TABLE OF CONTENTS

Contents

INTRODUCTION - ANIMALS (9.1.1). 3
INSECTS: CLASS – INSECTA (9.2.2). 3
INSECT DEVELOPMENT – LIFE CYCLE (9.1.3) 5
THE ECOLOGICAL ROLE AND IMPORTACE OF INSECTS (9.1.4). 10
INSECTS ORDERS (9.1.5). 12
CLASS: ARACHNIDA (Spiders and Relatives – "9.1.6"). 24
PHYLUM: ARTHROPOD - CLASS: MYRRIAPODA (9.1.7) 31
PHYLUM: MOLLUSCA (9.1.8) 35

PSG PROGRAMME (NCQF LEVEL 5)

MODULE 9

ARTHROPODS

- **OBJECTIVES** (9.1)

  - On complication of this module, you will:
  - Know what an invertebrate and an arthropod is.
  - Know what the characteristics of invertebrates are.
  - Know what the characteristics of insects are.
  - Be able to explain the three different types of insect life-cycles and give examples of each.
  - Understand why insects are so successful and the ecological importance of insects.
  - Have a basic understanding of insect's flight and their feeding behavior.
  - Be able to identify common insects' orders.
  - Be able to explain the difference between insects and spiders.
  - Know what the characteristics of the Arachnida are and be able to place spiders into two main sub-orders.
  - Know how to recognize the venomous spiders in Southern Africa which are of medical importance to human beings and know what type of venom they have.
  - Know what the characteristics of scorpions are and how to distinguish between the two main types of scorpions.
  - Know what the differences are between millipedes and centipedes, their particular feeding and anti-predator behavior.
  - Be able to produce basic information about all the common invertebrate phyla including; characteristics and description, habitat, feeding and behavior.

INTRODUCTION - ANIMALS (9.1.1).

- Animals belong to the Kingdom Animalia. Within that kingdom we focus mainly on animals represented in two of the phyla, namely the Vertebrates (animals with backbone) and the Arthropods (animals with jointed appendages). Among the vertebrates we look at Mammals, Birds, Reptiles and Amphibians; among the arthropods we investigate insects and arachnids (spiders, scorpions and the like).

❖ **What is an Arthropod?**

- The arthropod is the largest, most abundant and diverse phylum in the world. They are extremely diverse and can be found in all habitats that are capable of supporting life. The widespread occurrence of arthropods can probably be accounted for by their ability to adapt, made possible by their exoskeleton.
- The name Arthropod comes from the "Greek" words "**arthron"** meaning joint and **"podos"** meaning feet, and are usually referred to as animals with **jointed legs.** Arthropods are animals without an internal skeleton but rather have a **chitinous,** segmented exoskeleton (external skeleton) and they have jointed legs.

NB// Chitin – a tough semitransparent substance that forms part of the protective outer casing cuticle of some insects and other arthropods.

INSECTS: CLASS – INSECTA (9.2.2).

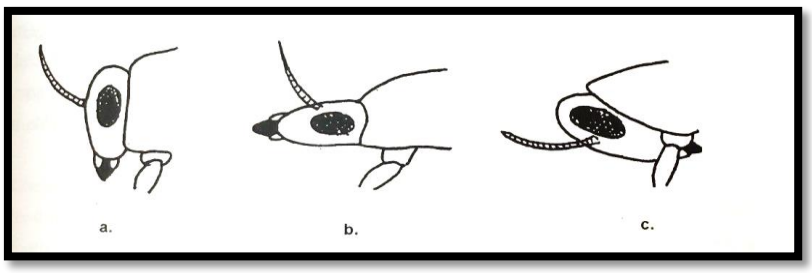
- Insects can be distinguished from their close relatives, spiders and scorpions by having six jointed legs and three body parts – **the head, thorax and abdomen.** Insects are the most abundant and successful of all terrestrial animals, making up 75% of the species diversity that have been described worldwide. The relationship between man and insects varies from one of intense conflict, to absolute harmony. The disease bearing insects and the agricultural pests have had a war waged on them from the earliest days. On the other hand, species such as bees are absolutely essential to the success of agriculture. Two thirds of all flowering plants are pollinated by insects. Southern African insects' fauna is represented by 29 orders. There are 579 families and over 80 000 species known in our region.

❖ **Classification (sub-division of in insects).**

- Insects are divided into two main sub-classes, namely: **Apterygota** (insects without wings) and **Pterygota** (insects with wings). Wingless insects – these insects are **Ametabolic**, meaning that **no metamorphoses take place.** Examples: Bristletails (fish moths & silverfish) and springtails etc. Among the winged insects we find metamorphoses ranging from incomplete (**hemi-metabolic)** to complete (**holo-metabolic).** Division hemi-metabola; insects with simple metamorphosis (no pupal stage) – examples: Dragonflies, Grasshoppers, Crickets, Stick insects, cockroaches, termites and bugs etc. Division holo-metabola; insects with a complete metamorphosis (with pupal stage) – examples: Antlions, Butterflies, Moths, Flies, Beetles, Bees, Wasps and Ants etc.

❖ **Insects Characteristics.**

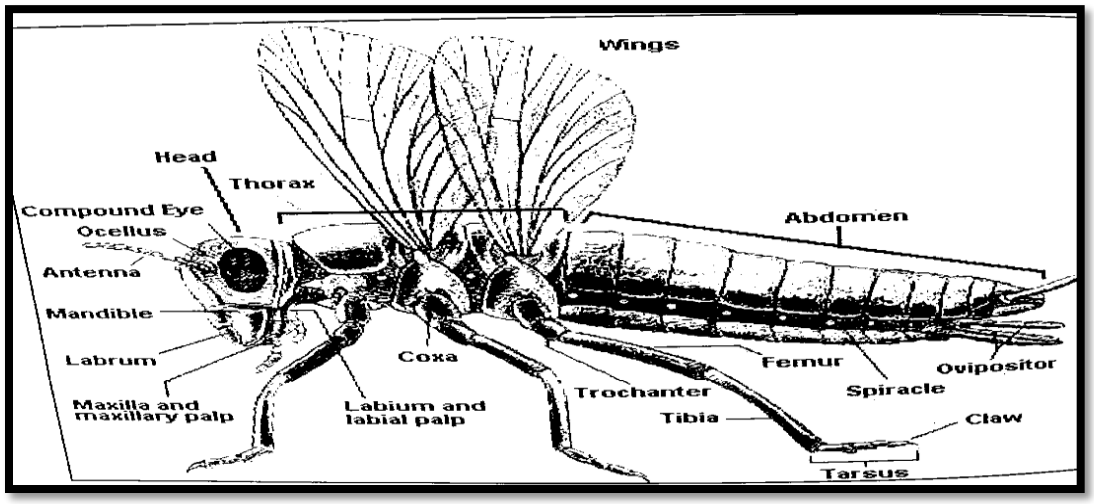
- All insects have bodies divided into three distinct parts viz; the head, thorax and abdomen:
  a. **The Head** – functions in sensory perception and food ingestion. There is a single pair of jointed antennae, usually a pair of compound eyes and several simple eyes, which may be arranged in several different ways. The mouthparts consist of **mandibles, maxillae** and a **labium.** These are usually covered with an extension of the head known as the **labrum.** The arrangement of mouthparts is very diverse and it is not feasible to cover them in this course.
  - The aspect of the head in relation to the body provides of grouping insects into three different categories. Insects having a head situated at the right angles to the body are known as (a) **Hypognathous** species. Their mouth mouthparts are situated at the bottom of the head, and allow for chewing & sucking types of feeding. Those species with the head in line with the long axis of the body are called (b) **Protognathous** and have their mouthparts located at the very edge of the head. This arrangement is usually found in predatory species. The last group are known as (c) **Opisthognathous**, and have their mouthparts facing rearwards between the legs and beneath the body; these insects are usually sap sucking species. (See pictures be low).



b. **The Thorax** – is the chest area of the insect and consist of three divisions, the **Prothorax, Mesothorax** and the **Metathorax.** Each of these divisions has a single pair of legs, and most species have two pairs of wings, the first being attached to the mesothorax and the second to the metathorax. The front legs pull the insect along, while the middle and the rear legs push it forwards. The middle pair of legs is usually the longest to prevent interference with the others.

c. **The Abdomen** – usually consist of 9 – 11 segments. The breathing apparatus are located on these segments and comprise openings to the atmosphere known as **Spiracles.** At the rear end of the abdomen is a pair of sensory appendages called **Cerci**. The abdomen hosts the general organs of the male and female insects. The female organs are often accompanied by an egg laying apparatus called the **Ovipositor**.

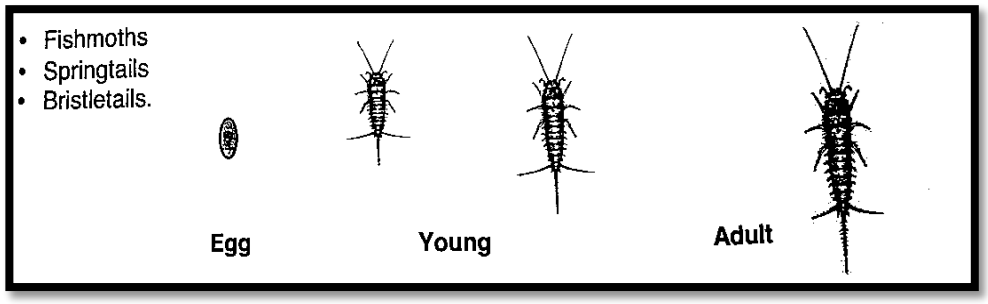
❖ **Insect Anatomy**: (see below):



INSECT DEVELOPMENT – LIFE CYCLE (9.1.3)

- As the growing insect sheds its old exoskeleton, it often undergoes changes in form; a process called **Metamorphosis.** The shedding of the exoskeleton is called **Moulting** and the stages between moults are called **Instars.**

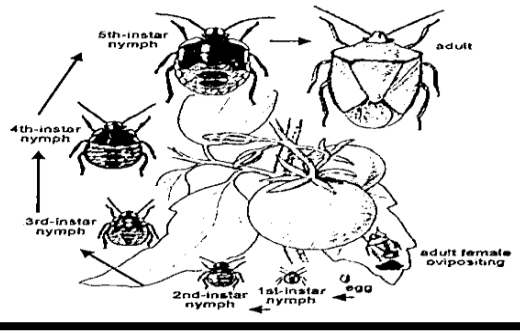
- Insects can be divided primarily into two groups; namely those with an incomplete metamorphosis (hemi-metabolic life cycle) and that have a complete metamorphosis (holo-metamorphosis life cycle), each order is further sub-divided into sub-orders, families and sub-families depending on the size and complexity of the group. Insects reproduce through internal fertilization and the laying of eggs. This is accomplished through the direct transfer of **spermatophore** from the male to the female via copulation. The spermatophore usually releases its sperm soon after copulation and finds its way into the **spermatheca** of the female. The sperm cells remain here until egg laying takes place at which time the is fertilized. This system allows for huge numbers of fertile eggs to be laid from a single mating. The way in which the lifecycle of an insect progresses is very important, and all species undergoes what is known as metamorphosis. This is the series of changes that an insect undergoes before it become a reproductive adult.
- There are two different types of metamorphosis; the first type is called incomplete metamorphosis and the second is complete metamorphosis. The incomplete system is characterized by eggs hatching into miniatures of adult. These juveniles undergo a series of moults or **ecdysis**, and eventually develop sexual organs and are able to reproduce. Complete is characterized by the eggs hatching into larvae which moult several times and at their last moult turn into pupae. This phase is called **pupation.**
- Their bodies develop through a process of metamorphosis of which there are three basic cycles:
    1. **Ametabolic Life Cycle** – this kind of life occurs in the primitive insects. The young hatch from eggs looks like miniature versions of the adults. They moult several times without changing too much until adult stage is attained. Insects with this type of lifecycle include: (see diagram below):



    2. (a) **Hemi-metabolic Life Cycle (incomplete metamorphosis)** – this type of life cycle (**exopterygote)** consists of eggs, nymphs & adults, but no pupae. In certain insects the nymph may resemble the adults more or less in appearance and lifestyle. (see diagram below):

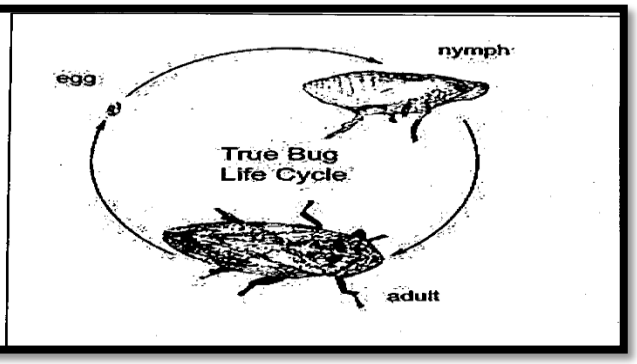
These include:

- Cockroaches
- Termites
- Praying mantids
- Earwigs
- Web-spinners
- Crickets
- Locusts
- Grasshoppers
- Stick insects
- Booklice
- Lice
- Bugs
- Thrips



- 2(b) **Another Form Of Hemi-metabolic Life Cycle** – this type is found in those insects that develop from eggs to nymph to adult, but in which the nymphal stage do not resemble the adults and live very differently from them. This occurs in those insects' orders where nymphs live in water, but the adults are flying land insects such as: (see diagram below):

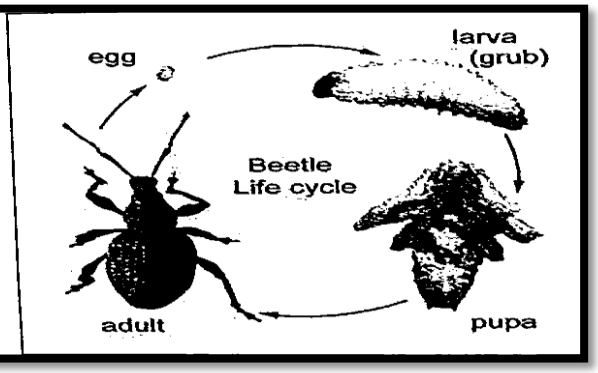
- Mayflies
- Dragonflies
- Damselflies
- Stoneflies
- Cicadas



3. **Holo-metabolic Life Cycle (complete metamorphosis) -** this kind of life cycle (**endopterygote**) is indicated by stages of eggs, larva (which differs drastically from adult), pupa & eventually the adult. (see diagram below):

This cycle occurs in:

- Alderflies
- Antlions
- Lacewings
- Beetles
- Hanging flies
- Flies
- Mosquitoes
- Fleas
- Caddisflies
- Butterflies
- Moths
- Wasps
- Bees
- Ants



- Some life cycles (Aphids, some Cockroaches) appear unusual because eggs hatch in the mother and the larvae or nymphs are then born (**larviparous)**. In other cases (certain flies) the larvae may even develop and form pupae within the mother and are then

born as complete adults. Yet all these insects follow the standard patterns of metamorphosis before they are born.

❖ Why Are Insects So Successful?

- The majority of them have the ability to fly which enables them to disperse over wide areas reaching new habitats and food sources. The ability to fly also allows them to escape from predators.
- The development of their metamorphic lifestyle in the form of complex life styles that have in many species allowed the different stages in the life cycle to exploit different sources of food, thus reducing competition between adults and the young.
- The development of a wide range of modifications to the mouthparts, that have given insects the ability to exploit a wide range of very different food sources and diets.
- The development and adaptation to a social way of life whereby each individual has a specific duty to perform and each individual works solely for the survival of the colony. This allows co-operate achievement of goals and tasks that would normally be beyond the capability of one or even a few individuals.

❖ Flight In Insects.

- The ability to fly gives insects the advantage over those arthropods that are only able to crawl, walk or run. Most insects have two pairs of wings, but these are often modified in various ways and in some species have been lost altogether where the insect's lifestyle does not require them.
- The co-ordination of flight is not achieved by the **Ganglia** (brain), but rather by a system of flight receptors located in the wings, the antennae and in the sensory hairs. These receptors provide information as to the speed, pitch, roll, yaw etc., being experienced by the insect in flight. Direction is maintained by locating the eye in a constant relation to the sun. Any variation off this path is corrected by altering the frequency and strength of wingbeats on different sides of the body. Some insects such as flies, have a system of gyroscopes that keep them correctly oriented during flight. Their second pair of wings has degenerated into small club-like appendages known as **halteres.** These send back information to the fly about flight control system, and flight is automatically stopped immediately the **tarsi** (feet) touch the substrate on which the insect lands.
- Insects are the only "cold-blooded" creatures capable of flight, and require a certain minimum temperature in order to fly successfully.

Some species open their wings and take in heat from the sun before flying, while others beat their wings in "neutral gear" to warm up the muscles.

- Some insect that does not have wings are: fleas, lice & scale insects. Insects show a wide variety of structural and aerodynamic adaptations; beetles for example have front wings that are not used for flying at all but are modified purely for protection of the back wings when the beetle is at rest. In the grasshopper and locusts, the front wings have a protective role and are also used for flying. Some orders of insects such as **Lepidoptera** (butterflies & moths) and **Hymenoptera** (wasps, bees & ants), the paired wings are locked together in a single aerodynamic unit. The **Diptera** (flies, mosquitoes etc.), have lost the use of one pair of wings (which remain only as vestigial lumps known as halteres) and therefore make use of only their front wings when flying. The wings of mayflies and dragonflies are long transparent structures with a complex network of veins. The wings of caddis-flies have hairs, while those of butterflies and moths are covered in powdery scales.
- Flight in insects is achieved through a complex a complex arrangement of muscles. This system allows certain species of insects like some midges to beat their wings up to 1000 times per second; butterflies and grasshoppers can beat their wings 4 to 20 times per second. Bees and flies can beat their wings about 190 times per second.

❖ Feeding Behavior of Insects.

- Insects have a wide variety of different mouthparts adapted to different diets.
  1) Chewing mouthparts – have heavy cutting mandibles and may be used for carnivorous or herbivorous feeding. The larvae of many insects have these mouthparts. Dragonflies and beetles have chewing mouthparts.
  2) Sucking mouthparts – are typical of butterflies and moths. These mouthparts consist of highly elongated maxillae, which form a tube through which the insects suck nectar.
  3) Piercing and Sucking mouthparts – are adapted for piercing through hard layers of skin or plant material and then sucking the contents from the pierced. Mosquitoes and sap-sucking insects have piercing and sucking mouthparts.
  4) Sucking and Chewing mouthparts – are a combination of two different forms. Examples of insects with sucking & chewing mouthparts are bees and wasps. The chewing mouthparts in bees

handle the wax and pollen while the sucking parts take care of the nectar and liquids consumed.

5) Biting mouthparts – are found on horseflies. These insects lacerate the skin of their victim and sponge up the blood that seeps to the surface.

- Feeding habits also vary considerably, with every food source being used by some or other species. Some species may even have a major change of diet as they mature in an effort to obtain the most nutrients and energy from a particular environment while the least possible energy.

THE ECOLOGICAL ROLE AND IMPORTACE OF INSECTS (9.1.4).

- Insects help to maintain the balance in nature. They play the roles of predator and parasites on other insects, animals as well as plants. They feed on many species of plants and their seeds as well as causing disease in both.
- Insects are widely used as a food source for many of the smaller predators. They form a vital link between plants and predators; for example, plant eating insects such as caterpillars, are fed on by other predators such as birds.
- Many insects are responsible for the pollination of plants, such as bees, blowflies and ants etc.
- Many insects play an important role in waste disposal. Woodborers slowly eat away trees that have had their bark stripped by elephants, man and lightning. Once the tree falls, termites take over the role of disposing the dead tree and making material available for decomposition. The larvae of skin beetles or trogid further consume dead animals. The larvae of horn borer moths consume horns and hooves. The larvae of blowflies eat dead meat. Dung is recycled by dung beetles and by disposing of the dung, flies are given less of a chance to breed in the dung, therefore helping to reduce the spread of disease. * NB// Researcher by the name of Dr. Leo Braack has shown that in summer an impala carcass can be stripped in less than a week by blowflies' maggots. *
- Many insects pass on a large variety of diseases helping to regulate populations and creating the balance in nature. They are also the vectors of a number of plant diseases, which are often caused by the sap feeders. Natural selection is an important ecological process by means of which the weaker individuals are eradicated from a population, while the stronger ones are enabled to reproduce. This ensures the long-term survival of species by continual adaptation to an ever-changing environment, Insects are important vectors for a

great variety of diseases of plants, animals, including humans; all of which help regulate numbers and balances in ecosystems. Mosquitoes, ticks and flies are important propagators of disease in animals.

❖ **Defense.**

- Toxic substances are present in many species, either being absorbed from food sources or created by body processes and are used as either venoms or poisons or both. Color also plays an important role with many species having bright contrasting colors to advertise the fact that they are dangerous – called **aposematic coloration.** Some species are cryptically colored, being **camouflaged** to blend perfectly into their surroundings. **Mimicry** (copying) of behavior and physical shape is also widespread.
- Some species feed on poisonous food plants to which the caterpillar is immune. The poison compounds (toxins) are kept within the body and although they cannot sting or bite, they can cause problems if eaten. They advertise this danger with bright colors (usually black, with red, orange, yellow or white) – aposematic colors, and is also used by many adults because the toxins stay in the body when the caterpillars pupate to become adults. Some harmless species then copy the colors of the dangerous species to avoid being attacked (mimicry).
- Some species have a very fast flight and can turn suddenly to avoid danger. Most moths have camouflaged wings to avoid detection when resting (because the wings are open), and even the colorful butterflies have almost no color on the underside of the wings that allows them to become invisible when resting with the wings closed. Some caterpillars have small spines on the body as armor plating and these are sometimes connected to poison glands. Many of the moth caterpillars have long hairs that not only make them look bigger but also have poison glands at the base of the hairs. These hairs either break off in the skin or scratch the skin causing irritation.
- Many caterpillars of the Swallowtails family (papilionidae) also have two organs called **osmeteria** that come out of holes behind the head when they are threatened. Its thought that they give off a bad smell or chemical that scares off enemies. These osmeteria are usually brightly colored so they might also just be designed to scare enemies away by sight. Some butterflies develop false heads and eyes at the back of the wings to fool predators into attacking the wrong end of the body.

❖ **Insect Communication.**

- Insects are able to communicate in many different ways. One of the most commonly used method is that of the release of **pheromones.** These chemicals may be used as a sex attractant, for trail marking, territorial marking etc. Other species such as the fireflies use visual stimuli. Avery common communication method is that of auditory signaling; - grasshoppers, crickets, cicadas etc., all use this system.

❖ **The Difference between Insects and Spiders.**

INSECTS	SPIDERS
Six legs.	Eight legs.
Head, thorax, abdomen.	Two body parts; cephalothorax, abdomen
Most have wings	Never have wings
Carnivores & Herbivores	Mostly carnivores
Complete & incomplete Metamorphosis	Incomplete metamorphosis

INSECTS ORDERS (9.1.5).

❖ **The most successful orders in terms of species are:**

- Coleoptera – Beetles.
- Hymenoptera – Wasps, Bees & Ants.
- Lepidoptera – Moths & Butterflies.

❖ **Others that will be dealt with are:**

- Isoptera – Termites.
- Neuroptera – Antlions & relatives.
- Hemiptera – Bugs.

❖ **Only those orders most likely to be encountered by a field guide are covered here:**

- Beetles (coleoptera) – there are more species of beetles than any other animal order with the weevil family being the biggest in the Animal Kingdom. Beetles make up a staggering 300 000 of the known insects' species. Beetles are characterized by having two pairs of wings with the front pair being hard to protect the membranous hind wings, called the **elytra.** In some species the front

wings are fused so that the beetle cannot fly and these species are then adapted to life on the ground, usually being able to run very fast.

- The immatures are called **grubs** and are worm-like in appearance. They often have a totally different diet to the adult and they undergo a metamorphosis in a cocoon structure to become an adult. They have a complete metamorphosis. Most have chewing mouthparts in both adults and larval stages, and feed mostly on vegetable matter, although some are carnivorous and some are aquatic; but the majority are terrestrial.

❖ **Dung Beetles:**

- Dung beetles are some the best-known beetles are very important in processing and removing dung. Dung that is left will destroy grazing (by covering growing grass) and will attract flies that could spread disease. The dung is eaten (coprophagy) and those species that roll dungballs will have two types, namely:

a) Food-balls – that are taken away to be buried and eaten.
b) Brood-balls – in which an egg is laid and the ball buried. The grub will hatch out and feed on the dung-ball, hollowing it out. This feeding behavior is sometimes heard by mammal predators above ground (such as honey badgers, hyenas & jackals) that will dig them up and eat the grub.
    - Removing the dung also returns vital nutrients to the soil. In addition, there are small animals called mites that use the beetles as a taxi. They are white in color and cling on around the neck area of the beetle, and when the beetle arrives at a dung source the mites jump off and start to eat fly eggs and fly larvae; and in this way control these pests and the disease they spread.

- Types of dung beetles:

I. Telecoprid – take dung (dung-balls) away from dung pad and burry it – food-balls/brood-balls.

(see picture below):



II. Endocoprid – No dung balls, they feed and lay eggs inside dung pad; normally on the upper part inside dung. (see picture below):



III. Paracoprid – Some will have dung balls; they lay eggs on the Perimeter of the dung pad and sometimes underneath. (See picture below):



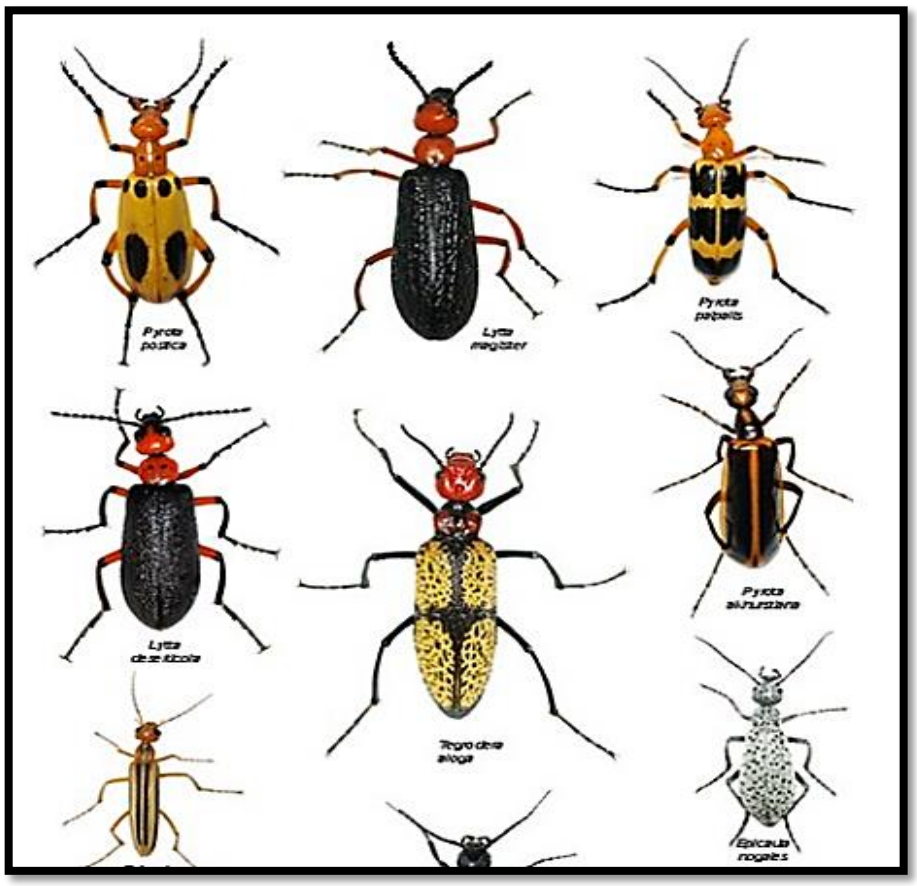
❖ **Ground Beetles.**

- Ground beetles are mainly nocturnal and can be seen on roads and pathways at night as they scurry about looking for prey (mainly invertebrates) that they run down with speed and overwhelm with the powerful mandibles. These beetles cannot fly and because they are vulnerable to predators on the ground they are usually equipped with formic acid that that they can squirt out of glands around the sides of the abdomen (for up to 1m). This is useful in deterring small predators as the acid usually hits them in the face causing dis comfort and pain. It causes blistering of human skin. To advertise the danger these beetles are usually colored black and white/yellow (nocturnal aposematic colors). The big "pincers" are used to hold prey and the female during mating. Some immature frogs and lizards mimic these beetles in color pattern and the way they walk (arched back) in an effort to fool predators. (Ground beetle picture below):



❖ **Blister Beetle.**

- These diurnal beetles produce a powerful body toxin called **cantharidin** that causes blisters (was used in field hospitals during wars to pull shrapnel from wounds), it releases the toxin from glands when molested, cannot bite or sting, usually strong aposematic coloration and often mimicked by other species (Batesian mimicry). The larvae actively prey on grasshopper eggs and therefore of use to man and they are vegetarian (eats flowers).
- NB// **Mullerian** mimicry is when two dangerous species copy each other's aposematic coloration to reinforce strength to their predators. (See picture below):



❖ **Firefly Beetles.**

- Firefly beetles are often thought to be flies but are actually beetles. They can be seen at night as small flashing yellow/green lights in tall grasses around marshes or moist areas. They are generally small orange or black beetles that have a unique way of producing light. In the rear segments of the abdomen they have special organs that produce light by mixing an enzyme and another substance on nerve instruction. The resultant flash of light is reflected outward by

special layers of crystals in the cells of that area. In most species both sexes fly and use this system in special code to attract mates.

- In some species however, the females are called **glow-worms** because they cannot fly and look like immature grub (although they are mature). These females crawl on vegetation while sending light signals and will sometimes mimic (copy) the light code of other species to attract them and when they arrive she attacks and eats them. The immature feed on snails but the adults generally don't feed; they just look for mates, reproduce and then die.
- NB// the light is produced by chemical reactions in the rear section of the body, where the enzyme **luciferase** oxidizes the substance **luciferini**, producing a cold light. (see picture below):



❖ **Butterflies.**

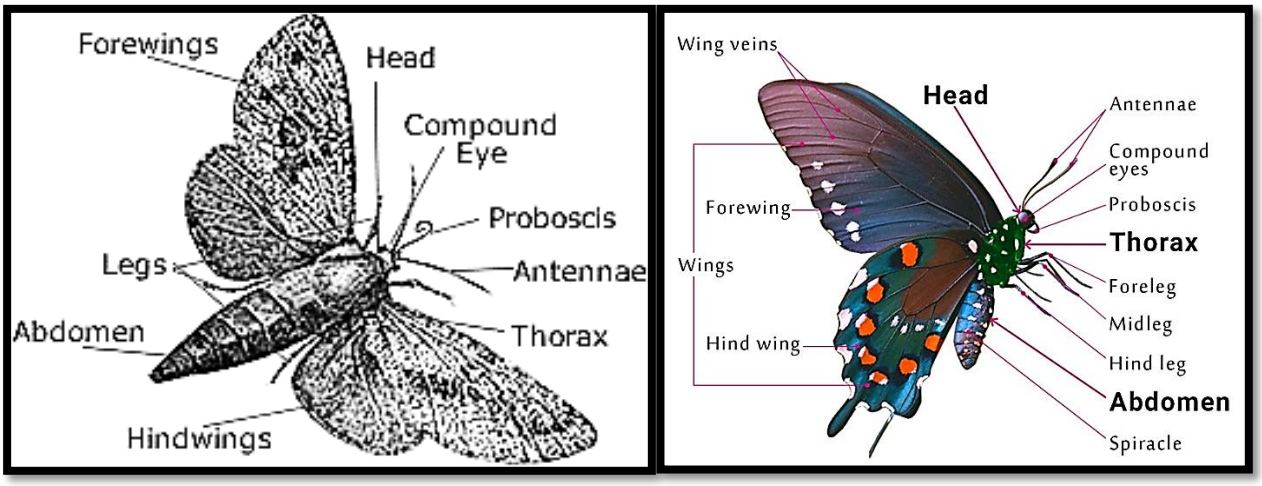
- Lepidoptera means 'scaled' wings and refers to the fine powdery scales on the surface of the membrane wing. The scales provide color for mating purposes, for warning predators and for camouflage.
- There are over 800 species in Southern Africa that are divided in 6 families as follows:
  - Hesperiidae – the skippers.
  - Papilionidae – the swallowtails
  - Pieridae – the whites
  - Lycaenidae – the blues and coppers
  - Nymphalidae – divided into 4 sub-families:

- Danaidae – the milkweed butterflies
- Satyrinae – the browns
- Acraeinae – the reds
-
- Nymphalinae or charaxinae – the brush-footed butterflies

- Tineidae – cloths moths (Ceratophaga vastella)

❖ **Differences between Moths and Butterflies.**

MOTH **BUTTERFLY**



Moths	Butterflies
Antennae are never clubbed	Antennae always clubbed or hooked
Mostly nocturnal	Mostly diurnal
Sit at rest with wings open	Sit at rest with wings closed
Have a hook (frenulum) linking wings	No frenulum linking front & back wings
Usually dull colored	Usually brightly colored

❖ **Habits and Breeding.**

- Butterflies and moths have touch sensors in the feet and sensors for smell and balance in the antennae. There are also special organs in the base of the antennae that help with orientation.
- The males can release pheromones (scents) to attract females from pouches in the wing scales. The adults eat a liquid diet of plant nectar and other juices that are sucked up through a long tubular mouth called a **proboscis.** The proboscis is often coiled up tightly in a circle below the head when not being used.

- The immatures (called caterpillars) are usually vegetarian and feed on plant material, but a few are carnivorous and ambush prey. Eggs are usually laid on the caterpillar's food-plant so that food is readily available when they hatch out. The eggshell is also eaten to give nutrients for growth.
- The caterpillar changes to an adult by a process called metamorphosis (where there is a major change in body structure) and after emerging from the cocoon (called the pupal case) the wet wings are pumped up with a body liquid similar to mammal blood called **hemolymph.** Once the wings are dry the adult flies away to feed and to find mates.
- Being insects, the body is divided into three parts with the thorax having 3 segments and the abdomen 10 segments.

❖ **Wasps, Bees, Ants.**

- Most species in this Order have venoms that they deliver in the form of a sting at the end of the abdomen. Most species tend to be social but there is also solitary species. In the social species the society is divided inti caste system very much like that of termites with every caste fulfilling a certain function.
- The adults of many species tend to be carnivorous (especially ants) but the grub-like larvae of many bees and wasps are also carnivorous – either actively hunting prey or being provisioned with it by the parent/workers. Ants are essentially wingless form of wasps. Some bee species are commercially important for the honey and wax that they produce.
- Many species make use of aposematic coloration (usually black and yellow) to warn enemies about their venomous stings. The matebele ants that can sometimes be seen crossing roads in 'columns' a few centimeters wide and over 1 meter long are the second largest ant in the world. Many ant species will tend or offer protection to bug insects such as aphids and scale insects. In return for this protection the ants feed off a delicacy rich in sugars and energy called **honeydew** that these insects secrete.
- Many wasps make the conspicuous nests that we see attached to buildings. Some of these are rounded or tubular mud nests that are made by spider-hunting and potter (mason) wasps. They fetch the mud with the mouth and glue it in place with saliva to make the nest, just like swallows do. These nests often have the paralyzed (but not dead bodies) spiders or caterpillars inside. This will provide the larva with fresh food supply when it hatches out; the prey will then be eaten alive. These nests are used by solitary species.

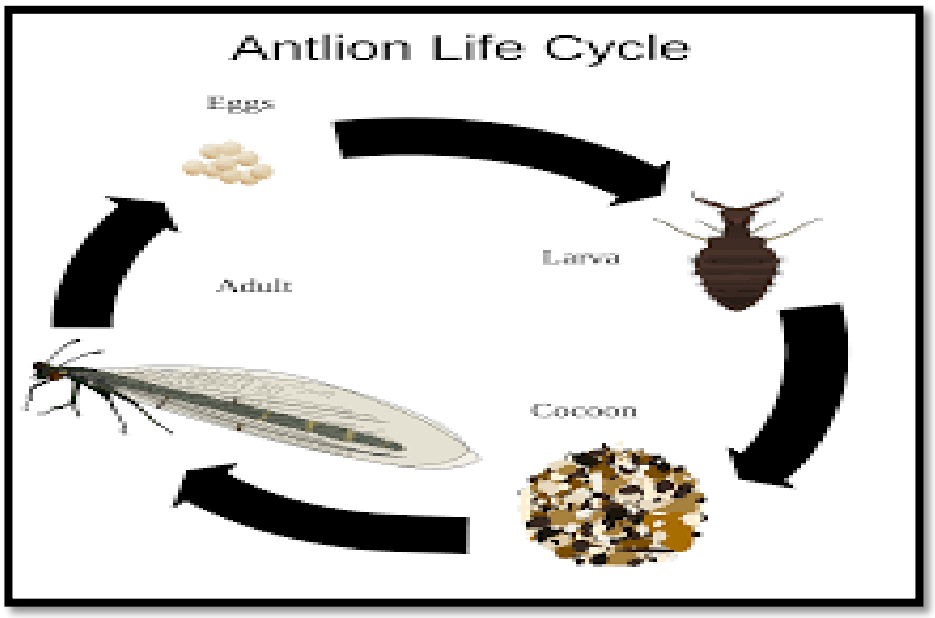
- The other common nests with the six-sided tubes that hang from a stalk are used by social species and the nest chamber is constructed from a material called **carton** (chewed plant and insects' parts). Each larvae is nursed by the workers of the group and fed regurgitated insect remains (usually caterpillar).
- This Order is also a very important source of pollinators for flowering plants and trees. Some will pollinate flowers because they wander around in them to find prey, not because they want nectar or pollen.



❖ **Antlions.**

- Antlions get their name from the larvae of many species that actively hunt and eat small invertebrates like ants. This they do by either moving through the soil in search of prey or by setting traps. These traps take the form of conical pits that are excavated in the soil. Eggs that are laid in the soil hatch to reveal a larva that looks like a tick with large pincers. It walks backwards through the soil; the sensory hairs on its body helping to locate prey and danger. When a suitable sandy spot in the shade is found then the antlion walks in circles and flicks sand outwards with the powerful pincers. As the circle get smaller the results is a pit (hole). The antlion then hides at the bottom of the hole under the sand and waits for an ant to fall in. It then grabs the ant with the mandibles and injects a saliva that turns the body of the prey to liquid (like a spider it has external digestion). This is then sucked up through the hollow mandibles. If the prey tries to escape then the antlion flicks sand at it so that it falls back down the hole.
- Antlion larvae can live in the soil for up to 7 years before pupating into an adult. They have no anus so all waste materials is kept in the body and only discarded during pupation. The adult usually do not feed and only live for a few weeks during which they mate, lay eggs and die. The adults look very much like dragonflies with wings that often patterned in black. Unlike dragonflies however they have long antennae and the wings are held roof-like over the body when at rest,

(dragonflies keep the wings at right angles to the body and have very short antennae). (See picture below).

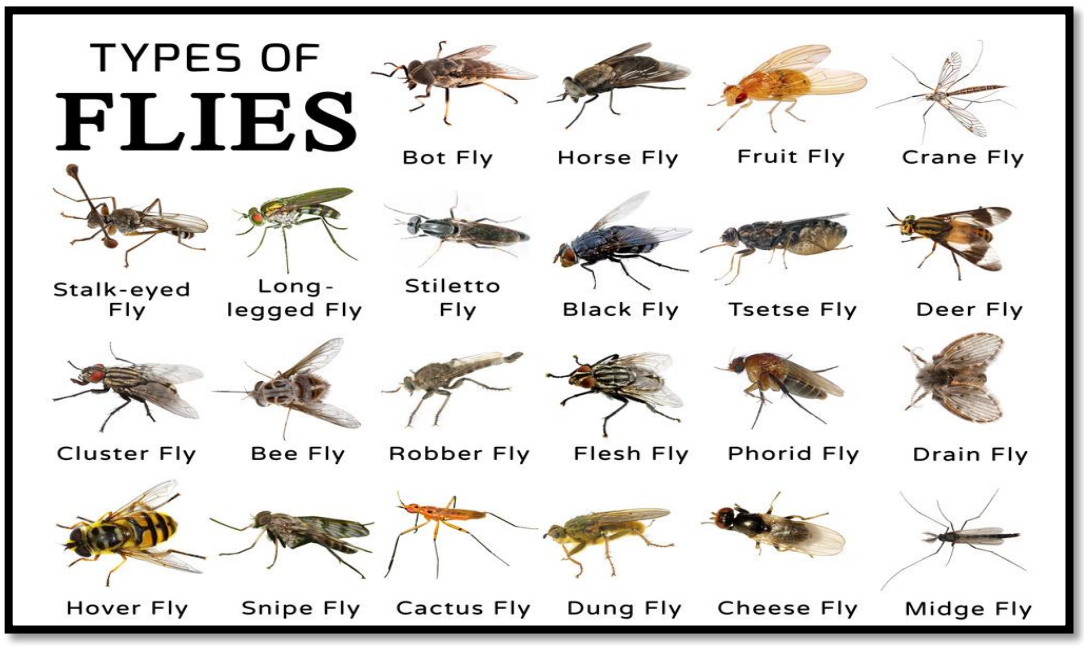


❖ **Flies (Diptera).**

- Flies are characterized by having only one pair of membranous wings. The other pair is reduced and modified to form stabilizers (called halters) for flight; enabling them to make all the amazing maneuvers that flies are renowned for. Flies are very important to man because they are major **vectors** (carriers and spreaders) of disease.
- This group includes the mosquitos that we know so well – they carry malaria. The flies that feed on blood (such as mosquitos, horseflies, louse flies, tsetse flies, etc.) do so in order to get protein for their own benefit and especially to enable the eggs to mature. It is therefore mostly the females that do this; with the males of these species feeding on plant or other juices. Flies feed on liquids that are sucked up through a short proboscis (feeding tube). Those species that are parasites on other animals have a special piercing proboscis (with sharp spikes called **lancets).**
- Many flies are useful in that they feed on waste materials and in this way get rid of this sites that 'breed' disease. Their immature form is a small, fat worm-like animal called a **maggot.** These hatch out of eggs very quickly and can reduce a carcass to nothing in a very short time. In fact, maggots of various species can help police find the age of a carcass because the incubation times and sequence in which different species feed on a carcass is so predictable. Both adults and

larvae are therefore carnivorous and the eggs are generally laid on the food-source so that the maggots can begin feeding immediately. Some species such as the tsetse fly do not lay eggs in the usual way. They give birth to live young (larviparous) – that either hatches immediately or hatches inside the female just before birth). A single baby is produced and because it undergoes most of its development in the female, it is nourished by special glands in the female's abdomen.

(See picture below):

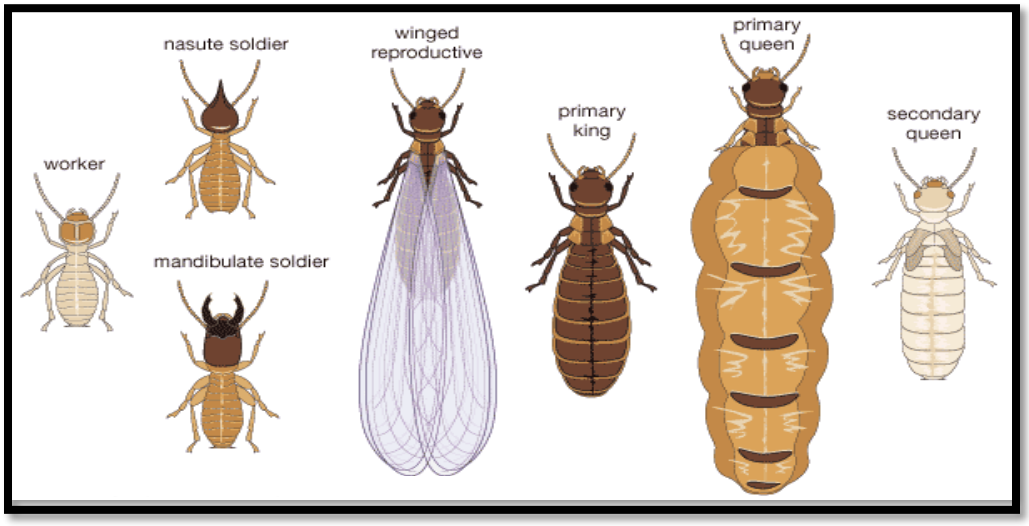


❖ **Termites *(Isoptera*)**

- ***Termitidae*** –common termites or macro-termis.
- ***Kalotermitidae*** – dry wood termites.
- ***Hodotermitidae*** – harvester termites.

- In terms of numbers of individuals, termites are among the most successful animals on the planet. They occur everywhere there is soil and vegetation. Termites are often called 'white ants' but this name is incorrect because although most species are pale in color, they are not white and they are not even related to ants. The fact that they are pale is as a result of lack of the brown pigment **melanin.** They are generally nocturnal and therefore do not need pigment – darker colors (such as those of ants) are usually a protection against the sun. They must therefore avoid the sun as much as possible and to accomplish this they will build sand covers over the food-source so that they can work in the shade. This also makes feeding more efficient because they can then feed 24 hours per day.

- It is interesting to note that most termites are blind and do everything by scent (pheromone) communication and brilliant cooperation. The society is divided into different groups called castes, namely:
  - **Reproductives –** the king and queen.
  - **Winged alates –** future reproductives.
  - **Workers –** clean, repair and build the nest, and take care of eggs and larvae.
  - **Soldiers –** defend the nest (colony).
  - (See picture below):



- The large termite mounds (correctly called **termitaria**) that dot the landscape in northern Botswana are a familiar sight but not all termites build such mounds. Many live in nests below the ground and have entrance tunnels and food collecting tunnels that can be seen at ground level. These tunnels can be used as vents or air tunnels that are used to regulate the temperature and humidity at the best level for survival and reproduction. The vents can be closed if the weather turns cold so as to stop warm air to escaping and can be opened or made bigger when it gets too hot and warm air needs to escape. Vegetation taken underground also decomposes and raises the temperature of the nest. Tunnels from the center of the nest often go down to the water table for moisture and the cooling effect it produces.
- Mounds generally occur in the larger colonial species indicating that these structures must be the most effective way of regulating conditions with the massive amount of heat being generated the processes in the colony. These species tend to cultivate fungal gardens (**termitomyces**) underground that are used to help break down the cellulose in their food (some species have small organisms in the gut that do this). The larvae and the royal pair are fed on this. To build the mound takes cooperation with all members working

together. The waste product from one worker is collected by another and then mixed with soil particles and set in place. On exposure to the sun it bakes hard (mound).

- A queen can live for up to 20 years, laying about 30 000 eggs per day. The mound is started in spring when winged reproductives called alates are released in large numbers from the mound by workers. The female will land, emit a scent signal (pheromone) that attracts a male and they will set off to start a new colony together. The wings come off when they land.
- It is possible that the queen selects a specific egg to be the next stage queen when she is about to die, allowing the colony to live up to 60 years with three generations of queens, hence – primary queen, secondary queen and tertiary queen. It is worth noting that most termites are blind and coordinate their activities by pheromones.

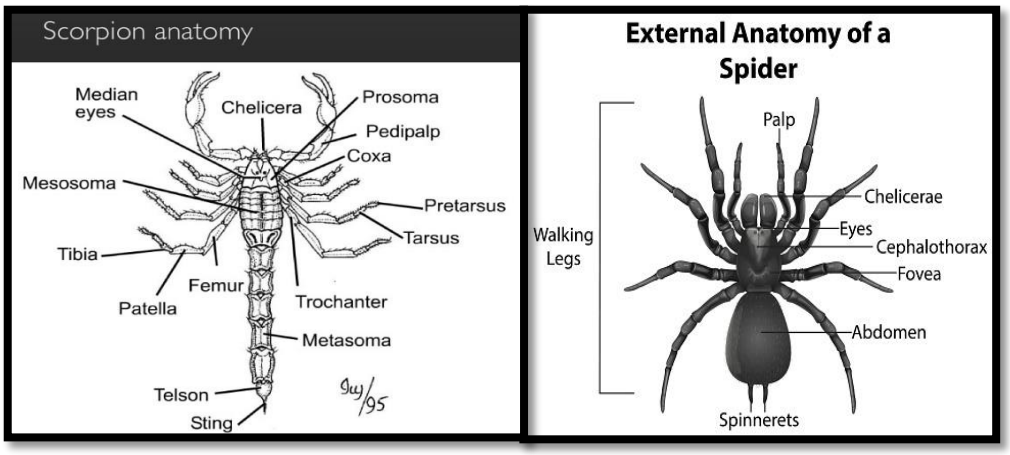
CLASS: ARACHNIDA (Spiders and Relatives – "9.1.6").

- The Class Arachnida comprises of the Order; Scorpions, Spiders, Ticks and Mites. The group has an extremely long fossil record, but scorpions in particular, date back from the **Silurian Epoch** of 400 million years ago. Most of today's forms are terrestrial, but some fossil species were known to be aquatic. These early species would have breathed by means of gills, and probably had fairly soft bodies.
- The movement of arachnids onto land required the development of lungs, modification of the limbs and a general hardening of the **epicuticle** (the outermost layer of an insect's exoskeleton) to prevent dehydration. Later, developments such as **silk** and **venom** apparatus were perfected as adaptation to their terrestrial way of life.

❖ External Anatomy.

- Arachnids all show fusion of the thorax and head into one unit, known as the **cephalothorax**. The abdomen is segmented in the scorpions, but has fused into one smooth unit in the spiders. The abdomen of scorpions is divided into two sections viz. the **pre-abdomen** (body section of the abdomen) and the **post-abdomen** (sting and tail). Their mouth parts consist of **chelicerae** and **pedipalps.** In some groups, these may be modified into biting and chewing apparatus (scorpions) or into sucking apparatus (spiders).

(see basic scorpion/spider anatomy below):



❖ **Arachnids – Spiders and Relatives**; will be dealt with in more detail below-:

- These are the most feared invertebrates that share our world, particularly the spiders and scorpions. They are all characterized by the following:
  - 6 pairs of jointed appendages – 1 pair of jaws (chelicerae), 1 pair of pedipalps (feelers/pincers) and 4 pairs of legs.
  - 2-part body – abdomen and cephalothorax (combined head and thorax) to which all the appendages are attached.
  - No antennae.
  - All are carnivorous
  - Never have wings.
- The groups that are generally encountered are the spiders, scorpions, ticks and solifuges' in the following Orders:
  - ***Araneae*** – Spiders.
  - ***Scorpiones*** – Scorpions.
  - ***Acarina*** – Ticks and mites.
  - ***Solifugae*** – Solifuges.
- Most have developed venoms to subdue and kill prey which delivered through fangs (spiders) or stings (scorpions). Ticks can have toxic saliva that has **anaesthetic** (insensetivity to pain) qualities that make the bite painless. Solifuges are nor venomous at all. Although a few species have venoms which are not dangerous to man and some can inflict painful bites and secondary infections may occur at the bite site; the majority of the species are harmless.

❖ Spiders.

- Characterized as follows:
  - Grow by shedding the exoskeleton (ecdysis) – there is no metamorphosis.
  - No segments on the abdomen.
  - Breathes with book-lungs in addition to trachea.
  - Always have simple eyes.
  - External digestion.
  - Internal fertilization.
- Spiders are broadly divided into 2 groups (although both have exceptions to the rules):

1. **Araneomorph Spiders** – generally web spiders that rely on a silk structure to catch prey. They have one set of book-lungs and jaws that work toward each other like a pincers. Generally small to medium spiders.
2. **Mygalomorph Spiders** – generally free-running spiders that chase and catch prey without silk webs. They have two sets of book-lungs and jaws that parallel to each other. Generally medium to large spiders.

- All spiders have organs called **spinnerets** at the end of the abdomen with up to 6 different types of silk glands that produce different silk for different purposes. Different silks are used to make web frames threads (not sticky), attachments discs, sticky strands, sperm webs (males only) and egg cases/cocoons (females only). Silk is a **protein** made up of many individual strands that make it incredibly strong, allowing it to support great weight. The silk is not stored but made and released when needed.

❖ Prey Capture.

- Once prey is caught, it is injected with venom and often tied with silk. It may be eaten immediately or stored. The venom not only kills prey but is also responsible for external digestion by turning the body insides to liquid that are then sucked up. The prey exoskeleton (called **carapace**) is either discarded or used as camouflage or a **stablimentum** (stabilizing mechanism) on the web. Some species ambush their prey from holes in the ground where they use a lid called **trapdoor** to hide themselves. Others will use silk to make a net to throw over the prey (**net-casting spiders)**.

❖ **Reproduction.**

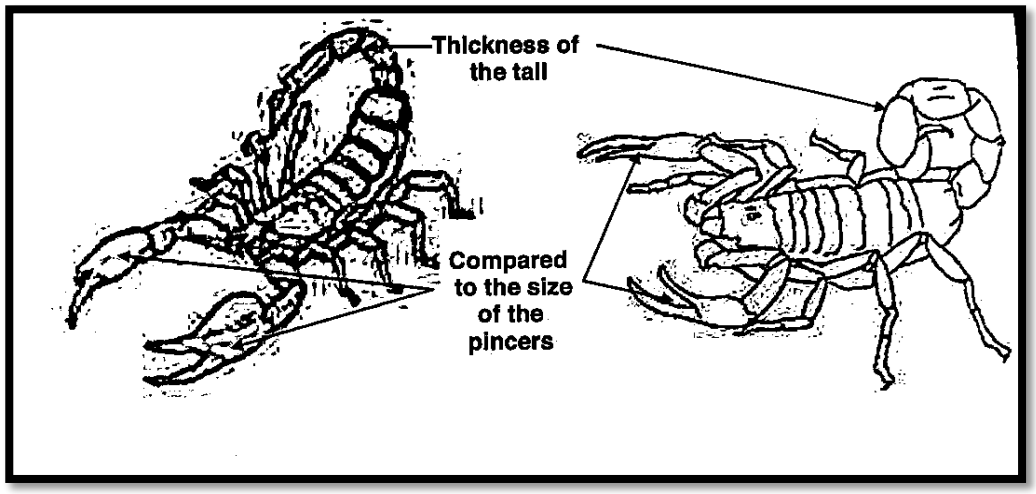
- Internal fertilization occurs with the male needing to transfer sperm to the female. Before finding a mate the male spins a small sperm web onto which he deposits a drop of sperm from his genital opening situated between the book-lungs on the belly. He then collects the sperm into a cavity at the end of his pedipulp. He then goes in search of a mate but must be careful as females are often a lor larger and could mistake the male to prey. Males with good eyesight often have courtship dances involving waving of pedipalps and tapping of feet.
- Those with poor eye sight pluck the strands of female's web in a code to get her attention and let her know that he is not prey. Some bring insects as food for the female to keep her busy while they are mating; while others make sounds to seduce the female. Once contact has been made and the female has **accepted**, the male inserts his palps into the female's genital opening (**epigynum**) to transfer sperm. The palps and epigynum are uniquely shaped in each specimen thereby creating "**lock & key"** mechanism to prevent cross-breeding. The sperm does not fertilize the eggs directly but is held in storage and only used when is needed.
- Araneomorphs maintain this sperm after moulting, but mygalomorphs do not and need to mate again after each moult. Egg-sacs are either carried around by the females in the spinnerets or jaws or deposited somewhere (usually well-camouflaged), and some females guard the egg sac. When hatched, the babies (called **spiderlings)** look identical to the adults. They either disperse rapidly or stay in a 'nursery' on the maternal web until able to fend for themselves. Some species also carry the spiderlings on their backs. Some spiderlings disperse by "**ballooning".** They move to a high vintage point where they release strands of silk and when long enough it is taken by the wind and the spiderling is carried away to colonise a new area. It takes 5 - 10 moults (instars) to reach adult stage. Most spiders live for 6 to 12 years, but some mygalomorphs (like baboon spiders) can live longer than 15 years.

❖ **<u>Scorpions.</u>**

- Characteristics are as follows:
  - The pedipalps are modified into pincers.
  - Segmented tail with a sting at the end.
  - Give birth to live young (viviparous & other species are ovoviviparous - producing young by means of eggs; hatched within the body of the parent).
  - Simple eyes clustered centrally on top of head.
  - All are venomous.
  - Internal fertilization.

- Like spiders, scorpions also undergo ecdysis.

- Two major families occur in Southern Africa - see the differences between two of the families below: (picture below):



	Scorpionidae	Buthidae
Tail	Thin tail	Thick tail
Pincers	Large pedipalps	Slender (small) pedipalps
Venom	Not very venomous	Very venomous

1) ***Scorpionidae*** **(Burrowing scorpions)** - have large pincers (pedipalps) and a thin tail with small sting, in relation to body size. This indicates that the prey is killed with the pedipalps as the venom is not powerful.
2) ***Buthidae*** **(thick-tailed scorpions)** - have small pincers and a thick tail in relation to body size. Prey is killed by the powerful **neurotoxic** venom. Stings from species can be fatal.

- Scorpions are generally nocturnal, hiding by day in any dark, concealed place such as burrows (natural or self-excavated), behind tree bark, beneath rocks or in cracks and crevices. They come out at night to actively hunt down prey, usually invertebrates, but also small vertebrates.

❖ **Reproduction.**

- Once potential mates find each other they perform a courtship dance where the pair grip each other pincers and walk back and forth together until a spot is found for the male to deposit a small bag of sperm (called **spermatophore**). He then gently walks backward and

guides the female over the spermatophore which bursts and fertilizes her when she touches it with her genital opening.

- Pregnancy is usually 3 - 9 months and then 5 to 90 live young that look exactly like the adults are born (no eggs are laid). They climb onto the mothers back where they stay for 1 - 2 weeks (when they moult). They then leave and move off on their own. In most species male moult 5 times and females moult 6 times before they reach sexual maturity. Some species live for more than 6 years.

❖ **<u>Solifuges/Red Romens</u>** (They are not spiders).

- Characteristics are as follows:
  - No venom glands
  - No spinnerets or silk glands.
  - Long, slender pedipalps that look like legs.
  - Two large simple eyes.
  - Massive parallel jaws.
  - Breathes through trachea.
  - Internal digestion.
- These dangerous looking arachnids have many common names in different areas. They are active predators, running very quickly to catch to catch their prey that is mostly invertebrates but also small vertebrates. Diurnal and nocturnal species occur. The pedipalps have sensors to identify prey which is then quickly grabbed by the massive jaws that are longer than those of any other arachnid in relation to body to body size. The jaws move rapidly backwards and forwards and also up and down, resulting in the prey being crushed within seconds. The semi-liquid material is then sucked up while solid material is left. Digestion is therefore internal, not external as in spiders. These arachnids can deliver a very painful bite. (See picture below):

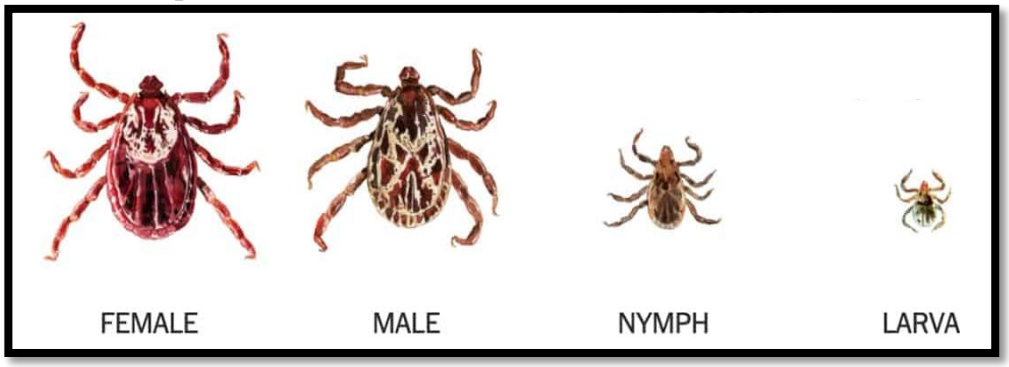


❖ Ticks.

- Are divided into 2 basic families:
  1. ***Ixodidae*** **(Hard ticks)** - have a hard shield (**scutum)** on the back that covers the whole upper surface of the male but only small area behind the head in the immature and female. I is often patterned with indentations or colors making identification easy. The mouthparts (called **gnathosoma** -adapted for sucking & biting) are visible when the tick is viewed from above. The body is very elastic allowing it to swell a lot when sucking blood. Ticks of this family transmits diseases. They only take 3 blood meals in their lives, once when a larva, once when a nymph and once when an adult.
  2. ***Argosidae*** (**Tampans/Soft ticks**) - except for the larva, the mouthparts are not visible from above. No scutum (hard shield) is present on the back resulting in the ticks being soft, leathery and wrinkled. Colorful species are rare with most being dull. These ticks generally live in sandy areas where they burrow under the sand for a few centimeters to wait for a food-source. They prefer shady areas and when an animal comes to rest in the shade the ticks are attracted by the carbon-dioxide breathed outby the animal. They follow this gas trail to the host, on which they feed before dropping off and burrowing into sand again to start the next part of the life cycle.
- All ticks are parasites on the outside of animals (called **ectoparasites**) and use various hosts to obtain meals of blood. Some have only one host, on which they live for their whole live but others use 2 or 3 different hosts (dropping off to the soil to moult between hosts). Many species are host specific, dropping off to the ground if they make a mistake and choose the wrong one. The larva has six legs whereas the nymphs and adults have 8 legs. The female lays the eggs on the ground and then dies. The males usually die on the host after mating.

- Ticks do not have a true head but a "**capitulum"** which has piercing mouthparts with backwards-pointing spines. This is what is pushed into the host as toxins, as toxins in the saliva act as an anaesthetic, and what secures the tick from being scratched off while it feeds.

(See picture below):



PHYLUM: ARTHROPOD - CLASS: MYRRIAPODA (9.1.7)

- The term Myriapoda is now defunct in zoological terms, but is still useful in uniting all arthropods that have elongated bodies with multiple legs and a distinct head. Previously **centipedes, millipedes, Pauropods and Symphylans** were all grouped together, but now each type belongs to its own class. The only two classes that will be dealt with in this module are the centipedes (***Chilopoda)*** and the millipedes ***(Diplopoda)***.

❖ **Centipedes: *(Class: Chilopoda)*.**

- The centipedes are well known throughout the world, with about 2500 species being known to science. The species belong to four orders of which will not be covered.

❖ **Centipede Characteristics:**

- Centipedes are terrestrial arthropods having a dorso-ventrally flattened appearance and many pairs of legs. They can attain quite large sizes, with tropical species often reaching a length of 30 cm. Many species have bright colors (**aposematic**) which serve as a warning to potential predators. Red, yellow, blue and green are all common centipede colors.
- The mandibles are well developed, having a toothed margin for grasping and tearing prey. These lie beneath the head and are positioned towards the outer edge. Beneath the mandibles are two pairs of maxillae, which are used for handling and manipulating food. Covering all these mouthparts are so-called poison claws or **forcipules** (modified, pincer-like front legs used to inject venom into prey). These are adaptations of the first body segment that have developed venom glands and ducts to transport venom to the sharp tips of claw. Behind the head and the first body segment are fifteen or more body segments, each bearing a single pair of legs.

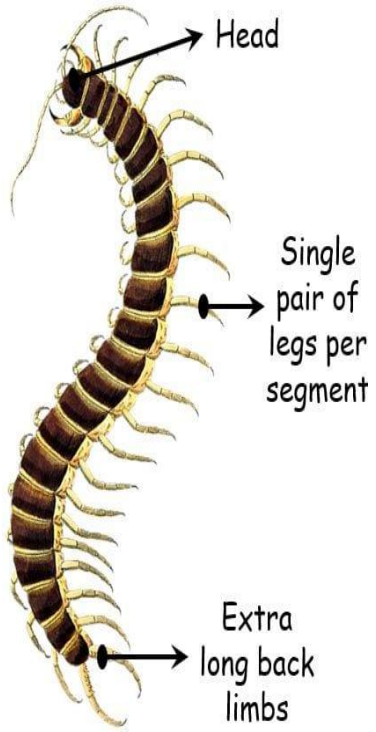
- The very pair of legs are usually enlarged into sensory and/or defensive apparatus. With these, some species are able to pinch quite hard. Other species bear **repugnatorial glands** (secrete offensive substances to deter predators) on the last four pairs of legs and are able to flick a sticky noxious substance onto enemies.

❖ **Nutrition.**

- The vast majority of species are predatory, feeding on small arthropods, and other invertebrates. Some of the larger species have been known to prey on birds, frogs, small mammals and reptiles. Prey is detected using the antennae and is overpowered with the forcipules and the venom that is produced. Many species are able to deliver a very painful bite, but none are known potentially lethal to man.

❖ **Reproduction.**

- Centipedes demonstrate a courtship display that may last up to an hour. After the display, the male spins a small web of silk from spinnerets, and into this he deposits a spermatophore. He then signals to the female who then picks it up and introduces it into her genital opening. About fifteen eggs are laid in a damp and protected spot, where the female broods them until they hatch. The hatchlings have their full compliment of legs and body segments at birth. Centipedes are quite long-lived, having a lifespan of up six years. (See picture below):



Millipedes: *(*Class: *Diplopoda)*.

- About 7500 species of millipedes are known worldwide. The best known of these are the **juliform** species, the common cylindrical species so familiar to Southern Africans.

❖ **Characteristics of Millipedes.**

- The class is different to the centipedes in that each body segment bears two pairs of legs. These body segments are called **diplosegments.**
- The head is large and usually bears a distinct eye or at least several **ocelli** (simple eyes). The mouthparts consist of cutting mandibles and maxillae for food handling. There is always a pair of antennae, which are used to tap the substratum ahead of the animal as it moves. This allows the millipede to detect food sources, a mate, enemies etc. The first body segment is legless, and segments 2, 3 and 4 all only have one pair of legs. The "shell" or **integument** is composed of calcium salts.

❖ **Locomotion.**

- The legs of millipedes are pulsed in waves according to the type of locomotion required at the time. When merely walking, only 12 or so legs are involved in the wave motion, but during pushing, up to 52 are involved. This motion allows the legs that have finished their pushing stroke to move forward in preparation for another push, while others are still busy pushing. In this way the millipede has a continuous forward thrusting force.

❖ **Protective and Defensive Strategies.**

- The slow nature of millipedes demands that they be well protected in order to escape from predators. This they have done very well and are amongst the best protected terrestrial arthropods. The integument (shell), being made of calcareous material affords some protection from predation of ants etc. Most species will coil up tightly to protect their ventral surfaces when they are disturbed or threatened. Pill millipedes roll into a very tight ball, not even exposing their legs.
- Other species will roll onto their backs and move very quickly in serpentine motion that may be designed to mimic the movement of a snake, or may simply be a means of increasing the speed with which it can evade enemies.

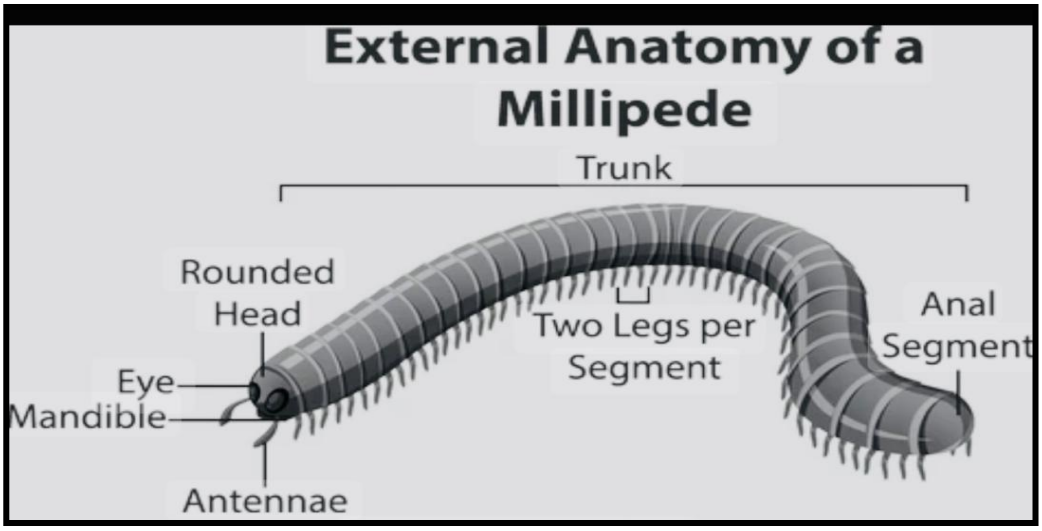
- Most species have repugnatorial glands (usually one pair of glands per diplosegment) with which they may deter predators. The glands secrete aldehydes, phenols, quinones and hydrogen cyanide. The chemicals themselves are deterrent, but some species can even squirt them up a distance of 30 cm in a fine spray.

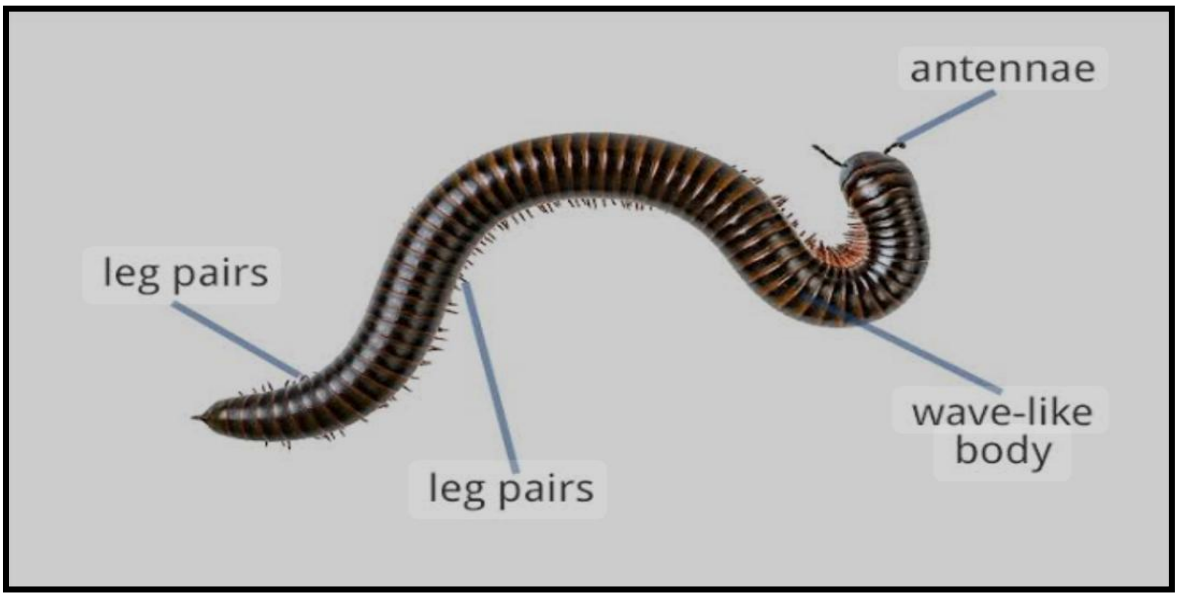
❖ **Food and Feeding.**

- All species are herbivorous, feeding on decomposing vegetation and new growth of healthy plants. Food is simply moistened with secretions from the mouth and then chewed off with the mandibles and swallowed.

❖ **Reproduction.**

- Millipedes locate one another for mating purposes by a trail of pheromones that is laid down. Once the male has located a female, he begins a courtship which involves tapping and stridulation on the **tergum** (a thickened dorsal plate on each segment) of a female. He then curls around the female and transfer of spermatophore takes place using the specially adapted legs of the seventh diplosegment. The female stores the spermatophore and the eggs are only fertilized when they are laid.
- From 10 to 300 eggs are laid in clusters in underground hollows. When the young hatch they are undeveloped, having only the first three pairs of legs and up to seven body segments only. As the animal grows, and the integument gets too tight, the millipede moults its skin. Each moult sees the animal develops more pairs of legs, until with final moult and the millipede is fully developed. Many species moult in specially constructed chambers similar to the ones in which the eggs are laid. The shed skin is eaten by the millipede. Millipedes may live for up to 10 years.





PHYLUM: MOLLUSCA (9.1.8)

- Molluscs form a large part of the animal kingdom, comprising over fifty thousand known and described species. The phylum includes animals as varied as snails, slugs, oysters, bivalves, octopus, squid and clams etc.

❖ Generally, combinations of the following characteristics are typical of molluscs:

- The lower surface of the body has developed into a muscular, creeping foot.
- The body is unsegmented and bilaterally symmetrical.
- Respiration is by means of gills or lungs.
- The upper body has developed into a system of two folds known as the mantle (body wall). This mantle secretes the shell, and hides the respiratory organs.
- The body is generally well supplied with mucous secreting glands.
- Their shell (if present) is dorsally positioned and has the shape and function of a shield.
- They have poorly developed heads.
- They breath by means of gills.

- The majority of these animals are encountered in marine and other aquatic environments. As a result, the only molluscs that a field guide is likely to encounter are the terrestrial **snails** and **slugs.** Consequently, only the Gastropods and of these, only the Order **Pulmonary** (freshwater and land snails and slugs) will be covered in this module material.

➢ CLASS: GASTROPODA - (Order: Pulmonata).

- There are approximately thirty-five thousand species of gastropods known worldwide, having had an unknown fossil record from the Cambrian epoch.

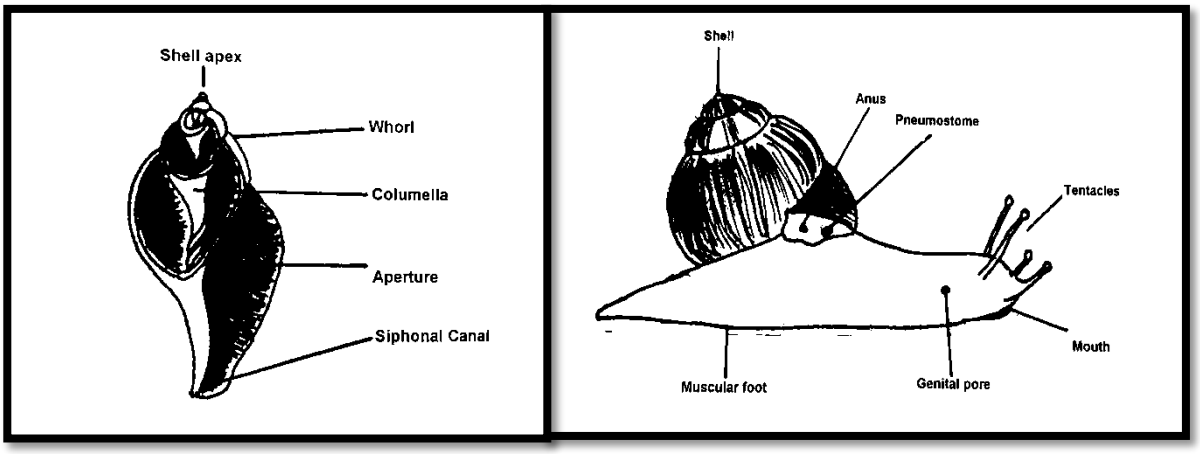
❖ Characteristics of Gastropods.

- They have developed well-defined head.
- Their shell has been modified from a shield into a retreat. The structure of the shell is always a univalve, i.e., in piece unlike those of the clams, oysters etc.
- The all undergo a peculiar change known as **torsion** (twisting - a 180-degree rotation).

❖ The Shell.

- The shell material is secreted by the mantle and consist of three typical layers. The outside layer known as the **periostracum** and serves to waterproof and protect the shell. The middle layer is the **prismatic layer** and consists of calcium carbonate. This serves to strengthen the shell and provide rigidity. The inner layer is called **nacreous layer** and consists also of calcium carbonate, but these are deposited in very fine layers. (Snail shell picture below):
- During periods of drought or during winter, a layer called **epiphragm** is secreted by the pedal glands; this prevents water. The shell is an **asymmetrical spiral** in its present form. It seems to have originated from the **planospiral** shape (that of a hosepipe coiled flat on the ground). The spiral of the shell may be either **dextral** (right hand twist) or **sinistral** (left hand twist).
- The spiral forms around the **columella,** a central pillar on which the whorls of the shell are deposited. This allows for a very compact design. Shells of this nature are carried obliquely to the long axis of the body. The shape has limited the efficiency of breathing through gills as in other molluscs. Consequently, many gastropods have developed a lung that opens to the atmosphere through the **pneumostome** (breathing pore).
- The tip of the shell is always the oldest, with successive layers of material being deposited around the opening in whorls. From the opening, the head and foot protrude from the shell. **Retractor muscles** draw the exposed body parts back into the shell when need arises.

(See picture below):



Torsion.

- A larval snail starts its life being bilaterally symmetrical i.e., each side of the body is equal in shape and dimensions. As the larva grows, one side of the body grows faster than the other, and causes the body to undergo a flexing action. This action ultimately twists the entire visceral mass through 180-degrees. This results in an asymmetrical body, with the anus and viscera having been twisted around to be located near the head.
- Torsion is very rapid in some species and may only take a few moments to be achieved. The function of torsion is thought to be safety, in that the head can be withdrawn into the mantle cavity leaving only the foot exposed to predation.

❖ **Locomotion.**

- The foot or the sole is **ciliated** (have hair-like projections) and has glands that produce mucous on which the animal walks. This form of locomotion is extremely slow. This movement is accomplished by a complex system of waves that pulse backwards or forwards along the foot and propel the animal along as if in a liquid medium. Mucous left behind is also used by snail to home in on communal hibernating and breeding grounds. This is done by a pheromone trail left in the mucus.

❖ **Nutrition.**

- Most molluscs feed by means of a **radula.** This is a tongue like a conveyer belt that has multiple chisel-shaped teeth on its surface. This is moved forward and upwards against the food source, and particles are rasped from the surface and swallowed into the gut. Most species are herbivorous, feeding on decaying and young plant matter. Others however are carnivorous, and many specialize in feeding on other species of snails.

❖ **Reproduction.**

- Snails and slugs are **monoecious** i.e., they have both sexes within the same body. Mating takes place reciprocally, with each individual inserting its penis into the vagina of the other and transferring the spermatophore. Eggs are laid by each individual in a moist locality where they develop for up to a month. On hatching they are miniature replicas of the adult. Snails can lay anywhere from a few hundreds of eggs at a time; depending on the species. Species like the Giant African Land snail, can lay 100 to 500 eggs, while others like freshwater snails may lay 30 to 400 eggs. (See picture below):

