PRACTICAL MANUAL

PRINCIPLES OF SYSTEMATICS (ZOO103)

Practical no. 1

Study of preserved invertebrate species and their classification upto class level a. Sponges

1.1 Porifera- sponges:

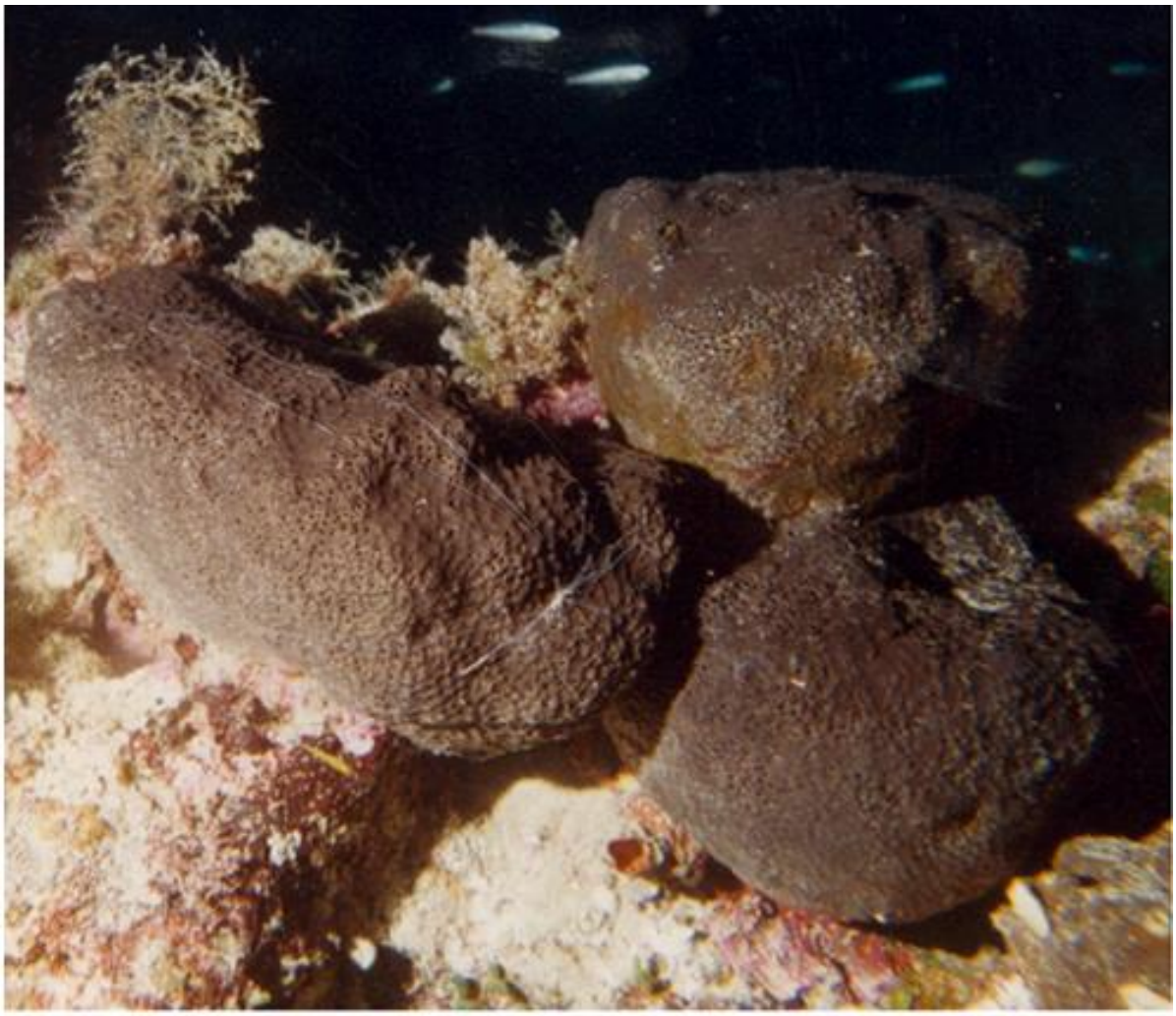
Phylum Porifera consists of sponges. There are around 800 different types of sponges. Most of which are marine. Freshwater fishes are filter feeders they use their body to trap any minute fishes. They are sessile. They are asymmetrically shaped and is made up of a protein called sponging and hard filaments called spicules which is made from calcium carbonate and silicon dioxide. The body of sponges has pores or gaps through which water enters their bodies. Sponges have a cellular level of organization. Choanocytes are cells that line the pores in a sponge and has a flagellum that twists to pull in water. Amebocytes are cells responsible for delivering the cells to every part of the sponge's body. Excess of water in the body leaves the body through the osculum. Sponges reproduce both sexually and asexually.

Sponges reproduce asexually by 1) external or internal buds

2) Fragmentation

Sponges can reproduce sexually. The male sponge releases the sperm into the water which enters the body of the female sperm. Fertilization takes place inside the body of the female sponge after which larvae released to the water.

1.1.1 Bath sponge (*Spongia officinalis*)



Kingdom:	Animalia
Phylum:	Porifera
Class:	Demospongiae
Order:	Dictyoceratida
Family:	Spongiidae
Genus:	*Spongia*
Species:	*S. officinalis*

Spongia officinalis grows in massive, globular lobes with fine openings which are slightly elevated and have cone-shaped voids (conules). Oscula can either be scattered or at the tip of the lobes.

Spongia officinalis have an ectosomal skeleton composed of primary and secondary fibers, Together, they form the conulose openings. The sponge also contains a choanosomal skeleton, which consists of a dense, irregular mesh of polygons formed by secondary fibers and primary fibers rise from it. The primary fibers are 50 to 100 nanometers in diameter and are composed of spongin and inclusions such as sand grains and spicules. The secondary

fibers are 20 to 35 nanometers in diameter and are composed of only spongin without inclusions.

Spongia officinalis is light grey to black in color.

Practical no. 2.

Study of preserved invertebrate species and their classification upto class level b. Cnidarians

1.2 Cnidaria

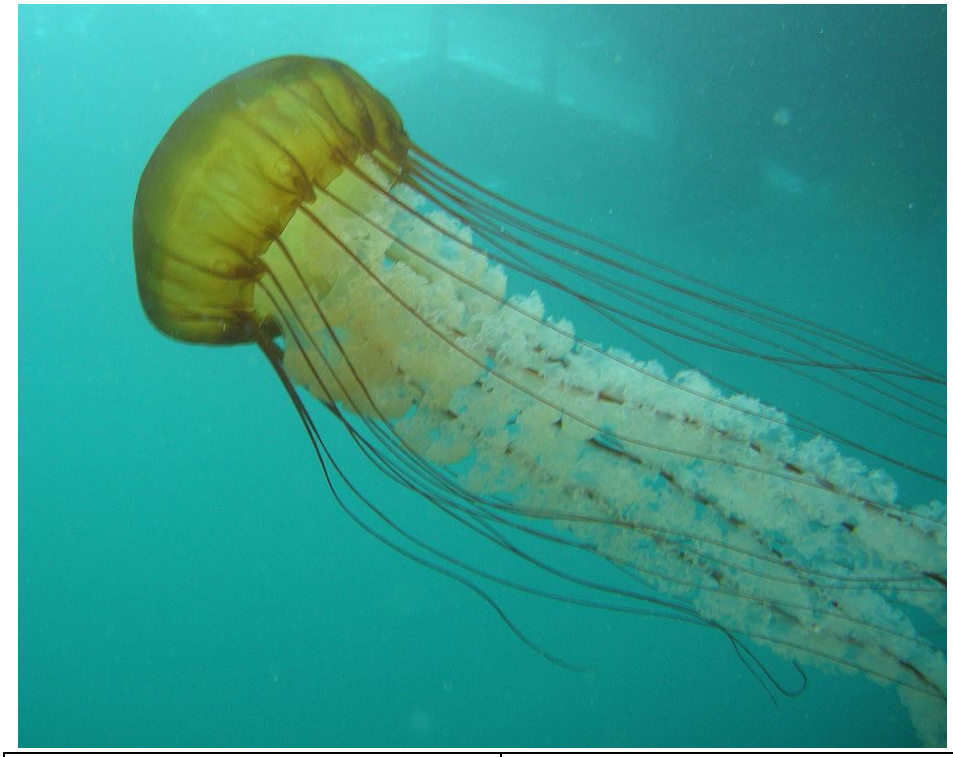
Phylum Cnidaria includes sea anemones, jellyfishes, hydra and corals. Except for hydra (freshwater organism), all the other cnidarians are marine. They have a spiral symmetry and have appendages that help them meet their nourishment. Cnidarians display two body shapes:

1) Polyp: They are sessile. They have arms and mouth at the top.

2) Medusa: They are motile with arms and mouth at the base.

Cnidarians may exist in both the forms at different stages of their life cycle or may exist in one of these two phases. Cnidarians have an empty gastrovascular pit which is fixed within the gastrodermis. Epidermis covers the outside of the cnidarian and jelly-like material called mesoglea is present between the layers. The special structure of the cnidarians is their stinging structure.

1.2.1 Jelly fish: Sea nettles (*Chrysaora fuscescens*)



Kingdom:	Animalia
Phylum:	Cnidaria
Class:	Scyphozoa

Order:	Semaeostomeae
Family:	Pelagiidae
Genus:	*Chrysaora*
Species:	*C. fuscescens*

Sea nettles have a distinctive golden-brown bell with a reddish tint. The bell can grow to be larger than one meter (three feet) in diameter in the wild, though most are less than 50 cm across. The long, spiraling, white oral arms and the 24 undulating maroon tentacles may trail behind as far as 15 feet (4.6 m). For humans, its sting is often irritating, but rarely dangerous.

Chrysaora fuscescens has proven to be very popular for display at public aquariums due to their bright colors and relatively easy maintenance. It is possible to establish polyps and culture *Chrysaora* in captivity. When provided appropriate aquarium conditions, the medusae do well under captive conditions.

Chrysaora fuscescens swim using jet propulsion by squeezing their bell and pushing water behind them, allowing them to swim against currents, although most of the time they prefer to simply float. Sometimes they pick up hitchhikers, including small fish and crabs, which hide inside the sea nettle's bell and may feed on it.

The *Chrysaora Fuscescens* use light sensing organs called ocelli to migrate from the deeper waters of the ocean to the surface.

1.2.2 Hydra*: Hydra vulgaris*

Kingdom:	Animalia
Phylum:	Cnidaria
Class:	Hydrozoa
Order:	Anthoathecata
Family:	Hydridae
Genus:	*Hydra*
Species:	*H. vulgaris*

The hydra have four to twelve tentacles that protrude from just outside the mouth. They feed by extending their tentacles and waiting for food to touch the tentacles. They then bring the food to their mouth, ingest and digest the organism. Anything that cannot be digested is egested. Ingestion and egestion occur through the mouth.

Like other hydras, *Hydra vulgaris* cling to a base object with a "foot" pad, shaped like a disk. The *Hydra* moves by releasing its grip on its base and is carried away by the current. *H. vulgaris* can also move by bending over, grabbing a surface with its tentacles, releasing its grip with its "foot" and flipping over itself.

Practical no. 3

Study of preserved invertebrate species and their classification upto class level c. Platyhelminthes

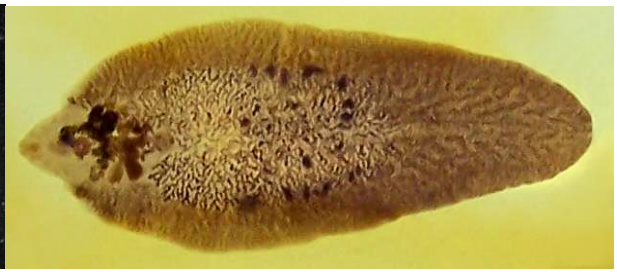
1.3 Platyhelminthes (Flatworms)

One main feature of phylum Platyhelminthes is that they are dorsoventrally smoothed and flattened. They have a definite posterior end and anterior end. This gives them a bilateral symmetry. Their bodies are rather strong and hence they are said to be acoelomate. A few flatworms are parasites. Others exist as free-living scroungers or carnivores. Examples of such flatworms are flukes and tapeworms. Flatworms have just a mouth for both nourishment and discharging wastes. Their sensory system is formed by a nerve net. They have eyespots that are light-sensitive at the foremost end. They also have particular flame cells to dispose of the waste. The most widely recognized free-living flatworm found in water or wet spots in the planarian. They are bisexuals.

Tapeworms are partitioned into areas called proglottids. The proglottids each have an entire reproductive framework which creates fertilized eggs. Tapeworms are bisexual. Tapeworm's front end is known as the scolex. It is adjusted with both snares and suckers so that it joins to the host's digestive tracts. Tapeworm eggs are known to withstand bubbling water.

Flukes have complex life cycles and it includes multiple hosts. Schistosomiasis is an ailment that affects the kidneys and liver which is caused by a fluke. No cure has been discovered yet.

1.3.1 Fluke: common liver fluke (*Fasciola hepatica*)

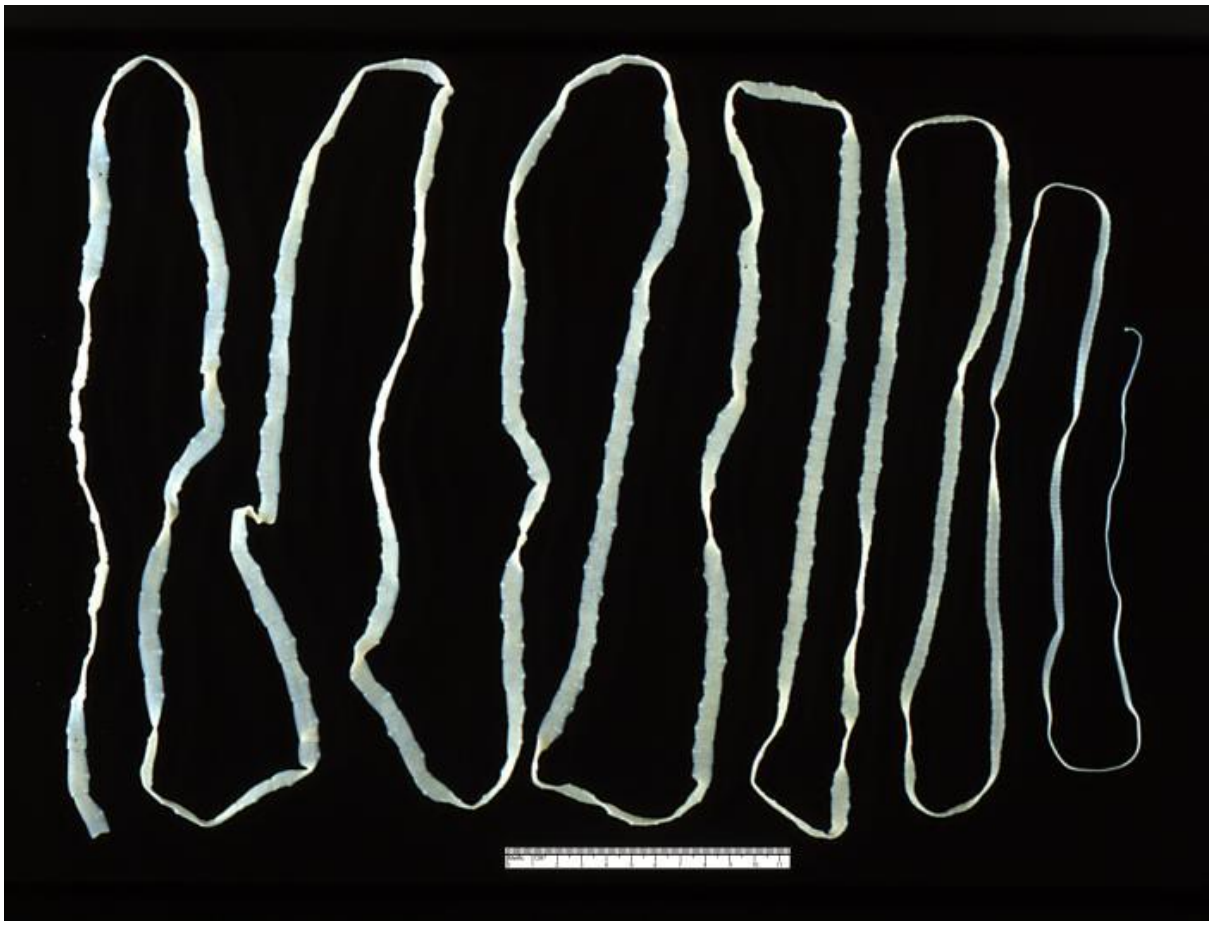


Kingdom:	Animalia
Phylum:	Platyhelminthes
Order:	Plagiorchiida
Family:	Fasciolidae
Genus:	*Fasciola*
Species:	*F. hepatica*

Fasciola hepatica, also known as the common liver fluke or sheep liver fluke, is a parasitic trematode (fluke or flatworm, a type of helminth) of the class Trematoda, phylum

Platyhelminthes. It infects the livers of various mammals, including humans, and is transmitted by sheep and cattle to humans the world over. The disease caused by the fluke is called fasciolosis or fascioliasis, which is a type of helminthiasis and has been classified as a neglected tropical disease. Fasciolosis is currently classified as a plant/food-borne trematode infection, often acquired through eating the parasite's metacercariae encysted on plants. *F. hepatica*, which is distributed worldwide, has been known as an important parasite of sheep and cattle for decades and causes significant economic losses in these livestock species, up to £23 million in the UK alone. Because of its relatively large size and economic importance, it has been the subject of many scientific investigations and may be the best-known of any trematode species.

1.3.2 Tapeworm: beef tapeworm (*Taenia saginata*)



Kingdom:	Animalia
Phylum:	Platyhelminthes
Class:	Cestoda
Order:	Cyclophyllidea
Family:	Taeniidae
Genus:	*Taenia*
Species:	*T. saginata*

Taenia saginata commonly known as the beef tapeworm, is a zoonotic tapeworm belonging to the order Cyclophyllidea and genus Taenia. It is an intestinal parasite in humans causing taeniasis (a type of helminthiasis) and cysticercosis in cattle. Cattle are the intermediate hosts, where larval development occurs, while humans are definitive hosts harbouring the adult worms. It is found globally and most prevalently where cattle are raised and beef is consumed. It is relatively common in Africa, Europe, Southeast Asia, South Asia, and Latin America.[1] Humans are generally infected as a result of eating raw or undercooked beef which contains the infective larvae, called cysticerci. As hermaphrodites, each body segment called proglottid has complete sets of both male and female reproductive systems. Thus, reproduction is by self-fertilisation. From humans, embryonated eggs, called oncospheres, are released with faeces and are transmitted to cattle through contaminated fodder. Oncospheres develop inside muscle, liver, and lungs of cattle into infective cysticerci.

Practical no. 4

Study of preserved invertebrate species and their classification upto class level d. Nematodes

1.4 Nematoda (Roundworms)

Roundworms are barrel-shaped organisms. Their size varies from minute to 20 inches long. Roundworms are pseudocoelomate; they have a body pit that is not totally lined.

1.4.1 Roundworm: Ascaris lumbricoides

Kingdom:	Animalia
Phylum:	Nematoda

Class:	Chromadorea
Order:	Ascaridida
Family:	Ascarididae
Genus:	*Ascaris*
Species:	*A. lumbricoides*

Ascaris lumbricoides is characterized by its great size. Males are 2–4 mm (0.08–0.2 in) in diameter and 15–31 cm (5.9–12 in) long. The male's posterior end is curved ventrally and has a bluntly pointed tail. Females are 3–6 mm (0.1–0.2 in) wide and 20–49 cm (7.9–19 in) long. The vulvais located in the anterior end and accounts for about one-third of its body length. Uteri may contain up to 27 million eggs at a time, with 200,000 being laid per day. Fertilized eggs are oval to round in shape and are 45–75 μm (0.0018–0.0030 in) long and 35–50 μm (0.0014–0.0020 in) wide with a thick outer shell. Unfertilized eggs measure 88–94 μm (0.0035–0.0037 in) long and 44 μm (0.0017 in) wide.

Intestinal nematode infections affect one fourth to one third of the world's population. Of these, the intestinal roundworm *Ascaris lumbricoides* is the most common. While the vast majority of these cases are asymptomatic, infected persons may present with pulmonary or potentially severe gastrointestinal complaints. Ascariasis predominates in areas of poor sanitation and is associated with malnutrition, iron-deficiency anemia, and impairments of growth and cognition.

1.4.2 Hookworm: Necator americanus

Kingdom:	Animalia
Phylum:	Nematoda
Class:	Chromadorea
Order:	Rhabditida
Family:	Ancylostomatidae
Genus:	*Necator*
Species:	*N. americanus*

Necator americanus is a species of hookworm (a type of helminth) commonly known as the New World hookworm. Like other hookworms, it is a member of the phylum Nematoda. It is an obligatory parasitic nematode that lives in the small intestine of human hosts. Necatoriasis—a type of helminthiasis—is the term for the condition of being host to an infestation of a species of *Necator*.

This parasite has two dorsal and two ventral cutting plates around the anterior margin of the buccal capsule. It also has a pair of subdorsal and a pair of subventral teeth located close to the rear. Males are usually 7–9 mm long, whereas females are about 9–11 mm long. The typical lifespan of these parasites is 3–5 years. They can produce between 5,000 and 10,000 eggs per day.

Practical no. 5

Study of preserved invertebrate species and their classification upto class level e. Rotifers

1.5 Rotifers

The phylum Rotifera have a crown of cilia at the head-enveloping their mouth for development and eating. Their bodies are protected with an external layer of chitin. Having separate genders, their reproduction is sexual. A few animal categories contain just females. They reproduce by parthenogenesis.

1.5.1 Rotifers: Brachionus plicatilis

Kingdom:	Animalia
Phylum:	Rotifera
Class:	Monogononta
Order:	Ploima
Family:	Brachionidae
Genus:	*Brachionus*
Species:	*B. plicatilis*

Brachionus plicatilis is a euryhaline (tolerate a wide range of salinity) rotifer in the family Brachionidae, and is possibly the only commercially important rotifer, being raised in the aquaculture industry as food for fish larvae. It has a broad distribution in salt lakes around the world and has become a model system for studies in ecology and evolution.

Practical no. 6

Study of preserved invertebrate species and their classification upto class level f. Annelids

1.6 Annelids (Segmented Worms)

The phylum Annelida consists of the segmented worms and is plentiful in the environment... External segments can be seen as a ring-like structure along the body. Segmentation gives worms more adaptability in terms of development and movement. Annelids have a tube inside their tube body arrangement known as a Coelom. It is completely lined and contains the body organs. Annelids are known to have bilateral symmetry, a developed mind and various sense organs demonstrating cephalization. The hydrostatic skeleton is present in the form of a coelomic liquid,

Worms have a place in phylum Annelida. Every segment of the earthworm has setae which are external abounds made of chitin. These help the earthworm to move and to tunnel into the soil. Earthworms are known to have a head and a central sensory system. Earthworms breathe through their moist skin.

Bloodsuckers or leeches are also present in the phylum Annelida. Most parasites live in water and suckers are present at both finishes of their bodies

1.6.1 **Earthworm:** ***Amynthas mekongianus***

Kingdom:	Animalia

Phylum:	Annelida
Class:	Clitellata
Order:	Opisthopora
Suborder:	Lumbricina
Family:	Megascolecidae
Genus:	*Amynthas*
Species:	*A. mekongianus*

Amynthas mekongianus, the Mekong worm or Mekong giant earthworm is a species of earthworm in the family Megascolecidae.

The Mekong giant earthworm may grow to a length of up to 2.9 m (10 ft). Compared to their great length, these worms are relatively slender. The type specimen was one metre long and 8 mm (0.3 in) wide at the broadest point (segment 5). It had 370 segments and was a greyish colour, rather paler on the ventral surface. The prostomium was poorly preserved. The second segment had 46 setae (bristles) in an incomplete ring with a gap on the ventral surface. Segments 3 to 25 bore about 100 setae each, arranged in a complete ring. The male pores were on segment 17, but this specimen was immature and lacked a clitellum.

Unlike most other species of giant earthworm, which generally inhabit pastureland, the Mekong worm burrows into the muddy banks of the River. The worm forms complex networks of tunnels and brings large quantities of ingested soil to the surface in the form of worm castings. The worms may be collected from the mud, but are more easily collected from underwater at depths around 40 cm (16 in). Little is known of the worm's ecology.

1.6.2 Leeches: *Hirudo medicinalis*

Kingdom:	Animalia
Phylum:	Annelida
Class:	Clitellata
Subclass:	Hirudinea
Order:	Arhynchobdellida
Family:	Hirudinidae
Genus:	*Hirudo*
Species:	*H. medicinalis*

Hirudo medicinalis, the European medicinal leech, is one of several species of leeches used as "medicinal leeches".

The general morphology of medicinal leeches follows that of most other leeches. Fully mature adults can be up to 20 cm in length, and are green, brown, or greenish-brown with a darker tone on the dorsal side and a lighter ventral side. The dorsal side also has a thin red stripe. These organisms have two suckers, one at each end, called the anterior and posterior suckers. The posterior is used mainly for leverage, whereas the anterior sucker, consisting of the jaw and teeth, is where the feeding takes place. Medicinal leeches have three jaws (tripartite) that resemble saws, on which are approximately 100 sharp edges used to incise the host. The incision leaves a mark that is an inverted Y inside of a circle. After piercing the

skin, they suck out blood whilst injecting anticoagulants (hirudin). Large adults can consume up to ten times their body weight in a single meal, with 5–15 mL being the average volume taken. These leeches can live for up to a year between feeding.

Medicinal leeches are hermaphrodites that reproduce by sexual mating, laying eggs in clutches of up to 50 near (but not under) water, and in shaded, humid places. A study done in Poland, concluded that they have been found inside the nest of large aquatic birds although, their effect on the bird is largely unknown.

Practical no. 7

Study of preserved invertebrate species and their classification upto class level g. Mollusks

1.7 Mollusks

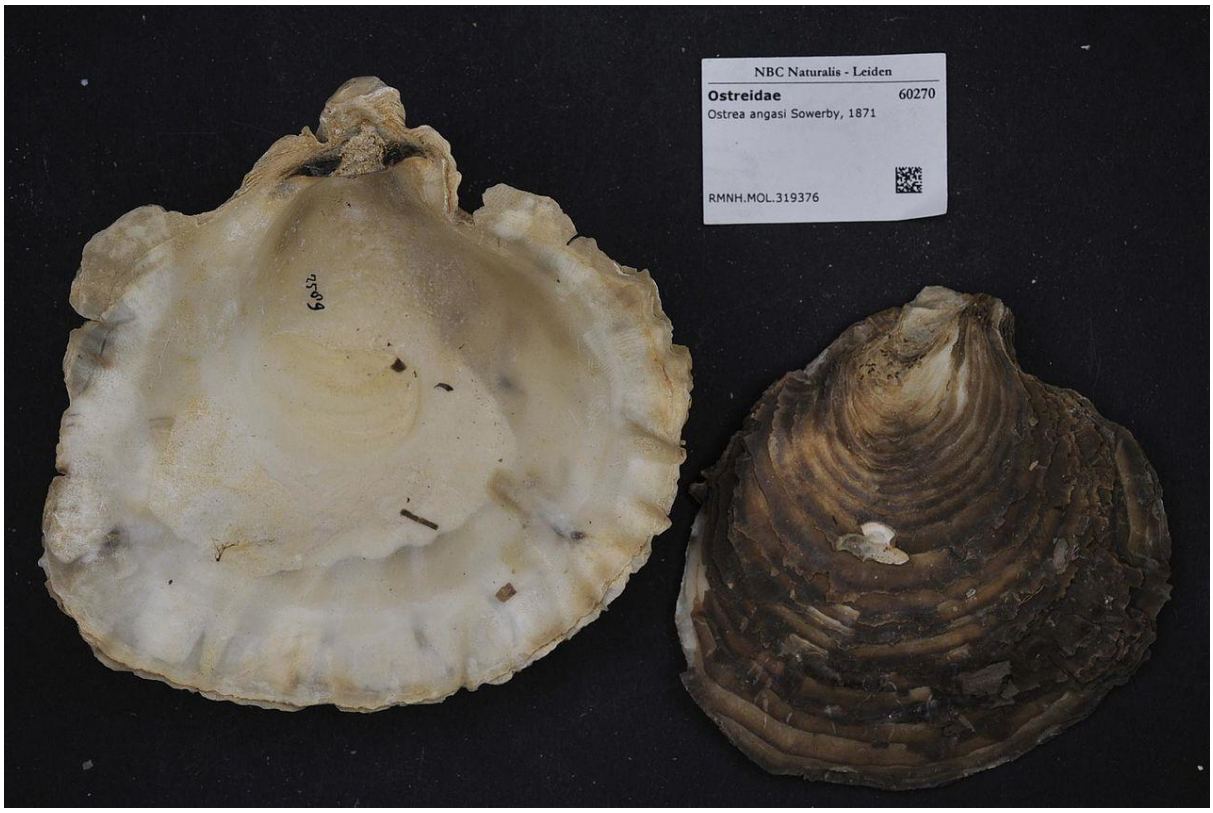
The phylum Mollusca consists of bivalves, octopus, snails and slugs, squid, and the chambered nautilus. They generally have sturdy limestone shells and are found in all natural surroundings. Mollusks have bilateral symmetry. Mollusks inhale through gills or lungs which is situated underneath a defensive layer called the mantle. All mollusks with a peculiar exception of bivalves possess a rasping, tongue-like radula for scratching sustenance. The circulatory framework includes a three-chambered heart and open-streaming framework but octopuses and squids are exceptions.

Gastropods have a foot on their stomach. Snails are a case of gastropod. When a snail does not have a shell it is called a slug. Snails and slugs stroll on their paunch. Marine snails have gills whereas land snails also called pulmonate snails to have an air gap for relaxing.

The class of mollusk called Bivalvia consists of shellfishes, clams, mussels, and scallops. These mollusks have two shells pivoted together by a tendon and solid adductor muscles are used to open and close the shells. They have gills. They move by stream drive.

Cephalopods have a foot on their head like octopus, squid, and nautilus. Most cephalopods possess mouths, arms, and jaws and are dynamic predators. They are in need of external shells apart from the Nautilus. Octopus's shell exits within their body.

1.7.1 Oyster: *Ostrea angasi*



Kingdom:	Animalia
Phylum:	Mollusca
Class:	Bivalvia
Order:	Ostreida
Family:	Ostreidae
Genus:	*Ostrea*
Species:	*O. angasi*

The southern mud oyster, Australian flat oyster, native flat oyster, native mud oyster, or angasi oyster (*Ostrea angasi*), is endemic to southern Australia, ranging from Western Australia to southeast New South Wales and around Tasmania. This species is found in sheltered, silty or sand-bottomed estuaries at depths between 1 and 30 metres. Flat oysters, like all other oyster species, are filter feeders, feeding on, and taking in anything small enough to be filtered in their gills. This may include plankton, microalgae or inorganic material.

1.7.2 Snail: *Helix pomatia*

Kingdom:	Animalia
Phylum:	Mollusca
Class:	Gastropoda
Order:	Stylommatophora
Superfamily:	Helicoidea
Family:	Helicidae
Genus:	*Helix*
Species:	*H. pomatia*

Helix pomatia, common names the Roman snail, Burgundy snail, edible snail, or escargot, is a species of large, edible, air-breathing land snail, a pulmonate gastropod terrestrial mollusc in the family Helicidae.

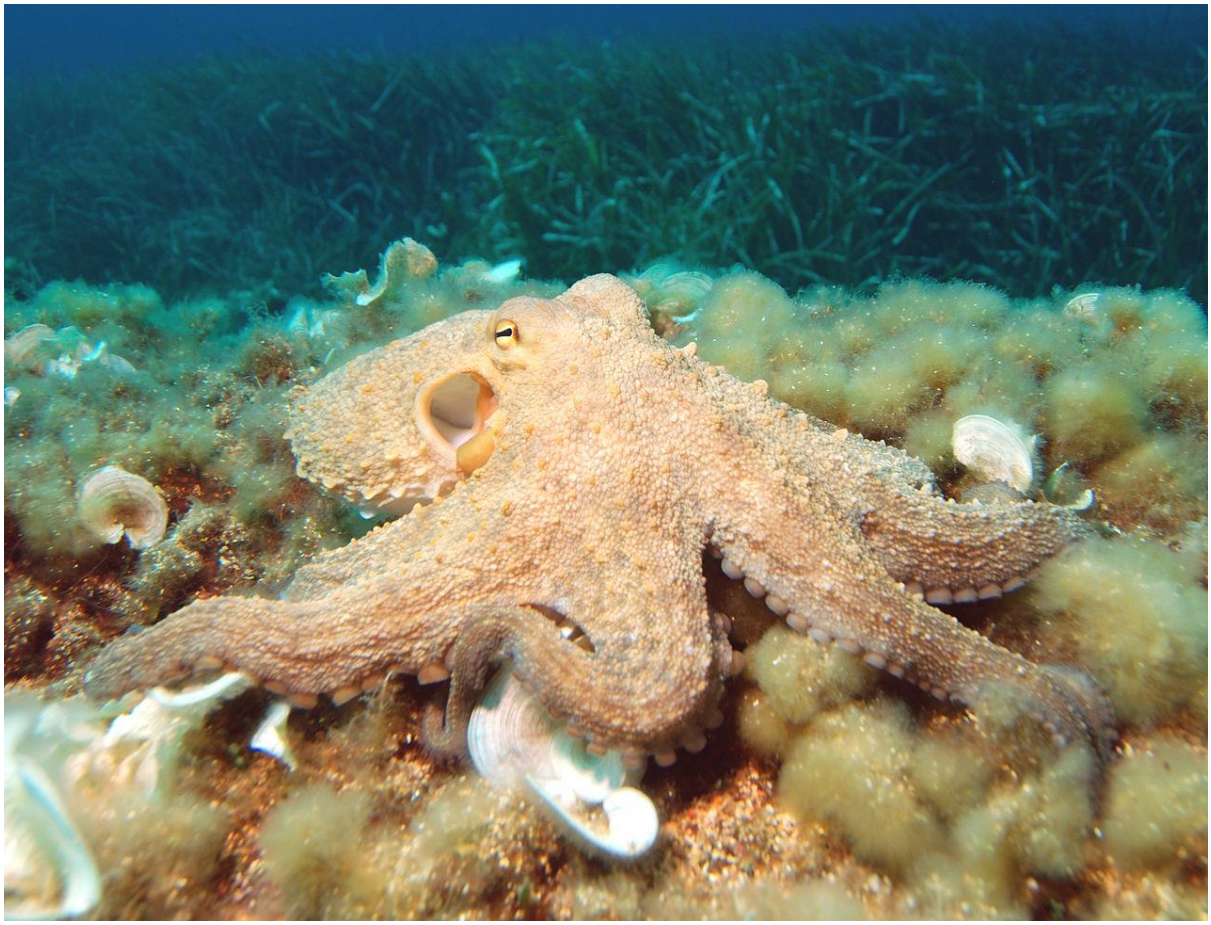
The shell is creamy white to light brownish, often with indistinct brown colour bands. The shell has five to six whorls. The aperture is large. The apertural margin is white and slightly reflected in adult snails. The umbilicus is narrow and partly covered by the reflected columellar margin.

The width of the shell is 30–50 mm. The height of the shell is 30–45 mm.

H. pomatia lives in forests, open habitats, gardens, and vineyards, especially along rivers, confined to calcareous substrate. t prefers high humidity and lower temperatures, and needs

loose soil for burrowing to hibernate and lay its eggs. It lives up to 2100 m above sea level in the Alps, but usually below 2000 m.

1.7.3 Octopus: *Octopus vulgaris*



Kingdom:	Animalia
Phylum:	Mollusca
Class:	Cephalopoda
Order:	Octopoda
Family:	Octopodidae
Genus:	*Octopus*
Species:	*O. vulgaris*

Octopus vulgaris grows to 25 cm (10 inches) in mantle length with arms up to 1 m (3.3 feet) long. It lives for 1–2 years and may weigh up to 9 kg (20 pounds). Mating may become cannibalistic.[5] O. vulgaris is caught by bottom trawls on a huge scale off the northwestern coast of Africa. More than 20,000 tonnes (22,000 short tons) are harvested annually.

The common octopus hunts at dusk. Crabs, crayfish, and bivalve molluscs (such as cockles) are preferred, although the octopus eats almost anything it can catch. It is able to change colour to blend in with its surroundings and is able to jump upon any unwary prey that strays

across its path. Using its beak, it is able to break into the shells of shelled molluscs. It also possesses venom to subdue its prey.

They have evolved to have large nervous systems and brains. An individual has about 500 million neurons in its body, almost comparable to dogs. They are intelligent enough to distinguish brightness, navigate mazes, recognize individual people, learn how to unscrew a jar or raid lobster traps.

The common octopus has worldwide distribution in tropical, subtropical and temperate waters throughout the world. They prefer the floor of relatively shallow, rocky, coastal waters, often no deeper than 200 m (660 feet). Although they prefer around 36 grams per liter (0.0013 lb/cu in), salinity throughout their global habitat is found to be between roughly 30 and 45 grams per liter (0.0011 and 0.0016 lb/cu in). They are exposed to a wide variety of temperatures in their environments, but their preferred temperature ranges from about 15 to 16 °C (59 to 61 °F).

Practical no. 8

Study of preserved invertebrate species and their classification upto class level h. Arthropods (Chelicerata)

1.8 Chelicerata

Chelicerata is a division within the Arthropoda, containing animals such as spiders, scorpions, harvestmen, mites and ticks. Like all arthropods, they have a segmented body and segmented limbs and a thick chitinous cuticle called an exoskeleton. Chelicerates have two body segments; a cephalothorax and an abdomen. They have no antennae, but have six pairs of appendages. The most anterior appendages are called the chelicerae and are normally modified into pincers or fangs. The following pair, the pedipalps, are also commonly modified. The posterior four pairs of appendages are normally used for walking. Other than the marine horseshoe crabs, the Chelicerata are found primarily in terrestrial environments worldwide. Around 8,000 described species are found in Australia, with approximately 80,000 recognised species worldwide. The only class within Chelicerata which is not entirely marine is the Arachnida. The arachnids are grouped into ten orders, the Scorpiones (scorpions), the Pseudoscorpiones (pseudoscorpions), the Araneae (spiders), the Amblypygi (whip-spiders), the Shizomida (schizomids), the Palpigradi (palpigrades), the Opiliones (harvestmen), and three groups of mites and ticks: Opilioacariformes, Acariformes and Parasitiformes.

1.8.1 Horseshoe Crab: *Limulus polyphemus*

Kingdom:	Animalia
Phylum:	Arthropoda
Subphylum:	Chelicerata
Order:	Xiphosura
Family:	Limulidae
Genus:	*Limulus*
Species:	*L. polyphemus*

Horseshoe crabs have been around for more than 300 million years, making them even older than dinosaurs. They look like prehistoric crabs, but are actually more closely related to scorpions and spiders. The horseshoe crab has a hard exoskeleton and 10 legs, which it uses for walking along the seafloor.

The body of the horseshoe crab is divided into three sections. The first section is the prosoma, or head. The name “horseshoe crab” originates from the rounded shape of the head, because just like the shoe on a horse’s foot, the head is round and U-shaped. It's the largest part of the body and contains much of the nervous and biological organs. The head has the brain, heart, mouth, nervous system, and glands—all protected by a large plate. The head also protects the largest set of eyes. Horseshoe crabs have nine eyes scattered throughout the body and several more light receptors near the tail. The two largest eyes are compound and useful for finding

mates. The other eyes and light receptors are useful for determining movement and changes in moonlight.

The middle section of the body is the abdomen, or opisthosoma. It looks like a triangle with spines on the sides and a ridge in the center. The spines are movable and help protect the horseshoe crab. On the underside of the abdomen are muscles, used for movement, and gills for breathing.

The third section, the horseshoe crab's tail, is called the telson. It's long and pointed, and although it looks intimidating, it is not dangerous, poisonous, or used to sting. Horseshoe crabs use the telson to flip themselves over if they happen to be pushed on their backs.

Female horseshoe crab are about one-third larger than the males. They can grow to be 18 to 19 inches (46 to 48 centimeters) from head to tail, while the males are approximately 14 to 15 inches (36 to 38 centimeters).

1.8.2 Spiders: *Plexippus petersi*

Kingdom:	Animalia
Phylum:	Arthropoda
Subphylum:	Chelicerata
Class:	Arachnida
Order:	Araneae
Infraorder:	Araneomorphae
Family:	Salticidae
Subfamily:	Salticinae

Genus:	*Plexippus*
Species:	*P. petersi*

Plexippus petersi is a species of jumping spider native to Asia and has been introduced to Africa and Pacific islands. The male is between 6 and 10 mm (0.24 and 0.39 in) in length, and the female is around 10 millimetres (0.4 in). This spider is commonly known as the tropical flycatcher or small zebra jumper.

The male *Plexippus petersi* is between 6 and 10 mm (0.24 and 0.39 in) long and the female is slightly larger. The head bears four pairs of eyes, one pair is larger than the others, forward-facing and movable, while the remainder are small and fixed in position. The cephalothorax is longer than it is wide and is brown with two darker reddish-brown bands on the dorsal surface. The abdomen is twice as long as it is wide and is yellowish-brown dorsally with two longitudinal darker brown bands which are broken posteriorly to give a pair of orangish spots on either side; the ventral surface is yellowish-brown and the spinnerets are greyish-brown. The pale parts of the abdomen are clad with whitish setae (bristles), and the darker areas are covered with brown setae. The legs are yellowish-brown, streaked with darker brown and darker near the joints, and have blackish-brown leading edges. There are scattered setae on the legs and the femur has a dense patch of brown hairs.

1.8.3 Scorpion: *Hottentotta tamulus*

Hottentotta tamulus, the Indian red scorpion, also known as the eastern Indian scorpion, is a species of scorpion of the family Buthidae. It occurs in most of India, eastern Pakistan and the eastern lowlands of Nepal and recently from Sri Lanka.

Total body length is about 50 to 90 mm. Males with flexed proximal margins of pedipalp fingers. Manus of pedipalps is also wider than female. There are 30 to 39 pectinal teeth in males, and 27 to 34 in females. Chelicerae are yellow and reticulated. Pedipalps are densely hirsute, whereas legs and metasoma are sparsely hirsute. Patella of pedipalps covered with short setae. Mesosoma is darker than rest of the body. Ventral carinae on metasomal segments are black. Chela without carinae. Dorsum densely and very finely granulated. Dorsum bears two short, inconspicuous marginal carinae. Telson is granulated.

The walking legs and the tip of the pedipalp pincers are bright orange-yellow to light reddish-brown in color. The mesosomal tergites always bear three distinct carinae. Their habitus is typical of buthid scorpions, with rather small pedipalp pincers, moderately thickened metasomal segments and a rather bulbous telson with large stinger. The base of the pedipalp pincers (manus) is slightly more inflated in males than in females.

1.8.4 Mites: *Trombidium holosericeum*

Kingdom:	Animalia
Phylum:	Arthropoda
Subphylum:	Chelicerata
Class:	Arachnida
Order:	Trombidiformes

Family:	Trombidiidae
Genus:	*Trombidium*
Species:	*T. holosericeum*

Trombidium holosericeum is a species of mite in the genus *Trombidium*. It occurs in Europe, Asia, and North Africa and is commonly confused with other red mite species.

This species is one of the largest mites in northern temperate zones, with a body length of about 4 mm (just over 1⁄8 inch). The soft, brightly red body is covered with fine hairs, giving it a velvety appearance. The small eyes are located on stalks. They have scissor-like chelicerae and their pedipalps are used as touch organs.

Its bright red color results from carotenoids, warning predators about the toxicity of the mite (aposematism). Almost nothing is known about the toxic substances used, but they are probably contained within the integument.

While adults live freely and are often found wandering about, searching for small animals and insect eggs for food, the larvae try to find a host to attach themselves to, often an insect like a grasshopper or diptere, but also arachnids like harvestmen or spiders. At this stage they are seen as red globules on their hosts, sucking body liquid without severely harming the host. These larvae then develop into free-living nymphs that resemble adults.

1.8.5 Ticks: *Ixodes ricinus*

Kingdom:	Animalia
Phylum:	Arthropoda
Subphylum:	Chelicerata

Class:	Arachnida
Order:	Ixodida
Family:	Ixodidae
Genus:	*Ixodes*
Species:	*I. ricinus*

Ixodes ricinus, the castor bean tick, is a chiefly European species of hard-bodied tick. It may reach a length of 11 mm (0.43 in) when engorged with a blood meal, and can transmit both bacterial and viral pathogens such as the causative agents of Lyme disease and tick-borne encephalitis.

In common with other species of *Ixodes*, *I. ricinus* has no eyes and is not ornate; it has no festoons (wrinkles along the posterior margin). The palpi are longer than they are wide, and an anal groove is above the anus. It has a hard dorsal shield which covers the entire opisthosoma (abdomen), but only part of it in females and nymphs. Adult males are 2.4–2.8 mm (0.09–0.11 in) long, and unfed nymphs are 1.3–1.5 mm (0.05–0.06 in) long; females are 3.0–3.6 mm (0.12–0.14 in) long before feeding and 11 mm (0.43 in) long when engorged.

Practical no. 9

Study of preserved invertebrate species and their classification upto class level i. Arthropods (mandibulata)

1.9 Arthropoda: Mandibulata

The mandibulates, consisting of the subphyla Crustacea, Myriopoda (centipedes, millipedes, pauropods, and symphylans), Hexapoda (insects and their relatives) constitute the largest and most varied arthropod group and are characterized by the presence of modified appendages (mandibles) flanking the mouth and used as jaws.

1.9.1 Crustaceans: *Abludomelita obtusata*

Kingdom:	Animalia
Phylum:	Arthropoda
Subphylum:	Crustacea
Class:	Malacostraca
Order:	Amphipoda
Family:	Melitidae
Genus:	*Abludomelita*

Species:	*A. obtusata*

Abludomelita obtusata is a brown colored species of amphipod crustacean. It may grow up to 9 millimetres (0.35 in) long and lacks a rostrum. It lives in marine sediments of any grain size, but with a preference for a mud content of 10%–40%.

Abludomelita obtusata is a small marine organism classified as an amphipod. It has a slender body shape and grows up to nine mm in standard length. The species is a brownish color, and has no rostrum. As a member of the Amphipoda order, *Abludomelita obtusata* is gonochorous and sexually dimorphic, with the females being larger than the males. In addition, males also have a distinct pair of second claws. A typical *Abludomelita obtusata* life span is approximately one year.

Abludomelita obtusata can reside in cold to moderate temperatures ranging from 0 to 12 degrees Celsius. However, the highest frequency of the species was found in a water temperature ranging from 11-14 degrees Celsius.

Majority of *Abludomelita obtusata* are found in a salinity range of 30-35 PPM.

1.9.2 Ant: *Harpegnathos saltator*

Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Insecta
Order:	Hymenoptera
Family:	Formicidae
Subfamily:	Ponerinae
Tribe:	Ponerini

Genus:	*Harpegnathos*
Species:	*H. saltator*

Harpegnathos saltator, sometimes called the Indian jumping ant or Jerdon's jumping ant, is a species of ant found in India. They have long mandibles and have the ability to leap a few inches. They are large-eyed and active predators that hunt mainly in the early morning. The colonies are small and the difference between workers and queens is very slight.

This species has an unusual colony structure compared to other ponerine genera. In the beginning, young winged queens fly out from their natal colony, mate with foreign males and start new colonies independently. Once the founding queen dies (after a few years), several daughter workers replace her as reproductives in the colony. It is characteristic of several ponerine ants that workers can mate (almost always with foreign males) and store sperm in the spermatheca. In *H. saltator*, many young workers inbreed with males from the same colony (their brothers). They fight to establish a dominance hierarchy, and a few high-rankers will become reproductives and lay eggs, so-called gamergates. Every year, new winged queens will be reared, and they will disperse and start the process again. The combination of queen and gamergate reproduction results in an increased lifespan of colonies.

1.9.3 Centipede: *Scolopendra subspinipes*

Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Chilopoda
Order:	Scolopendromorpha
Family:	Scolopendridae

Genus:	*Scolopendra*
Species:	*S. subspinipes*

Scolopendra subspinipes is a species of very large centipede found throughout eastern Asia. One of the most widespread and common species in the genus Scolopendra, it is also found on virtually all land areas around and within the Indian Ocean, all of tropical and subtropical Asia from Russia to the islands of Malaysia and Indonesia, Australia, South and Central America, the Caribbean islands, and possibly parts of the southern United States, but how much of this range is natural and how much due to human introduction is unclear.

It is among the largest centipedes with a maximum length of 20 cm (7.9 in). This centipede is an active, aggressive predator that preys on any animal it can overpower.

It has colour variations: its body is usually red or reddish brown with yellow or yellow-orange legs. In common with other members of genus *Scolopendra*, it has 22 body segments, with each segment having one pair of legs. A pair of modified legs known as forcipules can be found on its head, which is covered by a flat shield and bears a pair of antennae. The forcipules are the major tools used by the centipede to kill its prey or for defense, as they have sharp claws that connect to venom glands.

1.9.4 Millipede: *Harpaphe haydeniana*

Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Diplopoda
Order:	Polydesmida
Family:	Xystodesmidae
Genus:	*Harpaphe*
Species:	*H. haydeniana*

Harpaphe haydeniana, commonly known as the yellow-spotted millipede, almond-scented millipede or cyanide millipede, is a species of polydesmidan ("flat-backed") millipede found in the moist forests along the Pacific coast of North America, from Southeast Alaska to California. The dark coloration with contrasting yellow-tipped keels warn of its ability to exude toxic hydrogen cyanide as a defense. Despite the various common names given the species, the coloration pattern, cyanide defense, and associated almond scent occur in other flat-backed millipedes around the world.

Harpaphe haydeniana reach a length of 4–5 centimeters (1.6–2 in) when mature. The upper surface of the body is black to olive green, and is distinctively marked along the sides with patches of a yellowish colour. *H. haydeniana* has approximately twenty body segments, bearing a total of 30 (males) or 31 (females) pairs of legs. The difference between males and females is due to one pair of legs on the seventh segment in males being modified to form gonopods used for sperm transfer. Individuals may live for 2–3 years.

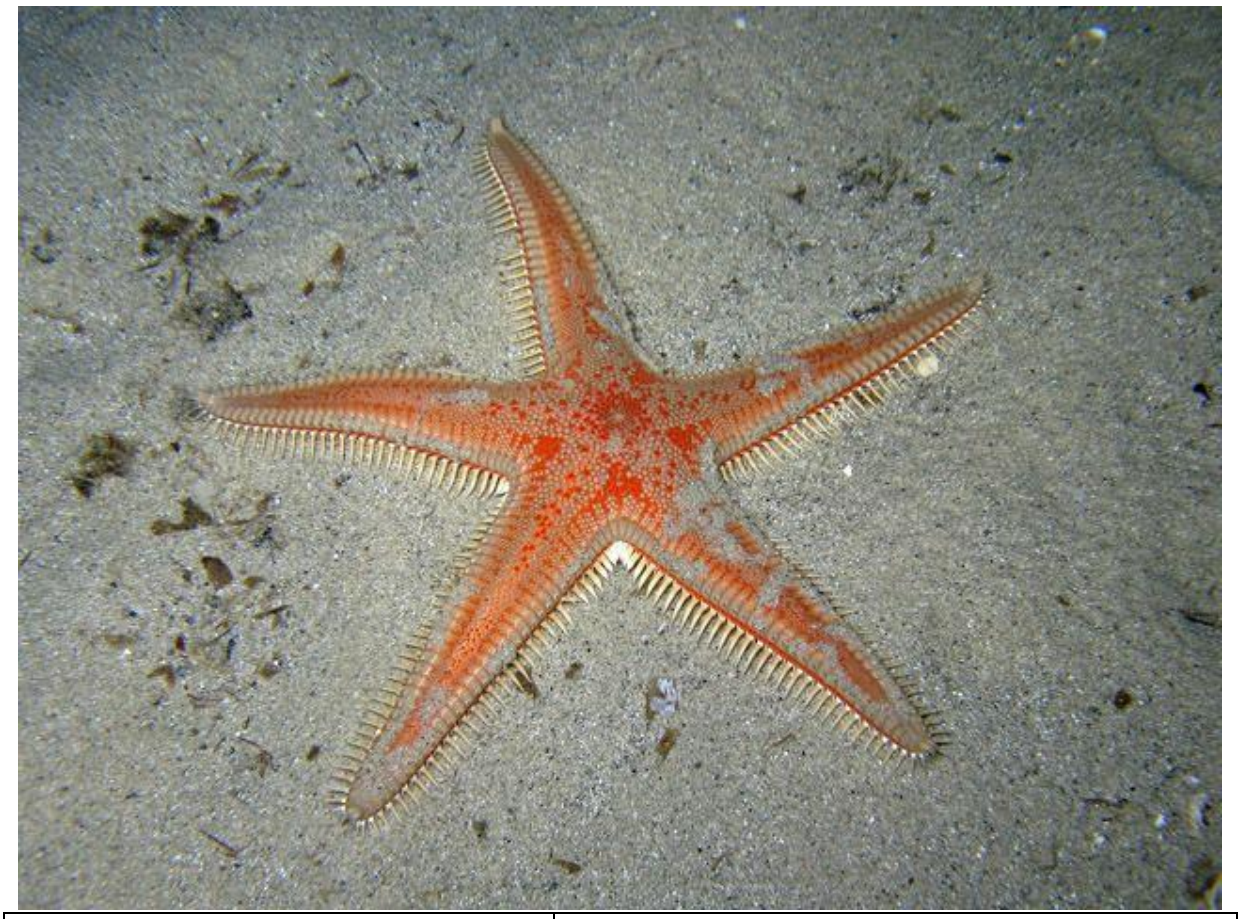
Practical no. 10

Study of preserved invertebrate species and their classification upto class level j. Echinoderms

1.10 Echinoderms

The phylum Echinodermata consists of the starfish, sea urchins, and sea cucumber. They are the most advanced invertebrates. Echinoderms' endoskeleton is made out of settled calcium plates called ossicles is their special feature. They have a water vascular structure. Water enters through an opening called the madreporite directly into a short stone channel into the ring trench. Outspread canals connect with the ring channel and make up the five-area symmetry. They replicate agamically by a discontinuity or also sexually with outside fertilization.

1.10.1 Starfish: *Astropecten aranciacus*



Kingdom:	Animalia
Phylum:	Echinodermata

Subphylum:	Eleutherozoa
Class:	Asteroidea
Order:	Paxillosida
Family:	Astropectinidae
Genus:	*Astropecten*
Species:	*A. aranciacus*

Astropecten aranciacus, the red comb star, is a sea star of the family Astropectinidae. *Astropecten aranciacus* lives very near the coast, and at low tide it buries itself in the sand, showing only the centre of its upper side which is swollen in the form of a cone. This cone acts like a sense organ. When it is touched, the cone contracts and the starfish buries itself on the sand again. Then at high tide, the starfish reappears on the surface of the substrate. It buries itself in the sand to shield parts of its body from the rays of the sun, especially the bottom surface which has no coloured pigment and is therefore particularly sensitive. *Astropecten aranciacus* lives on sandy, muddy or gravel bottoms at depths of 2–100 metres (7–300 ft). This species is active and easy to find in the late afternoon and during the night.

This starfish has superomarginal plates equipped with 1 to 3 small spines and inferomarginal plates with long, pointed, strong, regularly arranged spines. The inferomarginal spines have reddish-orange colour at the base and yellowish or white colour towards the tip. It is rugged with normal size disc and pointed arms. The colour of the aboral side is given by a succession of paxillae (from the top they look like round points) with upper extremity red-orange in various combinations with paxillae with upper extremity grey or beige. The superomarginal plates are usually grey or beige homogeneous. This is the largest species of Astropecten in the Mediterranean Sea, with a maximum diameter of 55 centimetres (22 in), although it usually measures about 30 cm (12 in).

It is a starfish with a lot of features and can be distinguished easily from the other species by colour and size.

1.10.2 Sea cucumbers: *Actinopyga echinites*

Actinopyga echinites, commonly known as the brownfish or deep water redfish, is a species of sea cucumber in the family Holothuriidae. It is native to the tropical Indo-Pacific region and is harvested for food.

Actinopyga echinites grows to a length of about 300 to 350 mm (12 to 14 in). It is widest in the middle, tapering slightly at both ends; the dorsal surface is arched while the ventral surface is flattened. The leathery skin is rough, being covered in papillae. The skin is strengthened by the presence of spicules, microscopic spike-like structures, which in this species are shaped like large rods. The colour of this sea cucumber is brown above and orange-brown below, and the upper surface often has sand adhering to it. The anus is surrounded by five beige anal teeth, and the pinkish Cuvierian tubules are occasionally discharged through the anus when the animal is stressed.

Practical no. 12

Preparation of Keys for the identification of Specimens

In the field of biology, classification plays a major role. With new species being discovered every day, it's important to have techniques in place to identify and classify them. One such tool is the dichotomous key. It helps identify organisms by directing the user to look at the known organisms.

In this simple guide, we will explain what is a dichotomous key and how to create one. Some examples are provided in the dichotomous key examples section; you can use any template to start your project right away. Download them as PNGs, JPEGs, SVGs or PDFs for publishing, printing, and sharing.

What is a Dichotomous Key?

Students and professionals use the dichotomous key to identify and classify objects (i.e. people, animals, plants, bacteria, etc.) into specific categories based on their characteristics. It's the most commonly used form of classification or type of identification key used in biology as it simplifies identifying unknown organisms.

Simply put, it is a method used to identify a species by answering a series of questions based on contrasting features (e.g.: physical characteristics) that have two possible outcomes.

"Dichotomous" means divided into two parts, hence the dichotomous keys always present two choices based on the key characteristics of the organism in each step. By correctly selecting the right choice at each stage, the user will be able to identify the name of the organism at the end. The further you divide the key, the more you learn about the specimen you are trying to identify.

When creating a dichotomous key, both qualitative (i.e. physical attributes such as how the organism looks, what color it is, etc.) and quantitative (i.e. the number of legs, weight, height, etc.) factors are considered.

It can be done in both a graphical (as a branching flowchart) or written format (series of paired statements organized sequentially). Most often, they are used to identify plant and animal species, although it can be used to classify any object that can be identified by a set of observable characteristics.

To easily draw connections between species to better establish proposed phylogeny create Cladograms.

What is the dichotomous key used for?

A dichotomous key is usually used for

- Identifying and categorizing organisms
- Helping students easily understand harder scientific concepts
- Organizing large amounts of information to make identification of an organism much easier

How to Make a Dichotomous Key?

Below we have listed the steps you need to follow when creating a dichotomous key.

Step 1: List down the characteristics

Pay attention to the specimens you are trying to identify with your dichotomous key. List down the characteristics that you can notice. For example, say you are trying to classify a group of animals. You may notice that some have feathers whereas others have legs, or some have long tails and others don't.

Step 2: Organize the characteristics in order

When creating your dichotomous key, you need to start with the most general characteristics first, before moving to the more specific ones. So it helps to have identified the more obvious and less obvious contrasting characteristics among the specimen before creating your dichotomous key.

Step 3: Divide the specimens

You can use statements (i.e. has feathers and no feathers) or questions (does it have feathers?) to divide your specimens into two groups. The first differentiation should be made on the most general characteristic.

Step 4: Divide the specimen even further

Based on the next contrasting characteristic, divide the specimen further. For example, first, you may have grouped your animals as *have feathers* and *have no feathers*, in which case the ones with feathers can be categorized as *birds* while you can further subdivide the ones that have no feathers as *having fur* and *having no fur*. Continue to subdivide your specimen by asking enough questions until you have identified and named all of them.

Step 5: Draw a dichotomous key diagram

You can either create a text-based dichotomous key or a graphical one where you can even use images of the specimen you are trying to identify. Here you can use a tree diagram or a flowchart as in the examples below.

Step 6: Test it out

Once you have completed your dichotomous key, test it out to see if it works. Focus on the specimen you are trying to identify and go through the questions in your dichotomous tree to see if you get it identified at the end. If you think the questions in your dichotomous key needs to be rearranged, make the necessary adjustments.

Best practices to keep in mind

- Consider only one characteristic at a time
- Use morphological or observable characteristics as much as you can
- Use major characteristics when dividing the organisms in the beginning and use lesser or less obvious characteristics to divide them into smaller groups
- When writing contrasting statements, rely on similar word formats (i.e. have feathers and don't have feathers)
- Be specific in your statements and avoid repeating the same characteristics
- Use questions that lead to yes or no answers rather than statements

To draw connections between species to better establish evolutionary connections use a Phylogenetic Tree Maker.

Practical no. 13

Methods of statistical analysis of samples from population T-test

Sample

In statistics and quantitative research methodology, a sample is a set of individuals or objects collected or selected from a statistical population by a defined procedure

Population

In statistics, a population is a set of similar items or events which is of interest for some question or experiment. A statistical population can be a group of existing objects or a hypothetical and potentially infinite group of objects.

Student t-test distribution

A t-test can only be used when comparing the means of two groups (pairwise comparison). If you want to compare more than two groups, or if you want to do multiple pairwise comparisons, use an ANOVA test or a post-hoc test.

The t-test is a parametric test of difference, meaning that it makes the same assumptions about your data as other parametric tests. The t-test assumes your data:

1. are independent

2. are (approximately) normally distributed.

3. have a similar amount of variance within each group being compared (a.k.a. homogeneity of variance)

If your data do not fit these assumptions, you can try a nonparametric alternative to the t-test, such as the Wilcoxon Signed-Rank test for data with unequal variances.

What type of t-test should we use?

When choosing a t-test, you will need to consider two things: whether the groups being compared come from a single population or two different populations, and whether you want to test the difference in a specific direction.

One-sample, two-sample, or paired t-test?

1. If the groups come from a single population (e.g. measuring before and after an experimental treatment), perform a paired t-test.

2. If the groups come from two different populations (e.g. two different species, or people from two separate cities), perform a two-sample t-test (a.k.a. independent t-test).

3. If there is one group being compared against a standard value (e.g. comparing the acidity of a liquid to a neutral pH of 7), perform a one-sample t-test.

Formula of t-test

Type	T-statistic	Degrees of freedom
One-sample t-test	$t = \frac{\overline{x} - \mu_0}{s/\sqrt{n}}$	df = n - 1

X = mean of sample

S = standard error

n= size of sample

μ0 = variance

Example

Ten individuals are chosen at random from a normal population and the heights are found to be in inches 63, 63, 66, 67, 68, 69, 70, 70, 71 and 71, in the height of these data, discuss the suggestion mean height in the population is 66 inches.

Practical no.14

Methods of statistical analysis of samples from Analysis of Variance

Analysis of variance

Analysis of variance (ANOVA) is a statistical technique that is used to check if the means of two or more groups are significantly different from each other. ANOVA checks the impact of one or more factors by comparing the means of different samples.

Grand Mean

Mean is a simple or arithmetic average of a range of values. There are two kinds of means that we use in ANOVA calculations, which are separate sample means and the grand mean. The grand mean is the mean of sample means or the mean of all observations combined, irrespective of the sample.

Hypothesis

Considering our above medication example, we can assume that there are 2 possible cases – either the medication will have an effect on the patients or it won't. These statements are called Hypothesis. A hypothesis is an educated guess about something in the world around us. It should be testable either by experiment or observation.

Just like any other kind of hypothesis that you might have studied in statistics, ANOVA also uses a Null hypothesis and an Alternate hypothesis. The Null hypothesis in ANOVA is valid when all the sample means are equal, or they don't have any significant difference. Thus, they can be considered as a part of a larger set of the population. On the other hand, the alternate hypothesis is valid when at least one of the sample means is different from the rest of the sample means. In mathematical form, they can be represented as:

$$H_o: \mu 1 = \mu 2 \ldots\ldots\ldots\ldots\ldots\ldots \mu L \qquad \text{Null hypothesis}$$

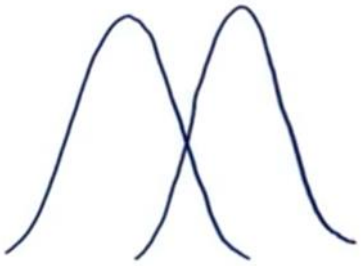
$$H_1: \mu 1 \neq \mu 2 \neq \ldots\ldots\ldots\ldots \mu L \qquad \text{Alternative hypothesis}$$

belong to any two sample means out of all the samples considered for the test. In other words, the null hypothesis states that all the sample means are equal or the factor did not have any

significant effect on the results. Whereas, the alternate hypothesis states that at least one of the sample means is different from another.

Between Group Variability

Consider the distributions of the below two samples. As these samples overlap, their individual means won't differ by a great margin. Hence the difference between their individual means and grand mean won't be significant enough.



Now consider these two sample distributions. As the samples differ from each other by a big margin, their individual means would also differ. The difference between the individual means and grand mean would therefore also be significant.

Such variability between the distributions called Between-group variability. It refers to variations between the distributions of individual groups (or levels) as the values within each group are different.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares (MS)	F
Within	$SSW = \sum_{j=1}^{k}\sum_{j=1}^{l}(X-\bar{X}_j)^2$	$df_w = k-1$	$MSW = \frac{SSW}{df_w}$	$F = \frac{MSB}{MSW}$
Between	$SSB = \sum_{j=1}^{k}(\bar{X}_j - \bar{X})^2$	$df_b = n-k$	$MSB = \frac{SSB}{df_b}$	
Total	$SST = \sum_{j=1}^{n}(\bar{X}_j - \bar{X})^2$	$df_t = n-1$		

Alternatively,

F = MST/MSE

MST = SST/ p-1

MSE = SSE/N-p

SSE = ∑ (n−1)s^{2}

Where,

F = ANOVA Coefficient

MSB = Mean sum of squares between the groups

MSW = Mean sum of squares within the groups

MSE = Mean sum of squares due to error

SST = total Sum of squares

p = Total number of populations

n = The total number of samples in a population

SSW = Sum of squares within the groups

SSB = Sum of squares between the groups

SSE = Sum of squares due to error

s = Standard deviation of the samples

N = Total number of observations