحت مملكة الاوليات**
Phylum: Sarcomastigophora **Subphylum:- Sarcodina** Eg.: *Amoeba proteus*	**شعبة اللحم سوطيات** **تحت شعبة اللحميات** مثال:- اميبا

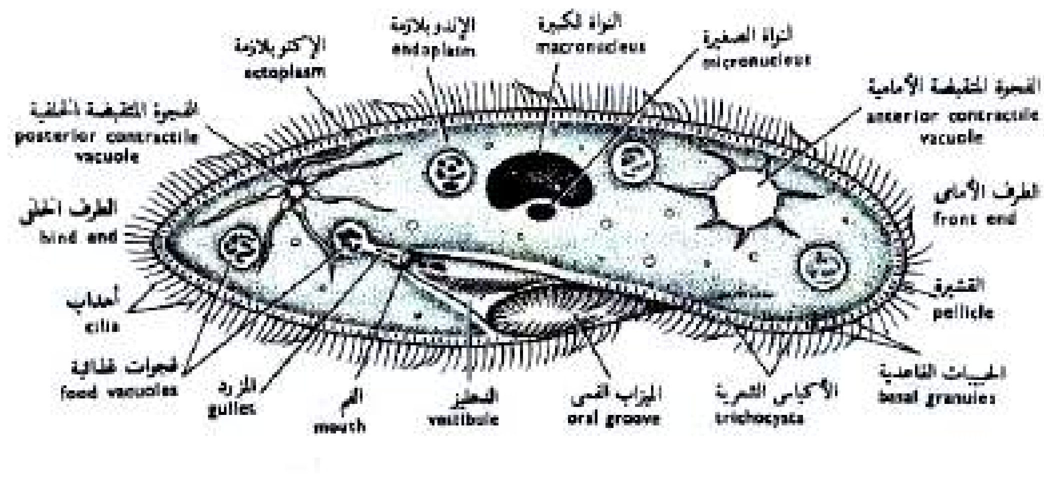

الطرف الأمامى المؤقت
temporary front end
الإندوسوم
endosome
النواة
nucleus
الطرف الخلفى المؤقت
temporary hind end
فجوات غذائية
food vacuoles
الفجوة المنقبضة
contractile vacuole
أرجل كاذبة ممتدة
extending pseudopodia
أرجل كاذبة منكمشة
retracting pseudopodia
الإكتوبلازمة
ectoplasm
الإندوبلازمة
endoplasm

Kingdom: Protista	**مملكة الطلائعيات**
Subkingdom: Protozoa	**تحت مملكة الاوليات**
Phylum: Sarcomastigophora **Subphylum:- Mastigophora** **Eg.: *Trypansoma* sp.** **Eg.: *Euglena* sp.**	**شعبة اللحم سوطيات** **تحت شعبة السوطيات** **مثال:- تريبانوسوما** **مثال:- يوجلينا**

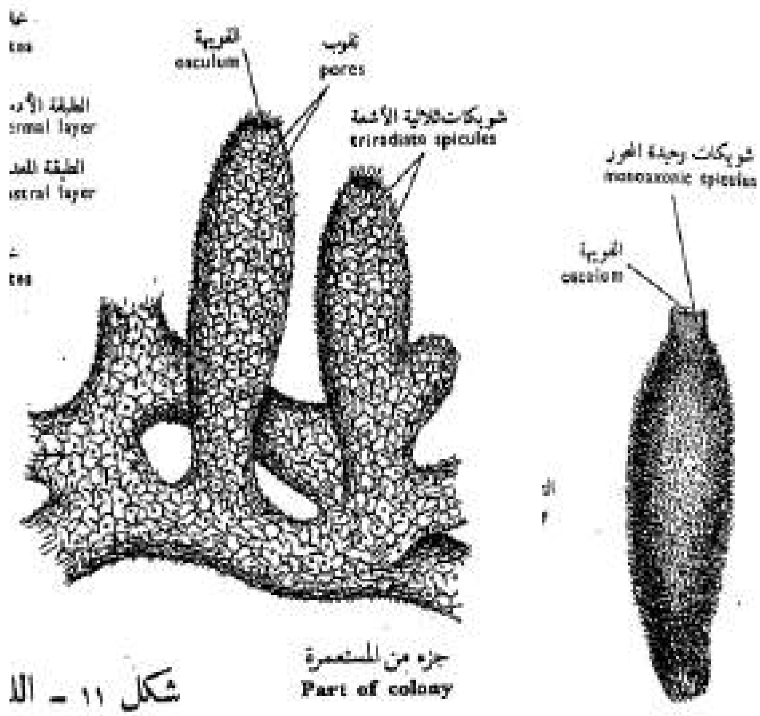


Trypanosoma *Euglena*

Kingdom: Protista	**مملكة الطلائعيات**
Subkingdom: Protozoa	**تحت مملكة الاوليات**
Phylum: Ciliophora Eg.: *Paramecium* sp.	**شعبة الهدبيات** مثال:- براميسيوم

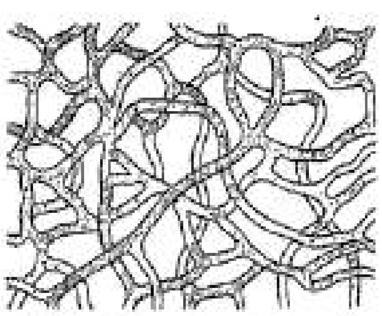

الإكتوبلازمة
ectoplasm
الإندوبلازمة
endoplasm
النواة الكبيرة
macronucleus
النواة الصغيرة
micronucleus
الفجوة المتقبضة الخلفية
posterior contractile vacuole
الفجوة المتقبضة الأمامية
anterior contractile vacuole
الطرف الخلفي
hind end
الطرف الأمامي
front end
أهداب
cilia
القشيرة
pellicle
فجوات غذائية
food vacuoles
gullet
الفم
mouth
الدهليز
vestibule
الميزاب الفمي
oral groove
الأكياس الشعرية
trichocysts
الحبيبات القاعدية
basal granules

Kingdom Animalia	**مملكه الحيوانات**
Subkingdom Metazoa	**تحت مملكة البعديات**
Phylum: Porifera (sponges) Eg.:- *Leucosolenia*	**شعبه المساميات (الاسفنجيات)** مثال:- اسفنج الاسكون



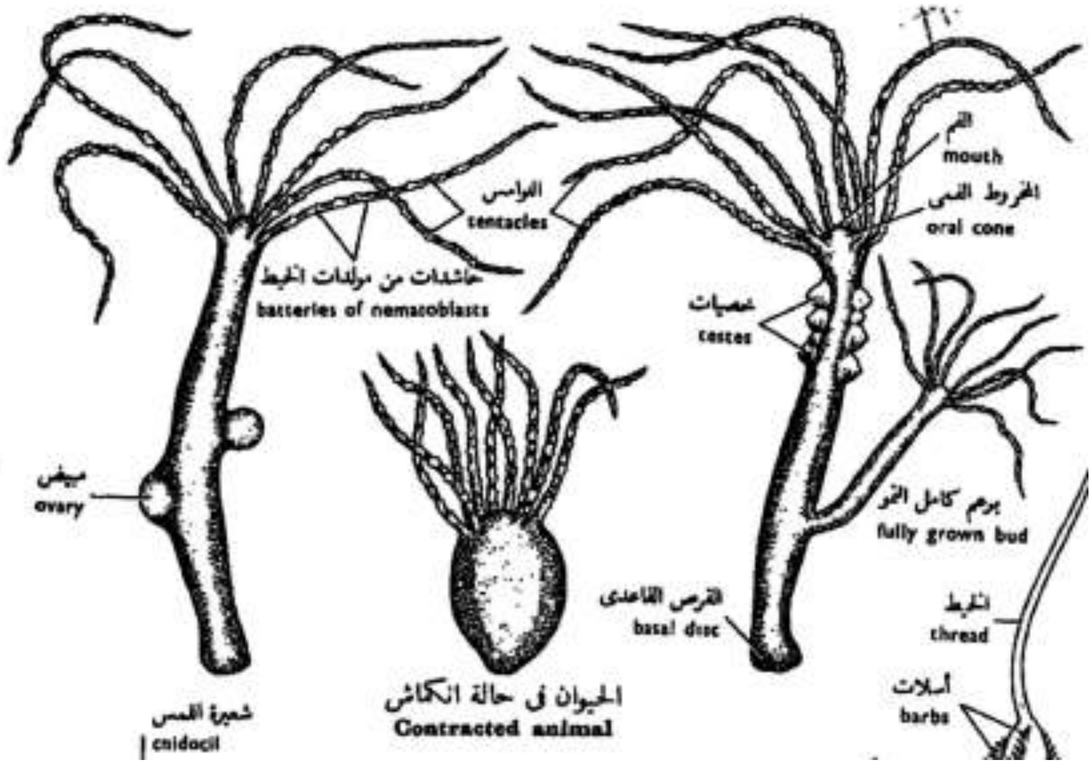
جزء من المستعمرة
Part of colony

شكل ١١ ـ اللا

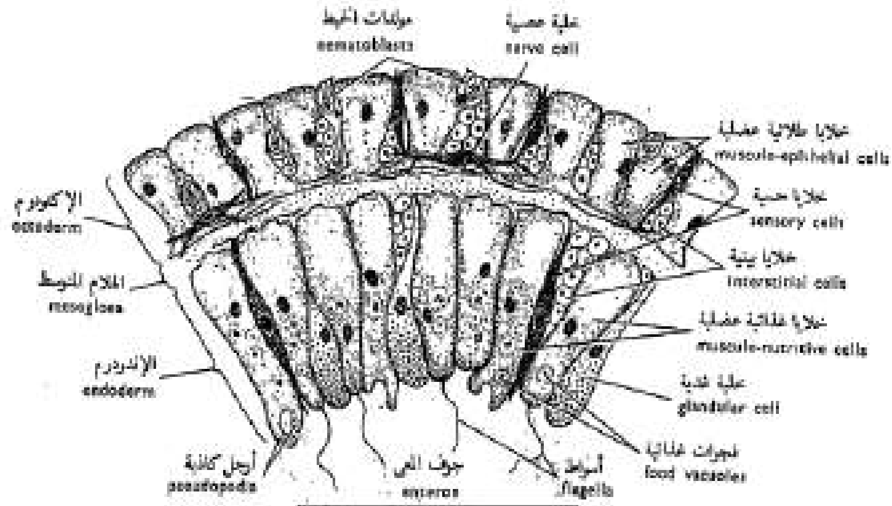


الألياف الإسفنجية من إسفنج الحمام
Spongin fibres from bath sponge

Kingdom: Animalia	**مملكة الحيوانات**
Subkingdom: Eumetazoa	**تحت مملكة البعديات الحقيقية**
Phylum: Coelenterata **Class: Hydrozoa** Eg.:- *Hydra* sp.	**شعبة الجوفمعويات** **طائفة الحيوانات الهدرية** مثال:- هيدرا

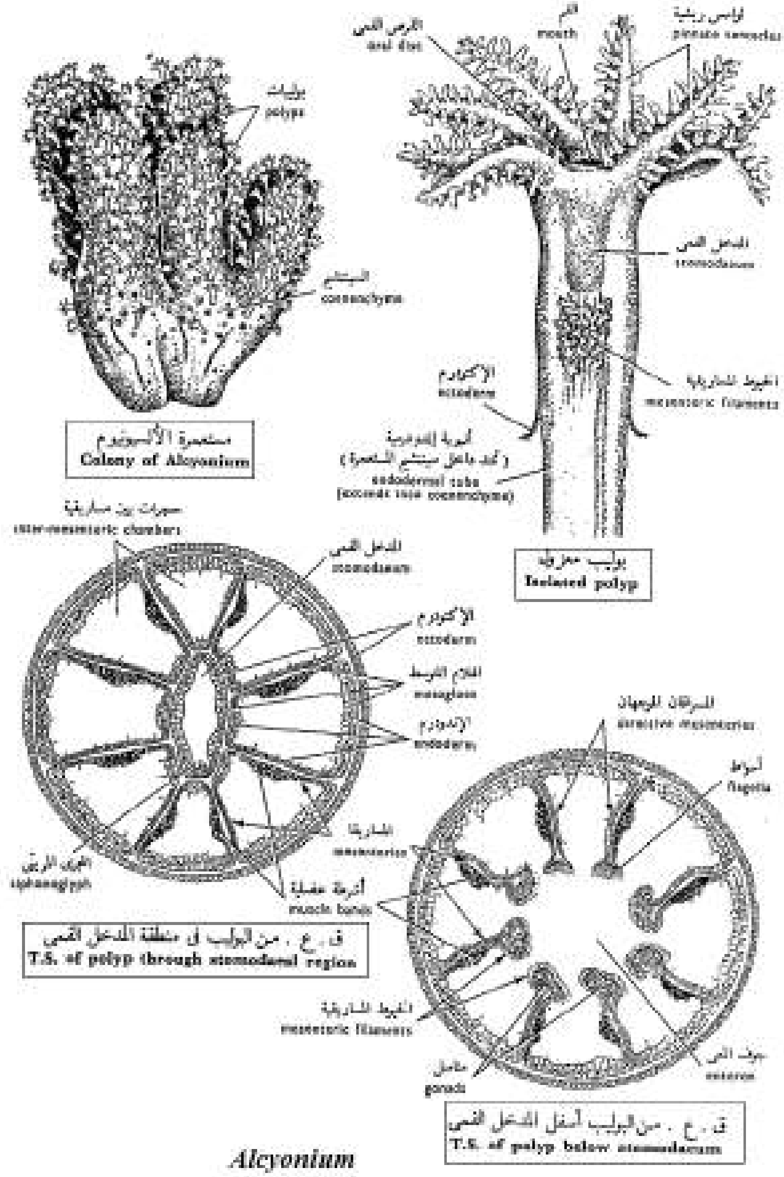


الفم
mouth
المخروط الفمى
oral cone
اللوامس
tentacles
حاشدات من مولدات الخيط
batteries of nematoblasts
خصيات
testes
مبيض
ovary
برعم كامل النمو
fully grown bud
القرص القاعدى
basal disc
الخيط
thread
أسلات
barbs
شعيرة اللمس
cnidocil
الحيوان فى حالة انكماش
Contracted animal



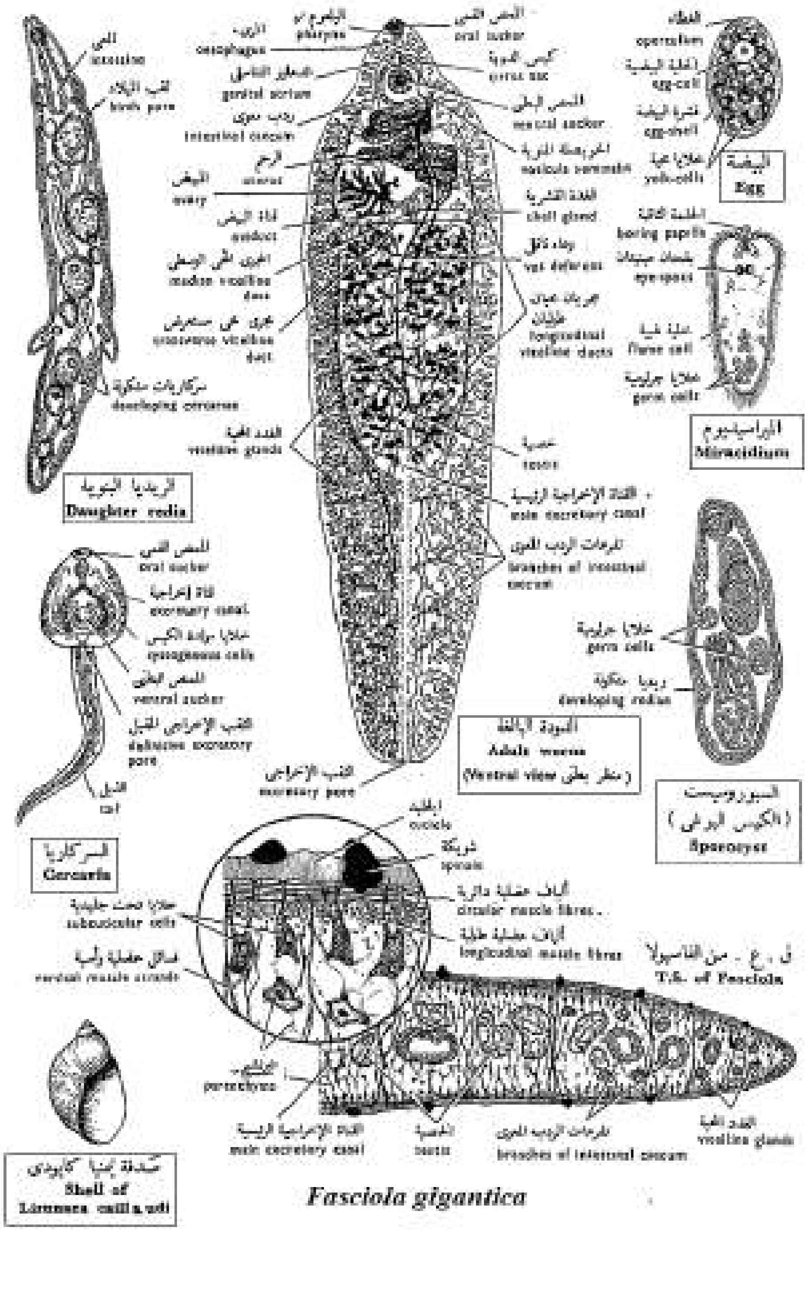
جزء من قطاع عرضي من الهيدرا
Part of T.S. of Hydra

Kingdom: Animalia	**مملكة الحيوانات**
Subkingdom: Eumetazoa	**تحت مملكة البعديات الحقيقية**
Phylum: Coelenterata **Class: Actinozoa** Eg.:- *Alcynium* sp.	**شعبة الجوفمعويات** **طائفة الشعاعيات** مثال:- السيونيوم


polyps
coenenchyma
مستعمرة الألسيونيوم
Colony of Alcyonium
oral disc
mouth
pinnate tentacles
stomodaeum
ectoderm
mesenteric filaments
endodermal tube
(extends into coenenchyma)
بوليب معزول
Isolated polyp
inter-mesenteric chambers
stomodaeum
ectoderm
mesogloea
endoderm
siphonoglyph
mesenteries
muscle bands
ق . ع . من البوليب في منطقة المدخل الفمي
T.S. of polyp through stomodaeal region
directive mesenteries
flagella
mesenteric filaments
gonads
enteron
ق . ع . من البوليب أسفل المدخل الفمي
T.S. of polyp below stomodaeum

Alcyonium

Kingdom: Animalia	**مملكة الحيوانات**
Subkingdom: Eumetazoa	**تحت مملكة البعديات الحقيقية**
Phylum Platyhelminthes **Class Trematoda** Eg.:- *Fasciola gigantica*	**شعبة المفلطحات** **طائفة الديدان الورقية** مثال:- الدودة الكبدية (فاشيولا)



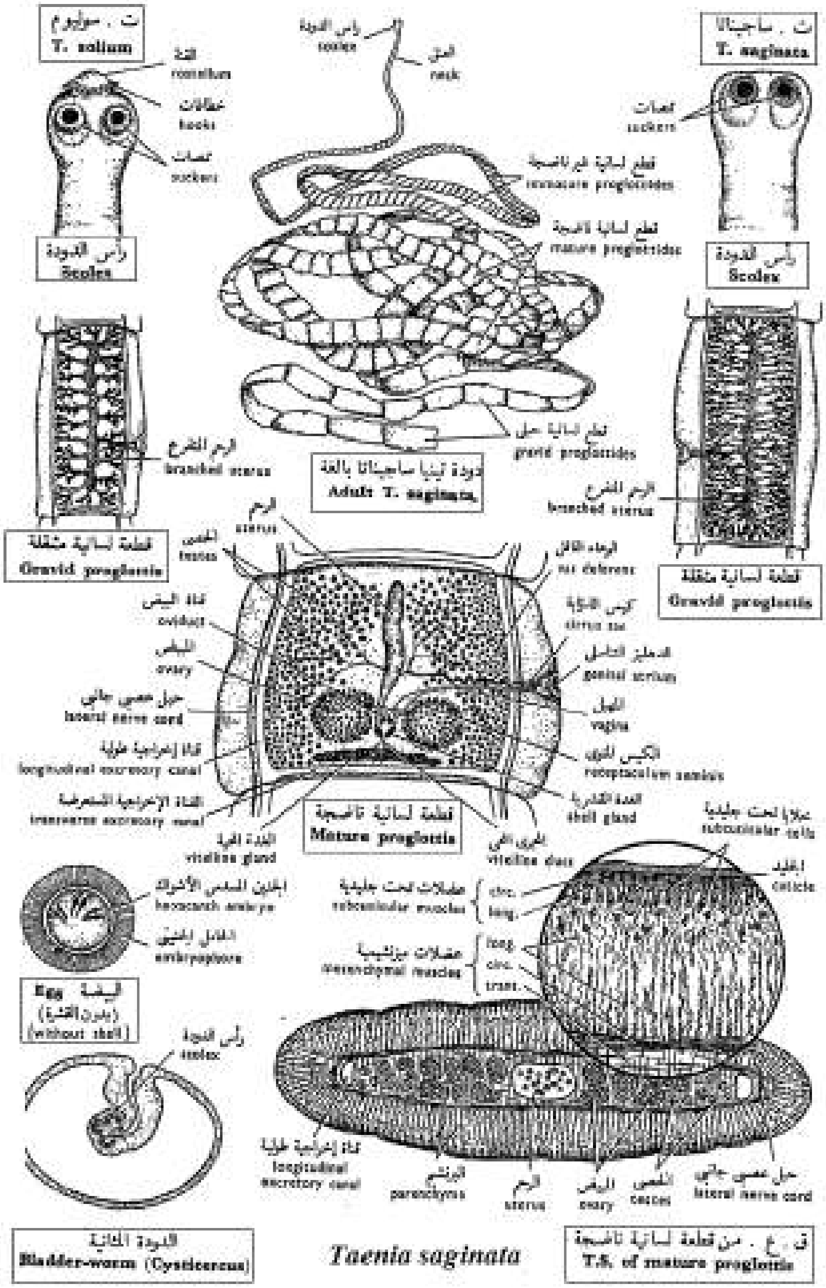
Fasciola gigantica

Phylum : Platyhelminthes **المفلطحات**

Class : Cestoda **الديدان الشريطية**

e. g. :*Taenia saginata* ***دودة البقر الشريطية***

e. g. : Taenia solium ***دودة الخنزير الشريطية***

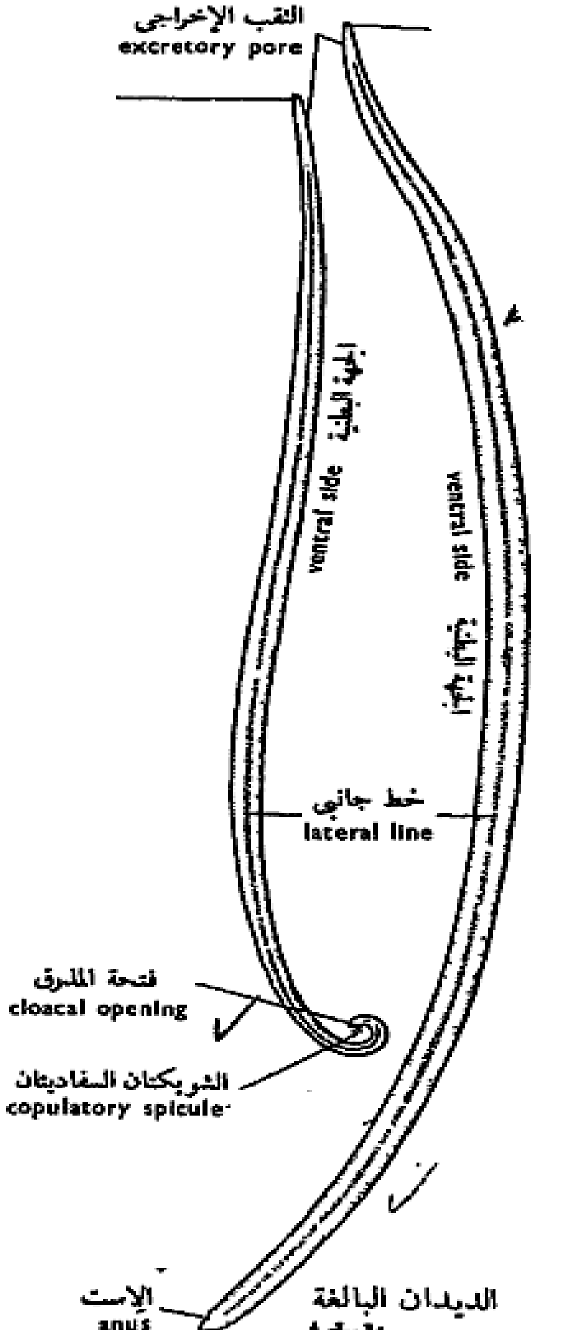


Taenia saginata

Phylum: Aschelminthes الديدان الأسطوانية (المجوفة)

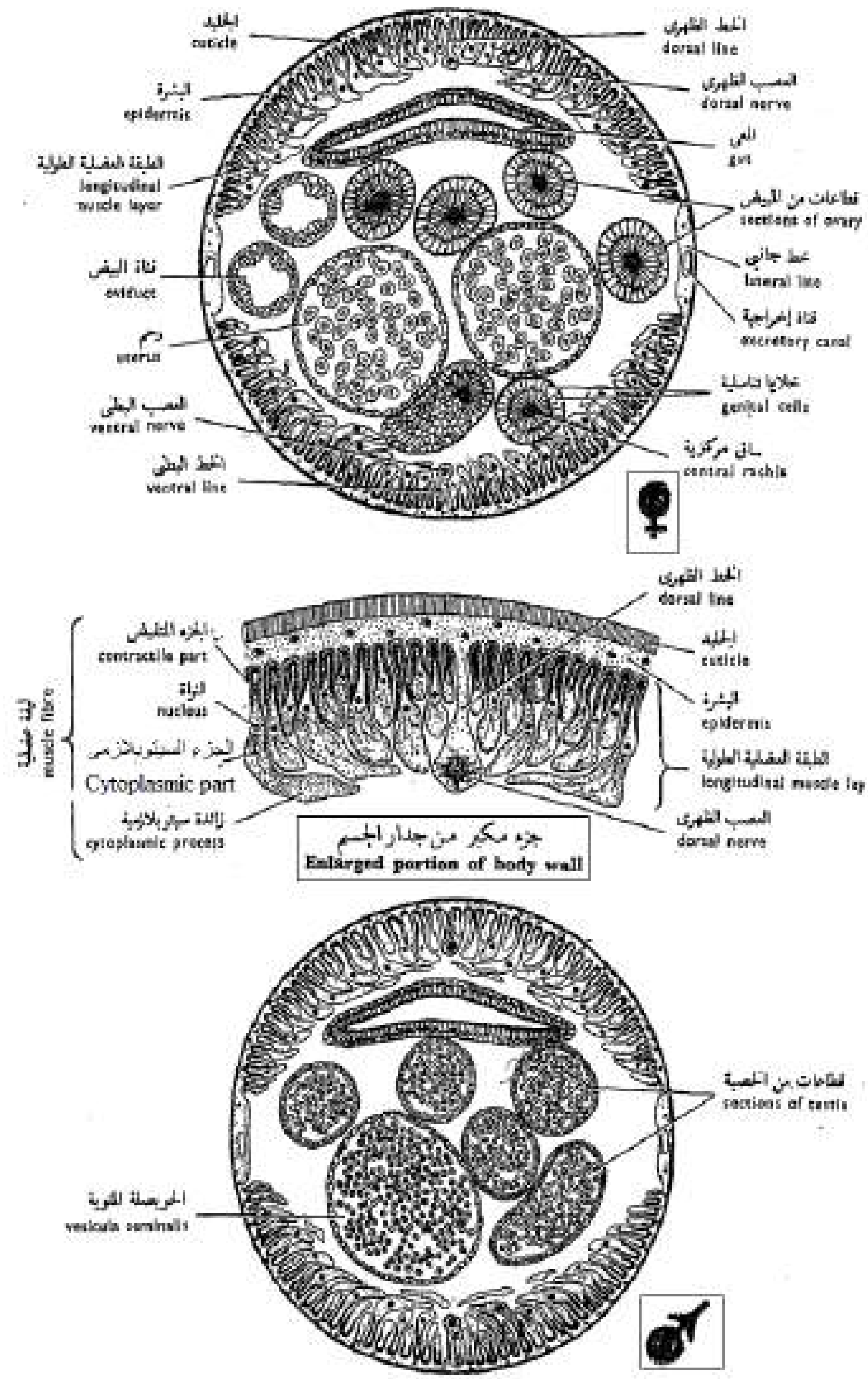
Order : Ascaridata

e.g. : ***Ascaris vitulorum*** **دودة الاسكارس**



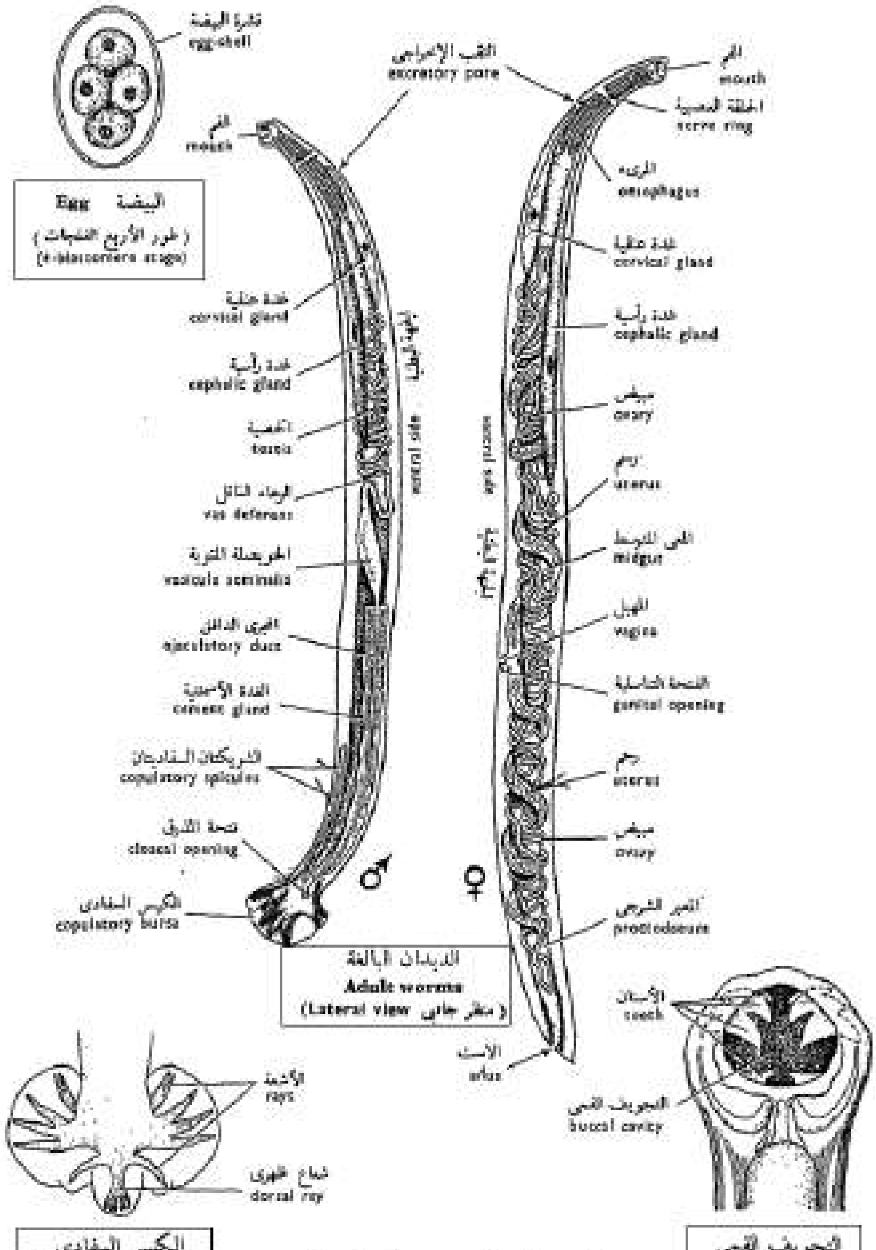
الديدان البالغة
Adult worms
(Lateral view منظر جانبي)

T. S. of *Ascaris vitulorum*



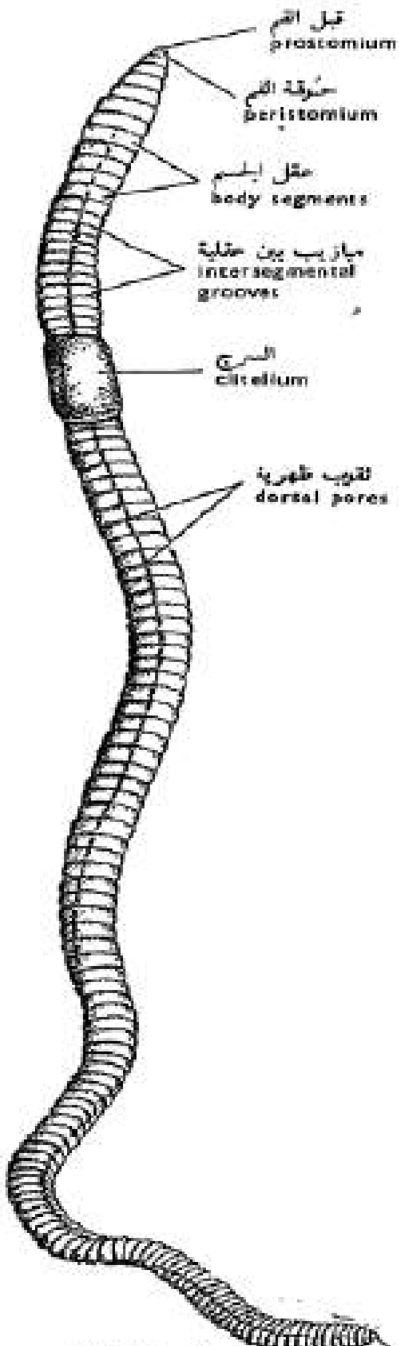
T.S. of female and male *Ascaris vitulorum*

Kingdom: Animalia	**مملكة الحيوانات**
Subkingdom: Eumetazoa	**تحت مملكة البعديات الحقيقية**
Phylum Aschelminthes Eg.:- *Ancylostoma duodenale*	**شعبة الديدان المجوفة** مثال:- انكيلستوما ديودونالى



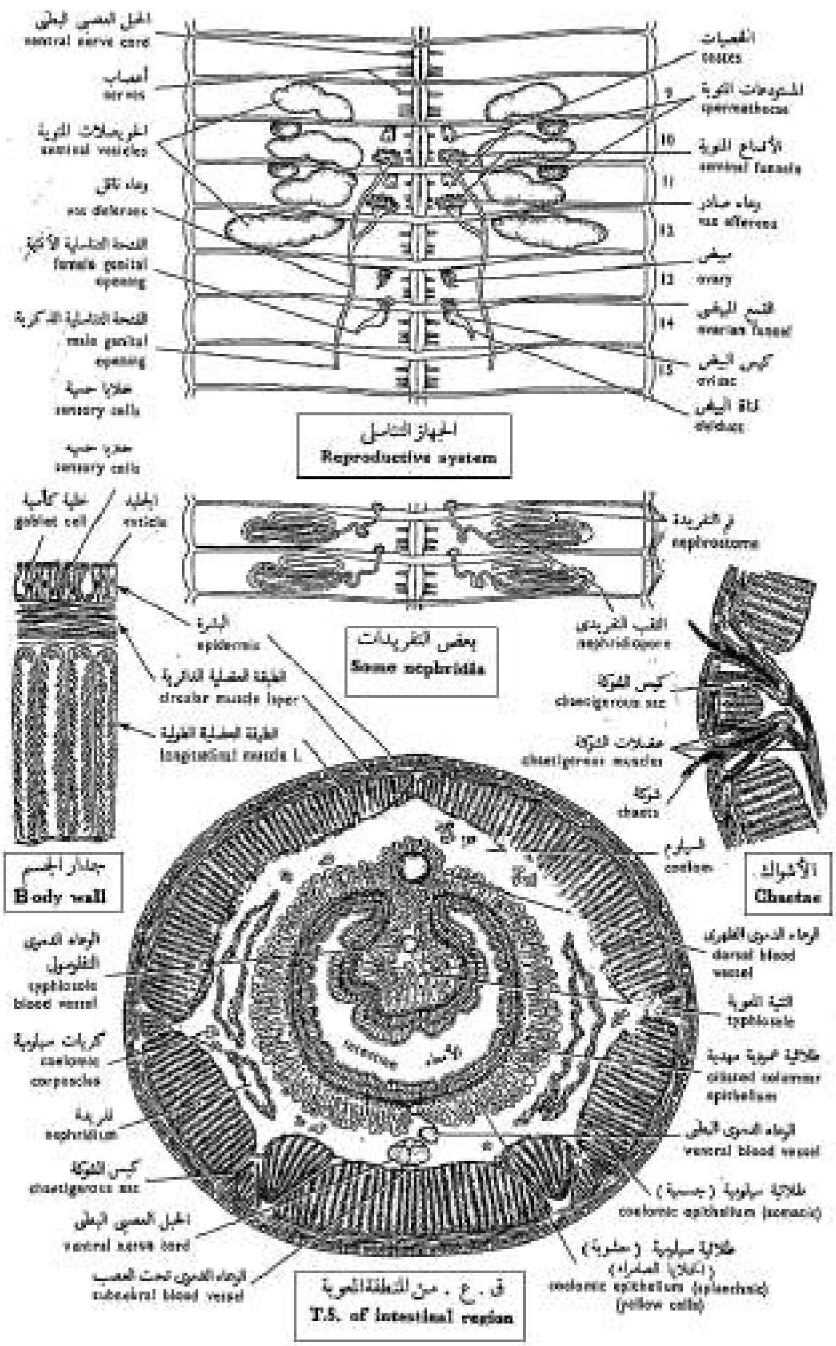
Ancylostoma duodenale

Kingdom: Animalia	**مملكة الحيوانات**
Subkingdom: Eumetazoa	**تحت مملكة البعديات الحقيقية**
Phylum: Annelida **Class Oligochaeta** Eg.:- *Allolobophora caliginosa*	**شعبة الحلقيات** **طائفة قليلات الاشواك** مثال:- دودة الارض



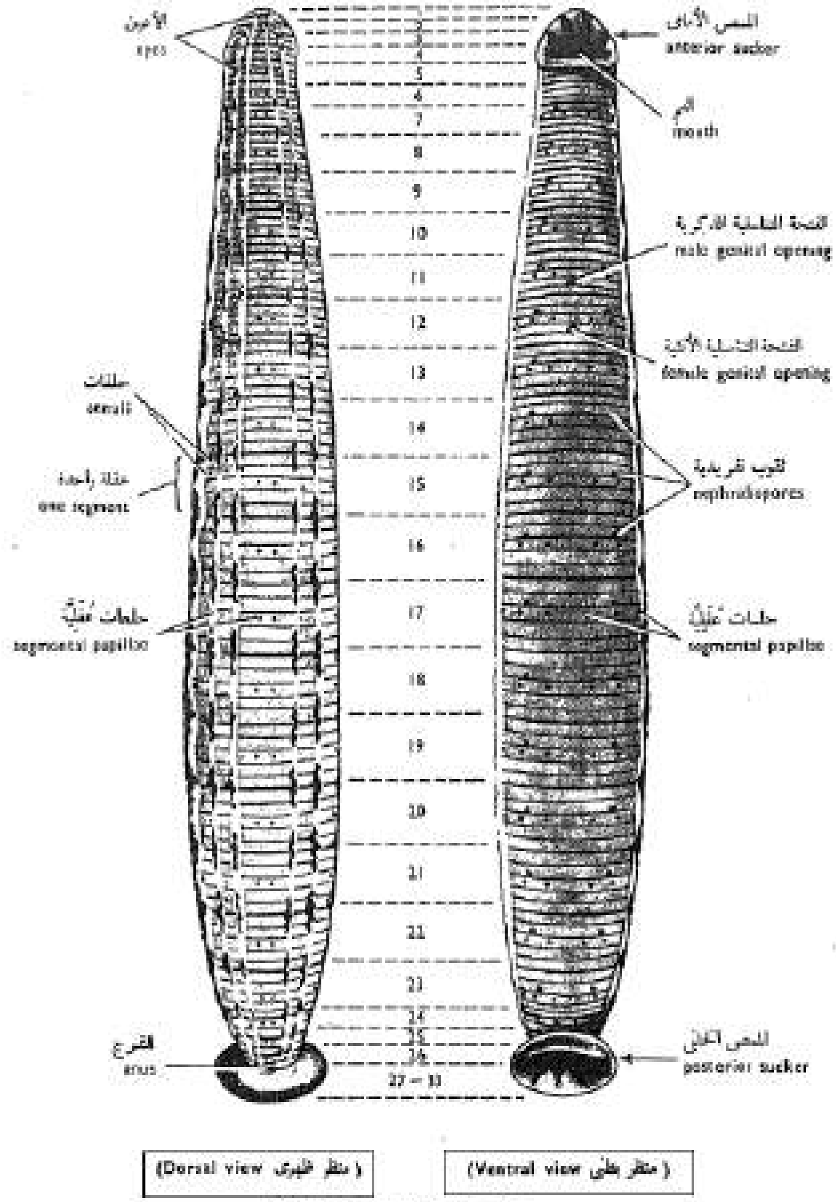
الدودة البالغة
Adult worm
(Dorsal view منظر ظهري)

T. S. in *Allolobophora caliginosa*



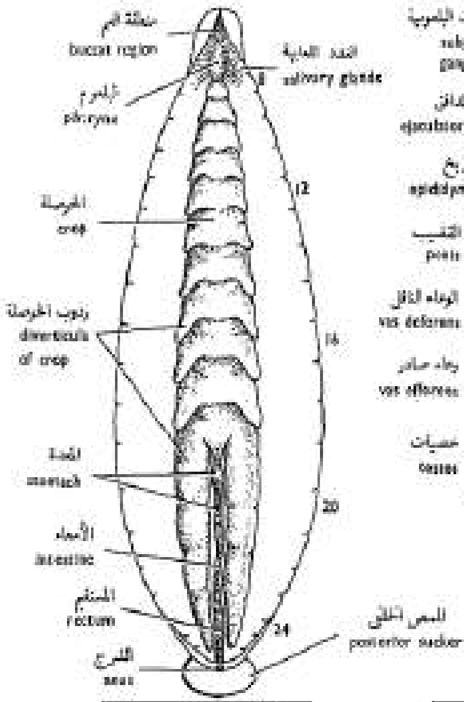
Allolobophora caliginosa

Kingdom: Animalia	**مملكة الحيوانات**
Subkingdom: Eumetazoa	**تحت مملكة البعديات الحقيقية**
Phylum: Annelida **Class Hirudinea** Eg.:- *Hirudo medicinalis*	**شعبة الحلقيات** **طائفة عديمة الاشواك (العلقيات)** مثال:- العلق الطبى

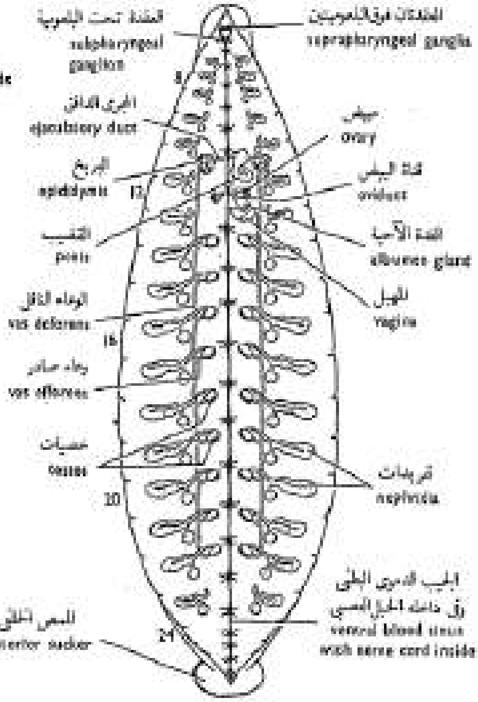


Hirudo medicinalis

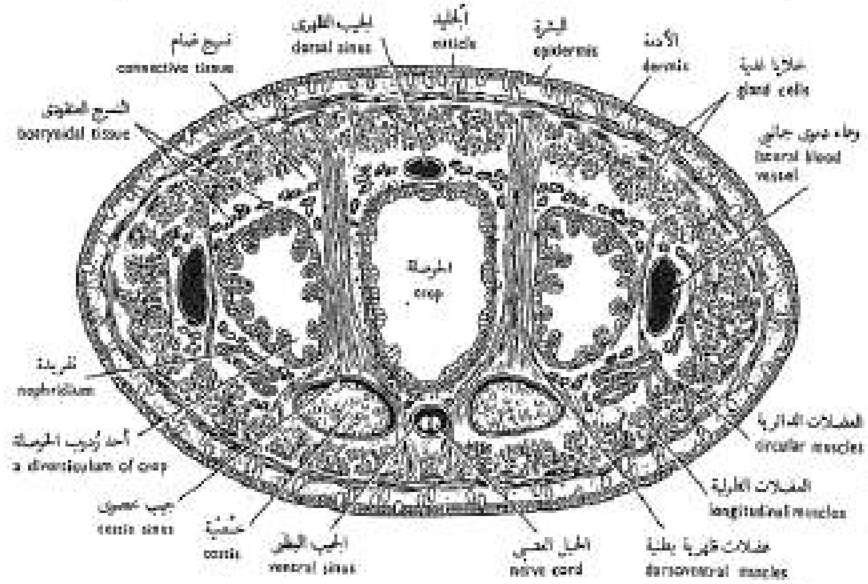
T. S. of *Hirudo medicinalis*



الجهاز الهضمى
Digestive system



الجهازان التناسلى والعصبى
Reproductive and Nervous systems



T.S. of *Hirudo medicinalis*

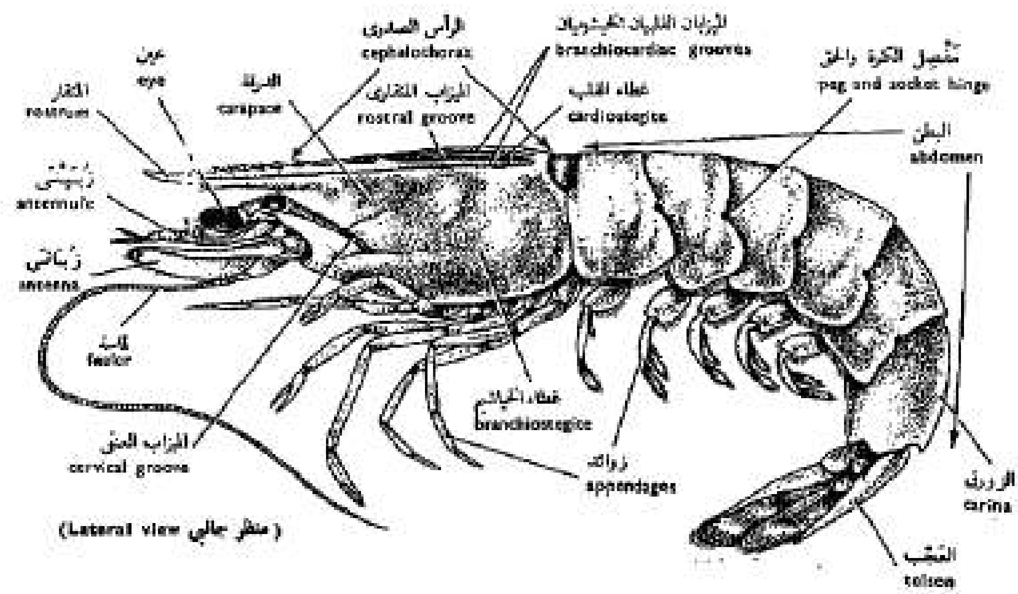
Phylum: Arthropoda **مفصلية الأرجل**

Class : Crustacea **القشريات**

Order : Eucarida **القشريات الحقيقية**

Family : Macrura **كبيرة البطن**

e. g. : *Penaeus japonicus* ***الجمبري***



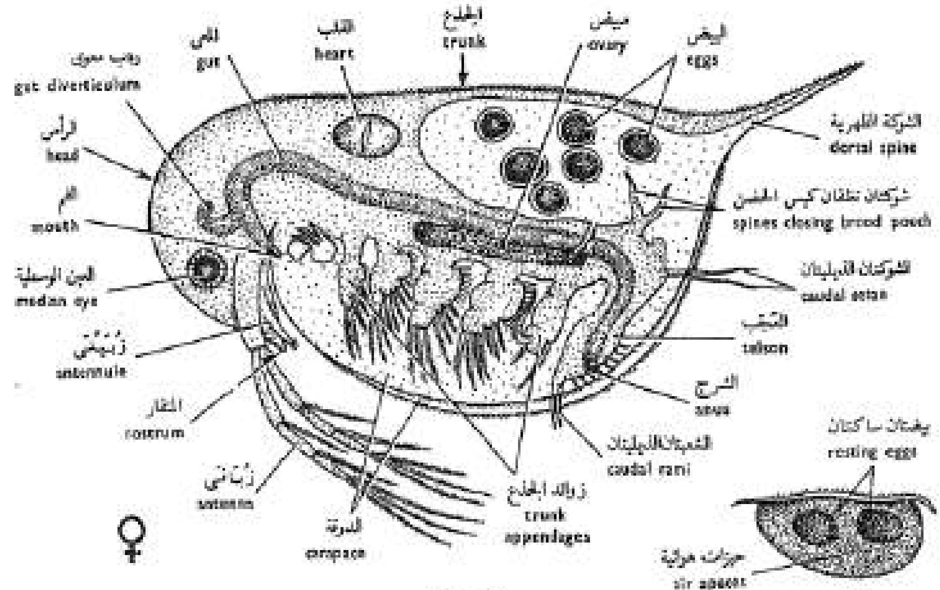
(Lateral view منظر جانبي)

Class : Crustacea القشريات

Subclass: Branchiopoda خيشومية الأرجل

Order : Cladocera متفرعة القرون

e.g. : *Daphnia* sp. برغوث الماء (الدافنيا)



الدافنيا
DAPHNIA

Ephippium

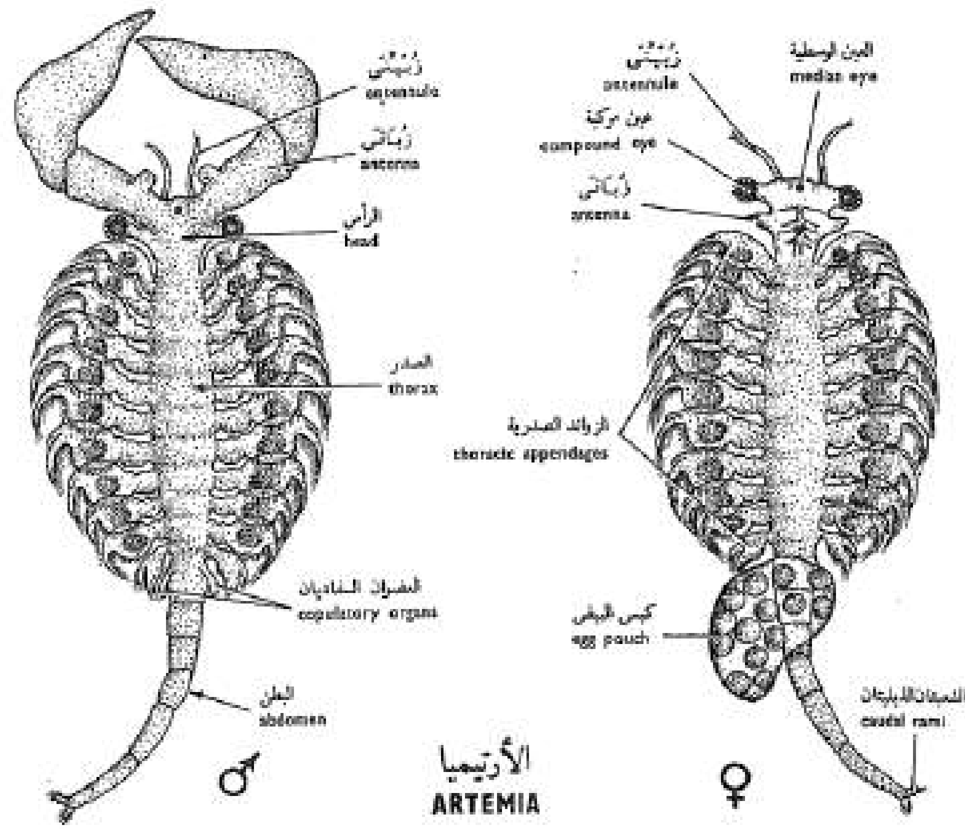
Phylum: Arthropoda مفصلية الأرجل

Class : Crustacea القشريات

Subclass: Branchiopoda خيشومية الأرجل

Order : Anostraca عديمة الدرقة

e.g. : *Artemia* sp. الأرتيميا

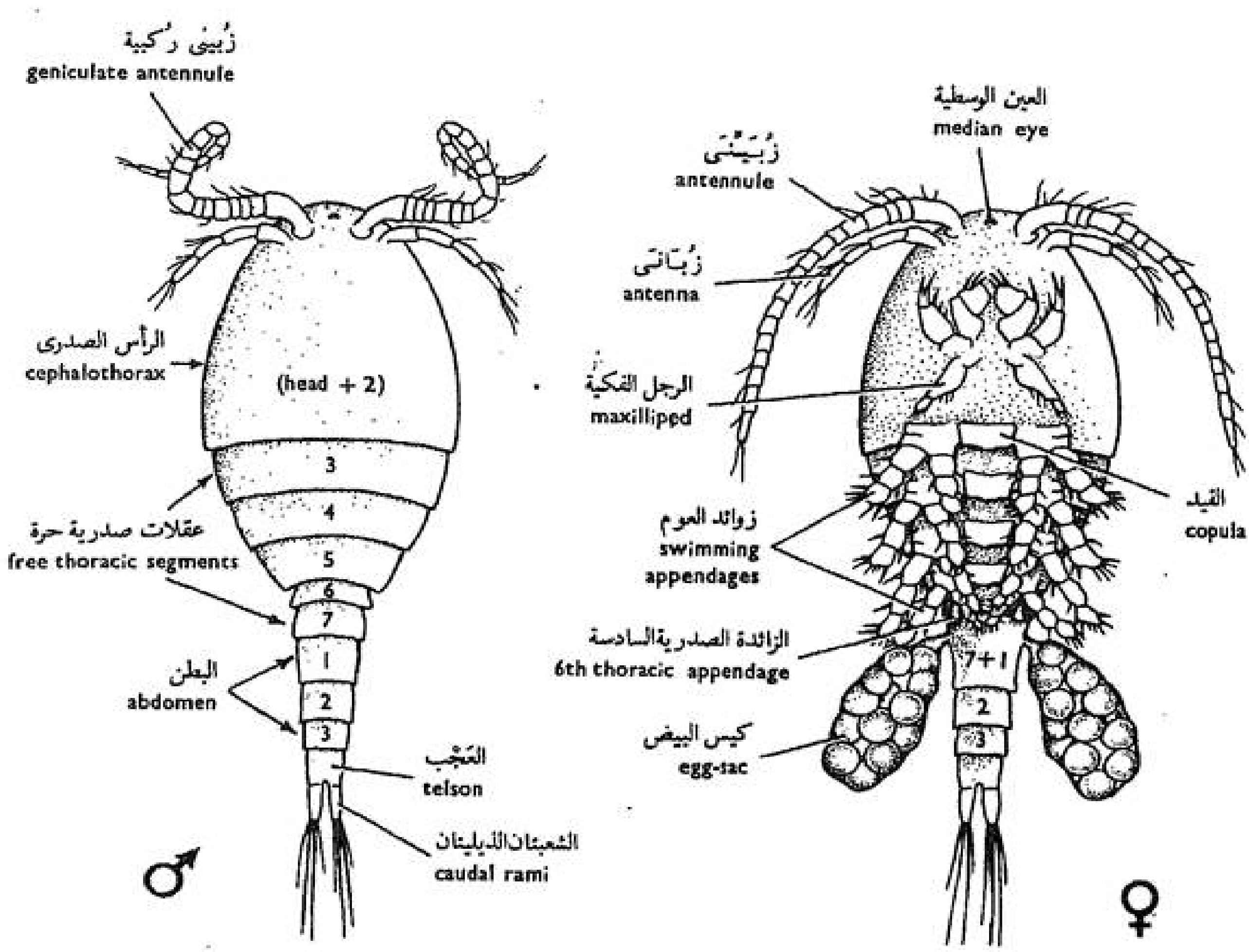

antennule
antenna
الرأس
head
الصدر
thorax
copulatory organs
abdomen
العين الوسطية
median eye
compound eye
thoracic appendages
egg pouch
caudal rami
♂
الأرتيميا
ARTEMIA
♀

Class : Crustacea

Subclass: Copepoda مجدافية الأرجل

Order : Eucopepoda

e.g. : *Cyclops* sp. السيكلوبس

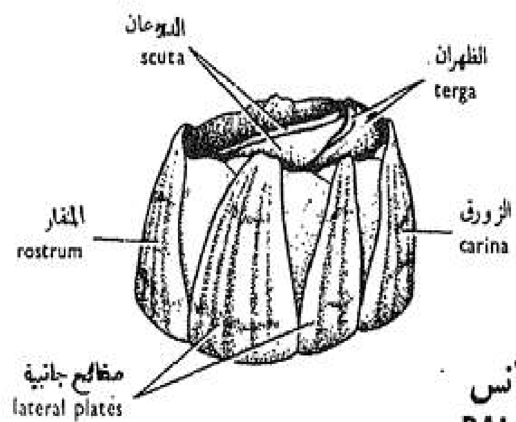


السيكلوبس
CYCLOPS

Class : Crustacea

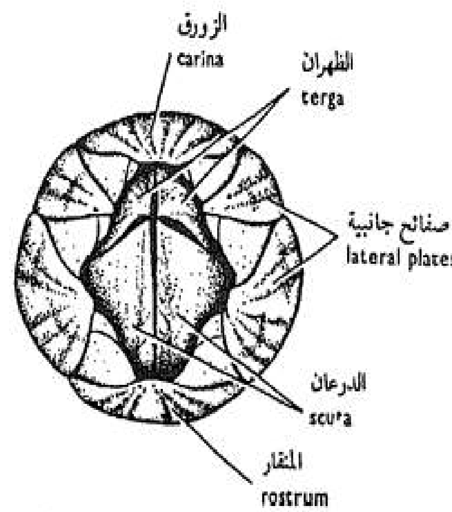
Subclass: Cirripedia زؤابية الأرجل

e.g. : *Balanus* sp. البالانس



(Lateral view منظر جانبي)

البالانس
BALANUS



(Upper view منظر علوي)

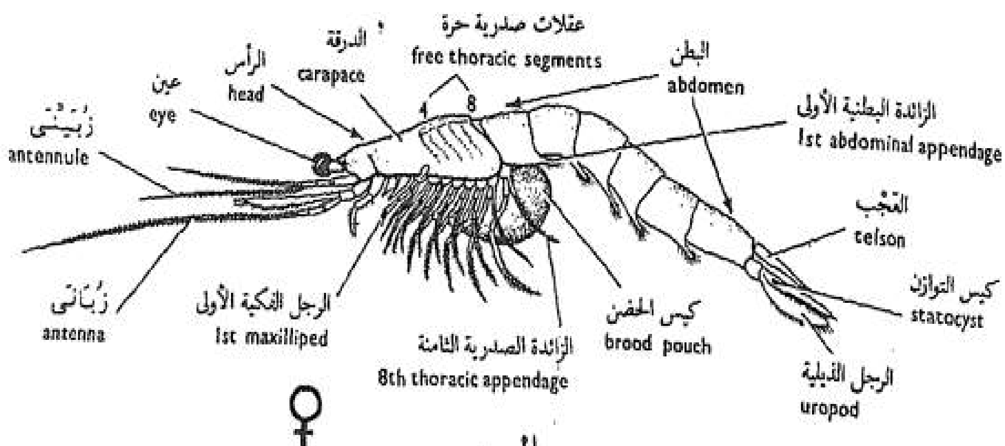
Class: Crustacea القشريات

Subcalss : Malacostraca **رخوية الهيكل**

Order : Peracarida **القشريات الكيسية**

Suborder: Mysidacea

e.g. : *Mysis* sp. ***الميسس***



الميسيس

MYSIS

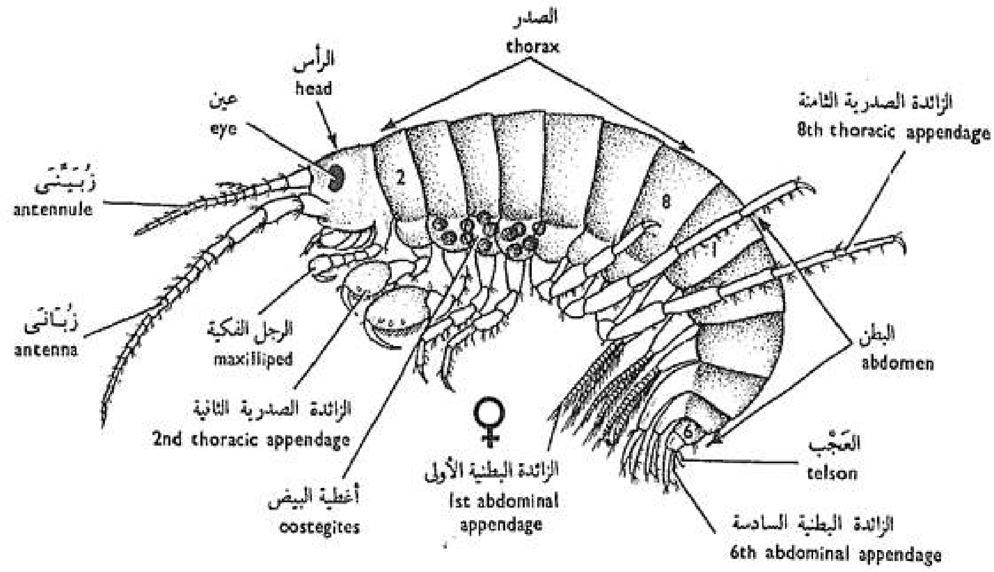
Class : Crustacea **القشريات**

Subcalss : Malacostraca **رخوية الهيكل**

Order : Peracarida **القشريات الكيسية**

Suborder : Amphipoda

e.g. : *Gammarus* sp. **الجمارس**

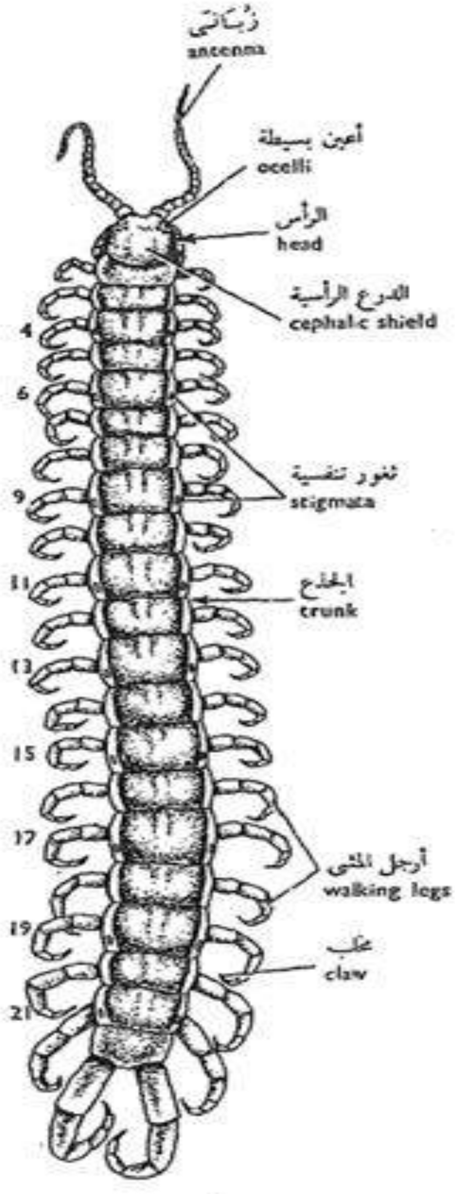


الجَمَّارس
GAMMARUS

Class : Myriapoda متعددة الارجل

Subclass : Chilopoda مئوية الأرجل

e.g. : ***Scolopendra morsitans 44 أم***



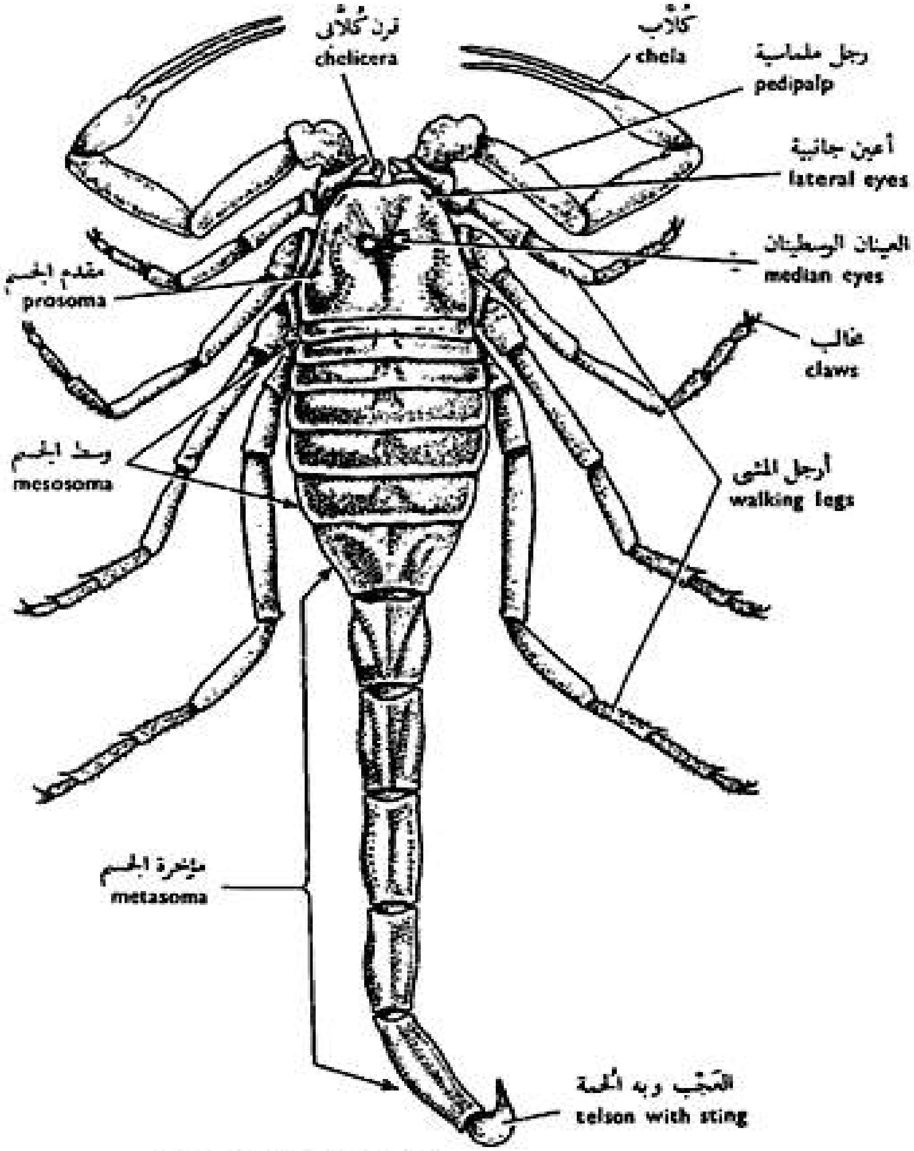
(Dorsal view منظر ظهري)

Phylum: Arthropoda مفصلية الأرجل

Class : Arachnida العنكبيات

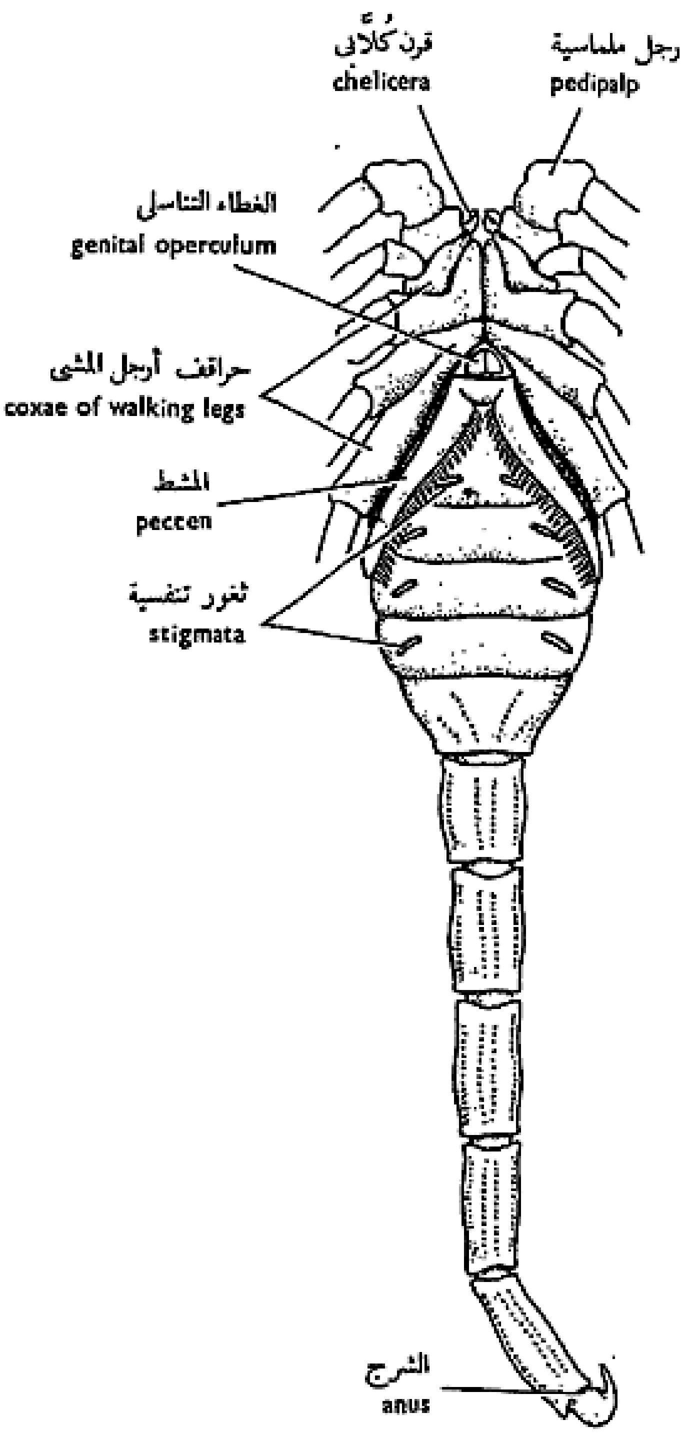
Order : Scorpionidea العقربيات

e.g. : ***Buthus quinquestriatus العقرب***



(Dorsal view منظر ظهرى)

القرن الكُلاّبى للعقرب
Chelicera of scorpion

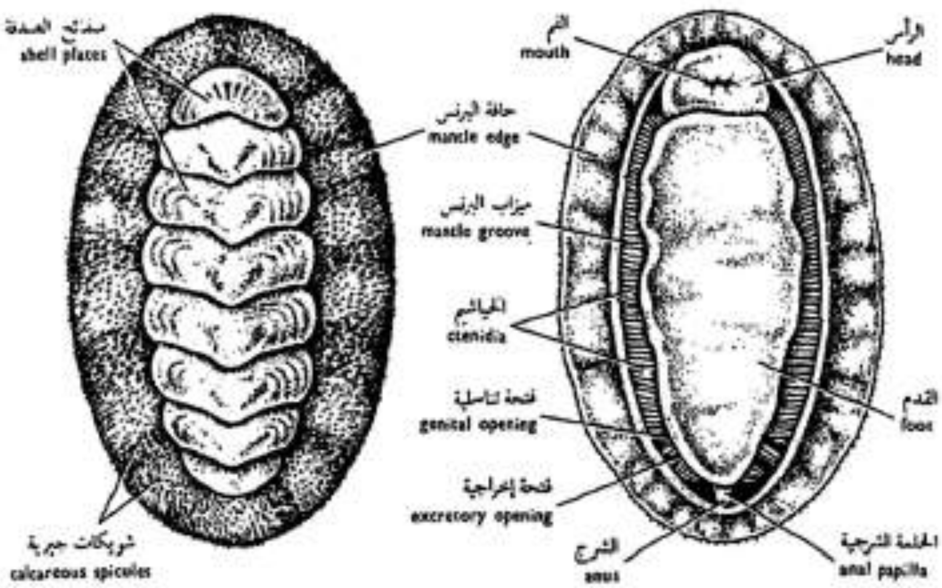


(Ventral view منظر بطنى)

Phylum: Mollusca الرخويات

Class: Amphineura (Placophora) مزدوجة العصب (ذات الدروع)

e.g. : *Acanthochiton spinigera* *الكيتون*



(Dorsal view منظر ظهرى)

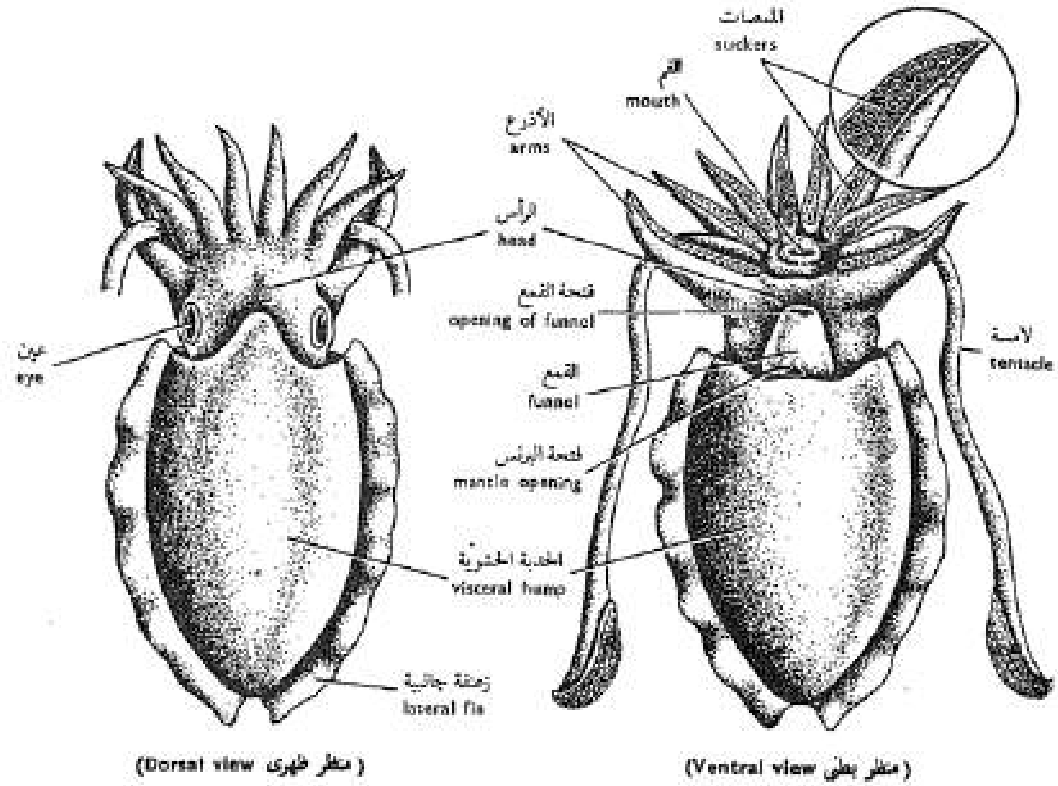
(Ventral view منظر بطنى)

Class : Cephalopoda الرأسقدميات

Order : Dibranchiata ثنائية الخياشيم

Suborder: Decapoda عشرية الأرجل

e.g. : ***Sepia savignyi الحبار***



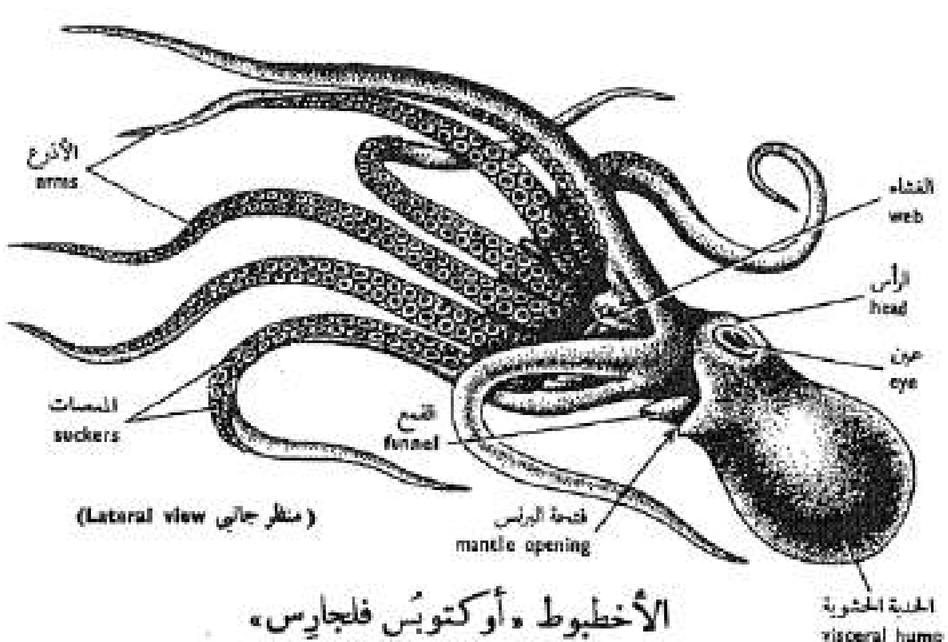
الممصات
suckers
الفم
mouth
الأذرع
arms
الرأس
head
فتحة القمع
opening of funnel
عين
eye
لامسة
tentacle
القمع
funnel
فتحة البرنس
mantle opening
الحدبة الحشوية
visceral hump
زعنفة جانبية
lateral fin
(Dorsal view منظر ظهري)
(Ventral view منظر بطني)

Class: Cephalopoda **الرأسقدميات**

Order: Dibranchiata **ثنائية الخياشيم**

Suborder: Octopoda **ثمانية الأرجل**

e.g.: *Octopus vulgaris* **الاخطبوط**



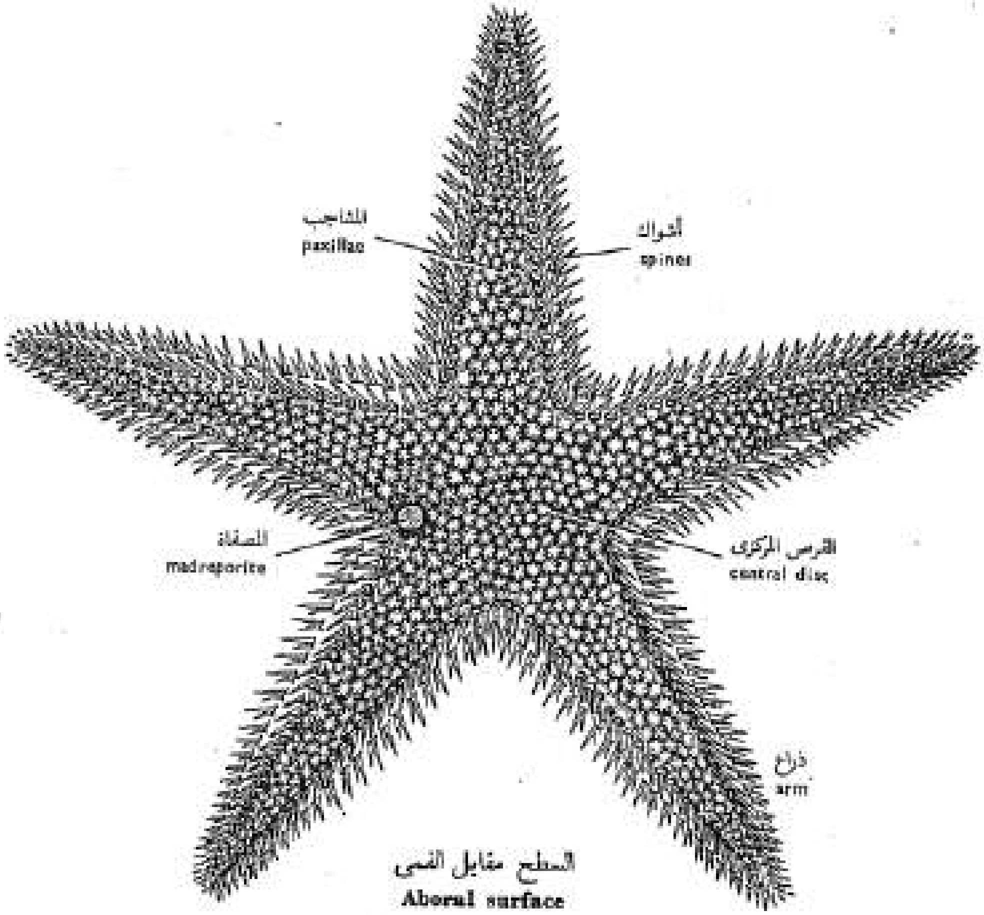
الأخطبوط «أوكتوبس فلجارس»
OCTOPUS VULGARIS

Phylum: Echinodermata شوكية الجلد

Subphylum: Eleutherozoa شوكية الجلد الحرة

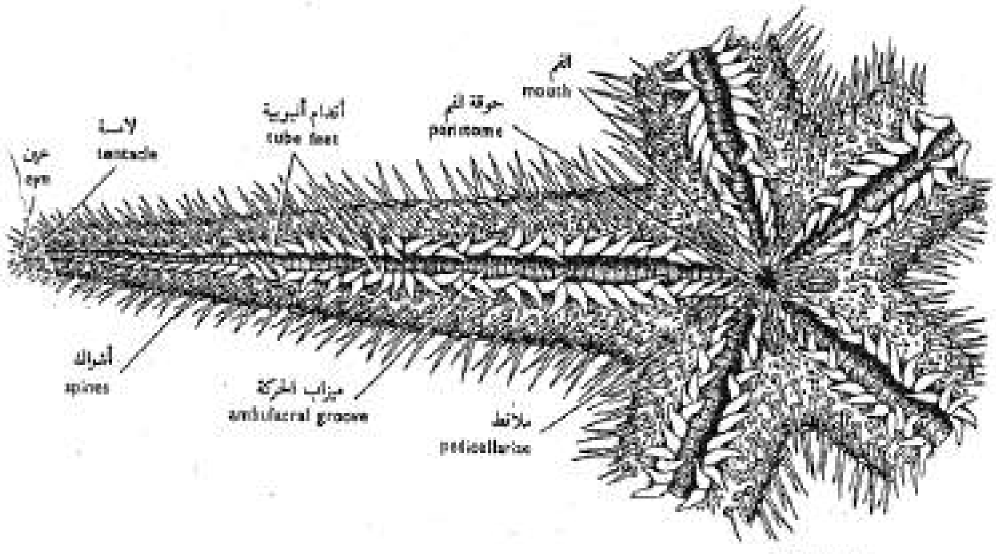
Class : Asteroideae نجوم البحر

e.g. : *Astropecten relitaris* *نجم البحر*



السطح مقابل الفمي

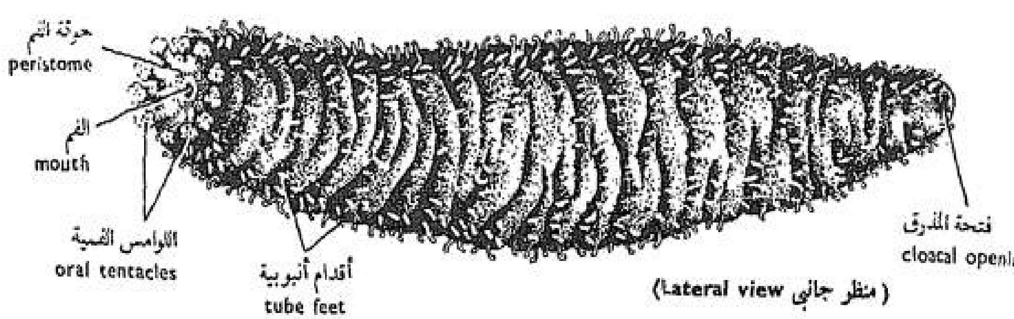
Aboral surface



نجم البحر «أستروبكتن رليتارس»
ASTROPECTEN RELITARIS

Class: Holothuroidea الخياريات

e.g.: *Holothuria curiosa* *خيار البحر*



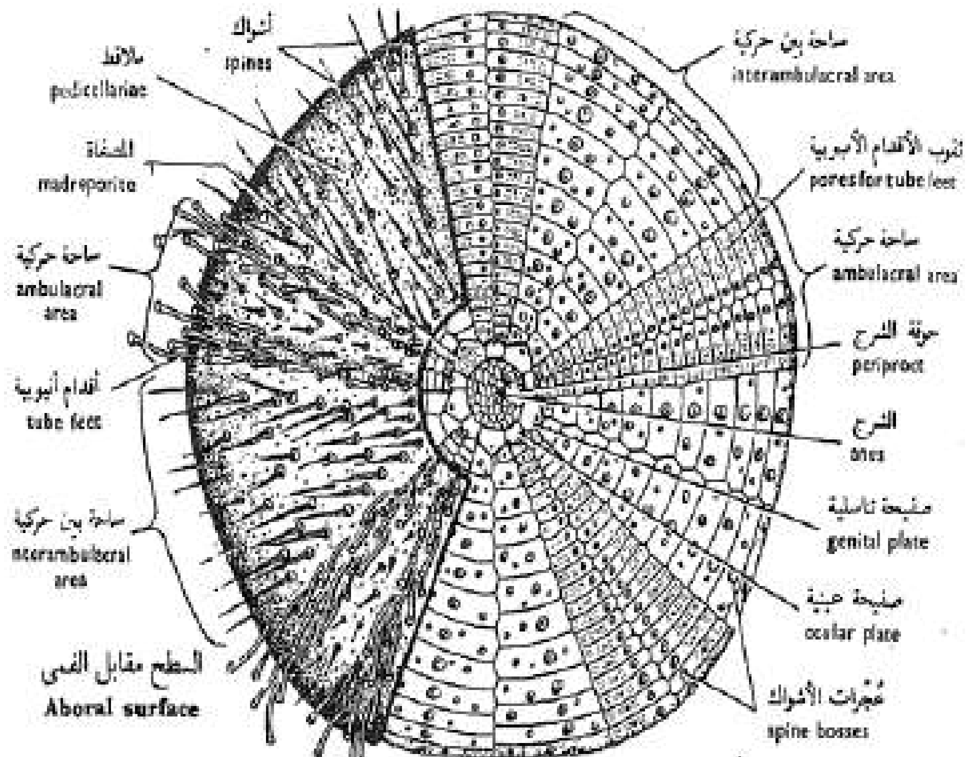
(منظر جانبي Lateral view)

Class : Echinoidea قنافذ البحر

Order: Endocyclica السواريات

e.g. : *Tripneustes gratilla*

قنفذ البحر المنتظم



Partly denuded animal حيوان معرى تعرية جزئية

الجزء العملى
للحشرات

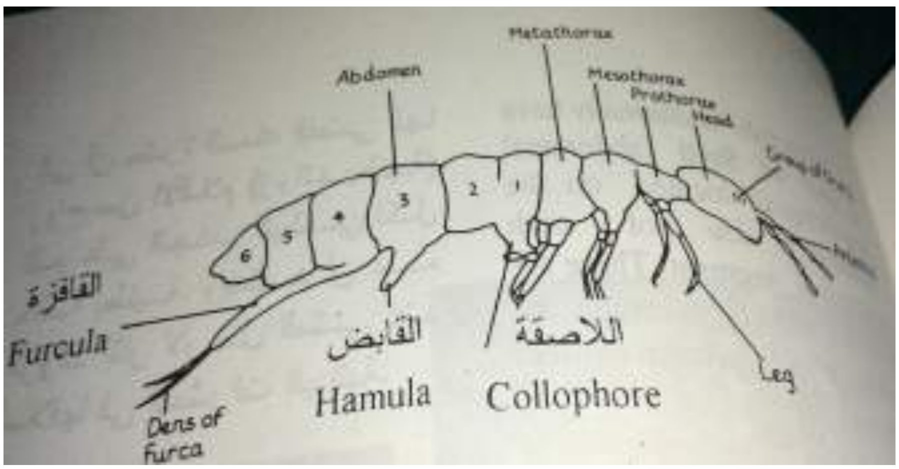
Class **: Insecta**

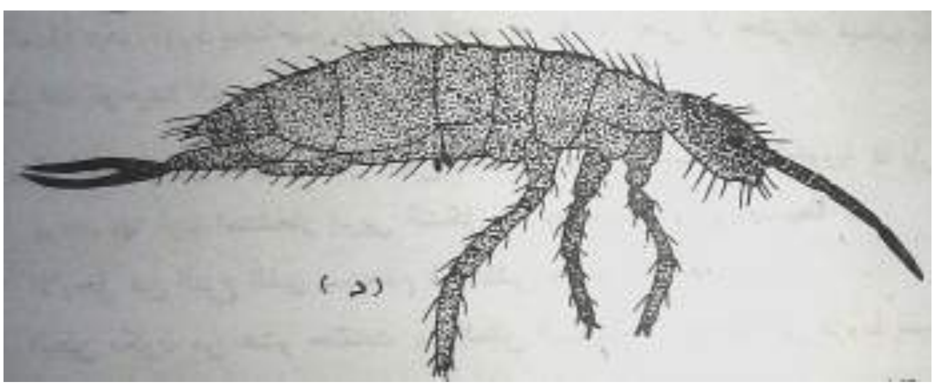
Subclass **: Apterygota**

Order **: Collembola**

Family **: Entomobryidae**

e. g. **: <u>Collembola</u> sp.** **الكلمبولا**





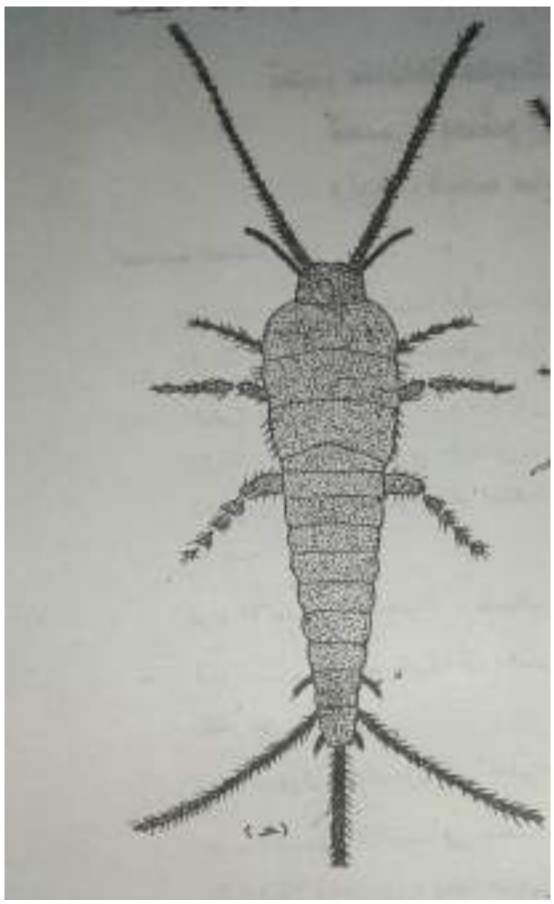
Class : **Insecta**

Subclass : **Apterygota**

Order : **Thysanura**

Family : **Lepismatidae**

e. g. : **<u>Lepisma</u> <u>saccharina</u>** **السمك الفضى**



Class **: Insecta**

Subclass **: Pterygota**

Division **: Exopterygota**

Order **: Odonata**

Family **: Libellulidae**

e. g. **: <u>Crocothemis</u> <u>erythraea</u>** **الرعاش الكبير**

Class **: Insecta**

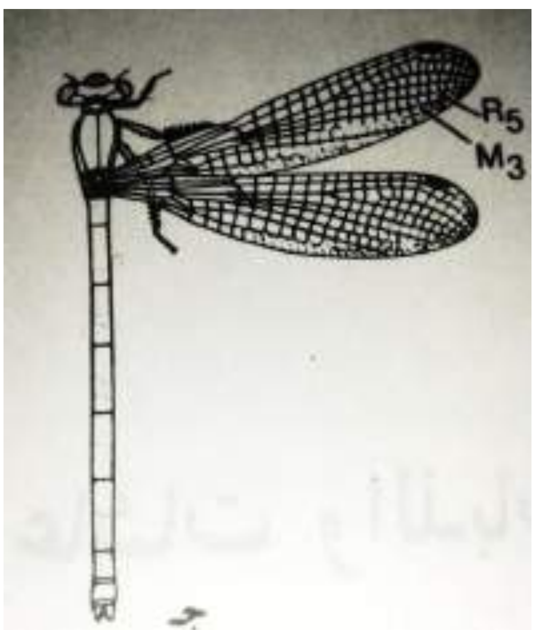
Subclass **: Pterygota**

Division **: Exopterygota**

Order **: Odonata**

Family **: Agrionidae**

e. g. **: <u>Ischnura senegalensis</u>** **الرعاش الصغير**



Class : Insecta

Subclass : Pterygota

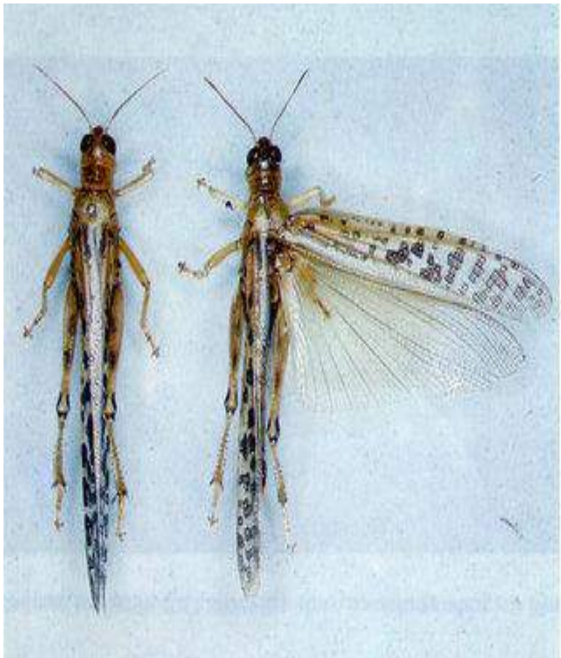
Division : Exopterygota

Order : Orthoptera

Suborder : Caelifera

Family : Acrididae

e. g. : Schistocerca gregaria الجراد الصحراوى



Class **: Insecta**

Subclass **: Pterygota**

Division **: Exopterygota**

Order **: Orthoptera**

Suborder **: Caelifera**

Family **: Acrididae**

e. g. **: <u>Anacridium</u> <u>aegyptiaca</u>** **الجراد المصرى**

Class **: Insecta**

Subclass **: Pterygota**

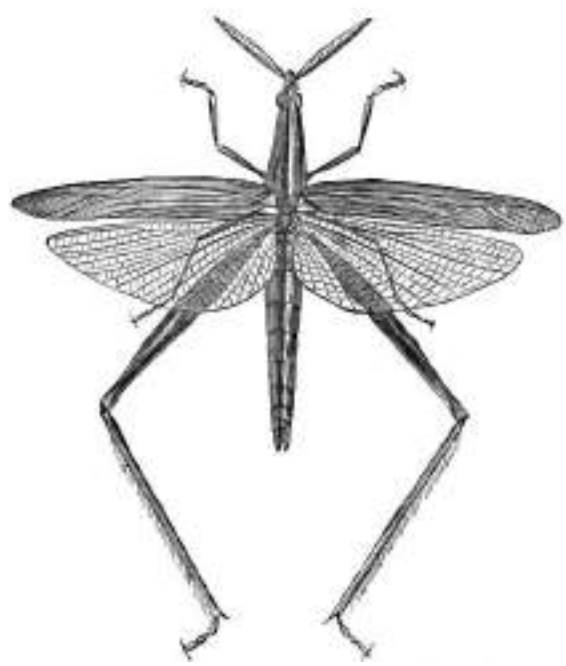
Division **: Exopterygota**

Order **: Orthoptera**

Suborder **: Caelifera**

Family **: Acrididae**

e. g. **: <u>Truxalis nasuta</u> الجراد ذو القرون الورقية**



Class : Insecta

Subclass : Pterygota

Division : Exopterygota

Order : Orthoptera

Suborder : Caelifera

Family : Acrididae

e. g. : Locusta migratoria **الجراد الروسى**

Class **: Insecta**

Subclass **: Pterygota**

Division **: Exopterygota**

Order **: Orthoptera**

Suborder **: Ensifera**

Family **: Tettigoniidae**

e. g. **: <u>Phaneroptera roseata</u>** **النطاط ذو القرون الطويلة**

Class **: Insecta**

Subclass **: Pterygota**

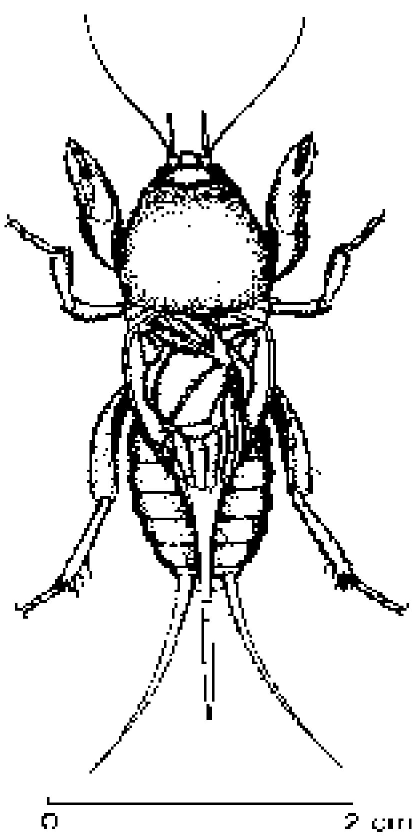
Division **: Exopterygota**

Order **: Orthoptera**

Suborder **: Ensifera**

Family **: Gryllotalpidae**

e. g. **: <u>Gryllotalpa</u> <u>africana</u>** **الحفار الافريقى**



Class : Insecta

Subclass : Pterygota

Division : Exopterygota

Order : Orthoptera

Suborder : Ensifera

Family : Gryllidae

e. g. : Gryllus bimaculatus **صرصور الغيط الاسود**

Class **: Insecta**

Subclass **: Pterygota**

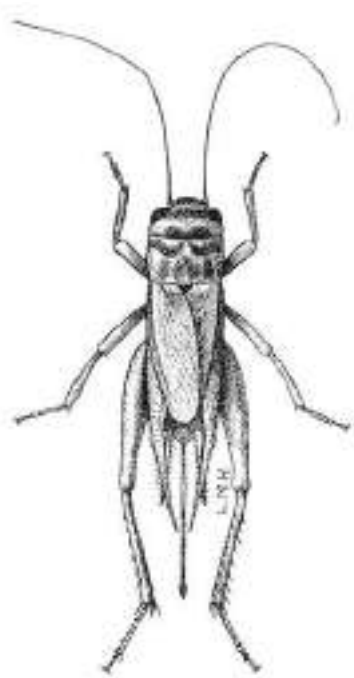
Division **: Exopterygota**

Order **: Orthoptera**

Suborder **: Ensifera**

Family **: Gryllidae**

e. g. **: <u>Gryllus</u> <u>domesticus</u>** **الصرصور المنزلى الاليف**



Class : Insecta

Subclass : Pterygota

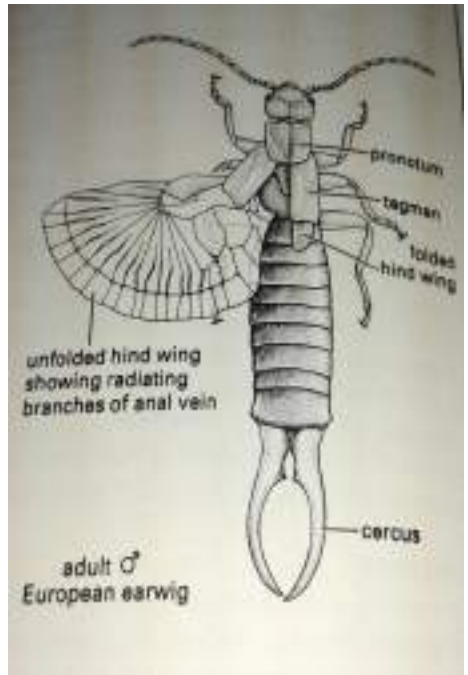
Division : Exopterygota

Order : Dermaptera

Family : Labiduridae

e. g. : <u>Labidura</u> <u>riparia</u> **ابرة العجوز**


MALE
FEMALE


pronotum
tegmen
folded hind wing
unfolded hind wing showing radiating branches of anal vein
cercus
adult ♂
European earwig

Class : **Insecta**

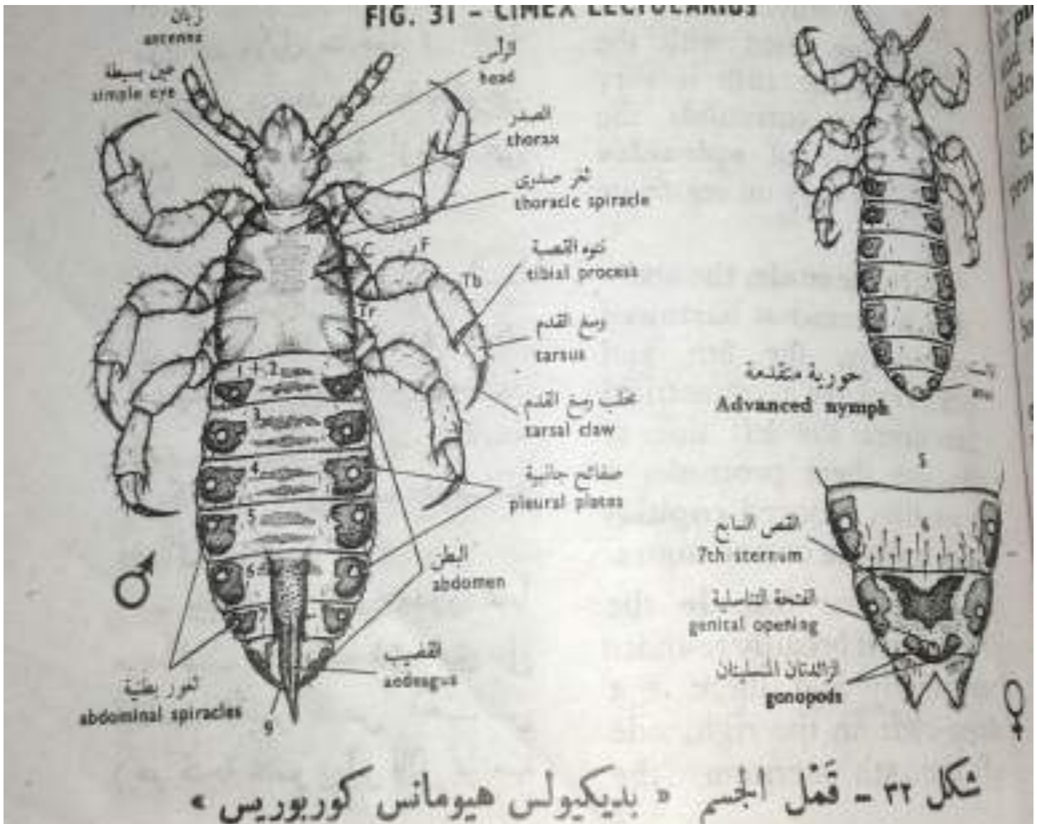
Subclass : **Pterygota**

Division : **Exopterygota**

Order : **Siphonculata**

Family : **Pediculidae**

e. g. : **<u>Pediculus</u> <u>humanus</u>** **قمل الانسان**



شكل ٣٢ ـ قمل الجسم « بديكيولس هيومانس كوربوريس »

FIG. 32 – PEDICULUS HUMANUS CORPORIS

Class : Insecta

Subclass : Pterygota

Division : Exopterygota

Order : Siphonculata

Family : Haematopinidae

e. g. : Haematopinus sp.

Class **: Insecta**

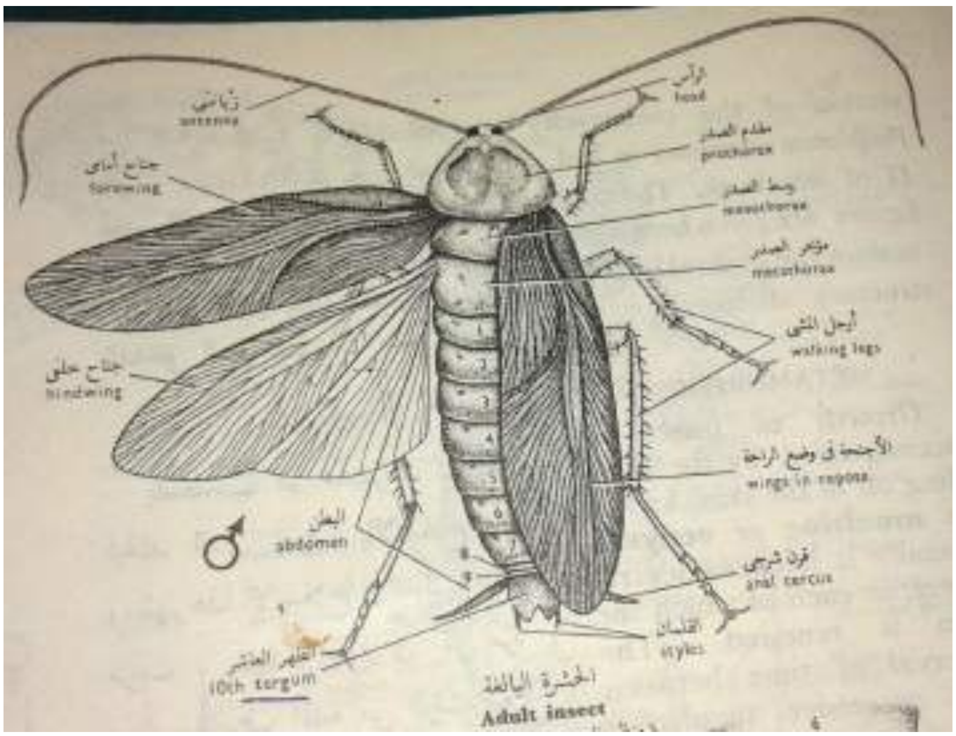
Subclass **: Pterygota**

Division **: Exopterygota**

Order **: Blattodea**

Family **: Blattidae**

e. g. **: <u>Periplaneta</u> <u>americana</u>** **الصرصور الامريكى**



Class : Insecta

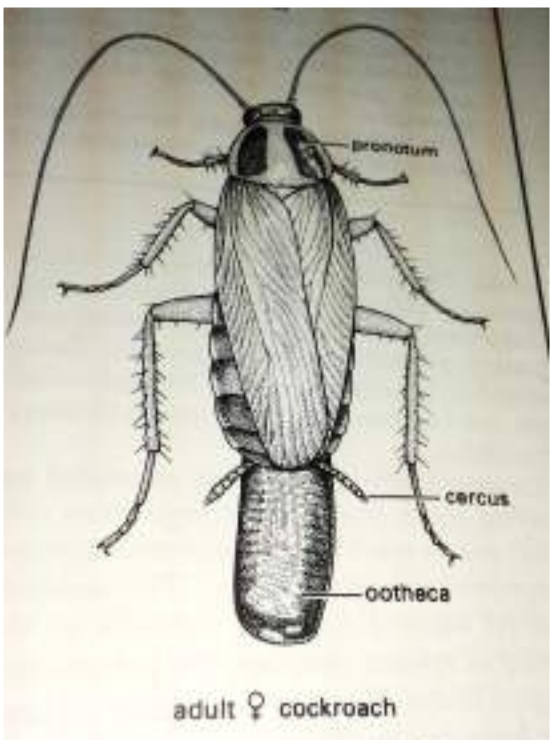
Subclass : Pterygota

Division : Exopterygota

Order : Blattodea

Family : Blattidae

e. g. : <u>Blattella</u> <u>germanica</u> **الصرصور الالمانى**



Class : **Insecta**

Subclass : **Pterygota**

Division : **Exopterygota**

Order : **Blattodea**

Family : **Polyphagidae**

e. g. : **Polyphaga aegyptiaca**

Class **: Insecta**

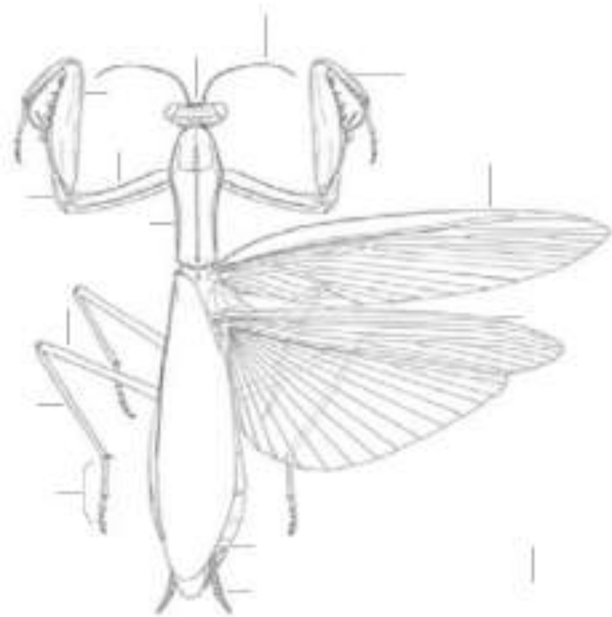
Subclass **: Pterygota**

Division **: Exopterygota**

Order **: Mantodea**

Family **: Mantidae**

e. g. **: <u>Sphodromantis</u> <u>bimaculata</u> فرس النبى ذوالبقعتين**



Class **: Insecta**

Subclass **: Pterygota**

Division **: Exopterygota**

Order **: Mantodea**

Family **: Mantidae**

e. g. **: Calidomantis savignyi** **فرس النبى الصغير**

Class : Insecta

Subclass : Pterygota

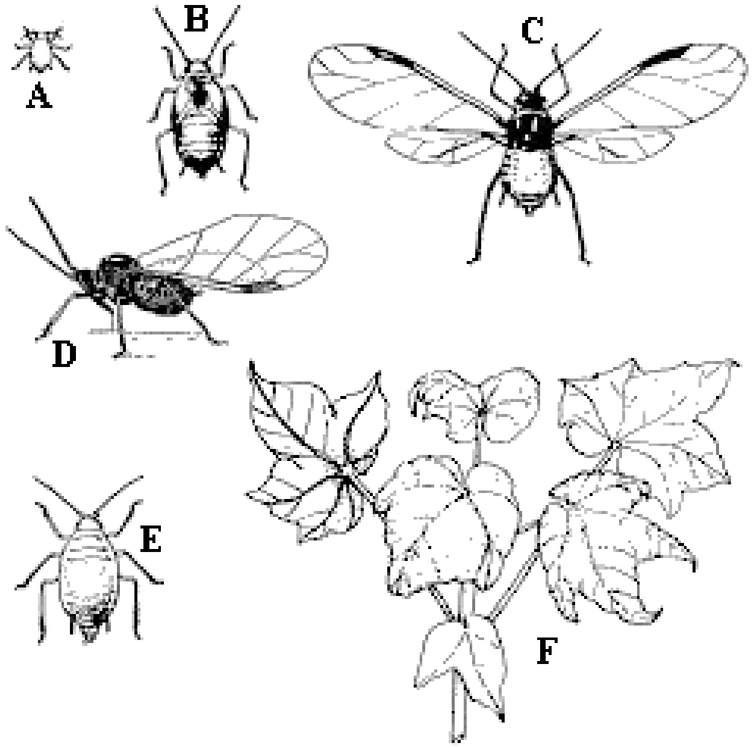
Division : Exopterygota

Order : Hemiptera

Suborder : Homoptera

Family :Aphididae

e. g. : <u>Aphis</u> <u>gossypii</u>   من القطـــــــن



Cotton aphid. A-B, Nymphs. C-E, Adults. F, Damage.

Class : Insecta

Subclass : Pterygota

Division : Exopterygota

Order : Hemiptera

Suborder : Homoptera

Family : Monophlebidae

e. g. : <u>Icerya</u> <u>aegyptiaca</u> البق الدقيقى المصرى

Class **: Insecta**

Subclass **: Pterygota**

Division **: Exopterygota**

Order **: Hemiptera**

Suborder **: Homoptera**

Family **: Monophlebidae**

e. g. **: <u>Icerya</u> <u>purchasi</u>** **البق الدقيقى الاسترالى**

Class : Insecta

Subclass : Pterygota

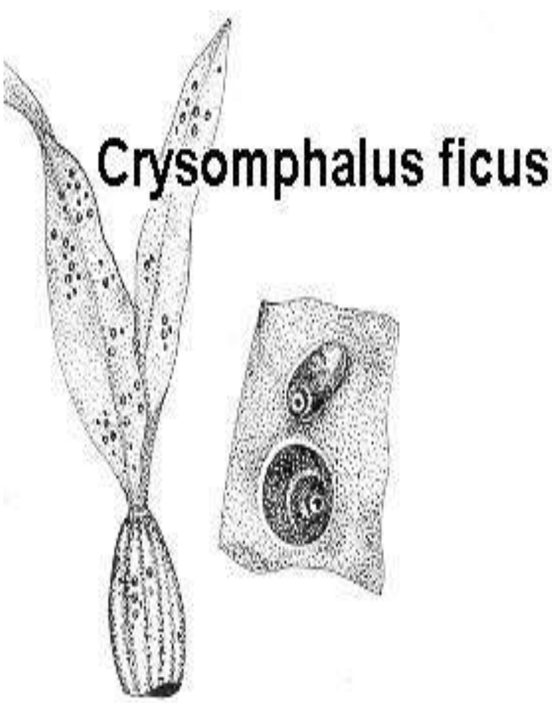
Division : Exopterygota

Order : Hemiptera

Suborder : Homoptera

Family : Diaspididae

e. g. : <u>Chrysomphalus</u> <u>ficus</u> **الحشرة القشرية السوداء**



Class : Insecta

Subclass : Pterygota

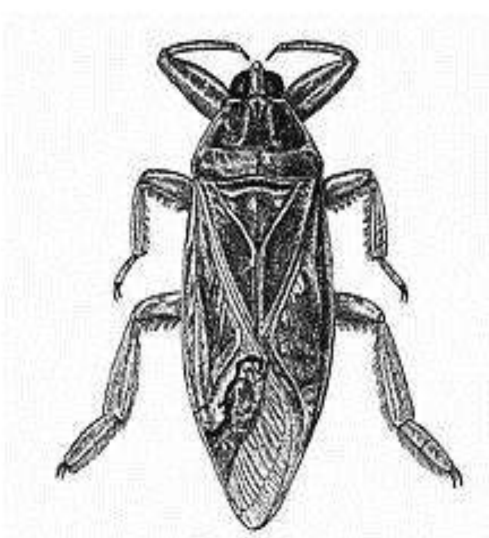
Division : Exopterygota

Order : Hemiptera

Suborder : Heteroptera

Family : Belistomatidae

e. g. : <u>Lethocerus</u> <u>niloticus</u> **بق الماء المارد**



Belostoma indicum.

Class : Insecta

Subclass : Pterygota

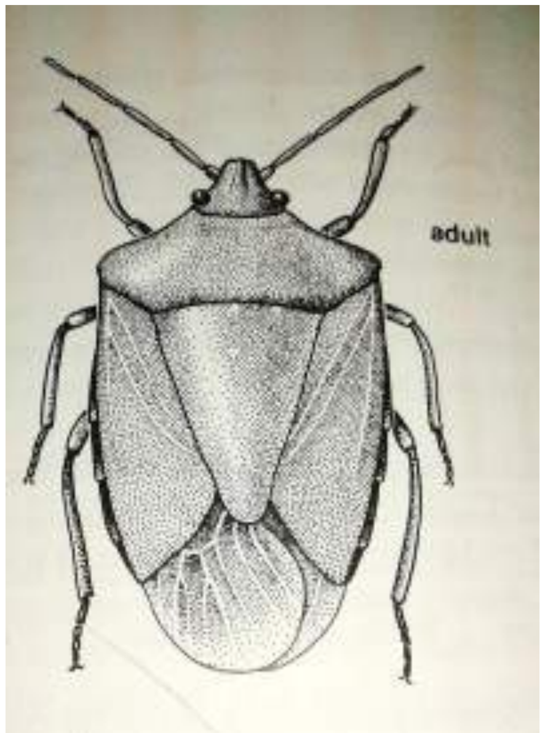
Division : Exopterygota

Order : Hemiptera

Suborder : Heteroptera

Family : Pentatomatidae

e. g. : <u>Nezara</u> <u>viridula</u> البقة الخضراء



Class : Insecta

Subclass : Pterygota

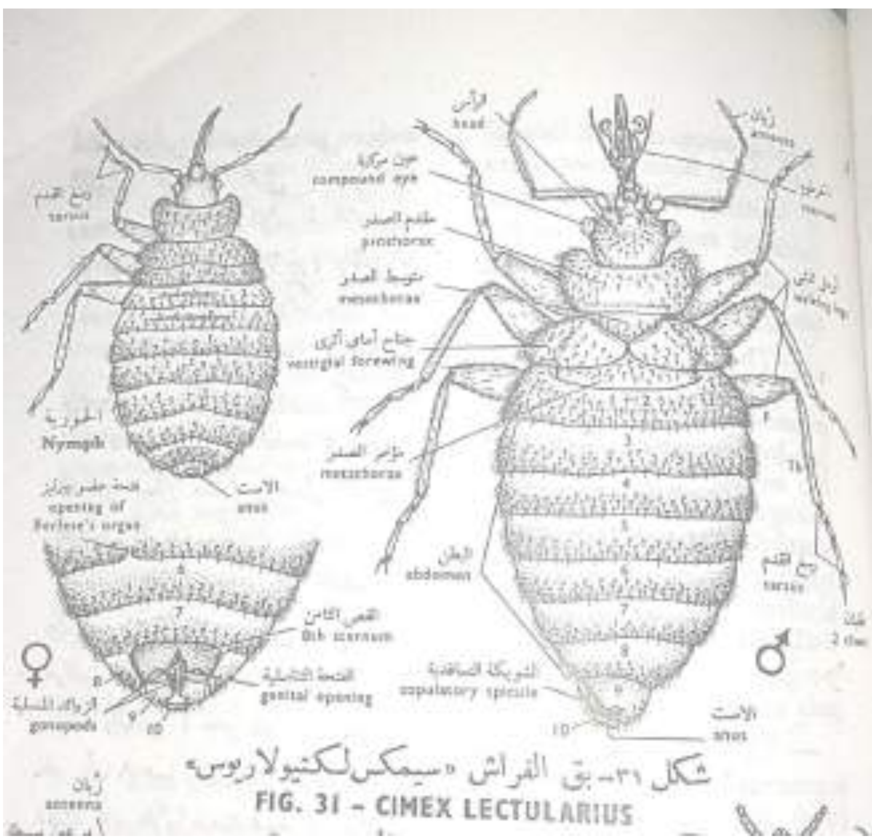
Division : Exopterygota

Order : Hemiptera

Suborder : Heteroptera

Family : Cimicidae

e. g. : <u>Cimex</u> <u>lectularis</u> بق الفراش



Class : Insecta

Subclass : Pterygota

Division : Endopterygota

Order : Neuroptera

Family : Myrmeleontidae

e. g. : <u>Creoleon</u> <u>africanus</u> اسد النمل

Class **: Insecta**

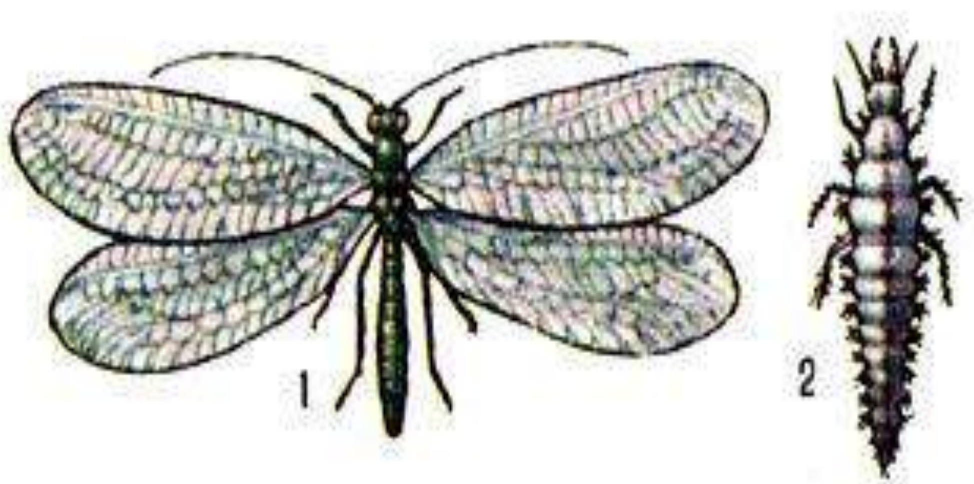
Subclass **: Pterygota**

Division **: Endopterygota**

Order **: Neuroptera**

Family **: Chrysopidae**

e. g. **: <u>Chrysopa</u> <u>vulgaris</u>** **اسد المن**



Class : Insecta

Subclass : Pterygota

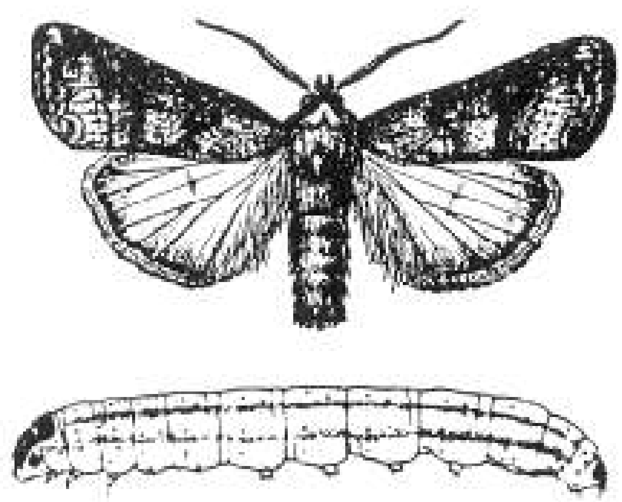
Division : Endopterygota

Order : Lepidoptera

Suborder : Heterocera

Family : Noctuidae

e. g. : <u>Agrotis</u> <u>ipsilon</u> **الدودة القارضة**



Class **: Insecta**

Subclass **: Pterygota**

Division **: Endopterygota**

Order **: Lepidoptera**

Suborder **: Heterocera**

Family **: Noctuidae**

e. g. **: <u>Sesamia cretica</u>** **دودة القصب الكبيرة**

Class : Insecta

Subclass : Pterygota

Division : Endopterygota

Order : Lepidoptera

Suborder : Heterocera

Family : Geometridae

e. g. : <u>Phytometra gamma y</u>الدودة نصف القياسية ذات الحرف

Class **: Insecta**

Subclass **: Pterygota**

Division **: Endopterygota**

Order **: Lepidoptera**

Suborder **: Heterocera**

Family **: Geometridae**

e. g. **: Phytometra ni** **الدودة نصف القياسية ذات البقعتين**

Class : Insecta

Subclass : Pterygota

Division : Endopterygota

Order : Lepidoptera

Suborder : Heterocera

Family : Geometridae

e. g. : Spodoptera littoralis دودة ورق القطن

Class **: Insecta**

Subclass **: Pterygota**

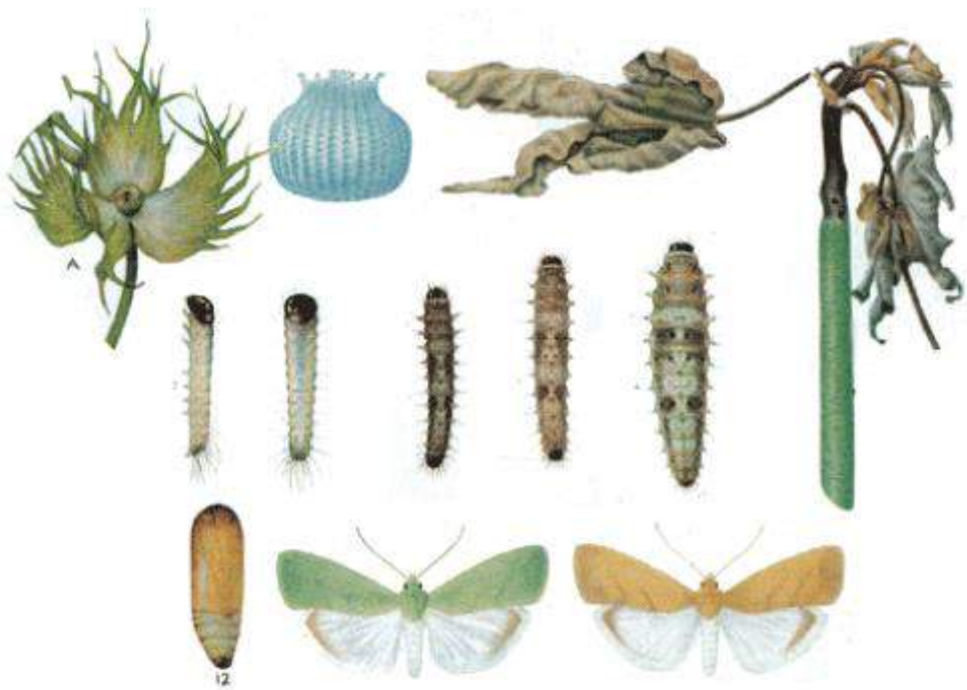
Division **: Endopterygota**

Order **: Lepidoptera**

Suborder **: Heterocera**

Family **: Noctuidae**

e. g. **: <u>Earias</u> <u>insulana</u>** **دودة اللوز الشوكية**



Class **: Insecta**

Subclass **: Pterygota**

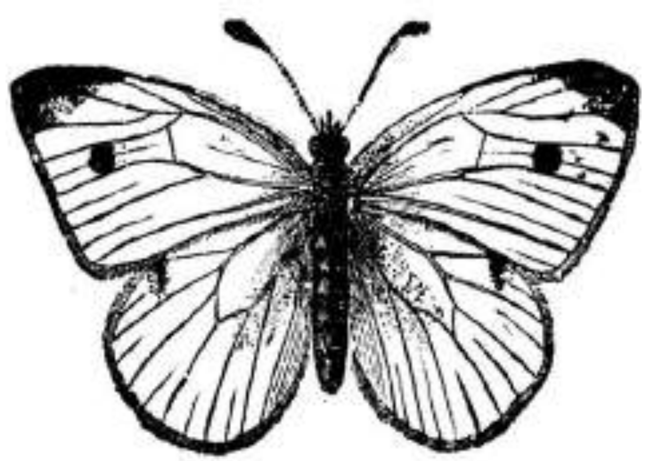
Division **: Endopterygota**

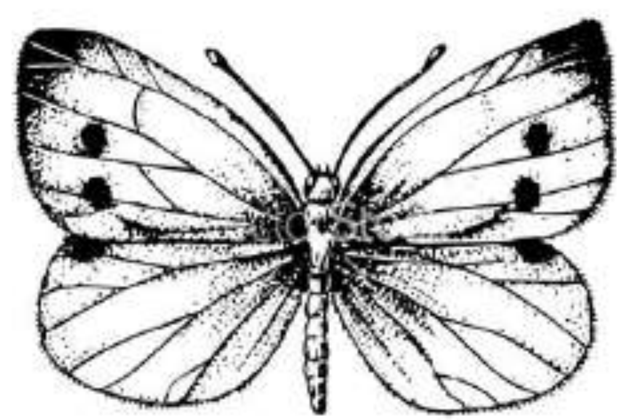
Order **: Lepidoptera**

Suborder **: Heterocera**

Family **: Pieridae**

e. g. **: <u>Pieris</u> <u>rapae</u>** **ابو دقيق الكرنب**





Female
Male

Class : Insecta

Subclass : Pterygota

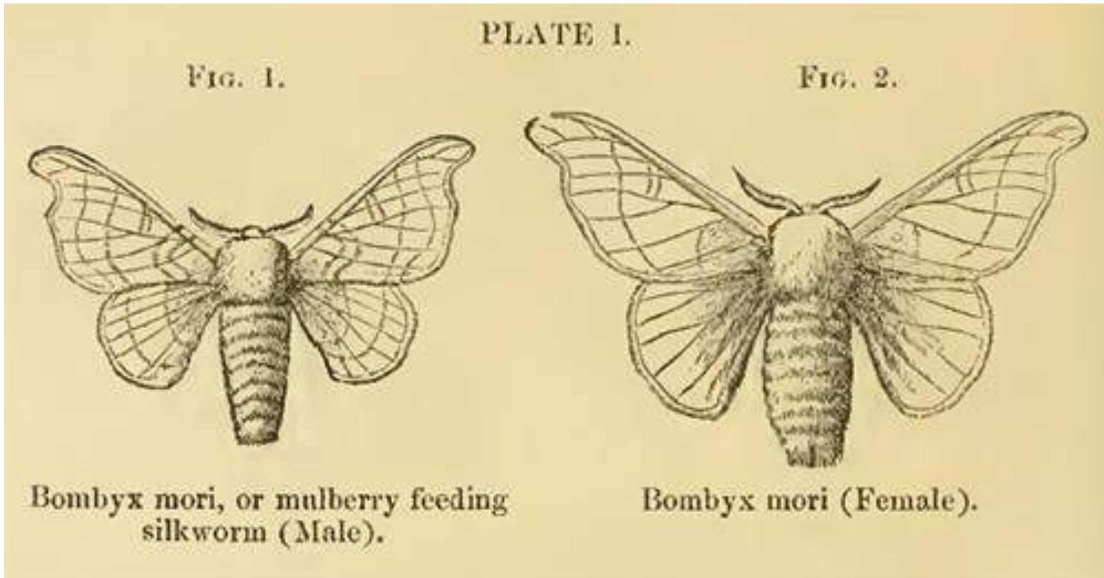
Division : Endopterygota

Order : Lepidoptera

Suborder : Heterocera

Family : Bombycidae

e. g. : <u>Bombyx</u> <u>mori</u> دودة الحرير



Bombyx mori, or mulberry feeding silkworm (Male).

Bombyx mori (Female).

Class : Insecta

Subclass : Pterygota

Division : Endopterygota

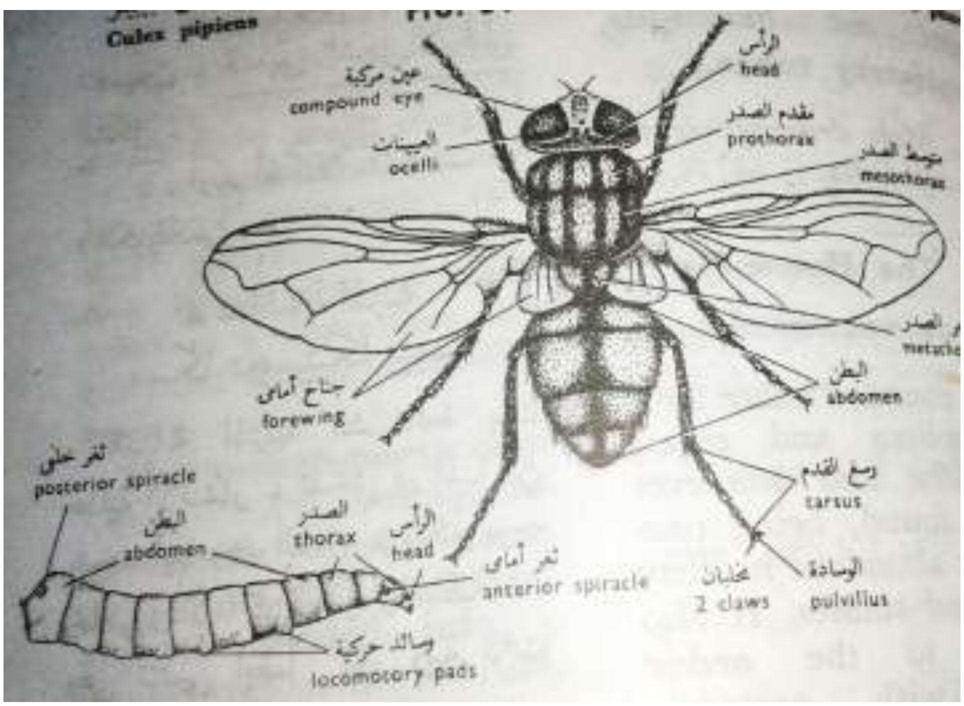
Order : Diptera

Suborder : Brachycera

Division : Cyclorrhapha

Family : Muscidae

e. g. : <u>Musca</u> <u>domestica</u> الذبابة المنزلية



Class : Insecta

Subclass : Pterygota

Division : Endopterygota

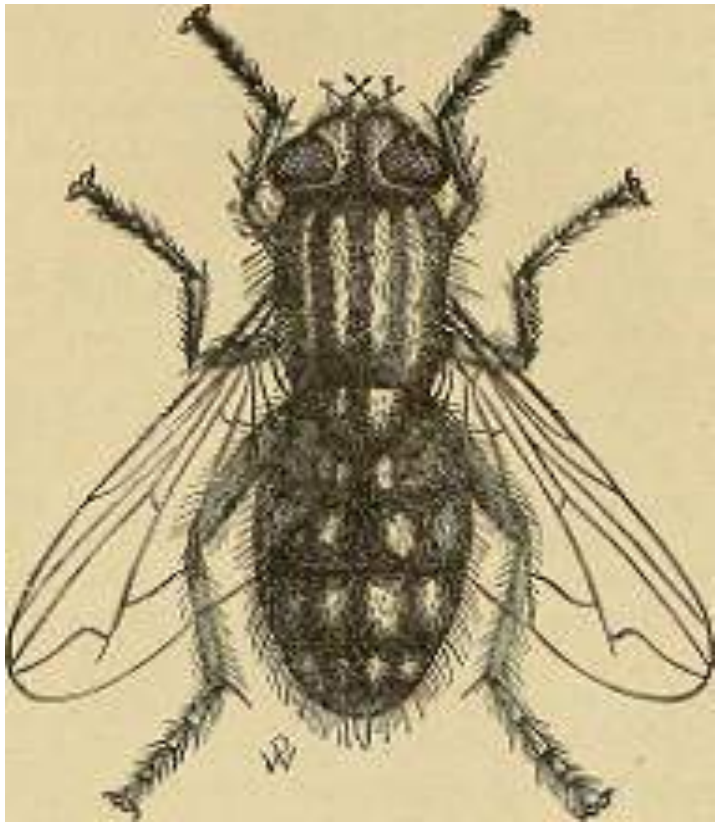
Order : Diptera

Suborder : Brachycera

Division : Cyclorrhapha

Family : Sarcophagidae

e. g. : <u>Sarcophaga carnaria</u> ذبابة اللحم



Class : Insecta

Subclass : Pterygota

Division : Endopterygota

Order : Diptera

Suborder : Brachycera

Division : Orthorrhapha

Family : Syrphidae

e. g. : Syrphus sp. ذبابة السيرفس

Class : **Insecta**

Subclass : **Pterygota**

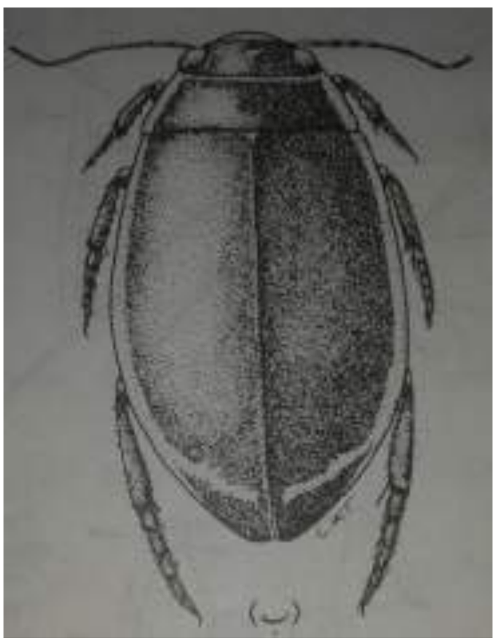
Division : **Endopterygota**

Order : **Coleoptera**

Suborder : **Adephaga**

Family : **Dytiscidae**

e. g. : **Cybister tripunctatus africanus** **خنفساء الماء**



Class : Insecta

Subclass : Pterygota

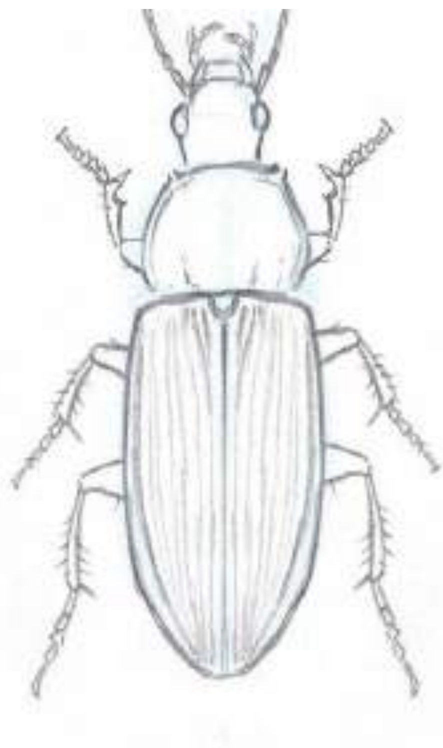
Division : Endopterygota

Order : Coleoptera

Suborder : Adephaga

Family : Carabidae

e. g. : Calosoma chlorostictum **خنفساء الكالوسوما**



Class : Insecta

Subclass : Pterygota

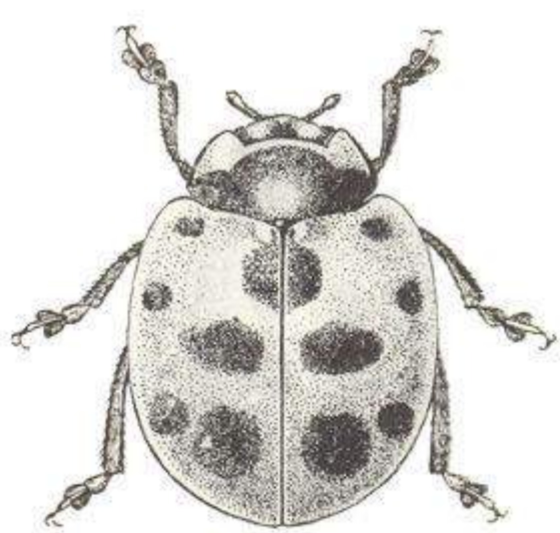
Division : Endopterygota

Order : Coleoptera

Suborder : Polyphaga

Family : Coccinillidae

e. g. : <u>Coccinella</u> <u>undecimpunctata</u> ابو العيد ذو ال 11 نقطة



Class : Insecta

Subclass : Pterygota

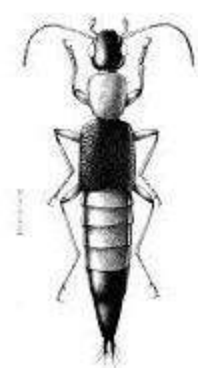
Division : Endopterygota

Order : Coleoptera

Suborder : Polyphaga

Family : Staphylinidae

e. g. : <u>Paederus</u> <u>alfierii</u> **الحشرة الرواغة**



Class : **Insecta**

Subclass : **Pterygota**

Division : **Endopterygota**

Order : **Hymenoptera**

Suborder : **Apocrita**

Family : **Vespidae**

e. g. : **Eumenes maxillosa** **دبور الطين البانى**

Class : Insecta

Subclass : Pterygota

Division : Endopterygota

Order : Hymenoptera

Suborder : Apocrita

Family : Vespidae

e. g. : _Vespa orientalis_ دبور البلح

Class : Insecta

Subclass : Pterygota

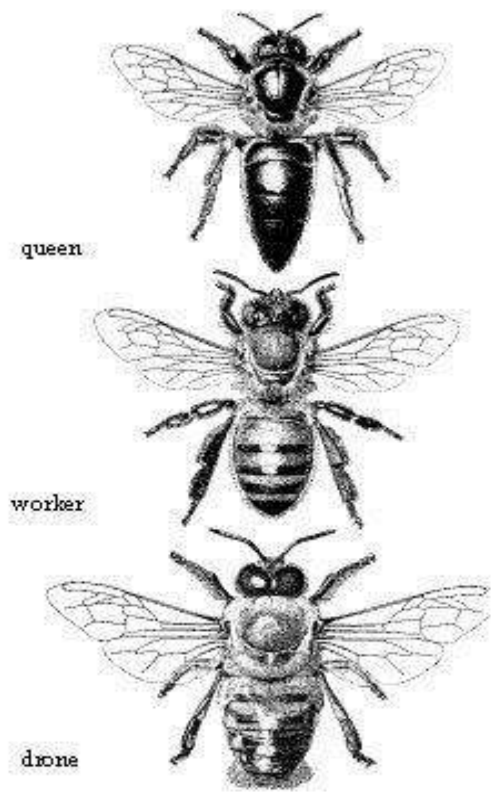
Division : Endopterygota

Order : Hymenoptera

Suborder : Apocrita

Family : Apidae

e. g. : Apis mellifera نحل العسل



Class **: Insecta**

Subclass **: Pterygota**

Division **: Endopterygota**

Order **: Hymenoptera**

Suborder **: Apocrita**

Family **: Apidae**

e. g. **: <u>Xylocopa aestuans</u>** **نحل الخشب**

Male

Female

Class **: Insecta**

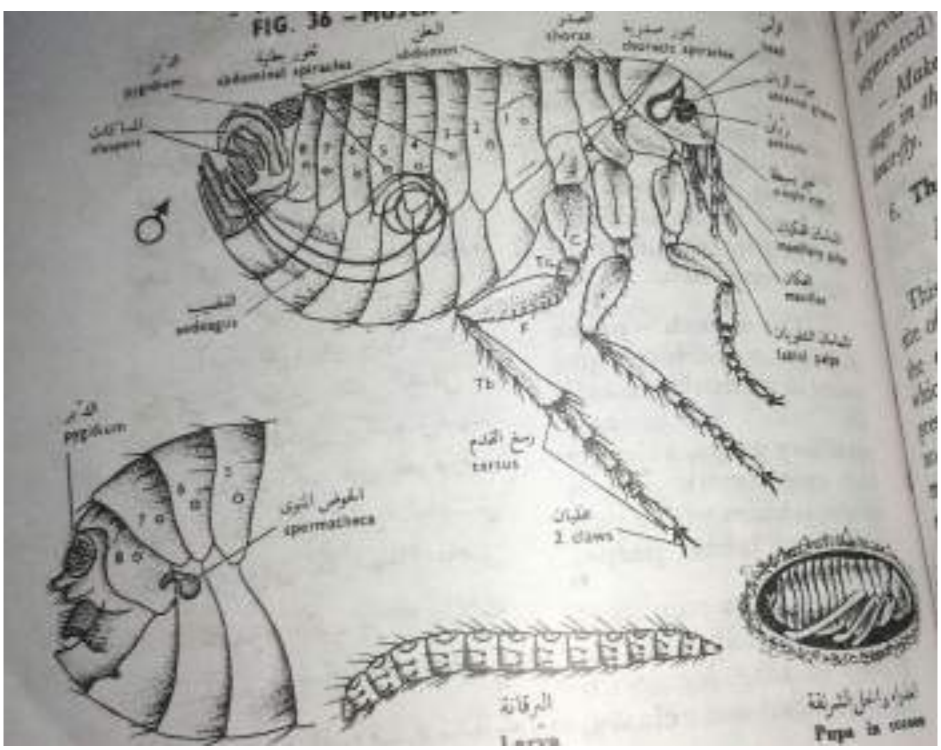
Subclass **: Pterygota**

Division **: Endopterygota**

Order **: Siphonaptera**

Family **: Pulicidae**

e. g. **: <u>Pulex</u> <u>irritans</u>** **برغوث الانـسان**



Class : Insecta

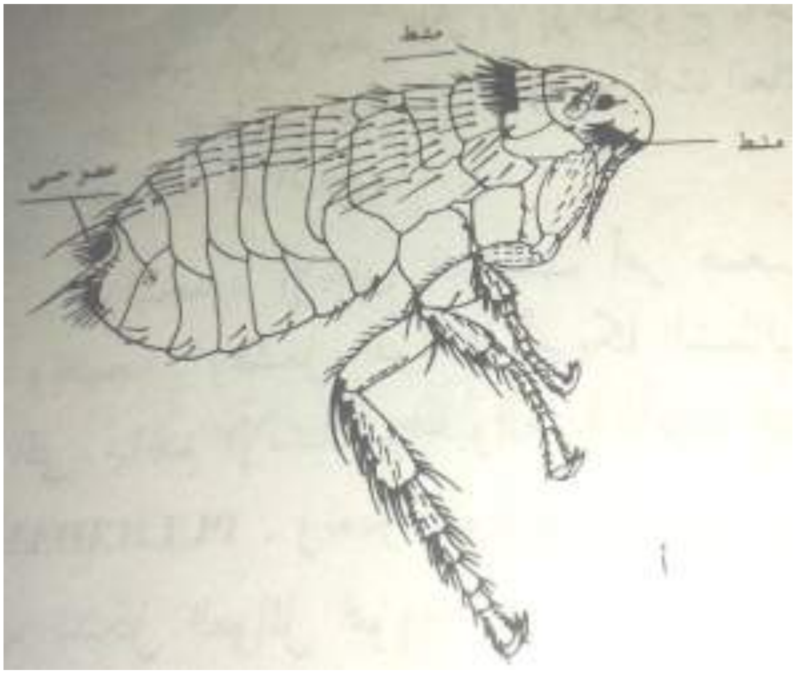
Subclass : Pterygota

Division : Endopterygota

Order : Siphonaptera

Family : Pulicidae

e. g. : <u>Ctenocephalides</u> <u>canis</u> برغوث الكلب



المراجع:

1- A. D. Imms (1960) : A General Textbook Of Entomology- printed and bounded in great Britain by Bulter & Tanner Led., Frome and London

2- احمد حماد الحسينى و اميل دميان (1969): بيولوجية الحيوان العملية الجزء الثانى. دار المعارف فى مصر.

3-احمد حماد الحسينى و اميل دميان (1969): بيولوجية الحيوان العملية الجزء الثالث .دار المعارف فى مصر.