

COURSE CODE: ZOO 261
COURSE TITLE: *Invertebrate Zoology*
NUMBER OF UNITS: 3 Units
COURSE DURATION: 3 Hours per week

COURSE DETAILS:

Course Coordinator: Prof Idowu, B.A.
Email:
Office Location: COLNAS BUILDING
Other Lecturer: Dr Oke, O.A.

COURSE CONTENT:

Identification, Phylogenic, General biology, behaviour and economic importance of Protozoa, Porifera, Coelenterates, Platyhelminths, Nematoda, Annelida, Mollusca, and Echinodermata including some principles of zoological nomenclature.

COURSE REQUIREMENTS:

The Course is compulsory for 300 level Zoology students of Biological Sciences Department. Students are required to participate fully in all theory and practical classes with 70% minimum attendance to qualify to write the final exam.

READING LIST:

LECTURE NOTES

GENERAL INSTRUCTIONS FOR ALL PRACTICAL ACTIVITIES

A. Make a general observation of all provided specimens.

Critical and systematic examination of the organism is vital. You should carefully examine and note the following:

- Size
- Shape/symmetry
- Colour
- External features (locomotory appendages, sensory structures, buccal and anal apertures etc).
- Internal features.

B. Comment on the basic characteristics of organisms such as

- morphology
- locomotion
- nutrition
- mode of existence
- reproduction
- behaviour

C. Every drawing assignment should incorporate

- Identification (generic and specific names when possible and common name)
- Classification of the specimen
- Annotation of the drawing
- Magnification or actual size of the specimen
- Notes of zoological interest (All drawings must be accompanied with notes on features of zoological interest).

D. All drawings and assignments should be presented in the appropriate blank pages in the manual.

E. All assignments must be signed by the class coordinator before the end of the following practical class.

PROTOZOA

Protozoa are one-celled animals found worldwide in most habitats. Most species are free living, but all higher animals are infected with one or more species of protozoa. Infections range from asymptomatic to

life threatening, depending on the species and strain of the parasite and the resistance of the host. Protozoa are **microscopic unicellular eukaryotes** that have a relatively complex internal structure and carry out complex metabolic activities. Some protozoa have structures for propulsion or other types of movement.

Protozoa are the most abundant animals in the world in terms of numbers and biomass. Their principal importance is as consumers of bacteria (*PROKARYOTES*). Bacteria play a vital role in maintaining the earth as a suitable place for inhabitation by other forms of life and protozoa play a vital role in controlling their numbers and biomass. Protozoa are also important as parasites and symbionts of multicellular animals.

Protozoa are defined as single-celled eukaryotic organisms, that feed heterotrophically and exhibit diverse motility mechanisms. However, it is impossible to draw a line between unicellular animals (consumers), plants (producers) and fungi (decomposers) and it is customary to speak of the Protista as a separate kingdom of unicellular eukaryotes that embraces *both* heterotrophic protozoa and autotrophic algae.

Protozoan diversity

Protists exhibit an enormous range of body form, even though they are largely microscopic, mainly ranging in size from 10-200 μm . Over 60,000 species have been described although you can be sure this is only a fraction of the total number of protist life forms.

The most striking differences among protozoa at the light microscope level are in the locomotory structures and the traditional classification of protozoa, found in most zoology textbooks and used within this unit, is based on these differences.

Protozoa may occur singly or in colonies (e.g. *Volvox*); may swim freely or be in contact with a substratum or be sedentary; may be housed in a shell (lorica) (e.g. foraminiferans, clothed in scales or other adhering matter, or be naked; they may or may not be pigmented. They may be parasitic (e.g. *Trypanosoma*) or symbiotic living attached to or inside other organisms (e.g. *Joenia*), even inside their cells.

Protozoan classification

Four major groups of protozoa are recognised.

The groups are:

[flagellates](#) (or Mastigophora)

[amoebae](#) (or Sarcodina)

[sporozoans](#) (or Sporozoa) and

[ciliates](#) (or Ciliophora). The above classification represents a convenient filing system.

The above classification is not therefore phylogenetic (i.e. reflecting the course of evolution). It is at present premature to try to construct a phylogenetic classification of protists, and for purposes of identification the above traditional classification is a starting point.

Flagellates

Also known as Mastigophora, the organisms are distinguished by their use of *FLAGELLA* as locomotory organelles and, in common with amoebae, usually multiply by longitudinal binary fission.

Some flagellates have a characteristic arrangement of the flagella, *DINOFLAGELLATES* for example.

Many flagellates are able to feed autotrophically as well as heterotrophically, and dinoflagellates are important primary producers (photosynthesisers) in lakes and oceans, yet they can also ingest prey and feed in an animal-like fashion.

This makes them difficult to classify and until recently flagellates were divided into plant-like Phytomastigophora and Zoomastigophora.

Probably the most structurally complex flagellates are those which live symbiotically in the guts of *WOOD-EATING INSECTS* (e.g. termites and wood roaches).

Amoebae

Amoebae move by means of flowing cytoplasm (Cytoplasmic streaming), usually with the production of pseudopodia. The pseudopodial morphology has been used in classification of amoebae.

Note that some amoebae live in shells from which the pseudopodia are extruded.

The Sarcodina (amoebae) are divided into two major groups or classes on the form of their pseudopodia.

RHIZOPODA have unsupported pseudopodia (lobopodia, filopodia or reticulopodia).

ACTINOPODA have radiating microtubule-supported axopodia

Sporozoans

These protozoa have no locomotory extensions of the body and all species are parasitic. Their motile stages move by bending, creeping and gliding and usually have an *APICAL COMPLEX* at their anterior end.

Most sporozoans are intracellular parasites or at least part of their life-cycle takes place inside a host cell. The apical complex seems to be structurally designed to assist host cell penetration.

Sporozoans reproduce by multiple fission and because they do not form true spores but all possess an apical complex the name Apicomplexa is often preferred. Malaria parasites (*Plasmodium*) and coccidians are among the most important sporzoan parasites.

Ciliates

Ciliates form an extremely large group distinguished by the possession of *CILIA*, two different types of *NUCLEUS* and transverse fission of the organism when it divides (c.f. flagellates and amoebae).

Summary: Key Features of Protozoa

Protozoa are unicellular organisms belonging to a number of different phyla.

Most are motile and heterotrophic.

Food is digested within a food vacuole.

Excess water is eliminated by means of a contractile vacuole.

Features of flagellates

Flagella are the locomotor or food-capturing organelles.

Features of amoeba

Pseudopodia are the locomotor or food-capturing organelles.

Skeletal structures are highly developed in this group.

Features of sporozoans

Ringlike, tubular, and filamentous organelles at the apical end of the body are a distinguishing feature of these parasitic protozoa.

Features of ciliates

Cilia are present at some stage in the life cycle.

Two types of nuclei are present: macronucleus and micronucleus.

Introduction to Cnidaria

Jellyfish, corals, and other s ingers

Cnidarians are incredibly diverse in form, as evidenced by colonial siphonophores, massive medusae and corals, feathery hydroids, and box jellies with complex eyes.

Yet, these diverse animals are all armed with stinging cells called nematocysts. Cnidarians are united based on the presumption that their nematocysts have been inherited from a single common ancestor.



The name Cnidaria comes from the Greek word "cnidos," which means stinging nettle. Casually touching many cnidarians will make it clear how they got their name when their nematocysts eject barbed threads tipped with poison.

Many thousands of cnidarian species live in the world's oceans, from the tropics to the poles, from the surface to the bottom. Some even burrow. A smaller number of species are found in rivers and fresh water lakes.

There are four major groups of cnidarians:

[Anthozoa](#), which includes true corals, anemones, and sea pens;

[Cubozoa](#), the amazing box jellies with complex eyes and potent toxins;

[Hydrozoa](#), the most diverse group with siphonophores, hydroids, fire corals, and many medusae; and

[Scyphozoa](#), the true jellyfish.

The phylum *Cnidaria* (pronounced nid-AIR-ee-ah) contains approximately 9000 living species worldwide. They are among the simplest of the so-called "higher" organisms, but are also among the most beautiful. The creatures in this phylum are radially symmetrical. This means that the parts of the body extend outward from the center like the spokes on a bicycle wheel. A common example of radial symmetry is the sea star (a member of the Echinoderm phylum) or the anemone, a Cnidarian (seen below).

The Cnidarians include the hydroids, jellyfish, anemones, and corals. All Cnidarians have tentacles with stinging cells in their tips which are used to capture and subdue prey. In fact, the phylum name "Cnidarian" literally means "stinging creature." The stinging cells are called cnidocytes and contain a structure called a nematocyst. The nematocyst is a coiled thread-like stinger. When the nematocyst is called upon to fire, the thread is uncoiled, and springs straight. The harpoon-like thread punctures through the cnidocyte wall and into the prey. Most Cnidarians also have a toxin in their stinger which helps to disable the prey. The nematocyst is fired either by the tentacle touching something, or in some cases by a nerve impulse from the animal telling it to fire.

Most Cnidarian's nematocysts are not harmful to humans, as the stinger cannot penetrate sufficiently into human skin to inflict any harm. There are some jellyfish, however, which can deliver extremely painful, and in a few cases, even fatal, stings to humans.

The Cnidarian can have one of two basic body types, polypoid or medusoid. The polypoid (POL-ip-oyd) is the configuration of corals and anemones, with the tentacles and mouth generally facing up, and the other side affixed to a substrate or connected to a colony of other creatures of the same species. In the Medusoid, the organism is essentially upside-down, with the mouth and

tentacles generally pointed down. These types of Cnidarians are usually free-swimmers, like jellyfish. This is why the anemone is sometimes called an upside-down jellyfish; that's just about what it is!

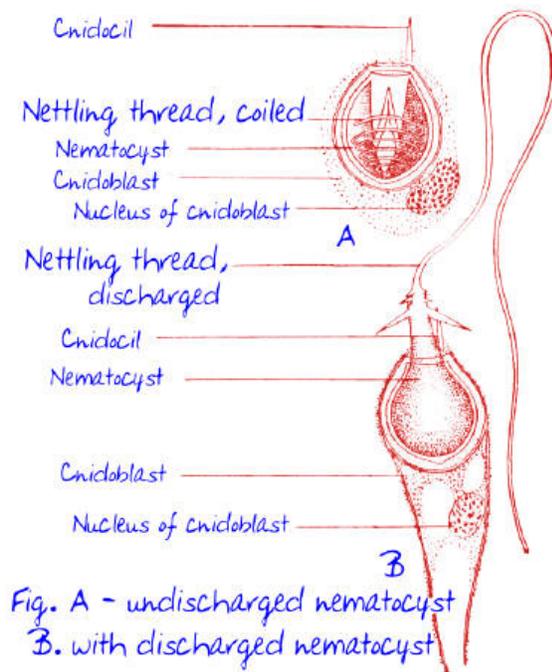
The Phylum is divided up into 3 Classes, called the Hydrozoans (meaning "water-animals"), the Anthozoans (meaning "Flower-animals") and Scyphozoans (meaning "bowl-animals").

HYDROZOANS

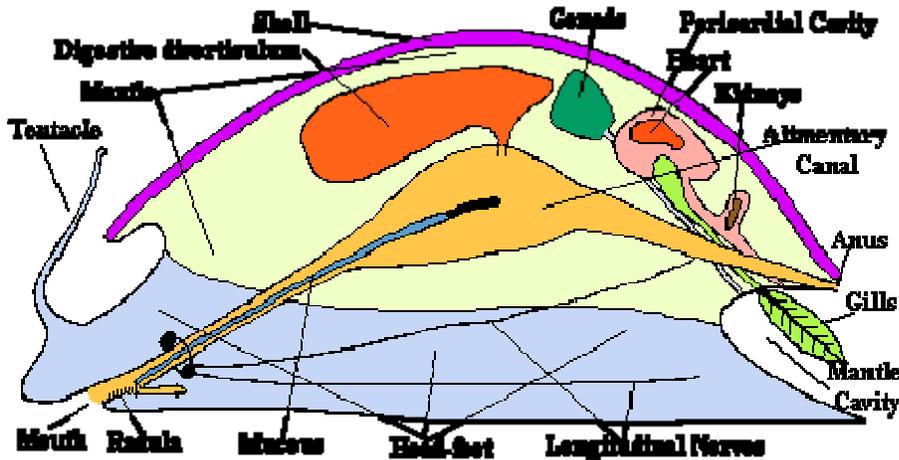
The Hydrozoans (hydroids) and Anthozoans (anemones, corals) are mostly all bottom dwelling animals, in a polypoid shape. This means that they live attached to the bottom with their tentacles and mouth pointing up. The northern Red Anemone is a good example of an Anthozoan. Some are solitary, meaning that they live alone, but some are colonial, meaning that they live in groups, connected together with living tissue, and share food resources.

SCYPHOZOANS

The Scyphozoans (SKY-foe-zo-ans) are the animals we call jellyfishes, although since they aren't real fishes, a better word is "jellies." The jellies drift along in the water generally with the mouth and tentacles pointing down. We call this a medusoid body form. Some jellies are extremely venomous to humans. Some can even kill people with enough contact of tentacle on bare skin, but most are not that dangerous, producing only a mild rash similar to that caused by poison ivy.



General Characteristics of Mollusks



Characteristics of Mollusca:-

- 1) Bilaterally symmetrical.
- 2) Body has more than two cell layers, tissues and organs.
- 3) Body without cavity.
- 4) Body possesses a through gut with mouth and anus.
- 5) Body monomeric and highly variable in form, may possess a dorsal or lateral shells of protein and calcareous spicules.
- 6) Has a nervous system with a circum-oesophageal ring, ganglia and paired nerve chords.
- 7) Has an open circulatory system with a heart and an aorta.
- 8) Has gaseous exchange organs called ctenidial gills.
- 9) Has a pair of kidneys.
- 10) Reproduction normally sexual and gonochoristic.
- 11) Feed a wide range of material.
- 12) Live in most environments.



Mollusks are a diverse phylum of invertebrate animals found predominantly in the sea, but with some members having adapted to fresh-water and terrestrial life. Living mollusks are divided into six classes: Gastropoda (snails and slugs),

Bivalvia (clams, oysters, and scallops), Cephalopoda (squids and octopi), Polyplacophora (chitons), Scaphopoda (tusk shells), and Monoplacophora (deep-ocean, limpet-like mollusks).

Mantle

- A thin tissue, called the mantle, encompasses the soft body of the mollusk and secretes a calcium carbonate shell in mollusks such as clams. Even mollusks that lack a shell, for example squid, still possess a mantle.

Feeding

- The mouth of many mollusks possesses a radula made of chitin for feeding. The radula of snails consists of small chitinous teeth embedded in muscles allowing the snail to rasp algae from substrate material or tear plant tissue from plants as they glide along the surface. The radula of squids and octopus forms a sharp beak that slices through flesh. Within this beak lies a tongue embedded with small, chitinous teeth. Bivalve mollusks lack a radula and feed by filtering the small plants and animals suspended in the water around them. Cone shells are snails that hunt other creatures using a venomous tooth made of chitin which harpoons the prey.

Foot

- The muscular foot of mollusks is another characteristic common in mollusks. Snails and slugs glide by contracting muscles within the foot. A slime trail secreted by the snail reduces abrasion between the foot and substrate. The clam's foot is a long muscle which the animal uses to burrow into sediments. Oysters attach to a substrate and have lost the need for a foot while scallops contract their adductor muscles to rapidly expel water out of the shell and propel the animal through the water. The foot of squids and octopi is located on the head of the organisms, hence the term cephalopod (cephalo meaning head, and pod meaning foot). Tentacles on cephalopods are attached to the foot allowing the animal to grasp prey.

Shells

- Most mollusks possess a calcium carbonate shell that protects their soft bodies. The shells of chitons are composed of eight interlocking plates on the dorsal region of the body. The shell of snails rides on the back of the snail allowing the protruding foot and head to retreat into the shelter when

threatened. Bivalves are so named for the two shells hinged together protecting the animal. The shell can be opened and closed using two adductor muscles located near the hinge on the anterior and posterior ends of the shell. These are the muscles cut when oysters are shucked. While squid and octopi have lost their shell, the nautilus is the only member of cephalopods still possessing a shell.

Sense Organs

- Snails sense their environment through smell and touch. Primitive eyes are located on the end of the antennae on the head allowing light detection but without the capacity of visualization of the environment. Most bivalves rely on touch and smell (chemical detection) for interpreting their environment. Scallops are equipped with eyes along the mantle again allowing for primitive light detection rather than actual seeing their surroundings. Cephalopods have sophisticated sense organs. The eyes of squid and octopi provide excellent seeing for hunting prey and detecting their environment. Squid and octopi can manipulate cells on their skin to camouflage themselves with their surroundings. These same cells are linked to communication between the animals allowing visual messages to be displayed

The Phylum Annelida

Etymology:- From the Latin *Anellus* a little ring.

Characteristics of Annelida:-

- 1) Bilaterally symmetrical and vermiform.
- 2) Body has more than two cell layers, tissues and organs.
- 3) Body cavity is a true coelom, often divided by internal septa.
- 4) Body possesses a through gut with mouth and anus.
- 5) Body possesses 3 separate sections, a prosohium, a trunk and a pygidium.
- 6) Has a nervous system with an anterior nerve ring, ganglia and a ventral nerve chord.
- 7) Has a true closed circulatory system.
- 8) Has no true respiratory organs.
- 9) Reproduction normally sexual and gonochoristic or hermaphroditic.
- 10) Feed a wide range of material.

11) Live in most environments.

The Annelida are a medium sized phylum of more than 9,000 species of worms. Most species prefer aquatic environments, but there are also a number of well known terrestrial species. Only a few species of annelids are commonly known to human beings, these include the delightful Rain, Dew or Earthworms that work so hard to make our soils healthy. e.g. *Lybrodriilus*, the Ragworms and Lugworms used by marine fishermen and the much smaller *Tubifex* or Red worms used by aquarists to feed their fish. In many countries people are still familiar with Medicinal leeches, and people who live closer to nature are naturally more familiar with a much wider range of Annelids than those who live in cities.

Despite the amazing and delicate beauty of polychaetes such as the Fan Worms, and the huge (really beyond estimation) economic debt owed by mankind to the Oligochaete Earthworms for their work in soil creation and maintenance many people still fail to appreciate their true wonder and beauty.

The earthworms, of which there are many species, are exceedingly important in soil creation, particularly in temperate areas. Without them, agriculture and perhaps the whole of human society as we know it would never have evolved. Like so much of the unnoticed invertebrate world earthworms are essential to our very existence. In marine environments the numerous species of Polychaetes play a fundamentally important role in the maintenance of food chains and the whole ecological balance of the seas, thus supporting the seemingly endless stocks of fish we like to eat.

Annelids have two main modes of existence, they either live rather quietly in holes or they live more active lives. The basic Annelid body plan is one of a head followed by a long thin body of numerous similar segments ending in a small tail. The head consists of a mouth (prostomium) and sometimes a peristomium, and the tail is more correctly called a pygidium, as it is not really a tail. Annelids are coelomate animals meaning they have a true coelom within their body. They have sets chaetae attached to each body segment, and these can be simple and small as in the Earthworms or complex and varied as in many Polychaetes. The head is often reduced and difficult to distinguish in the hole living species, but may be easily recognised, with eyes and other sensory devices in those species living a more active life.

Annelids are coelomate animals (meaning they have a true coelom, even if this is reduced secondarily). They normally have long thin bodies composed of a series of identical segments. These segments lie between the head, comprised of a prostomium, a mouth and sometimes a peristomium, and a tail called a pygidium. Growth occurs both laterally, by enlargement of the segments during the juvenile stages, and through the addition of new segments. New segments are produced by the foremost section of the pygidium. In some species they are produced throughout the animals life but in many species production stops once a certain set number of

segments has been achieved.

The Phylum Annelida is divided into 3 classes, one of which the Clitellata could really be called a Superclass, it contains three subclasses, the Oligochaeta, the Branchiobdella and the Hirundinea. The other two classes are the Polychaeta which contains the largest number of species and the Aelosomatida which contains very few.

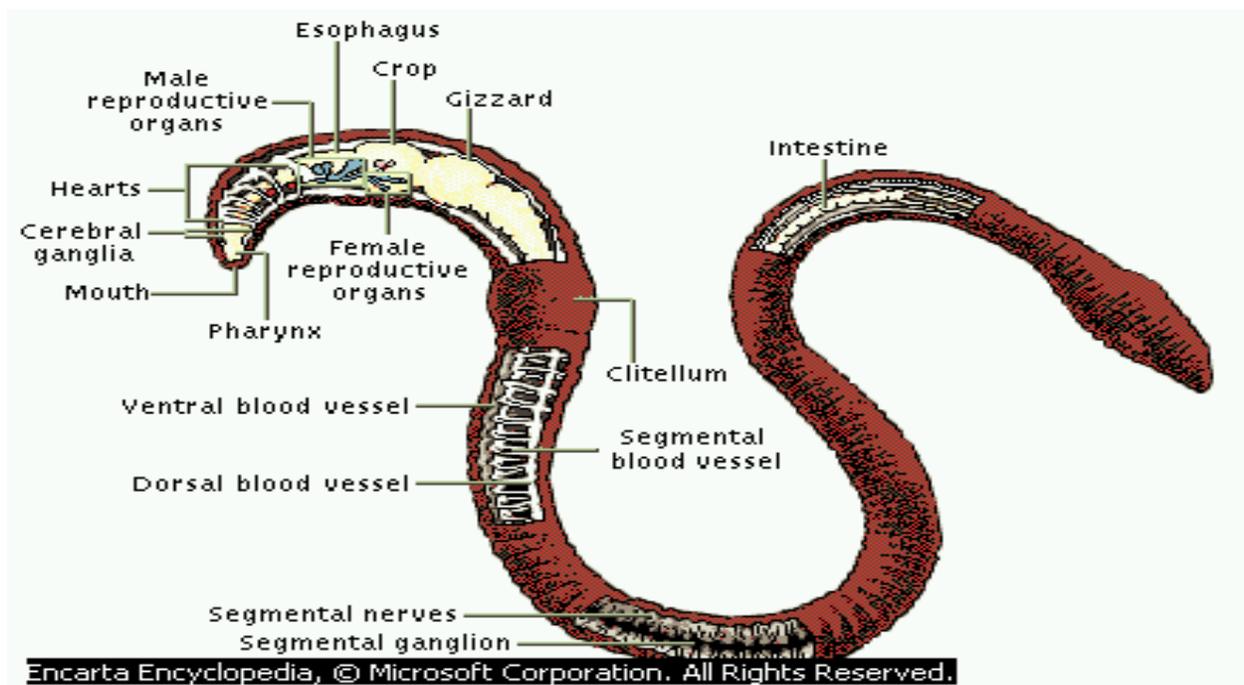
The class Polychaeta (Poly = many, Chaeta = bristle) are the most diverse and most speciose group of the Annelida containing over 5,500 species. They are predominantly marine animals and are divided ecologically into the Errantia and the Sedentaria depending on whether or not they live sedentary lives in holes or live more active lives. We now know that this is not a taxonomically valid classification but it is useful as it divides the class in two in terms of the number of families each group contains. The Errantia have well developed heads and complex parapodia (paddles) that they can use for swimming. They are often dorsoventrally flattened.

Most polychaetes are gonochoristic (meaning they are either male or female), however some are sequential hermaphrodites (meaning they are one sex first and then change to being the other sex). Reproduction is often accompanied by the production of special modified reproductive segments which may, or may not, become independent of the parent worm before mating. These segments are destroyed or die during or immediately after they have released their gametes (sperm and ova).

The class Aelosomata contains about 25 species of small to minute worms with many chaetae. They live in the interstitial zone of both fresh and brackish water environments. They are hermaphrodites with each animal possessing one ovary and two testis. They are little known to science and their classification is disputed with some authors considering them to be part of the Oligochaeta.

The class Clitellata contains three distinct groups.

- **The subclass Oligochaeta** (Oligo = few, Chaeta = bristle) are the second most numerous group of annelids with around 3,100 species. Oligochaeta live in marine, freshwater and terrestrial habitats. Generally they have a more rounded cross-section, a less distinct head and are less diverse in form than the Polychaetes. They are normally hermaphrodites, and possess a clitellum as adults, an organ which looks like a bandage of skin wrapped around the animal. This clitellum, from which the whole group takes its name has an important function in sexual reproduction, otherwise reproduction may be asexual by fission. A few species are parasitic but most species are free living. Example of Nigerian earthworm species found in UNAAB soil *Keffia proxipora*; *Millsonia nigra*; *Hippopera nigeriae* and *Libyodrilus violaceus*



The subclass **Branchiobdella** contains 147 species of small (about 1 cm long) aquatic whitish animals that are either commensals or parasites on Crayfish. They are mostly found in the northern hemisphere. Different species attach to their hosts at different places on the body, thus *Branchiobdella parastica* attaches to the under side of the abdomen while *Branchiobdella astaci* attaches to its hosts gills. *Branchiobdella hexodonta* and *B. astaci* are known to be parasitic feeding off host tissue but *B. parastica* is thought by some authorities to be a commensal.

The subclass **Hirundinea** contains the 500 or so species of animals commonly known as leeches. Leeches are well known for their blood sucking habits and their head to tail looping mode of locomotion. Except for the primitive *Acanthobdella peledina* leeches have no chaetae and 33 body segments. they have two suckers which in most cases are located one at the anterior (head) end of the body composed of segments 1-4 and the other at the posterior (tail) end composed of segments 25-33. Like the Oligochaeta from which they are believed to have evolved the Hirundinea occur in Fresh water, marine and terrestrial environments.

Arthropod

arthropod n. [Gr. *arthron*, joint; *pous*, foot] A phylum of invertebrates that contains the chitinous segmented, exoskeletoned, jointed-legged animals, such as centipedes, millipedes, insects, crustaceans, spiders, scorpions, and many other less well-known types.

Arthropods range in distribution from the deep sea to mountain peaks, in size from the king crab with its 12-foot armspan to microscopic [insects](#) and [crustaceans](#), and in taste from chocolate covered ants to crawfish jambalaya and lobster Newburg. Despite this unbelievable diversity, the basic body plan of arthropods is fairly constant. Arthropods have a stiff cuticle made largely of **chitin** and proteins, forming an exoskeleton that may or may not be further stiffened with calcium carbonate. They have segmented

bodies and show various patterns of segment fusion (**tagmosis**) to form integrated units (heads, abdomens, and so on). The phylum takes its name from its distinctive jointed appendages, which may be modified in a number of ways to form antennae, mouthparts, and reproductive organs.

Characteristics of the Arthropoda:-

- 1) Bilaterally symmetrical (in most cases).
- 2) Body has more than two cell layers, tissues and organs.
- 3) Body cavity a true coelom.
- 4) Most possesses a through straight gut with an anus (in most cases).
- 5) Body possesses 3 to 400+ pairs of jointed legs.
- 6) Body possesses an external skeleton (in most cases).
- 7) Body is divided in 2 or 3 sections.
- 8) Nervous system includes a brain and ganglia.
- 9) Possesses a respiratory system in the form of tracheae and spiracles (in most cases).
- 10) Possesses an open or lacunar circulatory system with a simple heart, one or more arteries, and no veins, (in most cases).
- 11) Reproduction normally sexual and gonochoristic, but can be parthenogenetic.
- 12) Feed on everything.
- 13) Live everywhere.

Beneficial Insects

Insects affect man's welfare in many ways. Many insects are beneficial to man.

Beneficial insects are divided into two main groups according to the nature of benefit derived from them. They are **Productive** and **Helpful insects**.

I. Productive Insects

These insects produce certain substances which are useful to humans. The important useful insect products are **Honey, Silk** and **Lac**.

A. Honey bee

Honey bees are social insects. They live as colonies. They are active throughout the year. They feed on the pollen and nectar of flowers.

The honeybees collect **nectar** from various flowers. The nectar is swallowed by the bees. In its stomach due to the action of enzymes certain changes happen to the nectar. Later in the bee hive it is regurgitated and stored in chambers as **honey**.

Apiculture or Bee keeping is the technique of rearing honey bees for honey and wax from their comb or beehives.

Uses of Honey and Bees wax

Honey has a high nutritive value. Its colour and smell varies in accordance with the nectar collected from different flowers. It is estimated that 200g of honey provides as much nourishment as 11.5 litres of milk or 1.6kg cream or 330g meat. One gram of honey provides approximately 33k.cal of energy. Honey has laxative, antiseptic and sedative characteristics. It is helpful in building up the haemoglobin of the blood. It

prevents cough, cold, and fever. It cures ulcers on tongue and alimentary canal. It is also used in the preparation of bread, cakes and biscuits.

Beeswax is also a natural secretion of the worker bee from the glands located in the abdomen. It is used in the manufacture of cosmetics, face creams, paints, ointments, insulators, plastic works, polishes, carbon paper and many other lubricants. It is also used in microtomy for block preparation of tissues.

B. Silk worms

Silk is another valuable product from the insect world. The silk is obtained as fine threads from the cocoons of various species of silkworms. **Sericulture** is the scientific management of production and marketing of natural silk from silkworms.

Types of Silk worms

1. **Mulberry silkworm - *Bombyx mori*** : This is a completely domesticated insect. Since the natural food of this worm is mulberry leaves, it is called mulberry silk worm. The silk produced by this moth is white in colour. It is called the mulberry silk.

2. **Tasar Silk worm : *Antheraea paphia***

This caterpillar feeds on ber, oak, sal and fig plants. The cocoon produced by this worm is smooth and hard. It is of hen's egg size. The cocoon yields reelable, brown coloured Tasar silk.

3. **Muga Silk worm: *Antheraea assamensis***: The native place of this species is Assam where it has now become a good source of cottage industry. The silk produced by this moth is known as **Muga silk**.

4. **Eri Silk worm : *Attacus ricinii***

The caterpillar of this worm feeds on castor leaves. The cocoons of this worm have very loose texture and the silk produced is called as **Arandi silk** locally. The threads are not glossy but much durable.

The sericulture plays a significant role some economy of the world.

Uses of silk

The raw silk is used in the manufacture of woven materials, knitted fabrics and garments. It is also used in parachutes, parachute cords, fishing lines, as sieves in flour mills, insulation coil for telephones and wireless receivers, and tyres of racing cars.

C. Lac insects

Another useful product we get from insects is **lac**. Lac is the resinous protective secretion produced by a kind of scale insect called ***Laccifer lacca***. They secrete a brown resinous substance called the **lac**. The minute red coloured larva of this insect, settles on succulent shoots of the host plants. While growing they secrete a resinous material which covers them. The twigs are harvested and the encrustations scraped, dried and processed to yield the lac of commerce.

The important trees needed for lac encrustation are the kusum, the Ber, Palas, Babul and sal. These trees are common in the western ghats.

Uses of lac

Lac is one of the most versatile natural resinous material. It has a unique combination of properties which render it useful in the plastics, electrical, adhesive, leather, wood finishing and other industries. In the electrical industry it used in the form of insulating varnishes and moulded insulators. It possesses very good adhesion to mica. It is an ingredient of varnishes, polishes, finishes wood used for protective and decorative purposes. It is a principal ingredient of sealing wax. It is also used in the manufacture of glazed paper, printing and water proof inks, nail polishes, dental plates, ammunition, bangles, wax crayons and optical frames.

II. Helpful Insects

This category of insects includes all forms which by their life activities help man in controlling the plant and animal pests. The most important of these helpful insects are the **insect feeding or entomophagous** forms including predators and parasites. These are important in maintaining a balance in insect populations.

Insect - Predators

These are generally larger than their prey. They can pounce upon and devour the prey easily. Among the insect predators, **lady bird beetles** are more useful to the farmers and gardeners. These small beetles are voracious and are highly prolific and long-lived. Both larvae and adults feed on a wide range of insects. Other common and well known predators are **Aphis lions** and **ground beetles**.

Insect parasites

Insect parasites are smaller than their hosts. They live continuously for atleast a part of their lifecycle on or within the body of the host. The **tachinid flies** parasitize caterpillars, beetles and other groups of insects. The **braconids** are a large group of small wasp-like insects that parasitize a wide range of insects including plant lice and caterpillars. Most group of insects are plagued by **ichneumon** parasites.

Employing insect **predators** and **parasites** for controlling the population of insect pests is known as **biological control**.

Insects as pollinators

Insects play an important role in the pollination of plants. Bees, wasps, ants, butterflies, beetles and thrips render valuable service in pollination. The services of honey bees are needed in the production of cultivated crops, such as apples, pears, plums and vegetables. Some plants like the yucca and smyrna fig are completely dependent upon insects for pollination.

Other useful insects

A number of insects feed on plants and they may aid in keeping plant weeds under control. The most successful use of an insect in the control of a plant was the introduction of the caterpillar of a moth (*cactoblastis cactorum*) to control the prickly pear (*Opuntia* spp) in Australia.

The Echinoderms

The echinoderms are marine forms and include Sea stars, brittle stars, sea urchins, sea cucumbers and sea lilies.

The most noticeable characteristics of the echinoderms are (1) the spiny endoskeleton plates, (2) The water –vascular system, (3) the pedicellariae, (4) the dermal branchiae, (5) radial or biradial symmetry.

Although their free-swimming embryos are bilaterally symmetrical, echinoderm adults have radial symmetry, an adaptation to a sluggish, or in some forms a sessile, existence.

Most echinoderms lack a head and move very slowly in any direction as they feed on algae or small particles sifted from sand or water.

The sea star, though, is a predator. It can slowly pursue prey (including bivalve molluscs) from any direction.

Echinoderms move on numerous tiny tube feet, delicate cylindrical projections that extend from the lower surface of the body and terminate in a suction cup.

Tube feet are part of a unique echinoderm feature, the water-vascular system, which functions in locomotion, respiration and food capture.

Echinoderms have a relatively simple nervous system with no distinct brain. Movements are loosely coordinated by a system of a nerve ring encircling the oesophagus, radial nerves to the rest of the body, and a nerve network to the epidermis.

The echinoderms lack a circulatory system, although movement of the fluid in their well-developed coelom serves the function.

Gas exchange occurs through the tube feet, in some forms, numerous tiny “skin gills” project through the epidermis.

Most species reproduce by shedding sperm and eggs into the water, where fertilization occurs and a free-swimming larva develops. Sexes are separate. Sea stars have the ability to regenerate lost parts; new individuals may form from a single arm, provided that part of the central body is attached to it.

Echinoderms possess an endoskeleton composed of plates of calcium carbonate beneath the outer skin.

Phylum Echinodermata

Class Stelleroidea (1) Sea stars *Asterias*

(2) Brittle stars *Ophiuroid*

Class Echinoidea (1) Sea urchins *Lytechinus*

(2) Sand dollars *Dendraster*

(3) Heart urchins

Class Holothuroidea (1) Sea cucumber *Cucumaria*

Class Crinoidea (1) Sea Lillies *Antedon*

(2) Feather stars