

SUB-STRAND 1.4: COMPARATIVE FORM AND FUNCTION IN PLANTS AND ANIMALS

ACHIEVEMENT INDICATORS

At the end of this sub-strand, students should be able to:

- ✓ Study the storage and utilization of food in plants.
- ✓ Compare and contrast the digestive systems of selected invertebrate and vertebrate animals to show increasing complexity.
- ✓ Discuss the process of digestion in selected organisms.
- ✓ Compare and contrast the gas exchange systems of selected organisms to show increasing complexity.
- ✓ Study the gas exchange system of selected aquatic and terrestrial organisms to their mode of life.
- ✓ Name and describe the different methods of transport in plants and animals.
- ✓ Recognise the increasing complexity of the vertebrate heart.
- ✓ Compare and contrast the excretory mechanisms of selected organisms to show increasing complexity.
- ✓ Compare and contrast osmoregulation in selected organisms to their mode of life.
- ✓ Evaluate the different forms of protection, support and movement in selected organisms.
- ✓ Compare and contrast support and movement in selected invertebrates and vertebrates.
- ✓ Explain the sensory system in plants and explain how its co-ordination helps the plants to survive.
- ✓ Explain the sensory system and relate the efficiency of co-ordination to symmetry type in animals.
- ✓ Explain the need for reproduction.
- ✓ Differentiate between the various asexual methods of reproduction in animals.
- ✓ Differentiate between internal and external fertilization.
- ✓ Evaluate the factors contributing to the reproductive success in plants and animals, using specific native examples.

BI 12.1.4.1 NUTRITION

- ❖ Nutrition is the process of providing food to the body cells for health and development (growth).
- ❖ Plants, bacteria, fungi, protists and animals, all need a constant supply of energy to survive and reproduce.
- ❖ They get their energy from food.
- ❖ Every organism has a nutrition method adapted to its lifestyle.

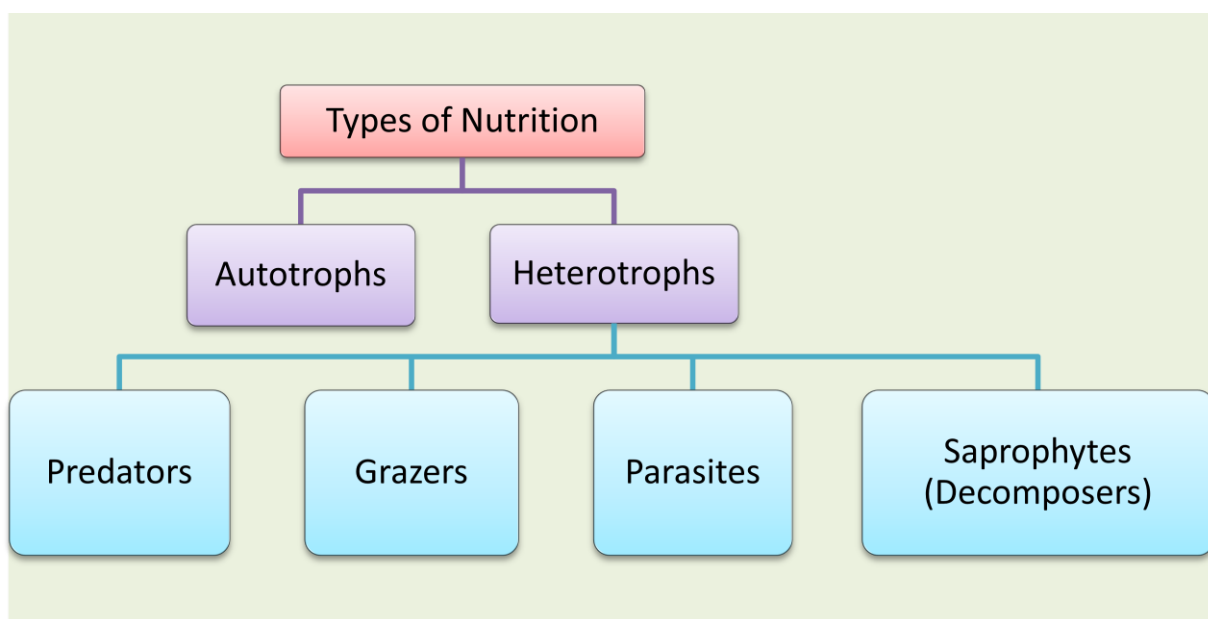
Nutrition methods

- ❖ Plants and animals have different processes of obtaining food (energy).
- ❖ Plants and some bacteria have chlorophyll (green pigment) to help them make their own food.
- ❖ Animals, fungi and other bacteria depend on plants and other organisms for food.

There are two main modes of nutrition: **Autotrophic** and **Heterotrophic**.

Autotrophic nutrition is the process by which green plants manufacture their own food by converting solar energy (sunlight) into chemical energy (food).

Heterotrophic nutrition is the process whereby organisms that cannot make their own food obtain their food (energy) either directly or indirectly from plants or other organisms.



X

Autotrophs (*'auto' means self*); organisms that are capable of making their own food using the solar energy (sunlight) into chemical energy (food) . E.g. plants, some bacteria and some protists.



Heterotrophs (*'hetero' means different or other*) organisms that cannot make their own food and depend on plants or animals food.
E.g. animals, fungi, most bacteria and protists.



Predators: organisms that prey (hunt and kill) on other organisms. E.g. sharks prey on big or small fish, toads prey on lizards and insects, cats prey on mouse and birds, mynah bird preys on worms.



Grazers: organisms that feed on an entire population, often without killing them. E.g. cows, goats, green sea turtle, filter feeders (kai and coral), herbivorous insects and some fish.



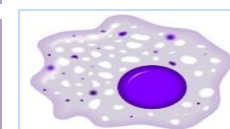
Parasites: organisms that live and feed on or in an organism of a different species and cause harm to their host. E.g. bacteria, fungi, fleas, ticks, nits, lice, tapeworms, protists etc.



Saprophytes (decomposers): organisms which get their energy by feeding on dead organic matter causing it to decay. E.g. fungi, bacteria, maggots, insects, grubs, snails, slugs, beetles, millipedes, ants etc.



Microphages: animals (mostly aquatic) that feed on very small particles suspended in water like phytoplankton and tiny organic fragments.



Fluid feeders: Are organisms that feed on liquid food from plants and animals. There are two groups of fluid feeders;

- **Wallowers** - are organisms that literally wallow (roll about relaxed in water or mud) in their foods. E.g. a gut parasite such as tapeworm.
- **Suckers** – are insects and spiders with mouthparts in the form of a proboscis for piercing and sucking. E.g. Housefly, mosquitoes.



Filter feeders: Include aquatic organisms like sponges, sea squirts, bivalve mollusc and mosquitoes on land. They employ filtering systems to collect, sort and concentrate the particles from water.



Gulpers: Organisms that gulp down their food whole and swallow without chewing their food first. E.g. snakes, *hydra*, sea anemone, frogs and fish-eating birds.



Masticators: Organisms that bite, tear or chew their food into smaller pieces before swallowing. Herbivorous animals such as a cow is a very good example of a masticator which chews its food for long.

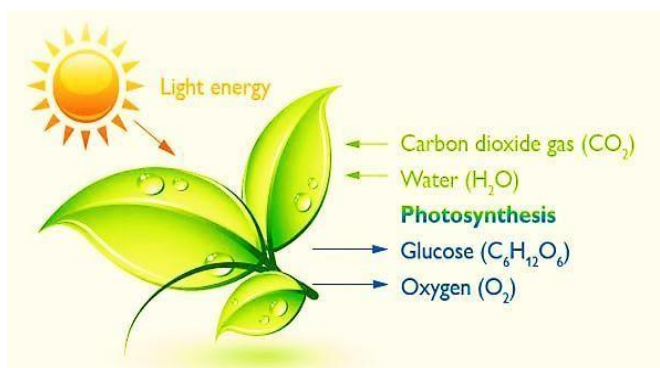


- ❖ **Heterotrophs depend on the autotrophs for food.**
- ❖ Food is required by the organ system of the body to keep the organism alive and to provide **energy** for the various bodily processes and activities carried out by the organism.
- ❖ Different types of organisms are adapted differently to their environment and way of life.
- ❖ **Active and large organisms** require plenty of energy and so need lots of food quickly.
E.g. humans, cows, dogs, cats etc.
- ❖ **Sessile organisms** require only small amounts of energy and so do not need much food.

Nutrition in Plants

Food manufacture

The food manufacturing (making) process in plants is called Photosynthesis. Photosynthesis has been widely discussed earlier hence, here will summarise the entire process.



Ingredients used:

- ❖ Plants need several inorganic materials in order to make food.

Following are the raw materials (ingredients) required for photosynthesis and the adaptations of plants for obtaining these materials.

Sunlight for energy	Adaptation
	• Pigments in the thylakoid membranes of the chloroplast absorb light (solar energy) from the sun. • Leaves are broad for maximum surface area for absorption of light. • Leaves are small to allow light to filter to the leaves on the lower branches. • Palisade layer, with the highest density of chloroplasts in its cells, is close to the top surface of the leaf in order to absorb more sunlight. • Irregular-shaped cells in spongy tissues enhance scattering of light, increasing the path length of light travelling through a leaf, thus increasing the probability of absorption. Path lengthening is important for the weakly absorbed wavelengths of light.
Carbon dioxide	
	• Carbon dioxide (for carbon and oxygen atoms) • Stomata on the bottom surface of the leaf are open to allow for diffusion of CO₂ from the air into the leaf. • The spongy mesophyll leaf has plenty of air spaces so the gas can diffuse more easily to the palisade layer. • Leaves are usually very thin to allow faster diffusion.

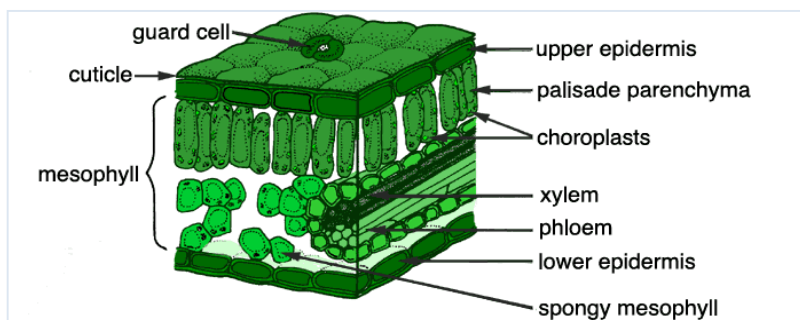
Water



Adaptation

- Water (for electrons, hydrogen ions, co-enzymes and minerals)
 - Root hair increases the root surface area for absorption.
 - The network of veins in the leaves helps transport water and carbohydrates.
 - Roots show geotropism and hydrotropism.

Cross-section of a Leaf

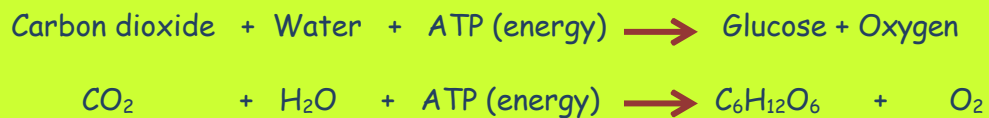


Source: <https://sciencevogel.wikispaces.com>

Leaf Structure	Adaptation for photosynthesis
Cuticle	– Prevents loss of water from leaves
Epidermis	– Transparent protective layer. – Protects leaf without inhibiting photosynthesis.
Palisade layer	– Palisade cells are filled with chloroplasts to absorb maximum light for photosynthesis. – Palisade cells are long and thin so light has to pass through as many chloroplast as possible.
Mesophyll layer	– Has plenty of air spaces that increase the surface area inside the leaf to maximize.
Stoma	– Allow exchange of CO ₂ and O ₂
Guard Cells	– Allow the stoma to open and close to regulate loss of water from the leaves
Xylem	– Conducts water in plants
Phloem	– Conducts food in plants

Use of Ingredients

- ❖ Plants use light, carbon dioxide and water as the ingredients for making food by the process of photosynthesis.
- ❖ Oxygen is produced as a by-product of photosynthesis.

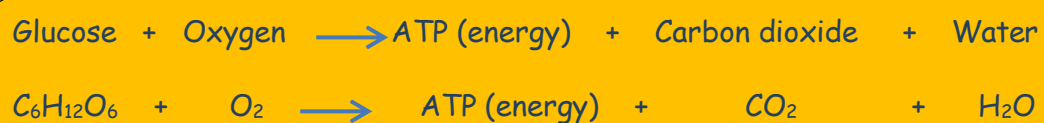


Food Storage by Plants

- ❖ Plants store most of the food they make until they need for growth or reproduction.
- ❖ Phloem carries food from the leaves to cortex cells in the stems and roots.
- ❖ Food is stored as starch or glucose in the cortex cells.
- ❖ Consumers eat plants to get energy from their stored food.
- ❖ Except for flower nectar and fruits, plants make all food for their own use.

Food Usage by Plants

- ❖ When a plant needs to use some of its stored food, it hydrolyses starch into molecules small enough to pass through cell membranes.
- ❖ This process of food hydrolyses is called **respiration**.
- ❖ Respiration in plants is carried out in the mitochondria just like in other organisms.
- ❖ The phloem then carries the food molecules to the cells that need energy.



Mineral needs in Plants

In addition sunlight, CO₂ and water, plants also need specific minerals:

- ❖ Minerals absorbed by plants have to be first dissolved in water, in which minerals form ions.
 - ❖ Charged ions cannot diffuse through the cell membrane due to mineral concentration often being higher inside a plant than outside.
- Therefore, plants actively transport minerals into their roots.

Mineral	Function/ role in Plants	When deficient and/ excess in Plants
Nitrogen	– Taken up by plants as NO₃⁻ and NH₄⁺ – Used in larger quantities than any other mineral nutrient. – Component of proteins, nucleic acids, cofactors. – Part of chlorophyll molecule.	– Most frequently deficient for normal growth of non-legumes. – Plants become stunted (become yellow) on the older leaves. – Nitrogen is mobile in the plant so new leaves may remain green. – Excess nitrogen may delay maturity. – Cause excess growth and little fruiting in melons and tomatoes.
Potassium	– Taken up by plants as K⁺ – Especially important in water/solute balance; involved in plant enzyme action. – It is a catalyst in many reactions; carbohydrate, starch and nitrogen metabolism. – Activates enzymes involved in photosynthesis, protein and carbohydrate metabolism. – Adjusts stomatal movement and water relations. – Helps disease resistance. – Increases quality of fruits and vegetables.	– Tips and margins of leaves turn brown. – Potassium is mobile so this occurs first on lower leaves. – Weakening of straw in grain crops (lodging). – Important in preventing non-protein nitrogen from accumulating in plants.
Phosphorous	– Taken up by plants as H₂PO₄⁻ and H₂PO₄²⁻ – Part of the protein molecule (phospholipids). – Necessary for transfer of energy during metabolic processes (ATP). – Speeds up maturity, promotes good root development, improves drought and cold tolerance, improves seedling vigour – Important in seed and fruit formation.	– Overall reduction in growth, causes stunting. – Dark green colour - purple cast in corn on lower leaves first because phosphorous is mobile. – Delay in maturity. – Failure of seed to form

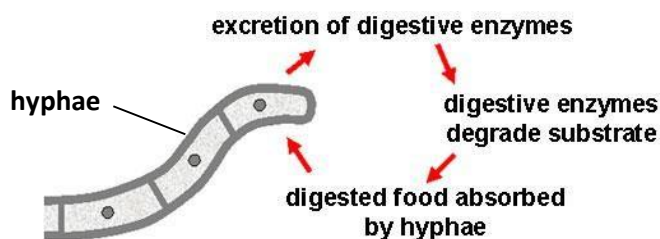
Calcium	– Taken up by plants as Ca^{2+}. – Important in cell walls and in forming the spindle during cell division. – Calcium pectate gives strength to cell walls. – Needed for peg development in peanuts. – Plant root and tip elongation.	– When calcium is immobile, new growth is affected. – Failure of terminal buds to develop – Symptoms are not usually seen under field conditions because other problems caused by acidity of soil will generally become limiting factors. – Liming prevents Calcium deficiency from occurring.
Magnesium	– Taken up by plants as Mg^{2+} – Component of chlorophyll; involved in plant enzyme action. – Related to phosphorus metabolism. – Large quantities found in seed.	– Mg is mobile so symptoms occur first in old leaves – Causes interveinal chlorosis (whitish or yellowish striping effect on grasses).
Sulfur	– Taken up by plants as SO_4^{2-}. – Constituent of 3 of the 21 amino acids which form protein cysteine and methionine. – Present in the organic compounds that give the characteristic odours of onion, garlic, and mustard.	– Similar to N deficiency symptoms. – It is less mobile than nitrogen so deficiency may be more apparent on younger leaves.
Manganese	– Taken up by plants as Mn^{2+} and Mn^{3+}. – Can be absorbed through the leaves – Required in small quantities - large amounts are toxic (acid soils). – Activation of enzyme systems. – Chlorophyll synthesis.	– Mn becomes immobile upper leaves develop yellow streaks.
Iron	– Taken up by plants as Fe^{2+} or Fe^{3+}. – Acts as a catalyst in the production of chlorophyll.	– Occur on high pH soils or certain plants. – Immobile so deficiency symptoms occur on young leaves. – Inter-veinal chlorosis may turn leaves completely white.
Copper	– Taken up by plants as Cu^{2+} (can be absorbed through leaves) – Very toxic if too much applied. – Copper is a catalyst in chlorophyll formation.	– Immobile so upper leaves affected; youngest leaves are yellow and stunted – Vegetables - plants wilt and develop a bluish green cast.
Adopted from: http://broome.soil.ncsu.edu/ssc051/Lec5.htm		

DIGESTION

Digestion by biological means involves both mechanical and chemical processes to break up food into smaller or simpler constituent parts that can be absorbed by the body.

- ❖ Different organisms have different methods to digest food.
- ❖ The two common modes of digestion are **external digestion** and **internal digestion**.

- ❖ **External digestion** is where food is digested from the outside through secreting enzymes that degrade food material and then absorbed through diffusion.

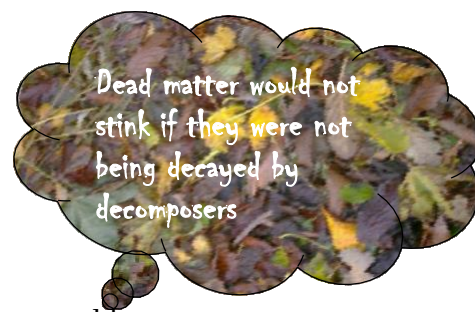


Source: <http://bioweb.uwlax.edu/>

- ❖ Cnidarians as well as some bacteria and parasites also employ external digestion for obtaining nutrients.
- ❖ But most bacteria and fungi are decomposers, or saprophytes. They secrete digestive enzymes onto dead matter and wait for the enzymes to decompose the food which is then absorbed into their cells using active transport.
- ❖ External digestion is not suitable for mobile organisms as it requires the organisms to stay with food until it has completed digestion and absorption.
- ❖ Whilst, most bacteria and fungi species are not motile, external digestion saves them the energy expense of taking in large molecules and having digestive organs.

Importance of Decomposers

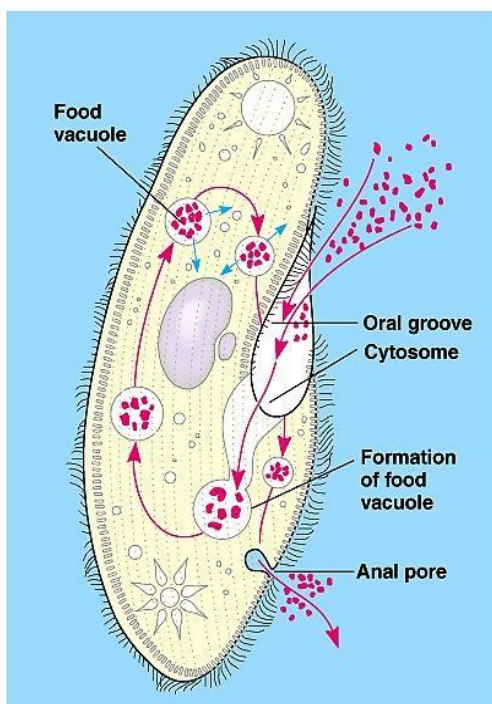
- ❖ Without decomposers, the world would soon be buried in dead leaves, animal corpses (dead body) and faeces.
- ❖ Plants would run out of minerals and without minerals, plants would not photosynthesize and the living world would suffocate and starve as it runs out of oxygen and food.
- ❖ Saprophytic bacteria and fungi quietly go about their business of acquiring energy from dead organic matter, and keep the world community alive by breaking down dead organisms and releasing minerals.



Nutrition in Protists

- ❖ Protists are unicellular organisms that are usually classified as a separate kingdom.
- ❖ Some protists function as one-celled plants; they photosynthesize.
- ❖ Others obtain food from their environment, like one-celled animals.
- ❖ A common example of protists is the Paramecium.
- ❖ Paramecium is a genus of protists that lives in fresh water.
- ❖ Their mode of locomotion is by beating of the cilia that cover their cell membranes.
- ❖ They feed on bacteria that float in water. Cytosome

How does a Paramecium feed?



Paramecium feeding steps:

1. A paramecium is a minute particle feeder which uses its cilia to beat food particles in the surrounding water down the oral groove. The oral groove and the cytopharynx (a sac-like structure at the end of the oral groove) act as the mouth of the Paramecium.
2. Food vacuoles surround the food accumulating at the end of the cytopharynx. Lysosomes, containing digestive enzymes, fuse with the vacuoles to digest the food.
3. The digested food diffuses through the cell cytoplasm and mitochondria oxidise it to produce ATP.
4. Wastes are egested by exocytosis at the cell membrane.

Source: <http://www.mun.ca/biology/>

Other Heterotrophic Protists

- ❖ Most other heterotrophic protists, such as Amoebas, also eat by endocytosis i.e. surrounding and digesting food in food vacuoles.
- ❖ Protist feeding is the simplest example of internal digestion.
- ❖ They digest food inside their bodies.
- ❖ This is important because protists are motile.
- ❖ A protist's energy needs are too great to stay in one place and wait for their enzymes to digest food.
- ❖ If protists had external digestion like fungi and bacteria, they would have starved.

Adaptations for Feeding

- Natural selection favours organisms with adaptation for efficiently ingesting the kind of food they need.
- For example, an organism that sucks blood has different mouth parts from animals that feed on grass.
- Similarly, an ant that eats wood has different mouth structures from insects that drink nectar.

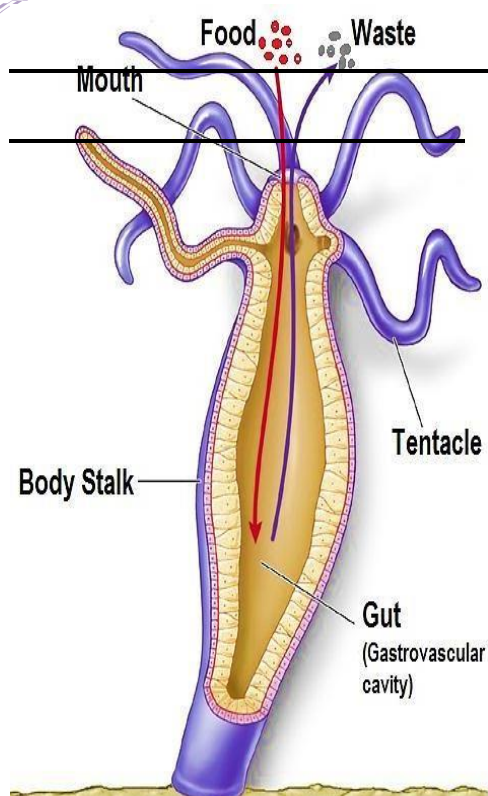
Nutrition in Animals

In Year 11, the human digestive system was studied. This year the varying digestive systems of other animals will be examined.

- ❖ All animals are heterotrophs with internal digestion.
- ❖ They all must ingest food, digest it, absorb the nutrients, and then egest any waste.
- ❖ Though, animal guts share the same basic functions, the animal digestive system is specially adapted to the animals' food and lifestyle needs.

Invertebrate Animal Digestive System

- ❖ Invertebrates are animals without backbones.
- ❖ Generally invertebrates have simple guts.
- ❖ In this section we will study the digestive system of representative from three invertebrates' phylums: Cnidarian, Annelida and Arthropoda.



Source: <http://www.zo.utexas.edu/faculty/sjasper/>

Nutrition in Cnidarians

Cnidarians have a simple 'sac-like' gut, with only one opening and one unspecialised gut chamber which suffices the energy needs of sessile cnidarians.

- ❖ Cnidarians do not have a circulatory system to deliver nutrients – digested food diffuses from the gut to the body cells.

Cnidarians feeding steps:

1. Food is trapped and pushed into the mouth with tentacles.
 2. Food is digested and absorbed in the one gut chamber.
 3. Waste is ejected back and out of the mouth.
- Example: *Hydra* shown on the left.

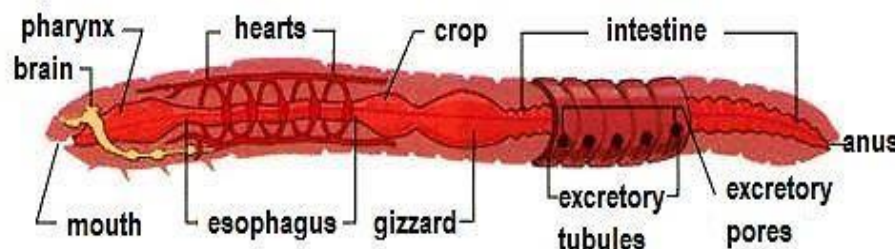
Adaptive Value of the Sac - like Gut

- The cnidarian gut is very simple since cnidarians have an inactive lifestyle.
- Simple cnidarians are sessile therefore, their cells do not need much energy.
- One gut opening and one gut chamber supplies enough food for their body cells.
- Since a cnidarian has only one gut opening, it must completely digest and absorb a meal and egest the wastes before it can eat anything else.
- An active animal cannot survive with such a simple digestive system.
- Humans need over 24 hours to fully digest a meal and egest the wastes.
- Motile animals need two gut openings to digest and absorb enough food for their cells.
- One opening ingests food and another egests wastes.

Nutrition in Annelids

- ❖ Annelids have a '**simple tube -like gut**' system.
- ❖ The annelid digestive system is more efficient compared to a cnidarian because it has two gut openings.
- ❖ In an annelid, food moves through the gut in only one direction.
- ❖ Thus, a worm can eat even while it is digesting food eaten earlier.
- ❖ An example of an annelid is the earthworm.

Earthworm Digestive System



Earthworm nutrition:

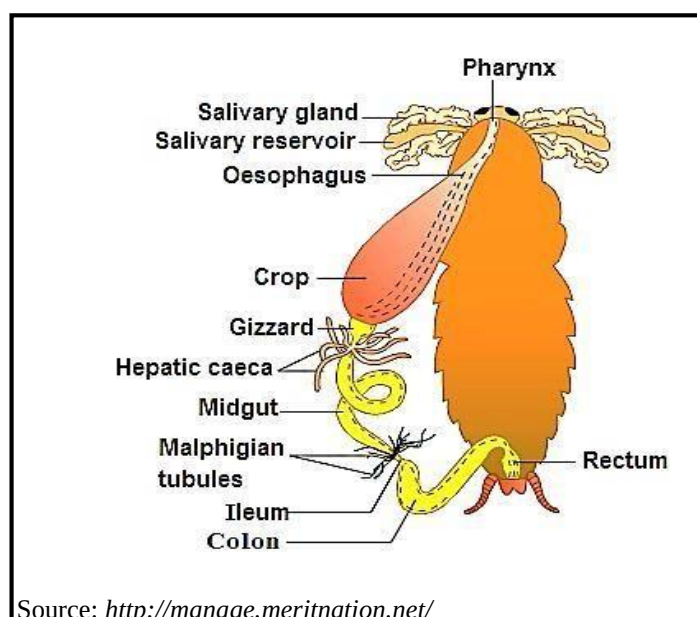
1. Earthworms suck in soil through the mouth using the muscular pharynx.
2. The oesophagus then moves the soil by peristalsis to the crop.
3. The crop stores the food until there is room for it in the gizzard.
4. The muscular gizzard grinds up food, serving the same function as our teeth.
5. The intestine both digest and absorb the bits of organic material contained in the soil. A typhlosole – a long ridge that hangs down into a worm's intestine – increases the surface area for nutrient absorption.
6. The inorganic portion of the soil and any indigestible material it contains are egested through the anus.
7. Blood absorbs digested food from the small intestine and carries it to the earthworm's body cells.

Adaptive Value of Specialised Chambers

- An earthworm has several specialised gut chambers; the pharynx, the crop, the gizzard and the intestine.
- Each chamber has a different function.
- Having specialised gut chambers allows several alimentary canal functions to proceed at the same time in different parts of the system.
- More complex animals, such as Arthropods and Chordates have an even greater number of specialised chambers.

Nutrition in Arthropods

- ❖ Arthropods are the most successful animal phylum of all.
- ❖ With all of the diversity, arthropods vary greatly in their diets and therefore, in their guts. We will study the cockroach digestive system as an example.
- ❖ Arthropods have a '**complex-tube like gut**' system.
- ❖ Insect gut has a greater number of specialised chambers than an annelid gut, including special organs for secreting enzymes and absorbing water from the faeces.



Source: <http://manage.meritnation.net/>

Cockroach Nutrition

1. A cockroach *cuts up its food* with mouthparts called **mandibles** and *holds its food* with **maxillae**. Saliva from the salivary glands *moistens the food*.
2. The **crop** stores food and the **gizzard** *grinds it*, just as in an earthworm.
3. The caecum (pronounced see-cum) secretes digestive enzyme into the mid-gut. (This organ is particularly important in herbivorous insects).
4. The **mid gut** *digests and absorbs food*.
5. The **hind – gut** *absorbs water* from the faeces. This is extremely important for water conservation in terrestrial insects.
6. Indigestible food is egested out through the anus.
7. The blood absorbs digested food from the mid- gut and carries it to the insects body cells.

Intestinal Parasites

- ❑ Many animals from flies to humans get infected with intestinal parasites which obtain their food from their host animal.
- ❑ The two main types of intestinal parasites are the Helminths and Protozoa.
- ❑ Helminths are the worm-like parasites with many cells.
- ❑ Examples of helminthes are hookworms, flatworms, roundworms, tapeworms.
- ❑ Protozoa is a single-celled animal-like microscopic organism that cannot survive in the absence of water.
- ❑ A common intestinal protozoan is Giardia, Crystosporidium.
- ❑ Parasites can get entry into the intestines through the mouth from uncooked or unwashed food, contaminated water or hands, or by skin contact with larva in infected soil.
- ❑ These parasites do not need a digestive system of their own since food in the small intestine of the host has already been digested by the host.
- ❖ Intestinal worms have evolved to absorb digested food directly from their host's intestine. All they need to do is to hold on and reproduce.
- ❑ Therefore, they only have organs for attachment and reproduction.

Vertebrate Animal Digestive System

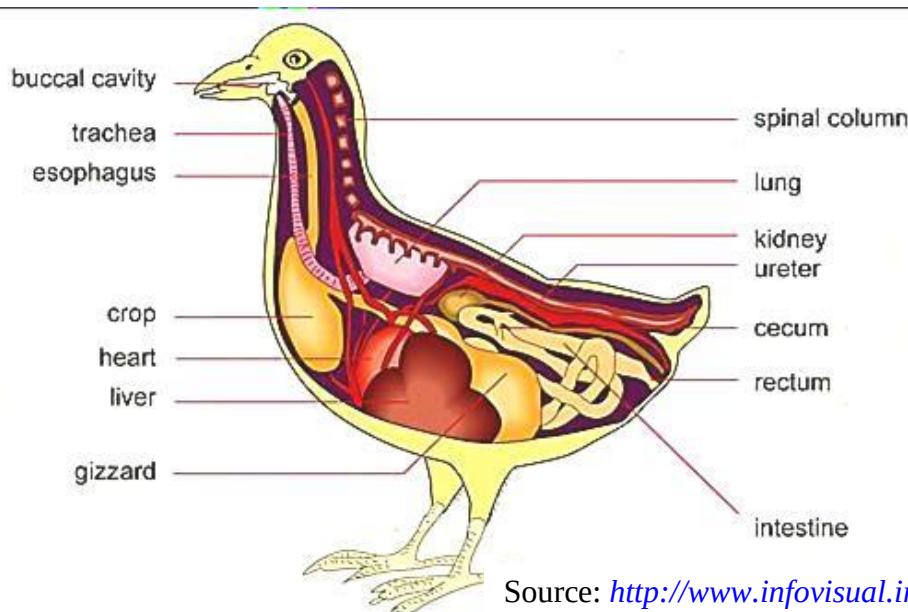
- ❖ Vertebrate animals have the most **complex digestive systems** of all.
- ❖ They have two gut opening and long alimentary canals divided into many specialised chambers unlike the digestive system of annelids and arthropods where the digested food is absorbed by the blood and nutrients are transported to all the body cells.
- ❖ In year 11, we had studied the human digestive system, this year we will focus on the digestive system of few other vertebrates such as birds, some herbivores and carnivores.

Nutrition in Birds

Adaptation for feeding

- Birds, especially those that eat fish are classed as '**gulpers**'.
- Birds have beaks that are adapted in shape and size for ingesting particular kinds of food.
- For example.
 - Hawks have sharp hooked beaks for tearing up prey.
 - Herons have long pointy beaks for 'fishing'.
 - Honeyeaters have long curved beaks for sucking flower nectar.
 - Parrots have short strong beaks for cracking seeds.
- Birds **do not** have teeth because they are too heavy and will add to the weight during flight.
- Instead, birds have muscular **gizzards** for grinding up food. (Most birds eat small stones to help their gizzards grind up food) they also have a crop for food storage.
- Otherwise, a bird gut is similar to the guts of the other vertebrates.

Bird Digestive System



Source: <http://www.infovisual.info>

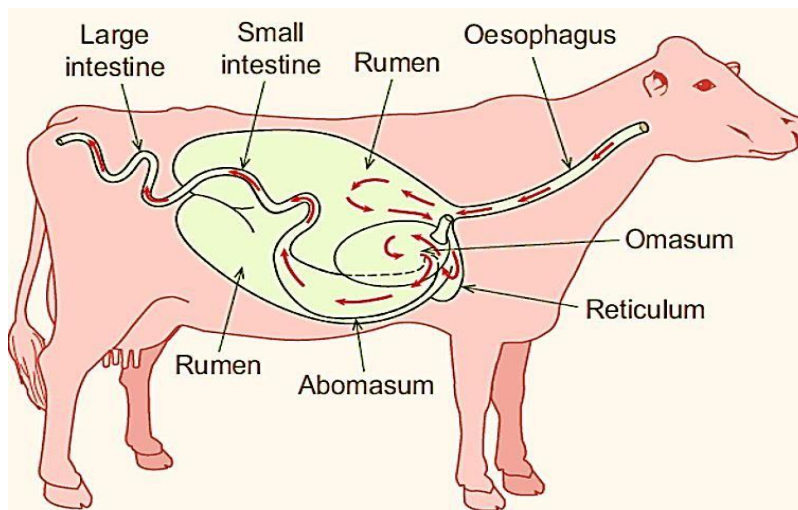
1. **Mouth:** food enters here.
2. **Oesophagus (Gullet):** transports food from the mouth to the stomach.
3. **Crop:** a pouch in the oesophagus that stores food temporarily before moving it to the stomach.
4. **Stomach (Proventriculus/ Gizzard):** principally the organ where food is broken into smaller units. It has two parts; **Proventriculus**- stores food.
Gizzard - muscular part of the stomach that uses grit (sand/ gravel) to grind grains and fibre into smaller particles.
5. **Small Intestine** – it has three parts; duodenum, jejunum and ileum- aids in digestion and nutrient absorption.
6. **Liver:** the largest glandular organ in the body that aids in the metabolism of carbohydrates, fats and proteins.
7. **Cecum:** bacterial action in the cecum helps breakdown undigested food passing through the intestine. The cecum turns into the large intestine, which connects with the cloaca.
8. **Large Intestine:** primarily functions to absorb water, dry out indigestible foods and eliminate waste products.
9. **Cloaca:** Where the digestive, urinary and reproductive systems meet.
10. **Vent:** the external opening of the cloaca that passes waste out.

Herbivore and Carnivore Guts in Mammals

- ❖ Human guts cannot digest plants. If eaten, it would just pass through the alimentary canal and out of the anus.
- ❖ This is due to plants cells having very tough cell walls made of cellulose.
- ❖ The cellulose is not digested easily by the human digestive system.
- ❖ The human digestive system lacks the enzymes that are capable of cellulose digestion.

Nutrition in Cattle

- ❖ Cattle belong to a class of animals known as ruminants.
- ❖ Due to the double chewing (regurgitation) in cows they are a good example of ‘**masticators**’.
- ❖ They have four compartments to their stomach and chew their cud.
- ❖ In addition, ruminants have an unusual configuration of teeth.
- ❖ Their small and large intestine are designed to handle large volumes of material.
- ❖ Cattles are evolved to exist on large amounts of fibre.
- ❖ They do not do well on all grain or high fat diets.



Source: <https://lh6.googleusercontent.com>

- ❖ Despite these adaptations for plant digestion, the faeces of cows and other herbivores will show that some grass has still passed through the gut *undigested*.

Adaptation in herbivorous mammals for digesting plants	
Feature	Purpose
Wide, flat teeth	– For grinding leaves between their teeth like humans
Double chewing	– Herbivores chew plant material, swallow it and then regurgitate it to chew it again later.
Symbiotic bacteria	– Herbivores have special cellulose-digesting bacteria that live in their guts. – These bacteria help the animal break down the cellulose in the cell walls. – In exchange, the herbivore provides the bacteria with food. Often these bacteria are housed in the caecum.
Very long intestine	– This allows herbivores more time to digest and absorb the food.

Comparison of Vertebrate Carnivores and Omnivores with the vertebrate herbivore nutrition

Vertebrate Carnivores (eat other animals) E.g. Lions	
Feature	Purpose
Sharp teeth	For catching and tearing prey
Shorter intestine	Allows for faster digestion
Simple digestion	Since all the digestive juices for digestion of flesh is present.
Vertebrate Omnivore (eat both plants and animals) E.g. Humans	
Feature	Purpose
Sharp canine teeth	For tearing flesh
Flat molar teeth	For grinding food (plants)
Caecum	Hosts cellulose digesting bacteria

Nutrition Methods of Heterotrophs

Nutrition Method	Adaptive Value
External digestion	- Food is digested outside the body so there is no need for digestive organs; - Appropriate only for small sessile organisms because the organisms must stay on the food until it is completely digested. <i>e.g in saprophytic bacteria and fungi.</i>
Internal Digestion	- Food is digested inside the body so that the organisms can move about while food is being digested and absorbed. - Appropriate for motile organism. - <i>e.g in animals and protists</i>
Food vacuoles	- Food is enclosed and digested in a cell's food vacuoles; - Appropriate for motile unicellular organisms that have cell organelles. - <i>e.g in protists</i>
Gut-sac-like	- Only one gut opening and one gut chamber so food is ingested and wastes egested through the same opening. - Food must be completely digested and absorbed and the wastes egested before the animal can eat again; sufficient to supply nutrients to cells of sessile animals. - <i>e.g in cnidarians</i>
Gut –tube (with specialised gut)	- Two gut openings so food moves one-way through the gut - This digestive system allows consumption of large amounts of food as it allows animals to eat continuously. - <i>e.g in most animal phyla, including annelids, arthropods and chordates.</i>

chambers)

- Alimentary canals of animals with two gut opening have specialized sections along the gut.
 - Each section doing a different digestive task - this speeds digestion as it allows many different digestive functions to go on at the same time.
- e.g* of some specialised chambers: crop for food storage, gizzard for grinding food, caecum and glands for enzyme secretion, hind gut for absorption of water.

Evolutionary Trends in Nutrition

- ❖ The more recently evolved organism groups have more complex nutrition methods.
- ❖ For example, a mongoose has two gut openings with many specialised chambers while a mushroom can survive by secreting enzymes and then absorbing the nutrients.
- ❖ The factor here is *speed*.
- ❖ Motile organisms need more energy and they need it more quickly than sessile organisms.
- ❖ ***The faster organisms move, the more efficiently its digestive system must process food.***
- ❖ As the ability for speed increases, the following trends in the nutrition methods of organisms can be observed:
 1. Increasing capacity for ingestion.
 2. Increasing specialisation of gut chambers.
 3. Increasing surface area for nutrient absorption.
 4. Specialisation of a transport system to carry nutrients from the digestive system to body cells.

Nutrition and Other Body Systems

- ❖ The organ system of multicellular organisms cannot function on their own/ alone.
- ❖ Nutrition often depends upon other body systems for the following functions.
 1. The organisms must be able to find food (or in the case of autotrophs, inorganic materials for making food).
 2. The organism must distribute the nutrients to all body cells once it has digested food.
 3. The organisms must take in and distribute oxygen to decompose the nutrients in cells by respiration.
 4. The organisms must excrete the metabolic wastes created by breaking down the nutrients.
- ❖ Thus, the nutrition system of multicellular organisms usually works together with the nervous, transport, gas exchange and excretion systems.

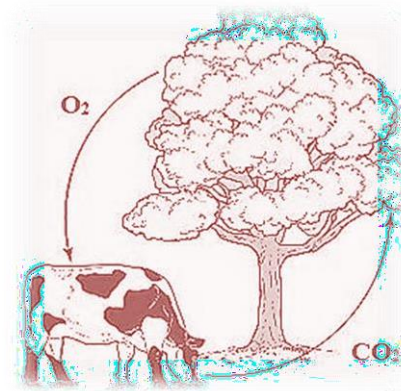


SELF TEST

1. Give two examples of organisms that fit in each of the following consumer categories;
 - (i) predator, grazer, parasite, saprophyte.
 - (ii) minute particle feeder, gulpers, masticators, wallowers, filter feeders, fluid feeders
2. Give at least two adaptations in plants that allows them to obtain maximum:
 - (i) Sunlight
 - (ii) CO₂
 - (iii) Water
3. Why do plants need magnesium?
4. Fungi and bacteria have external digestion.
 - (i) Explain what external digestion means.
 - (ii) What is the potential disadvantage of external digestion?
 - (iii) Why is this disadvantage not a problem for fungi?
5. Heterotrophic protists take in food by surrounding it with a piece of cellular membrane, forming a vesicle. What is this kind of transport called?
6. Describe two ways grasshoppers are adapted for eating grass.
7. What is the advantage of a gut with two opening over a gut with just one?
8. Why do you think insects do not have external digestion or a sac – like gut?
9. What is the advantage of a gut with specialised chambers?
10. Make three points of comparison between the digestive system of a jelly fish and an earthworm. Relate each point to the lifestyle of the organisms.
11. Why doesn't an intestinal parasite have a digestive system?
12. Why don't birds have teeth? How do they grind up their food?
13. Why is most plant material so difficult to digest? Describe three ways herbivorous mammals are adapted to digest plants.
14. For each of the following organisms, describe how digested food reaches their body cells: a hibiscus plant, a paramecium, a coral polyp, an earthworm, a mosquito, a human.
15. Over time, nutrition methods have evolved to be more efficient and complex.
 - (i) In what ways have nutrition methods become more efficient?
 - (ii) What evolutionary trend has led to selection for efficient and complex methods?

BI 12.1.4.2

GAS EXCHANGE



- ❖ Organisms release energy from the food they digest by “burning” the food with oxygen.
- ❖ This process is called *respiration*, as seen earlier in **Nutrition**.
- ❖ Respiration occurs in both plants and animals.

Organisms must take in oxygen and then excrete the carbon dioxide waste produced, as the respiration reaction releases energy from glucose.

- ❖ The gas exchange system of each kind of organism is particularly adapted to its environment and way of life.
- ❖ The more energy an organism requires, the more oxygen it needs to oxidise food.
- ❖ The more oxygen it needs, the faster it must exchange gases.
- ❖ Active organisms need a large energy supply and so must have a very efficient gas exchange system.
- ❖ On the other hand, sessile organisms do not need as much energy and so their gas exchange systems are less efficient.

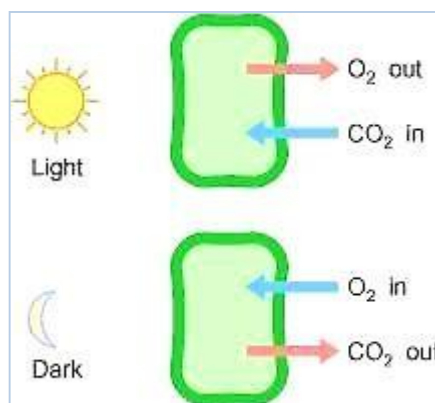
Gas Exchange in Plants

- ❖ Plants need carbon dioxide for photosynthesis and oxygen for respiration.
- ❖ They rely solely on direct diffusion for gas exchange.
- ❖ Plants are sessile and do not need rapid gas exchange therefore, they are adapted for a slow diffusion method.

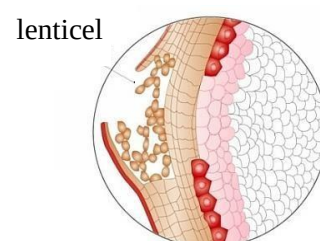
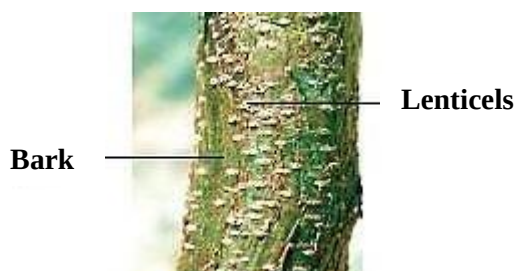
Factors affecting rate of gas exchange in plants	Efficient gas exchange systems must
❖ The area available for diffusion. ❖ The distance over which diffusion occurs. ❖ The concentration gradient across the gas exchange surface. ❖ The speed with which molecules diffuse through membranes.	❖ have a large surface area to volume ratio ❖ be thin ❖ have mechanisms for maintaining high concentration gradients ❖ be permeable to gases.

Flowering plants exchange gases through their **stomata** present on the leaves:

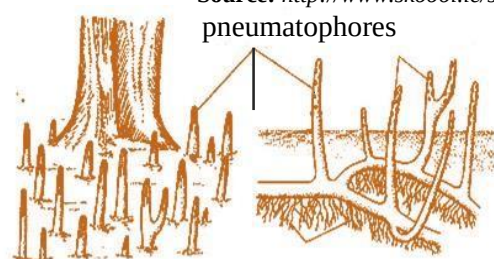
- In the light there is a net intake of carbon dioxide for photosynthesis and a net output of oxygen from respiration.
- In the dark there is a net intake of oxygen for respiration and a net output of carbon dioxide.
- Terrestrial plants get plenty of air so they usually have stomata on the bottom of their leaves.
- Aquatic plants have their leaves near or under the water, but they also need to breathe.
- Plants that float on the surface of the water have their stomata on top, where they have access to air.
- Plants that live completely under water gather CO₂ from the water. When they release O₂ you can see tiny air bubbles gathering around them.
- Woody plants use **lenticels** for exchanging gases.
- Lenticels are raised loose cork tissue in woody stems, roots and some fruits which function in gas exchange for aerobic respiration.
- Live non-photosynthetic cells tissue cells below the dead cork layer need oxygen gas.
- They also need to get rid of carbon dioxide waste gas.
- Lenticels allow oxygen in and carbon dioxide out.



Source: <http://www.rsc.org>



Source: <http://www.skool.ie/skool/pneumatophores>



Plants can open their stomata to get gases by direct diffusion but they face water loss at the same time. Therefore, at night and during water shortages plants conserve water by closing their stomata.

Gas exchange in Pneumatophores

Pneumatophores are erect roots with specialized structures that allow for respiration. E.g. root mangroves.

Adaptation for Gas Exchange in Plants

Plants have several adaptations that allow gases to diffuse in and out relatively quickly. These adaptations include:

- ❖ **Stomata**, small openings in the underside of most leaves, which allow gases to diffuse in and out.
- ❖ **Air spaces** in the spongy layer of a leaf to allow carbon dioxide to diffuse more quickly to the photosynthesising palisade layer.
- ❖ **Thin leaves with broad surfaces** to maximise surface area to volume ratio for faster diffusion to cells.
- ❖ **Lenticels** (small holes in the bark) in woody plant stems and small gaps in the stem surfaces of herbaceous plants that allow plants to respire.

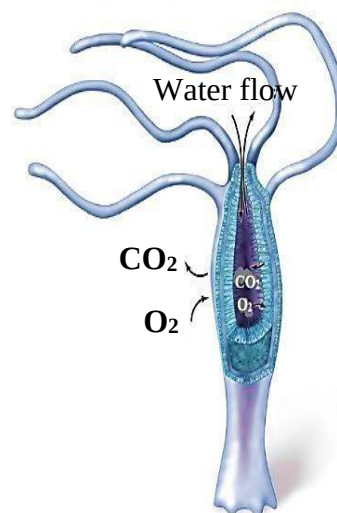
Gas Exchange in Animals

- ❖ Small and sessile organisms can often get enough oxygen by diffusion alone.
- ❖ Larger, more active organisms must have a specialised organ system for exchanging gases quickly.
- ❖ Gas exchange systems in most active animals rely upon transport systems to deliver oxygen to cells and to carry away carbon dioxide waste.
- ❖ All organisms even those with specialised gas exchange systems, depend upon diffusion to exchange oxygen and carbon dioxide across the respiratory surfaces.
- ❖ To assist this diffusion, the respiratory surfaces (lungs, skin, and gills) of all animals have the following three adaptations:
 1. The respiratory surfaces are **moist to dissolve** oxygen and carbon dioxide.
 2. They have a **large surface area** for gas exchange.
 3. They are **extremely thin** so gases can pass through more quickly.

Gas Exchange in Invertebrates

Gas Exchange in Cnidarians – direct diffusion

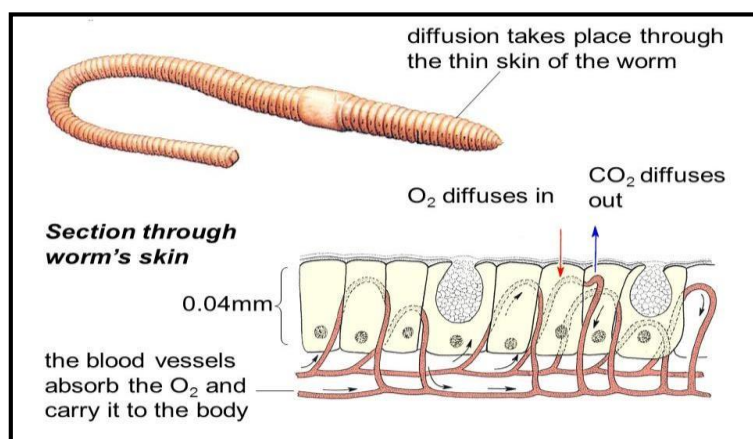
- ❖ Cnidarians are well aquatic and relatively sessile.
- ❖ Some common cnidarians include corals, sea anemones and jelly fish.
- ❖ These animals rely on simple diffusion to exchange oxygen and CO₂ between cells and surrounding water.
- ❖ A cnidarian's cells do not need much oxygen since these animals are inactive.
- ❖ Thus, cnidarians do not need a transport system to carry gases to and from their body cells.
- ❖ Oxygen and carbon dioxide move to and from a cnidarian's body cells by diffusion alone.



Source: <http://image.slidesharecdn.com/>

Gas exchange in Annelids – diffusion through the skin

- ❖ Annelids (segmented worms), exchange gases between the air and the blood by direct diffusion.
- ❖ For this diffusion to occur, it is very important for the skin to be moist.
- ❖ The skin is kept moist by body's physiological processes such as secretion of moistening fluid by the mucus gland and by behavioural processes of the worms living in damp areas, avoiding sunlight and feeding at night.
- ❖ The worm's blood carries oxygen to the body cells and carbon dioxide away from the cells.



Source: <http://images.slideplayer.com/>

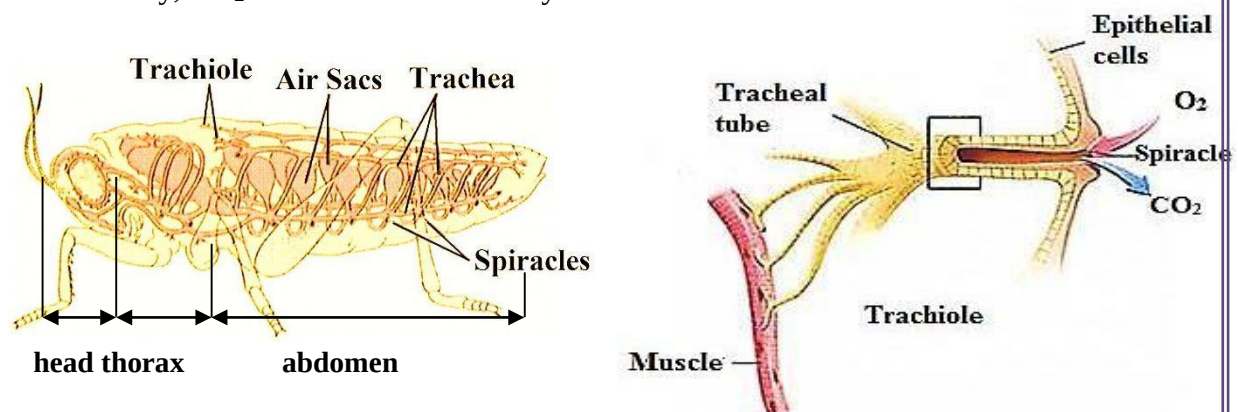
- ❖ If an annelid's skin surface dries up and the oxygen diffuses into the blood, the worm will suffocate and die.
- ❖ However, desiccation poses little threat to worms in their natural underground habitat.
- ❖ Annelids mostly burrow into soil to avoid desiccation due to over exposure to air and sunlight.

Gas Exchange in Insects – Diffusion through a tube system

- ❖ Insects cannot survive on gas diffusion through the skin because:
 - Most insects live above the ground and so cannot keep their skin moist.
 - They are so active that diffusion through their outer surface alone cannot provide enough oxygen to their body cells.
- ❖ Insects have a unique gas exchange system.
- ❖ Even though insects have a transport system, insect blood does not carry oxygen to body cells.
- ❖ Instead, insects have a separate system of air pipes called **trachea** and **trachioles** through which air diffuses to and from body cells.
- ❖ The openings to these pipes, usually found on the underside of an insect, are called **spiracles**.

Steps of gas exchange in insects:

- ❖ Air enters through the external openings in the thorax called the spiracles.
- ❖ The air moves into the trachea and branches out into the trachioles. These trachioles are connected to the body cells. Movement of the abdomen, thorax and air sacs assist air movement.
- ❖ Air (oxygen) reaches the body cells through the trachioles.
- ❖ Similarly, CO₂ diffuses out of the body.



Source: <http://e08595.medialib.glogster.com/>

Source: <https://classconnection.s3.amazonaws.com>

Adaptation of insects for water conservation

In order to reduce water loss from the moist walls of the trachea most insects;

- ❖ partially close their spiracles when they are not active.
- ❖ The trachioles pass the cells just like capillaries pass by each cells in humans, this prevents loss of moisture.
- ❖ The trachioles are thin and moist at all times allowing for faster diffusion of gases between the trachioles and the body cells.
- ❖ Larger, flying insects sometimes pump their abdomen in and out to aid the movement of air into their spiracles.

Adaptive Value

- ❖ This form of gas exchange through a tube system is not suitable for larger and active animals.
- ❖ The body volume of larger animals is too great to be supplied by this kind of system.
- ❖ They need oxygen to be actively pumped to body cells.
- ❖ However, insects are quite small, so the gases do not have to diffuse very far to reach each of their body cells.

Gas Exchange in Vertebrates

- ❖ Vertebrate animals tend to be quite active hence, all vertebrates have specialised respiratory organs and a pumped transport system to meet the energy demand of their body processes.
- ❖ Vertebrates actively pump or suck the surrounding air (or water, in the case of fish) to get oxygen into their food quickly by the process of breathing or inhalation.
- ❖ Vertebrates are capable of adjusting the speed of gas exchange to the rate of their cells' respiration.
- ❖ For example, your breathing rate increases when you run because active muscles cells need plenty of energy and your breathing rate decreases when you are sleeping because resting cells do not need much oxygen.
- ❖ Transport of gases to and from gas exchange surfaces uses blood or the circulatory system in most animals (except for insects), therefore, gas exchange and transport systems are in close contact.
- ❖ Therefore, for effective gas exchange, vertebrate respiratory surfaces must;
 - ✓ **be well supplied with blood capillaries**
 - ✓ **be thin and moist at all times**
 - ✓ **have a large surface area.**

The adjustment of the breathing rate by the vertebrates to the respiration rate of their cells is another example of homeostasis

Gas Exchange in Fish

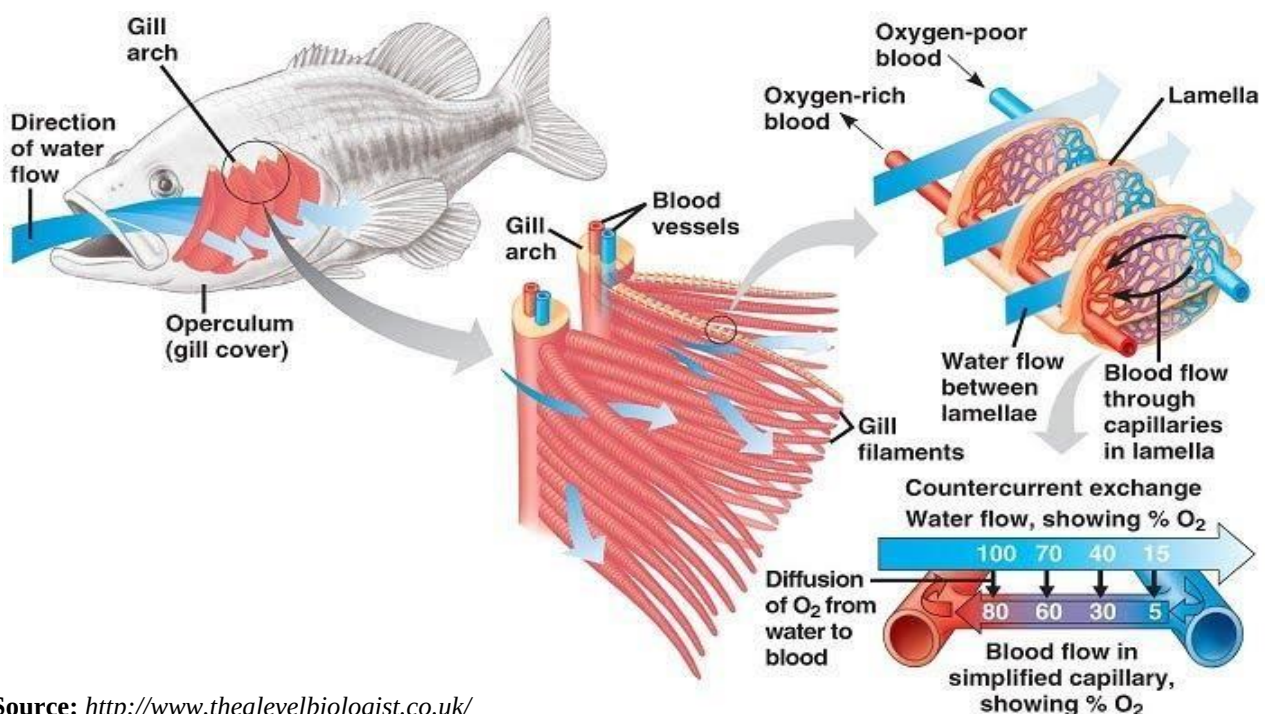
- ❖ Fish have internal **gills** to exchange gases with water while in tadpoles the gills are located externally.
- ❖ Gills rest outside a fish's body, though they are protected under gill covers.
- ❖ Exchanging gases with water is more difficult than exchanging with air because;
 - Water contains less oxygen than air.
 - Water is harder to pump over the respiratory surface because it is denser.
- ❖ Fish have several adaptations for overcoming these problems.

Fish Adaptations for Getting Oxygen from Water

- ❖ Fish constantly pump fresh water over their gills using a muscular pharynx.
- ❖ Tiny ridges called **lamellae** on folds called **gill filaments** greatly increase gill surface area for gas exchange.
- ❖ Structures called *gill rakers* trap any bits of food.
- ❖ Gills dependent on the buoyancy of the water for support.
- ❖ Gills are packed with blood capillaries.

The direction of the blood flow in the gills is in the opposite direction to the flow of water on the gills. This **counter current flow** maximizes the concentration gradient thus maximizing the diffusion of O_2 from the water into the blood and CO_2 from the blood into the water.

Gas Exchange in Fish



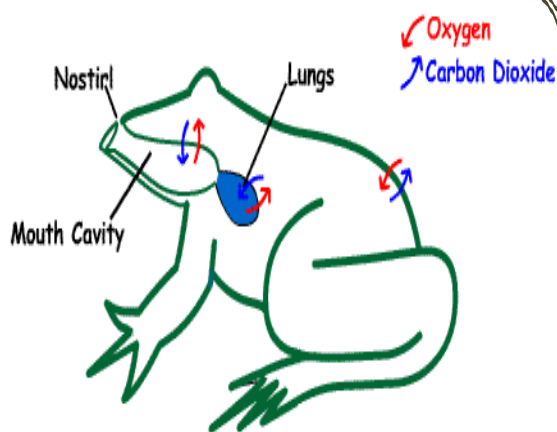
Source: <http://www.thealevelbiologist.co.uk/>

Adaptive Value

- ❖ Since all the fish are aquatic, their respiratory system is specially adapted for exchanging gases with water and would suffocate quickly out of water.
- ❖ Out of water, fish gill filaments stick together greatly reducing the surface area for gas exchange.
- ❖ The gills quickly dry up and then no longer able to dissolve gases for exchange.
- ❖ Fossil remains suggest that fish were the first vertebrates to evolve and have been around for approximately 400 million years longer than we humans.

Gas Exchange in Amphibians –gills, lungs and skin

- ❖ Amphibians were the first vertebrates' adapted for life on land.
- ❖ They form the evolutionary link between fish and land vertebrates.
- ❖ Young amphibians, i.e. **tadpoles** survive in water using external **gills** for gas exchange.
- ❖ Adult amphibians live on land, relying partly on their lungs.
- ❖ The land- dwelling adult forms, use their moist skin and their lungs for gas exchange. For effective diffusion amphibians must keep their skin moist at all times.
- ❖ To stay moist, toads and other amphibians often hide under rocks or logs until it rains or until after the sun sets.



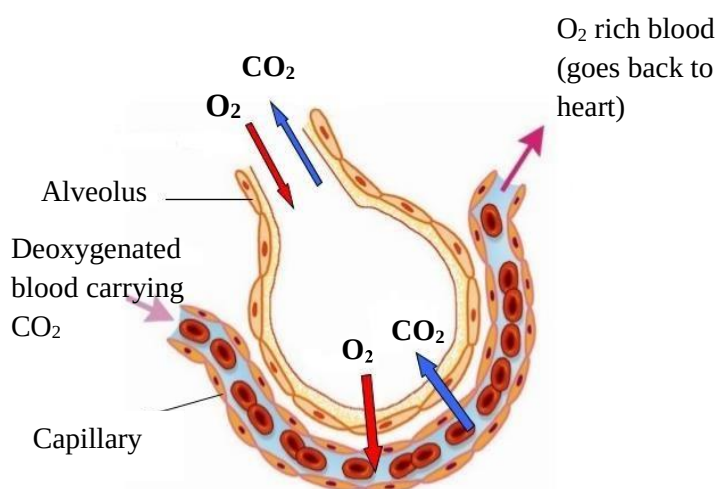
Source: <https://upload.wikimedia.org/>

Gas Exchange in Reptiles, Mammals and Birds – lungs

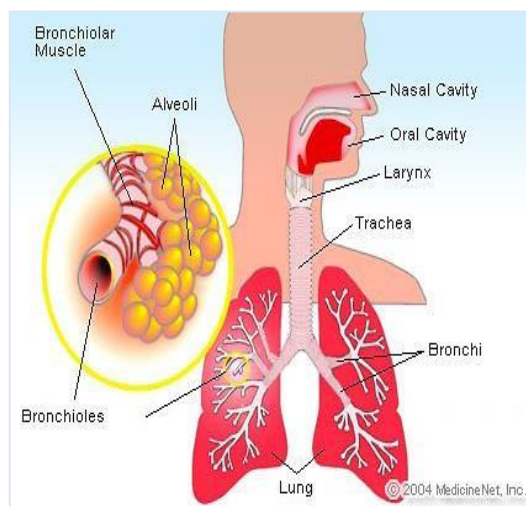
- ❖ Reptiles, such as lizards and snakes, were the first vertebrates adapted for living their entire lives on land.
- ❖ Evidence suggests that birds and mammals later evolved from reptiles.
- ❖ These three vertebrate classes have lungs and muscles specialised to suck air.

Adaptation for Efficient Gas Exchange

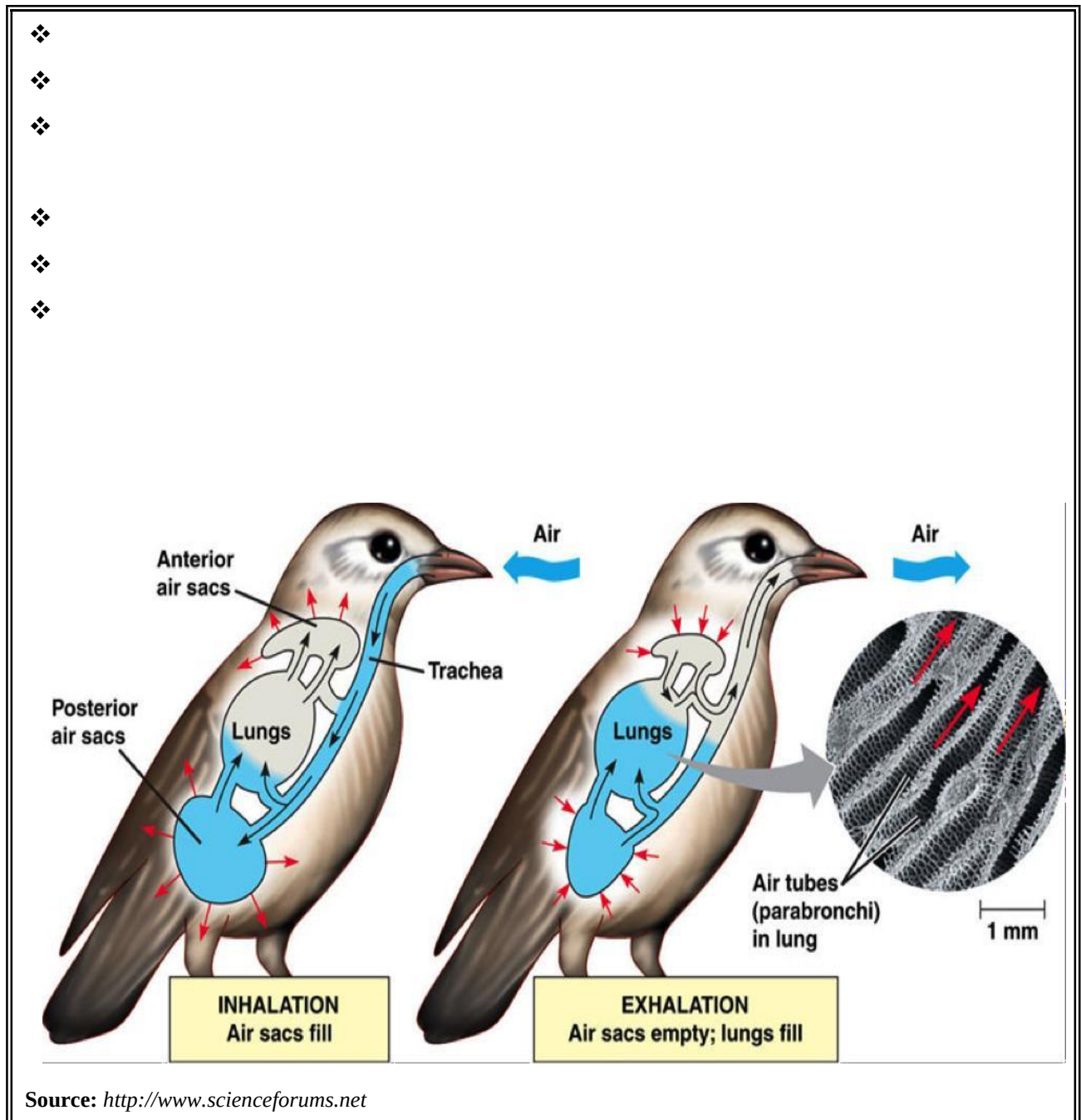
1. The alveoli in the lungs have thin, moist surfaces.
2. The alveoli create a large surface area for gas exchange.
3. Their lungs are extremely well supplied with blood capillaries.



Source: <http://image.slidesharecdn.com/>



Source: <http://www.emedicinehealth.com>



Adaptations for Gas Exchange		
Gas Exchange Method	Organisms Group	Adaptive Value
Direct Diffusion – no respiratory organs or connection with a transport system.	Plants, bacteria, protist, fungi, cnidarians	Supplies sufficient oxygen to the cells of small or sessile organisms.
Diffusion through the skin into blood.	Worms, adult amphibians	Supplies blood with oxygen in organisms that are able to keep their skin moist at all times.

Gas Exchange Method	Organism group	Adaptive Value
Diffusion through tube network – air diffuses to body cells through tubes, no connection to transport system.	Insects and spiders	Supplies sufficient oxygen to the cells of small organisms conserves water since tubes are inside the body.
Gills – gas exchange between water and the blood capillaries inside gills, gills hang outside of the body	Crustaceans, bivalves, immature amphibians	Adapted for exchanging gases with water (gill filaments, water pumped over gills, counter-current blood flow in gills)
Lungs – gas exchange between inhaled air and the blood capillaries supplying the lungs; lungs are inside the body	Adult amphibians, reptiles , mammals, birds	Adapted for very efficient exchange of gases with air in order to supply cells of large active land animals; conserves water

Evolutionary Trends in Gas Exchange

- ❖ The more an organism moves the more energy it uses energy.
- ❖ For example, a jellyfish drifts around in the ocean and occasionally pumps water to push itself forward and due to its inactive lifestyle, the jellyfish suffices its gas exchange needs by diffusion only.
- ❖ A fish on the other hand, darts around quickly looking for food and evading predators and hence, it needs a more active form of gas exchange system compared to the jelly fish.
- ❖ The more energy it uses, the more oxygen it needs and the more carbon dioxide waste it produces.
- ❖ As speedier organisms evolved, they needed more efficient gas exchange systems which actively pumped air or water and linked with a transport system.
- ❖ Additionally, terrestrial organisms evolved adaptations for reducing water loss from their respiratory surfaces.



SELF TEST

1. Why do organisms need oxygen?
2. Briefly describe how each of the following organisms is adapted to get the oxygen for its cells needs: *a hibiscus bush, a jellyfish, an earthworm, a housefly, a toad, a chicken.*
 - a. Water lily leaves, which float on the surface of the water, have stomata on the upper surfaces of their leaves instead of the lower. Why are their stomata on the upper leaf surfaces?

- b. How would stomata arrangements be a problem for land plants?
3. Every organism on the planet uses up oxygen in respiration, yet we have not run out of oxygen. Explain why.
4. List the four respiratory surface adaptations for gas exchange that every vertebrate has.
5. Bacteria and protists have no specialised structures for gas exchange. Gases simply diffuse in and out of the cells.
 - a. What animal phylum also depends upon direct diffusion of gases to and from cells?
 - b. Explain why most animal groups cannot rely on direct diffusion to their cells for their gas exchange?
7. Earthworms reflexively move away from light. How is this behaviour adaptive for their method of gas exchange?
8. Compare insect's method of gas exchange to that of an earthworm. Relate the differences to the animals' lifestyles.
9. Explain why an elephant could not survive with the trachea and spiracle system of gas exchange that insects use.
10. Why it is important for insects to partly close their spiracle when they are not very active?
11. Why do vertebrates need a particularly efficient method of exchanging gases?
12. Give two reasons why land animals cannot use gills for gas exchange.
13. Choose three organisms you have studied and explain the adaptation of each for increasing their surface area for gas exchange.
14. Choose three terrestrial organisms you have studied and explain the adaptations of each for increasing their surface area for gas exchange.
15. Explain why getting oxygen from water is more difficult than getting it from air and describing how fish overcome these difficulties.
16. Why does a vertebrate's breathing rate vary with its activity level?
17. What is the primary difference between lungs and gills? How is the difference adaptive?
18. Dolphins and whales, both aquatic mammals, have a small breathing hole in the middle of their backs. Explain how the location of this hole might be adaptive.
19. In what way are the lungs of a 'bird' more efficient than those of a mammal or reptile? Why do birds need this more efficient respiratory system?
20. The term 'gas exchange' refers to the exchange of what gases?

- ❖ All organisms have adaptations for getting nutrients and exchange gases.
- ❖ Complex organisms have a transport system that connects with their nutrition and gas exchange systems.
- ❖ This system delivers nutrients and oxygen and carries away cellular waste.
- ❖ In some organisms, the blood carries disease-fighting materials and distributes hormones.
- ❖ The transport system of each organism is adapted to its environment and way of life.
- ❖ Some organisms do not need a separate system at all if they are very small or inactive.
- ❖ Diffusion alone takes care of their transport needs. Other organisms are active and need an efficient transport system to supply their cells with food and oxygen

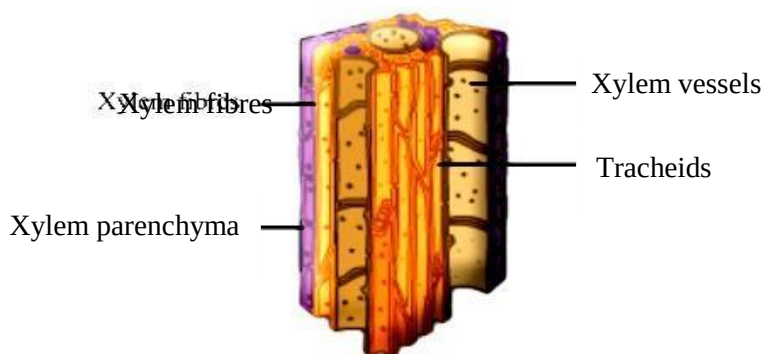
TRANSPORT IN VASCULAR PLANTS

- ❖ Vascular plants are plants with specialized structures for conducting water and food
- ❖ Plants absorb water and minerals through their roots and transport them to the leaves and stems for metabolic use, e. g. photosynthesis.
- ❖ Examples of vascular plants include flowering and seed plants, trees, ferns, conifers, etc
- ❖ Xylem transport water and minerals from roots to shoots.
- ❖ Phloem transport sugars and other organic nutrients from where they are produced or stored to where they are needed for growth and metabolism.
- ❖ Algae and mosses lack a vascular system, therefore, they live in wet habitat where water and food diffuse directly into their cells.

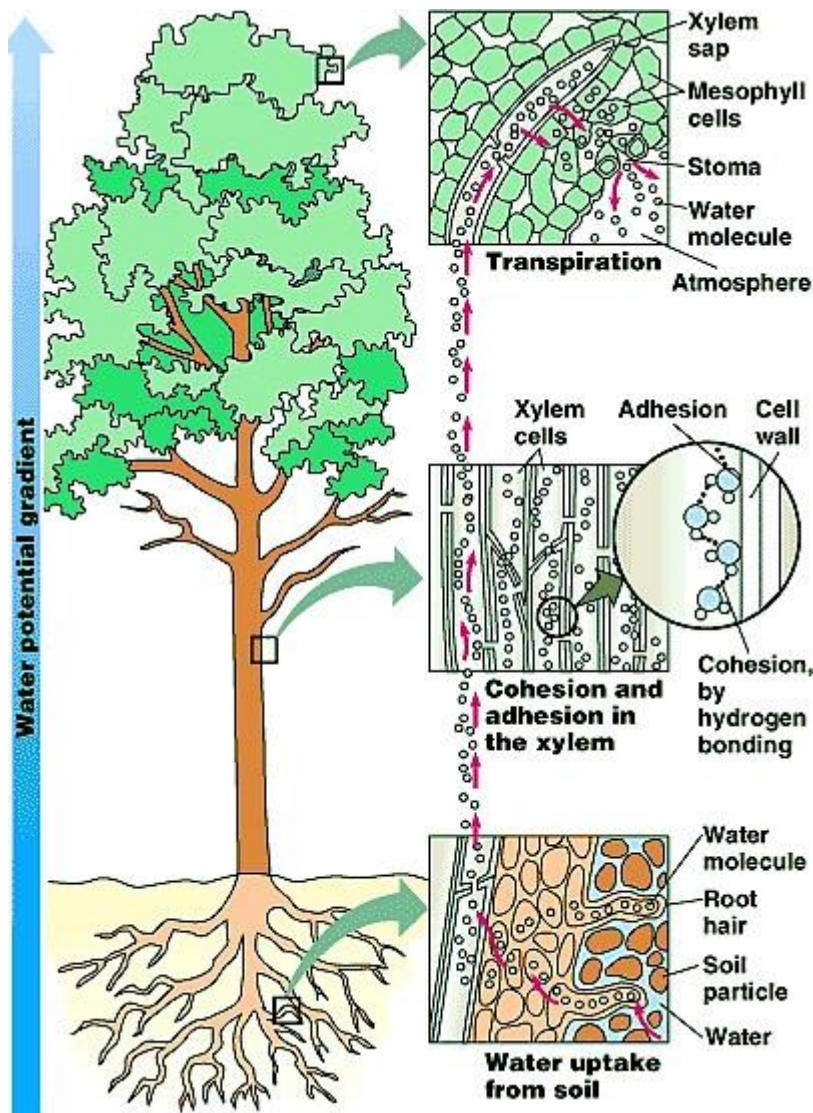
The deepest root of a mango tree might be over 60 meters from the highest leaves. Yet water and minerals must get up to these leaves and food must get down to the roots and other plant parts. Tube systems of xylem and phloem carry water, minerals and food through the plant.

Xylem – the transport of water and minerals

- ❖ Xylem cells are specially adapted for carrying water and dissolved minerals through plants.



Water Transport



Source: <http://plantcellbiology.masters.grkraj.org>

- ❖ Water manages to reach the top of every tall tree by being 'sucked' up by the xylem as water evaporates from the leaves.
- ❖ This is called the **cohesion theory** of water transport.

The Cohesion Theory of Water

1. Water evaporates from the leaves via transpiration, mostly through open stomata.
2. The pulling action of transpiration sucks water up through the xylem tubes.
3. Since water molecules stick together (i.e., they are cohesive), when water molecules leave the plant through the stomata, they pull up molecules from below to take their place.

✚ So, according to this theory, water moves up through xylem by a combination of **transpiration pull** and **water cohesion**.

- ❖ Additionally, the higher concentration of minerals in roots than in soil causes water to move into roots by **osmosis**.
- ❖ The force of water moving into roots is called **root pressure**. This pressure helps to push water up the xylem.
- ❖ Plants need enough water;
 - to remain **turgid**
 - to use in photosynthesis
- ❖ They also must lose a lot of water by transpiration in order to pull water up from the roots.

Mineral Transport

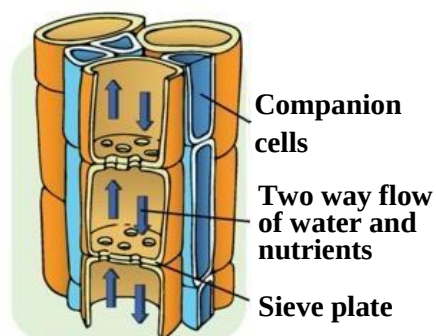
- Water can move easily through the cell membrane of root cells by osmosis.
- Dissolved minerals, however, are charged and so cannot pass through the phospholipid bilayer of cell membranes.
- Also, the concentration of minerals is often higher inside the plants than outside.
- Thus, root cells depend on active transport to bring minerals into the xylem.
- The active transport of minerals into the roots requires ATP from respiration, but food is made far away in the leaves.
- Roots get the glucose required to make this ATP through the phloem.

Phloem

- ❖ Phloem cells are adapted for carrying food from leaves to all other parts of plants.
- ❖ Plant starch (carbohydrate) is produced by photosynthesis. These starch molecules are too large to pass through cell membranes.
- ❖ Starch must be hydrolysed into sucrose for transport through phloem.
- ❖ The solution of water, sucrose and other food molecules (organic materials) in the phloem is called **sap**.
- ❖ The transport of the sap is called **translocation**.
- ❖ Sap in the phloem is under very high pressure (as much as five times higher than air pressure in a car tyre).
- ❖ This pressure helps push sap through phloem.
- ❖ Phloem tissue is made of two kinds of cells; **sieve cells** and **companion cells**.

Sieve cells

- The sieve cells are continuous tubes throughout the plant.
- The end wall of this continuous tube has lots of little holes in the cells walls at both ends so the sap can pass through more easily.
- These porous ends of sieve cells are called sieve plates.



Source: <https://dr282zn36sxxg.cloudfront.net>

Companion cells

- The companion cells provide the sieve cells with ATP for active transport.
- Sieve cells can carry sap in their own direction, companion cells direct sieve cells to carry food to stems and roots for storage or to cells that need it for energy.

Transport in Animals

- ❖ Small or sessile organisms do not actually need a transport system.
- ❖ They can often get the materials they need by diffusion alone.
- ❖ Larger, more active organisms must have a specialised organ system for bringing food and oxygen to and waste away from their cells.
- ❖ All organisms, including those with specialised transport systems, depend upon *diffusion* to move materials *in* and *out* of body cells.

Transport in Invertebrates

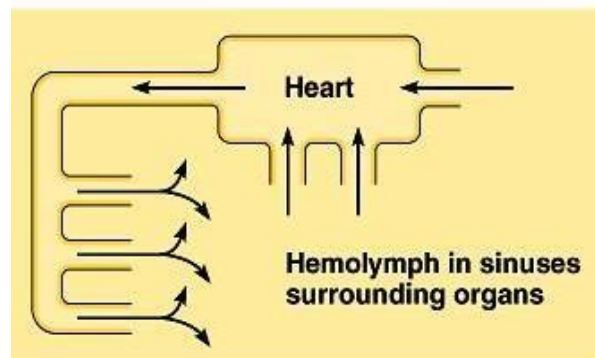
Transport in Cnidarians – direct diffusion

Cnidarians rely on direct diffusion to supply their cells with nutrients from their gut obtained from the surrounding water.

- ❖ Since cnidarians are sessile and diffusion is a slow process, they do not require an efficient transport system.
- ❖ They do not use up nutrients and gases or produce wastes very quickly like other larger animals

Transport in Arthropods and Molluscs- Open circulation

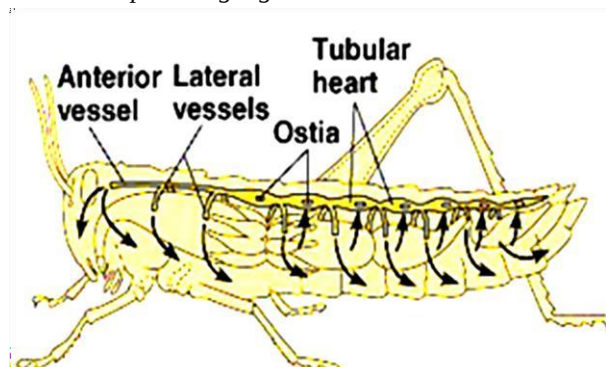
- ❖ Arthropods (such as insects and shrimp) and most molluscs' (such as snails and clams) have open circulation.
- ❖ Open circulation means that the blood is not enclosed in vessels, but instead flows in an open body cavity, bathing body cells directly.



Transport in a Grasshopper

- ❖ In a grasshopper, a long heart pumps blood into an open body cavity called a **haemocoel** (hee-mo-seal).
- ❖ The blood in the haemocoel bathes the body cells directly.
- ❖ It is not enclosed in blood vessels.
- ❖ Arthropod blood transports nutrients and cellular wastes.

Source: <https://lh6.googleusercontent.com/>



Adaptive Value for a closed circulatory system

- ❖ Most animals have closed circulatory systems.
- ❖ Vessels contain their blood. Their blood never touches body cells directly.
- ❖ A closed system is necessary in larger animals for the following.
 - 1) Artery contraction can adjust the amount of blood flowing to each part of the body according to its activity level.
 - 2) A large animal filled with blood would suffer great difficulty walking with so much fluid sloshing around. If it ever tripped and fell it would burst open.
 - 3) Blood flow through a body cavity is too slow to supply enough oxygen to the cells of larger animals.
- ❖ For small organisms such as insects, the blood flow through a body cavity is fast enough to supply sufficient nutrients to their body cells.
- ❖ Additionally, insects do not rely upon their transport system to supply oxygen to their cells.
- ❖ Open circulation is not quick enough.
- ❖ Insects and spiders have a separate **tracheal system** that allows gases to diffuse directly to their cells.

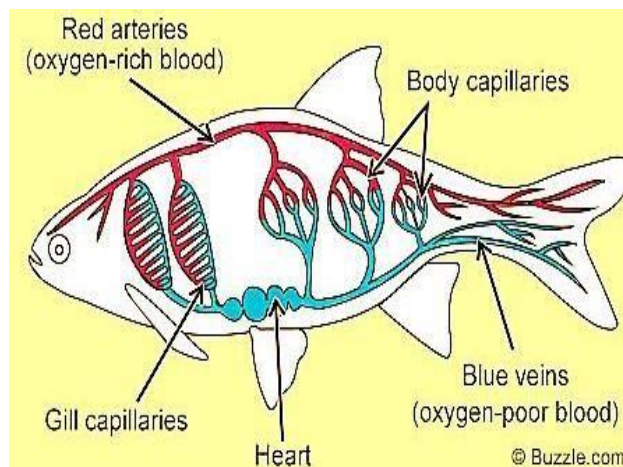
Insect blood has no haemoglobin therefore, it's not red on colour. It has greenish-yellow blood which contains nutrients and body wastes, but no oxygen.

Transport in Vertebrates

- ❖ Vertebrates' animals are generally larger and more active than invertebrates so they need more efficient transport systems.
- ❖ All vertebrates have a closed circulatory system with a chambered heart to pump blood.

Transport in Fish (closed, single – loop circulation)

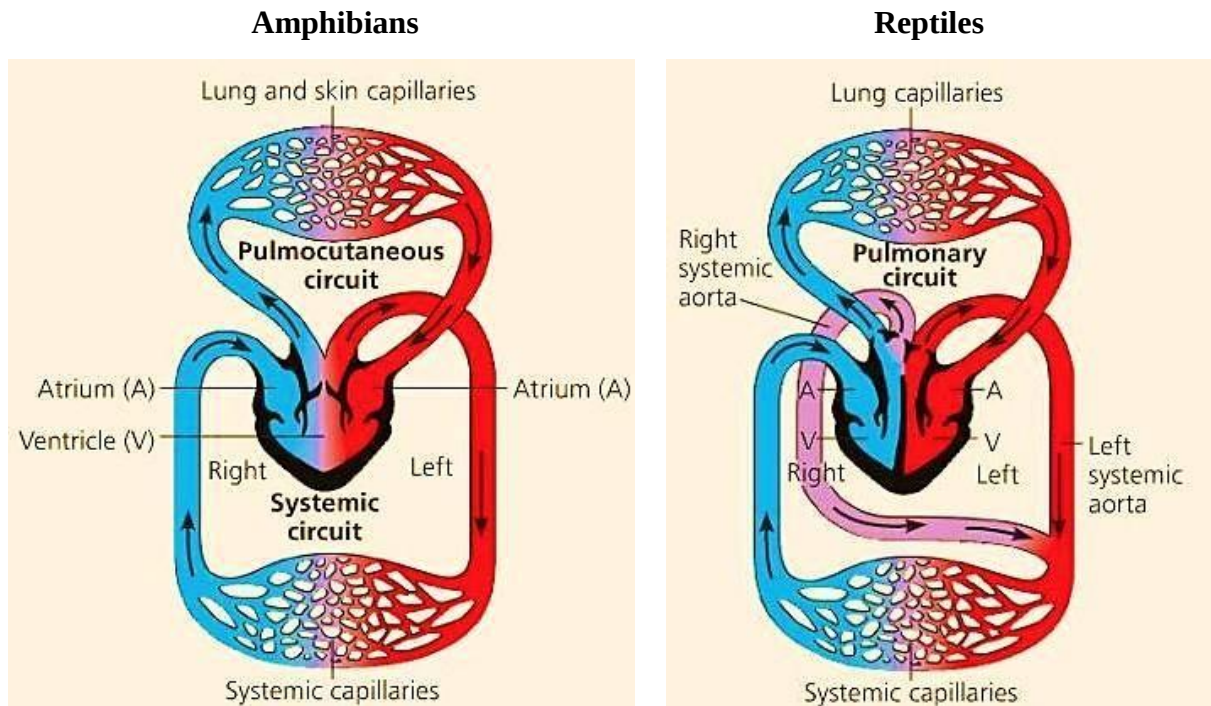
- Fish have the simplest circulation system with two chambers – one auricle and one ventricle.
- The heart pumps the blood in only one loop, from ventricle to gills to body cells back to the heart.
- A fish heart does not have to pump as hard like in land animal because water reduces the force of gravity.
- Fish blood can make it through the gills and the body without returning to the heart for a second push.



Source: <http://www.buzzle.com/>

Transport in Amphibians and Reptiles - Closed, partial double-loop circulation.

- ❖ Amphibians (toads) and reptiles (snakes, lizards, etc) both have three- chambered heart with two auricles and one ventricle.
- ❖ They have a closed partial double loop circulatory system.
- ❖ A single ventricle pumps oxygenated blood to the body and deoxygenated blood to the lungs.
- ❖ This circulation is only a partial double loop because the two loops overlap.
- ❖ Oxygenated and deoxygenated bloods mix in the ventricle.



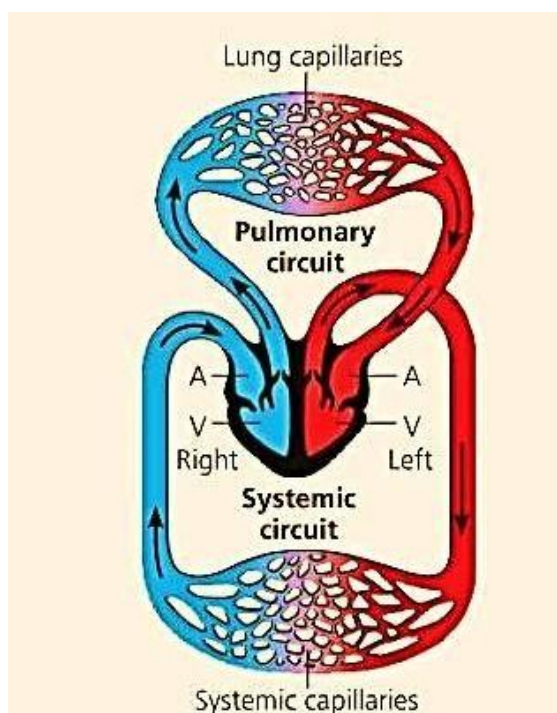
Adaptive Value

- In amphibians and reptiles, oxygenated and deoxygenated blood mix in the single ventricle. Some of the blood that the heart pumps to the lungs is already oxygenated. Some it pumps to the body is deoxygenated.
- Since amphibians and reptiles are cold- blooded and generally less active than birds and mammals, they can manage with less efficient blood circulation.
- Additionally, most reptiles have at least a partial wall in their ventricle to separate the oxygenated and deoxygenated blood. This increases the efficiency of their transport system.

Transport in Mammals and Birds - Closed, double-loop circulation

- ❖ Mammals and birds have four-chambered hearts – two auricles and two ventricles.
- ❖ Their blood circulates in two loops.
- ❖ One loop is between the heart and the lungs.
- ❖ The other is between the heart and the rest of the body.

Mammals and Birds



Adaptive Value

- Mammals and birds have the most efficient transport system of all organisms.
- Their deoxygenated and oxygenated blood is completely separated into the right and left sides of the heart.
- The heart pumps blood to the body forcefully since blood returns to the heart for a second push after it passes through the lungs.
- Mammals and birds need efficient transport for:
 - 1) **They are warm blooded.**
 - 2) **They are very active.**
 - 3) **Flight in particular consumes energy very quickly.**

- ❖ Some mammals, such as whales and elephants, are very large. Without an efficient transport system, they would not be able to supply their cells with enough oxygen to survive.
- ❖ Bird and mammal brains have a more developed cerebrum than most animals. The cerebrum consumes large amount of oxygen and nutrients.

Warm – blooded versus Cold – blooded

- Mammals and birds are warm-blooded.
- They keep their body temperatures constant regardless of environmental temperature.
- For e.g., humans keep their body temperature at 37°C, regardless of the temperature of the environment they are in.
- Normally air temperature is lower than the body temperature of birds and mammals.
- Therefore, these animals constantly lose heat to the air.
- Keeping the body warm in spite of constant heat loss requires plenty of energy.
- This is why warm-blooded animals need a very efficient oxygen and nutrient supply.
- All other animals, including fish, amphibians and reptiles, are cold-blooded.
- Their body temperatures vary with the environmental temperature.
- Cold- blooded animals consume less energy than warm- blooded animals.
- However, when the air is cold they cannot be very active because their metabolic reactions are too slow (the rates of virtually all reactions increases as temperature increases).

ADAPTATIONS FOR TRANSPORT

- ❖ All cells need a constant supply of nutrients and oxygen and removal of metabolic wastes.
- ❖ Direct diffusion is suitable for that have large surface area - area to volume ratios.
- ❖ Larger, active organisms need a special transport system to carry materials to and from their cells.
- ❖ The transport system of larger animals may interact with the following systems:
 - ✓ The **digestive system** to get nutrients.
 - ✓ The **respiratory system** to exchange gases.
 - ✓ The **excretory system** to remove nitrogenous wastes and excess salts.

Transport Method	Organism	Adaptive Value
Direct Diffusion	- bacteria - fungi - protists - cnidarians	no separate transport system, materials diffuse directly to and from cells; supplies enough materials and carries wastes away fast enough to support small or sessile organisms
Open Circulation	- arthropods - molluscs	blood is pumped by a heartbeat into an open body cavity, it is not contained in vessels; sufficient for small organisms which have a separate system that provides cells with oxygen
Closed Circulation	- annelids - vertebrates	blood does not directly touch cells, it is contained in vessels; needed in active, larger organisms to adjust blood flow to different body parts and to supply materials and remove wastes quickly.
Single – loop Circulation	- fish	blood passes through the heart only once (blood from the gills does not return for a second push before going to the rest of the body cells.); blood can make it through the gills and the rest of the body because being under water reduces the effect of gravity.
Partial double-loop Circulation	- reptiles - amphibians	blood passes through the heart twice but mixes in the single ventricle; blood gets the extra push it needs to flow against gravity in land animals
Double loop Circulation	- birds - mammals	blood passes through the heart twice, oxygenated and deoxygenated blood do not mix; this is the most efficient transport system of all.



SELF TEST

1. Transport systems often link with the following systems: digestive, gas exchange, and urinary. Explain the reasons for each of these connections.
2. What three factors are believed to help water move up through xylem? Describe how each force works.
3. How do plants absorb water from the soil? How do they absorb minerals?
4. Describe how food is transported in vascular plants.

5. What two kinds of cells make up phloem? What is the function of each?
6. Describe how xylem cells and sieve cells are specially adapted for their functions.
7. What is the difference between open and closed circulation? Give an example of an organism with each kind of circulation.
8. Why don't large organisms have open circulation?
9. Write out the path of blood flow in hornet, an earthworm, a fish, a toad and a bulbul. For each choose the words that apply from the following list: left ventricle, right ventricle, right auricle, left auricle, ventricle, auricle, simple heart, haemocoel, vessels near body cells, vessels in gills, vessels in lungs, heart-like vessel, Ostia.
10. In animals with closed circulation, the blood does not actually touch the animal's cells. How do the materials move between the cells and the blood?
11. What is the difference between single-loop and double loop circulation? Is circulation in these loops closed or open?
12. State how many chambers the heart of each of the following animals has: a frog, a mynah, a dog, a fish.
13. In spite of having only single loop circulation, a fish's circulatory system is able to supply cell nearly as quickly as the double-loop circulatory system of a mammal. Why?
14. Define the words cold-blooded and warm-blooded and give example of an animal with each.
15. State one advantage and one disadvantage of being cold-blooded.
16. Which is more efficient, a three-chambered or four-chambered heart? Why?
17. Why must birds sit on their eggs while other egg-laying animals, such as fish and mosquitoes, do not?
18. Compare the transport system in an annelid and in a fish.

BI 12.1.4.4 EXCRETION AND OSMOREGULATION

Homeostasis means to maintain a constant stable internal environment/condition. Some common homeostasis processes in organisms to maintain stable environment includes:

- (1) Regulation of blood pH.
- (2) Regulation of blood sugar level. Mammals use insulin and glucagon.
- (3) Regulation of excess water and ions by kidneys and liver in vertebrates.
- (4) Regulation of constant body temperature in warm-blooded animals.
- (5) Regulation of oxygen content in blood.
- (6) Regulation of water content in blood and lymph fluid.

The two processes which play an essential role in homeostasis are: (1) Excretion and (2) Osmoregulation.

To prevent osmotic problems, organisms excrete waste products of their metabolic reactions and regulate the balance of solutes and water in extracellular fluid.

Excretion

- ❖ **Excretion** is the process of removing **metabolic waste** products from the body.
- ❖ Excretion is **different** from **egestion**. **Egestion** is removal of **undigested waste** material from the body via alimentary canal (Example: Faeces).
- ❖ Metabolic waste products can be harmful to the organisms and therefore needs to be excreted (removed) from the body.
- ❖ Carbon dioxide from respiration and nitrogenous wastes from deamination of amino acids are two major metabolic wastes.
- ❖ Carbon dioxide is excreted from the body via exhaling and nitrogenous waste is excreted by kidneys.
- ❖ Some small sessile organisms have the ability to diffuse the metabolic wastes out of their body directly but for larger active organisms which produce more metabolic waste, special systems and organs are in place to excretion.
- ❖ Every species has a waste-removal system suitable for its lifestyle and environment.

Osmoregulation

- ❖ Osmoregulation is the process of maintaining the solute concentrations constant in the fluid in and around cells to avoid it from becoming excessively flaccid or turgid.
- ❖ Too much or too little of any solute can kill an organism.
- ❖ Excretion intertwines closely with osmoregulation as it gets rid both water and solutes.
- ❖ For terrestrial organisms, osmoregulation requires adaptations for water conservation.

PLANTS: EXCRETION AND OSMOREGULATION

- ❖ Plants use most of the waste products they produce, including CO₂, O₂ and ammonia.
- ❖ CO₂ is used in photosynthesis; O₂ for plant respiration and ammonia for nitrogen.
- ❖ Those gases which are not immediately required by the plant for photosynthesis or respiration are diffused out.
- ❖ While plants do not have to worry much about excretion, most land plants face the constant threat of dehydration.

Water Conservation in Terrestrial Plants

- ❖ Water is needed by plants for two things: (1) photosynthesis and (2) maintaining cell turgidity.
- ❖ Terrestrial plants need transpiration to pull water up from their roots and to cool their leaves.
- ❖ Plants lose about 90% their water intake by transpiration through open stomata.
- ❖ If a plant loses more water than it absorbs, it will wilt and eventually die.

Adaptations of Plants to Reduce Water Loss

- **Waxy Cuticle**- covers stems and the top surface of leaves to prevent water evaporation.
- **Stomata**- present mainly on the bottom-side of the leaves in order to reduce transpiration.
- **Guard Cells**- closes stomata at night and whenever the plant does not have enough water.
- **Adjustment of Leaf Angle**- in order to reduce the amount of the leaf surface exposed to sunlight, some plants can adjust the angle of their leaves leaf sun on the leaves when excess water is being lost via transpiration.

Stomata & Guard Cells

When guard cells are:

- Turgid- stomata opens
- Flaccid- stomata closes

Additional Water Loss Adaptations

Some plants have the ability to survive in very dry environments. Some additional adaptations which they have to conserve water are:

- **Succulence**—plants store water in fleshy leaves, stems or roots in gel-like compounds and cells from which it is not easily lost. Example: cactus and aloe vera.
- **Thick Cuticle**- reduces water loss via transpiration.
- **CAM Plants**- these plants open stomata at night to capture CO₂ and during the day they keep the stomata closed but continue to photosynthesize.
- **Protection Structures/compounds**—stored water is protected from thirsty animals using spines, bitterness and needle-like structures.
- **Drought dormancy** – some desert plants withstand desiccation in drought periods by appearing dead or near-dying but will flourish back again once there is rain. Some plants also drop off all the leaves to reduce transpiration.

PLANTS: EXCRETION AND OSMOREGULATION

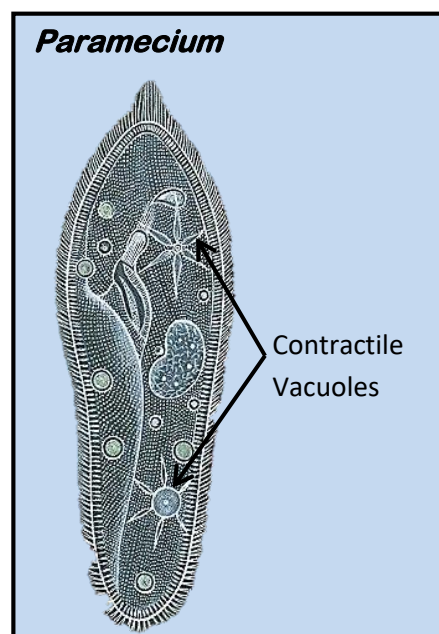
- ❖ Plants excrete some waste through diffusion.
- ❖ During the day, excess oxygen gas produced by photosynthesis is released through the stomata.
- ❖ Carbon dioxide produced by respiration is normally used up during photosynthesis. At night, carbon dioxide is not used up as fast as it is produced and is released as a waste product.
- ❖ Plants also eliminate waste by **abscission** where the waste is accumulated in the vacuoles of the aging leaf cells which eventually die and fall off, removing waste in the process.
- ❖ The sticky, milky or oily substances (resins, gums, latex) that ooze from the bark of trees are excretory products.
- ❖ Osmoregulation in plants is mainly maintained by the stomata.

PROTISTS: EXCRETION AND OSMOREGULATION

- ❖ Unicellular protists do not have to invest into large systems for excretion and osmoregulation.
- ❖ They rely on simple diffusions to get rid of their metabolic wastes.
- ❖ Note: Not all protists are unicellular there are some multicellular protists also.
- ❖ Protists living in fresh water face a lot of osmotic problems since water constantly moves into their body cells. To encounter this problem, such protists have special cell organelles and/or mechanism in place to remove excess water.

Osmoregulation in *Paramecium*

- ❖ *Paramecium* is a genus of unicellular freshwater protists.
- ❖ The solute concentration in the *Paramecium*'s cell cytoplasm is higher than in the fresh water outside the body/cell. Thus, water moves in by osmosis, causing the cell to swell.
- ❖ In order to maintain solute balance, all *Paramecium* have special cell organelles called **contractile vacuoles** that actively take in excess water and squeeze it back out of the cells.
- ❖ Contractile vacuoles pump water out of the body to maintain a stable solute and water concentration inside the cell cytoplasm.
- ❖ If the contractile vacuoles stop working, the *Paramecium*'s cell will fill up with water and eventually burst.
- ❖ Since contractile vacuoles are squeezing water out against the concentration gradient, it requires energy and therefore mitochondria is usually located near the contractile vacuoles.
- ❖ When mitochondria produce energy via respiration process, it produces CO₂. This CO₂ is excreted by diffusion and also by contractile vacuole along with water.



Source: www.suggestkeyword.com

ANIMALS: EXCRETION AND OSMOREGULATION

- ❖ Excretion and osmoregulation in animals depends on its lifestyle and environment.
- ❖ Excretion in aquatic animals is easy since poisonous ammonia wastes are readily diluted with plenty of water.
- ❖ Osmoregulation is a problem for aquatic animals due to osmosis. Water moves into freshwater animals and out of saltwater animals.
- ❖ On the other hand, excretion can be a problem for terrestrial animals since they must also conserve water.
- ❖ Terrestrial animals constantly lose water by:
 - Excretion of urine;
 - Evaporation from the skin and respiratory surfaces;
 - Elimination of water by drinking, eating food that contains water; and
 - Producing metabolic water by the respiration reaction.

Nitrogenous wastes result from the breakdown of excess amino acids. Most of an amino acid molecule can be used for energy, but the nitrogen part is waste. The three types of nitrogen –containing wastes are:

1. **Ammonia** - the original product of deamination: very toxic (poisonous) so it must be diluted with plenty of water e.g. aquatic animals- Fish, tadpoles
2. **Urea**- made from ammonia, not as toxic as ammonia e.g. terrestrial mammals
3. **Uric acid** – insoluble nitrogen waste crystal, not toxic e.g. insects and reptiles.

Excretion and Osmoregulation in Invertebrate Animals

I. Aquatic Invertebrates: Cnidarians and Mollusc (Bivalves)

Excretion and Osmoregulation

- ❖ Sessile aquatic animals in which ammonia diffuses out into the surrounding water.
- ❖ These organisms are small and create metabolic wastes slowly. Therefore, they do not need a special excretory system.

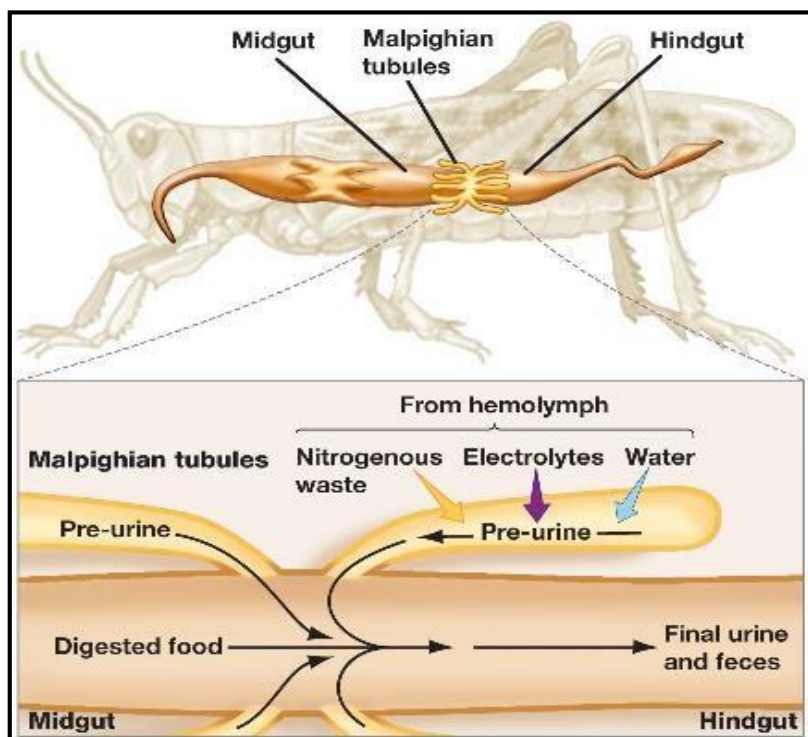
Water Conservation

- ❖ They live in water; therefore do not worry about dehydration.

II. Terrestrial Invertebrates: Insects

Excretion

- ❖ Excretory organ of the insects are known as **Malpighian Tubules**. These are tube extensions of the gut which float in the open blood cavity (haemocoel).
- ❖ Excretory products of insects are **uric acid**. The Malpighian tubules absorb nitrogenous wastes from the blood and convert it to **uric acid**.
- ❖ The tubules join with the hind gut and uric acid crystals pass out with the faeces.



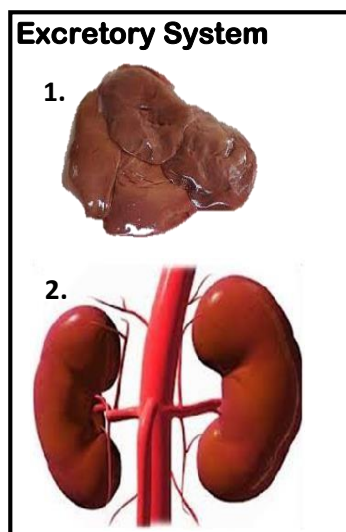
Source: www.emaze.com

Water Conservation

- ❖ Insects are terrestrial animals which face the constant threat of dehydration. Their water conserving adaptations include:
 - Excretion of solid uric acid crystals instead of urea which needs to be diluted in water.
 - Waxy exoskeletons reduce water evaporation from body surfaces.
 - The moist respiratory surfaces of the trachea are inside their bodies in order to reduce evaporation.
 - Closing of spiracles when they are inactive.
 - The hind gut reabsorbs water from the faeces.

Excretion and Osmoregulation in Vertebrate Animals

- ❖ All vertebrates share similar excretory systems which include:
 - (1) **Liver**- which deaminates excess amino acids; and
 - (2) **Pair of kidneys**- which filter the resulting nitrogenous wastes out of the blood.
- ❖ Using hormones, the brain tells the kidneys how much water and salts the body needs to retain to maintain homeostasis.



Source 1: www.eatmedaily.com

Source 2: www.clinicalstudies.com.au

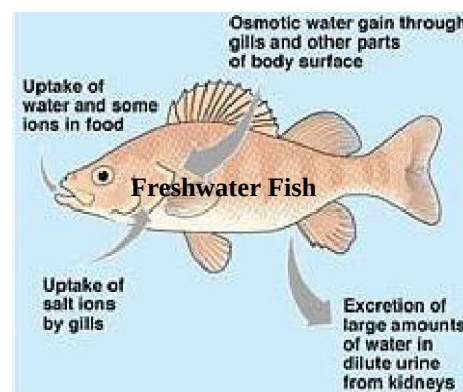
I. Aquatic Vertebrates: Fish

Excretion and Osmoregulation

- ❖ Both fresh and saltwater fish excrete ammonia directly into water therefore no energy is spent on converting it to urea.
- ❖ However, fish face osmotic problems. Water constantly moves into freshwater fish's cells and move out of a saltwater fish's cells.

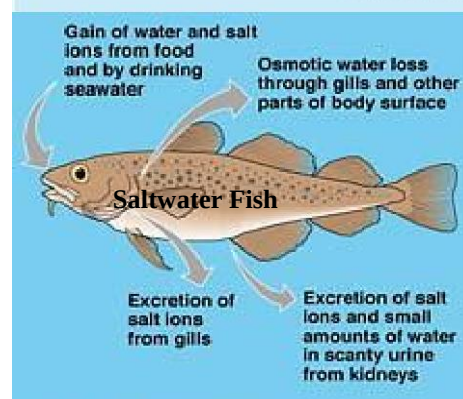
Freshwater Fish

- ❖ The solute concentration in the cells of a freshwater fish is higher than that of the surrounding water and therefore water constantly moves into the fish's gill cells and the fish loses a lot of salts.
- ❖ They maintain water balance by constantly excreting large amounts of very dilute urine.
- ❖ Freshwater fish replaces salts by actively absorbing them from surrounding water through special cells in their gills.



Saltwater Fish

- ❖ The salt water surrounding ocean fish has a higher solute concentration than that inside fish cells.
- ❖ Thus saltwater fish constantly lose water by osmosis.
- ❖ To solve this problem, ocean fish constantly drink salt water and then excrete excess salt through special cells in their gills.



Source: www.pleasanton.k12.ca.us

II. Terrestrial Vertebrates:

1. Amphibians (Example: Frog)

Excretion, Osmoregulation and Water Conservation

- ❖ Adult life spent on land but the body not well adapted for conserving water.
- ❖ Amphibians partly breathe through their skin and therefore the skin needs to be moist for gases to dissolve and diffuse.
- ❖ Since breathing takes place via skin; the skin lacks additional protective coverings.
- ❖ Amphibians excrete urea which requires dilution with water.
- ❖ Since amphibians spent juvenile (young) part of their lives in water, finding moist habitats are easy for them.

2. Reptiles (Example: Gecko/Lizard; Turtles)

- ❖ Well adapted for conserving water.
- ❖ Ability to excrete **solid uric acid crystals** (also known as: urates) and **urea**.
- ❖ Excreted uric acid is white in colour while urine is colourless.
- ❖ To conserve water, reptiles have scales covering their skin and exchanging of gases uses lungs. Lungs are inside their bodies to reduce evaporation from moist respiratory surfaces.

The droppings of house lizard and birds are mostly white and black/brown. The white part is the uric acid crystals and the brown part is faeces (undigested food).

3. Birds

- ❖ Also excrete uric acid.
- ❖ To prevent dehydration:
 - Feathers cover the body.
 - Scales on legs (where there is no feathers)
 - Gas exchange via lungs which is kept moist inside the body.

4. Mammals

- ❖ Excrete urea diluted in water.
- ❖ To replace the amount of water lost urine, by evaporation and by exhalation, most mammals must drink water quite regularly.
- ❖ The feeling of thirst caused by hormones is an adaptation to remind the mammal to rehydrate.
- ❖ Humans require plenty of drinking water since they lack heavy fur to prevent evaporation from skin.
- ❖ On the other hand, some dessert mammals (Example: Camels) are well adapted for water conservation since they manage to survive only on the water they derive from respiration and food.
- ❖ Osmoregulation in kidneys occurs at **loop of Henle**. Here, most of the body fluids and essential nutrients are reabsorbed. Most of the water is also reabsorbed from the undigested food in the large intestine.
- ❖ Osmoregulation is also maintained by the anti-diuretic hormones (ADH). The water level in the blood needs to be constant to avoid cell damage and therefore when the body is dehydrated, this hormone release by the pituitary gland. It travels in the blood to the kidneys where it affects the tubules so more water is reabsorbed into your blood. Hence, lesser volume of more concentrated urine is produced. The level of water in your blood increases until it is back to normal.

Advantages of Excreting Uric Acid

(Insects, Reptiles and Birds)

1. Reduces water loss since it does not require dilution.
2. Solid uric acid is lighter than liquid urine - aids in flight since it does not add extra weight.
3. Embryos developing in eggs do not poison themselves with their own wastes since uric acid is harmless compared to if they excreted urea or ammonia.

SUMMARY TABLE		
Method of Excretion and Osmoregulation	Organisms	Adaptive Value
Direct Diffusion No excretory system, wastes simply diffuses out.	Plants, bacteria, some protists, fungi, cnidarians, some molluscs	▪ Sufficient for sessile organisms. ▪ Energy not spent/ wasted.
Contractile Vacuoles Cell organelle which absorbs excess water and pumps it out of the cell.	Freshwater protists	▪ Removes water that constantly moves into the cell by osmosis.
Malpighian tubules Tube extensions of the gut which float in the haemocoel	Insects	▪ Absorbs uric acid from the haemocoel. ▪ Light-weight excretory product- aids in flight. ▪ Not poisonous to the organism. ▪ No dilution required.
Kidneys and Liver	Vertebrates	▪ Very efficient blood filtering. ▪ Precise control of the body's water/solute concentration.

Evolutionary Trends

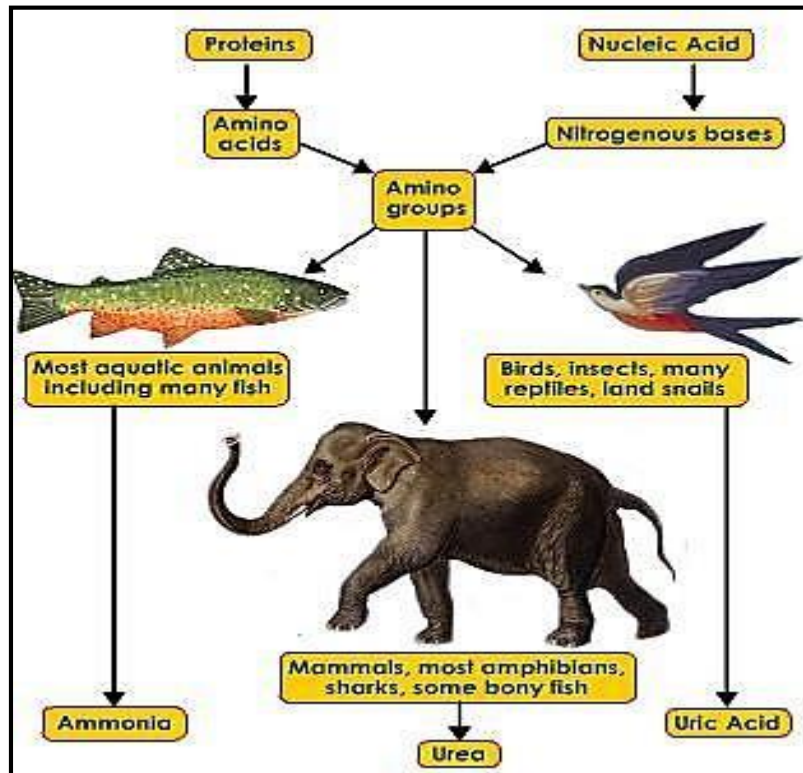
Excretion varies greatly between invertebrates and vertebrates, depending on the complexity of the organism.

Excretion in invertebrates varies from protozoa that are by diffusion through the membrane, the Porifera from cells that specialize in this function, and arthropods which have specialized excretory organs- malpighian tubes.

Excretion in vertebrates is characterized by the presence of an excretory organ located mostly in dorsal, posterior end of the vertebrae, which are called the kidneys.

In the kidneys are capable of excreting waste in various forms as outlined in the diagram below.

Excretory systems of Vertebrates



Source: www.tutorvista.com



SELF TEST

1. Explain the difference between osmoregulation and excretion.
2. How is homeostasis different from excretion and osmoregulation?
3. Identify the function of the liver as part of the excretory system in vertebrates.
4. Name three nitrogenous waste products produced by animals.
5. Identify some water conservation adaptations of terrestrial plants.
6. Identify four ways in which insects reduce water loss.
7. Briefly explain how human excretory system (liver and a pair of kidney) conduct excretion and maintain osmoregulation.
8. Correct the sentences below to make it true:

Marine fish continually gain water through osmosis. In order to maintain osmotic balance of its body cells with the surrounding water, such fish drink water continuously drink water and excrete very concentrated urine from liver.

9. Identify the advantages and disadvantages of the excreting the following products:

Waste	Advantages	Disadvantages
Ammonia		
Uric Acid		
Urea		

10. What is the advantage of excreting uric acid rather than urea in the egg-laying terrestrial reptiles and birds?
11. Identify the major disadvantage that fish would face if it instead of excreting ammonia it converted and excreted urea.
12. Compare excretion of a jellyfish with that of a terrestrial mammal. Explain with reference to their lifestyle, the adaptive value of the excretory method to them.
13. Name the structure that maintains osmoregulation in freshwater *Paramecium* and explain the significance of many mitochondria surrounding this structure. Would the seawater/ marine *Paramecium* also have the same cell organelle to maintain osmoregulation? Explain your answer.
14. Briefly outline how homeostasis ensures a constant body temperature and blood sugar levels in humans. You may refer to internet sources and reference textbooks to answer this question.

BI 12.1.4.5 PROTECTION, SUPPORT AND MOVEMENT

Organisms possess certain structures and/or adaptive features which provide them with some form of protection, support, and movement to successfully exploit their environment.

The adaptive structures often include those that provide **protection** from dehydration, disease and predators; **support** against gravity; and **movement** for finding food and escaping predators.

Organism's means of protection, support and movement are suited to its way of life.

Example

Centipedes have poisonous bites which they use to defend themselves, their food and their habitat. Land plants have the shiny waxy cuticles to reduce transpiration. Tall trees have heartwood and lignin to strengthen their stems. Birds and bats have extremely light-weight bodies and broad wings.

Factors Affecting Protection, Support and Movement

- ❖ **Aquatic and Terrestrial Habitat-** organisms dwelling in aquatic habitats have totally different requirements in terms of support, movement and protection from the organisms that dwell in terrestrial habitats due to the nature of the environment that they are exposed to.

Aquatic Organisms (Water)	Terrestrial Organisms (Land)
➤ No need to protect itself from dehydration since it lives in water	➤ Needs to protect itself from dehydration
➤ In the water, the pull of gravity experienced by the organism is reduced due to the buoyant force in the opposite direction.	➤ Requires stronger support system to cater for the strong gravitational pull that is experienced by the body.
➤ Movement in water requires different structures to aid in movement (example, fins in fish to swim)	➤ Movement on land requires different structures (example, skeletal structure made of bones)

PLANTS: PROTECTION, SUPPORT AND MOVEMENT

Movement in Plants

- ❖ Plants do move but since they make their own food, they have limited movement capabilities.
- ❖ Plant movements are not extensive because they do not have to travel from one place to another in search of food.

- ❖ Some lower group of plants (algae) show locomotion with the help of cilia but the higher plants can only exhibit change in position of the organs.
- ❖ The major types of movement in plants are: (1) Tropic and (2) Nastic movements.
- ❖ Since tropic movements (tropisms) have been extensively studied before; we will only concentrate on nastic movements.

Nastic Movement

- ❖ Movement due to changes in turgor or changes in growth.
- ❖ These movements are non-directional.
- ❖ **Nyctinasty**- movement in plant organ in response to the onset of darkness. Also known as ‘sleep movement’.
Example: many leguminous close leaflets at night and also the ‘*vaivai*’ or ‘*mocemoce*’ plants.
- ❖ **Photonasty**- movement of plant organs in response to light.
Example: opening and closing of flowers.
- ❖ **Chemonasty**- movement of plant organs in response to chemical/nutrients.
Example: Dragon fly and Venus fly trap.
- ❖ **Thigmonasty**- movement of plant organs in response to vibration or touch.
Example: Sensitive grass

Examples of Plants that Move

Plants that Move to Capture and Consume Prey

Sundew



Source: www.growsundews.com

Venus Fly Trap



Source: www.vishub.org

Waterwheel



Source: www.sarracenia.com

Plants that Move Leaves

Sensitive Grass



Source: www.etsy.com

Partridge Pea



Source: www.grownative.org

Yellow Neptunea



Source: www.stevenfoster.com

Plants that Spread Seeds or Pollens by Rapid Explosion

Squirting Cucumber



Source: www.crete-birding.co.uk

Resurrection Plant



Source: www.quantumbiologist.com

Resurrection Plants display remarkable ability to survive near desiccation causing it to appear nearly dead but when rehydrated these plants are revived.

Protection in Plants

Protection in Plants- From being Eaten, Pulled and/or Torn

- ❖ In order for the plants to protect their stored food for later use in growth and reproduction, they have certain adaptive features which prevent the consumers (herbivores and omnivores) from eating it.
- ❖ Ways in which plants protect themselves can be categorised into three groups: (1) Structural Defence; (2) Chemical Defence; (3) Behavioural Defence.
- ❖ Some such adaptive features of the plants which provide protection from being eaten are:

1. Thorns and Spines (Structural Defence)

Rose Plant



Lemon Tree



Cacti



2. Poisonous Leaves (Chemical Defence)

(Note: These leaves are not poisonous to all organisms but some specific ones)

Neem Leaves



Lanтана



Mother-in-law's Tongue



3. Hairy Leaves and Stems (Structural Defence)

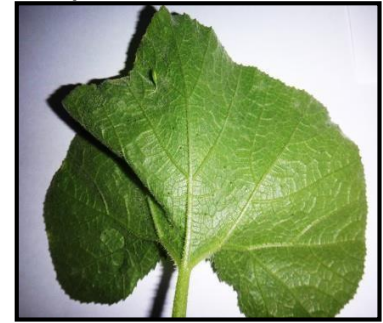
Tomato leaves and stem



Eggplant leaves



Pumpkin Leaves



4. Thick Leaf Cuticles



5. Sharp Leaf Edges (Structural Defence)

Coriander family



Coconut Leaves



Conifers



6. Bad Smell (Chemical Defence)

Western Skunk Cabbage



Dead Horse Arum Lily



Corpse Flower



Source: <http://listcrux.com/top-10-flowers-that-smell-real-bad/>

7. Bark (Structural Defence)



8. Sensitive Grass (Behavioural Defence)



Source: www.gardenrant.com

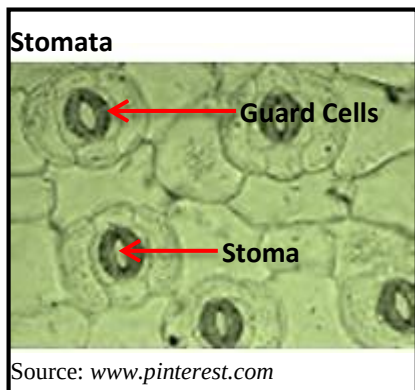
- ❖ Investing in adaptive features for protection uses up a lot of energy and therefore some plants do not invest in any special defence mechanism against herbivores and omnivores.
- ❖ As a form of protection, such plants only have an epidermis and cuticle and therefore produce enough food to survive even when some is consumed.
- ❖ Plant's cuticle and epidermis not only protects against it being eaten but also helps protect against diseases just as our skin does.
- ❖ Bark on trees provides additional protection.

Protection in Plants- From Dehydration/ Desiccation

- ❖ Just as we perspire (sweat) to cool our skin so does the plants via the process of transpiration.
- ❖ Transpiration is the movement of water through the plant and its evaporation from the aerial (top) parts especially through the leaves.
- ❖ When water is drawn up from the roots and lost through the leaves via stomata, the plant gets cooled.
- ❖ However, when there is limited water available as in the case of prolonged dry seasons and droughts, plants choose to close their stomata.
- ❖ The adaptive features of **land plants** which protect from desiccation are:
 - (1) More stomata is present on the lower surface of the leaf than on the upper surface
 - (2) Stomata have guard cells which open and close the stomata as per need.
 - (3) Waxy cuticle on the upper surface of the leaves reduces the water loss via transpiration from the top surface.
 - (4) Presence of tiny hair-like structures on the leaves also helps reduce transpiration.

Interested in Seeing Stomata!!!

1. Take a leaf
2. On the underside of the leaf, paint a small section with clear nail polish (keep the nail polish layer thin)
3. Dry the nail polish
4. Stick a clear cello-tape on the dried nail polish.
5. Pull out the cello-tape from the leaf and stick it onto a clean glass slide.
6. Observe the slide under a microscope.



Aquatic Plants

Aquatic plants do not have to conserve water and therefore have different adaptive features and mechanisms from the land plants.

- ❖ Some aquatic plants, especially the floating plants lack guard cells on the stomata and some do not have any stomata at all (submerged plants).
- ❖ For the floating plants, the stomata are present on the upper surface of the leaves to enable exchange gases with the air.
- ❖ Mostly the submerged plants lack waxy cuticles or have a very thin layer of the waxy cuticle to aid in efficient gas exchange while some floating aquatic plants have the thick waxy layer to repel water and keep the stomata clear.

Water Lily



Source: www.wisegeek.org

Support in Plants

- ❖ The main role of the plants as producers is to photosynthesise. In order to do carry out this role effectively, plants need mechanisms which enable them to gather the key ingredients required for photosynthesis.
- ❖ The key ingredients required for photosynthesis are: water, carbon dioxide and sunlight.
- ❖ Carbon dioxide is easy to obtain because it is present in the air. However, obtaining sufficient amount of sunlight and water pose some problems for plants.

Support in Plants to Acquire Adequate Sunlight

In order to maximise the amount of the sunlight received, many plants grow upwards and outwards. However, the taller a plants grows the more support it needs against gravity.

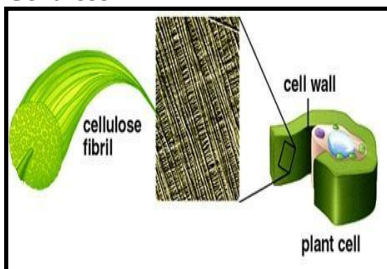
Support in Herbaceous Plants

- ❖ Herbaceous plants are “soft-stemmed” plants such as herbs and other small plants.
- ❖ Herbaceous plants do not live for long.



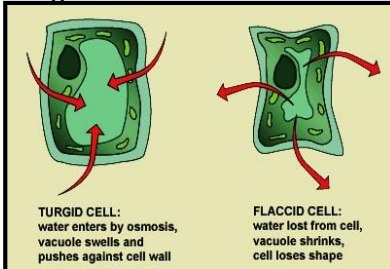
- ❖ These plants mostly don't grow tall and therefore not very strong methods of support needed.
- ❖ Those herbaceous plants that grow tall (eg. Balabala and banana) fall down easily.
- ❖ These plants support themselves in three ways:
 1. **Cellulose in plant cell walls** – cellulose is a tough carbohydrate that makes plants cell walls rigid.
 2. **Turgor Pressure** –pressure created when fluid is tightly filled in each cell. In presence of sufficient water, the cells remain turgid. When plants lose too much water, the cells become flaccid (limp) from water loss and wilts.
 3. **Cortex tissue** – cortex cells are the unspecialised cells lying between the epidermis and the vascular tissues. These cells and other strong fibrous cell tissues is the major component in plants stems and roots. Cortex cells also store starch.

Cellulose



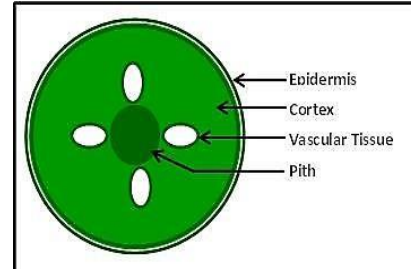
Source: McGraw-Hill Companies

Turgid Cell



Source: visualvocabulary.blogspot.com

Cortex Tissue



Other Adaptations for Support in Herbaceous Plants

- ❖ Some herbaceous plants grow tall without investing much in its own support mechanisms.
- ❖ Examples of such plants are epiphytes and climbers.
- ❖ **Epiphytes** root themselves in the tall plants instead of soil to receive adequate sunlight. The host plants are not negatively affected by the epiphytes. Some examples of epiphytes are:
 - ❖ **Climbers** root themselves in the soil but climb upon tall plants and other support structures such as sticks etc.
 - ❖ In order to climb other support structures, climbers invest in structures such as tendrils, spines or wrap. Climbers are often stuck in the shade of their host plant.
 - ❖ Some examples of climbers are: bean plants, bougainvillea, yam plants, pumpkin plants

Tendrils - small cucumber (gherkins)



Support in Woody Plants

- ❖ Woody plants have evolved strong support mechanisms to enable them to grow tall without using other plants as support.
- ❖ These plants live for long and therefore they make big investments in their support mechanisms.
- ❖ In addition to cellulose and turgor pressure, woody plants have:
 1. **Lignin**- a very strong carbohydrate that strengthens cell walls.
 2. **Heartwood**- dead xylem at the centre of the stem which has filled with hardened sap.
 3. **Root System**- which is deep and extensive to anchor the plants in the ground.

Interesting Facts:

▪ Tallest Plant

Name: Hyperion

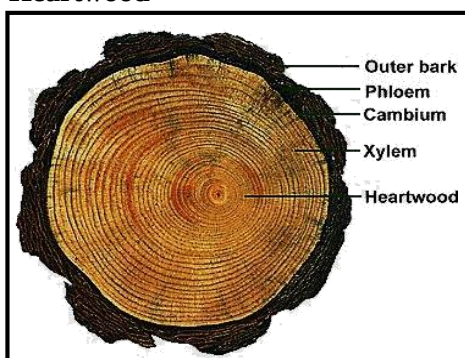
Height: ≈ 116 m

▪ Oldest Plant

Name: Pine species

Age: ≈ 5064 years

Heartwood



Source: www.claytondavis1.weebly.com

Root System



Source: www.123rf.com

SUMMARY TABLE FOR PLANTS

	Herbaceous Plants			Woody Plants
	Normal	Epiphytes	Climbers	
Example	Plants: pawpaw, balabala, hibiscus	Orchids; some ferns	Mile-a-minute	Trees: Dakua, Mahogany,
Movement	Limited movement for pollination etc. It is not <u>motile</u> (Moving or having the power to move spontaneously)			
Protection against predation	• Thorns and spines • Poisonous or sharp leaves • Bad smell • Leaves with thick cuticle • Barks • Woody plants grow tall			
Protection against Desiccation (terrestrial)	• More stomata on lower surface than on upper surface • Waxy cuticle on upper surface • Guard cells to close the stomata • Tiny hair-like structures on the leaves to reduce transpiration			
Support	• Cellulose • Turgor pressure • Cortex tissues	• Strong thick roots • Small size	• Tendrils • Twining- stems that can bend, twist and coil • Adventitious roots	• Heartwood • Lignin • Extensive root system

ANIMALS: PROTECTION, SUPPORT AND MOVEMENT

Movement, Support and Protection

- ❖ Not all animals can move, some are sessile (can't move).
- ❖ Those animals that can move invest in structures that will help them best to move in their environment. For example: Fish invest in fins to swim in aquatic environment, land animals invest in legs, leg-like structures and wings).
- ❖ Animals which do not move have some form of mechanism to bring food to their body.

Example

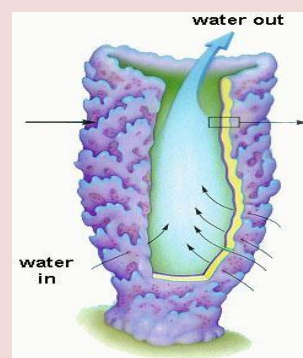
Sponges are sessile and therefore the food enters the body with the water current. As water moves in and out of the body, **microvilli**, lining the inner part of the body traps food.



Source: www.hdwallpapers.in



Source: www.circusystem.weebly.com



Source: www.uic.edu

Movement, Support and Protection in Invertebrates

- ❖ Invertebrates are animals which lack a backbone.
- ❖ The invertebrate animals belong to phylum:

Porifera (Sponges)



Source: www.youtube.com

Cnidaria (Jellyfish and corals)



Source: www.reddit.com

Platyhelminthes (flukes, tapeworms, flatworms)



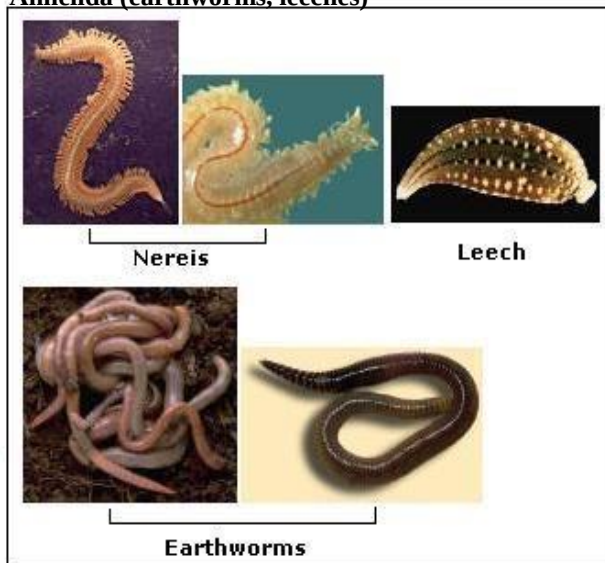
Source: www.blog.nus.edu.sg

Aschelminthes class Nematoda (roundworms)



Source: www.froggynaan.com

Annelida (earthworms, leeches)



Source: www.tutorvista.com

Mollusca (snails, bivalves)



Source: www.biovik.blogspot.com

Echinodermata (Sea stars)



Source: www.evolutionevidence.org

Arthropoda (Insects)



Source: www.portaldoprofessor.mec

- ❖ This year we will only look at the support, movement and protection in animals belonging to phylum Cnidaria, Annelida and Arthropoda.

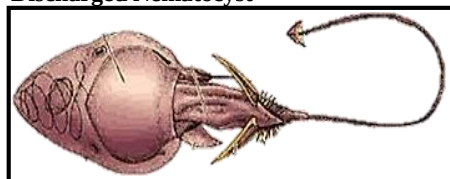
1. Hydrostatic Skeleton: Cnidarians and Annelids

- ❖ Cnidarians (jelly fish) and annelids (earthworms) do not have a skeleton.
- ❖ Instead, they support their bodies with a hydrostatic skeleton.
- ❖ A hydrostatic skeleton is a fluid filled body cavity.
- ❖ Since cnidarians and annelids are not very large-sized and highly active animals, hydrostatic skeleton is sufficient for them.

Protection

- ❖ Despite the ability to allow gas exchange with the surrounding water, a hydrostatic skeleton does not provide any form of protection from dehydration and predation.
- ❖ All cnidarians are aquatic and therefore do not face a dehydration problem. For protection from predators and for killing prey (obtain food), many cnidarians have poisonous stingers called nematocyst.
- ❖ Terrestrial annelids protect themselves from both dehydration and predators by staying underground. Earthworms have rigid hairs (bristles) on their bodies which can grip tightly onto the soil, making it difficult to be pull out of the ground.

Discharged Nematocyst

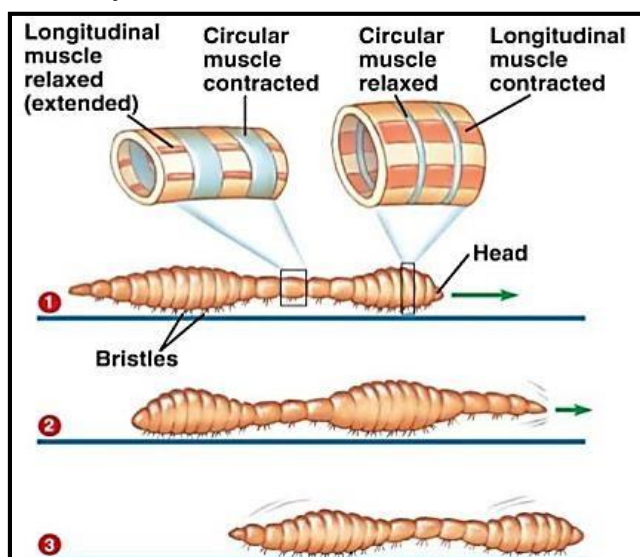


Source: www.biologyeducation.net

Support and Movement

- ❖ The hydrostatic skeleton gives shape to the cnidarian's body. For movement, they rely on the contraction of the muscle to and the internal fluid to move. Cnidarians do not need much support structures because they are buoyed (upward thrust) by water.
- ❖ The hydrostatic skeleton also gives shape to the annelid's body. For movement, terrestrial annelids, especially earthworms, rely on the contraction of the muscles and the internal fluid to create peristaltic movements. To move, it pushes its internal fluid forward by contracting circular muscles in one body region and relaxing the muscles in another. The worm contracts the muscles in a wave down its body, moving itself forward. The bristles on the bottom side help it grip the soil as it pushes its body forward, region by region.

Use of Hydrostatic Skeleton and the Muscles to Move



Source: www.slideshare.net

2. Exoskeleton: Arthropods

- ❖ Exoskeleton is the skeleton outside the body.
- ❖ It is the hard outer covering.
- ❖ Arthropods (insects, crabs, prawns, spiders) have exoskeleton.
- ❖ Arthropods exoskeleton is made of chitin and protein.
- ❖ Chitin is a strong and stiff carbohydrate.



Advantages of Exoskeleton	Disadvantages of Exoskeleton
➤ Exoskeletons provides protection against: ▪ predation ▪ damage of the internal tissues ▪ dehydration in terrestrial animals	➤ Exoskeletons cannot grow and therefore the animal needs to shed the exoskeleton (moult; ecdysis) in order to grow. ➤ During the moulting period the animal is prone to diseases, predation and terrestrial animals to dehydration. ➤ Animal has to invest a lot of energy into making new exoskeletons. ➤ Exoskeletons are very heavy and therefore the animal has to spend a lot of energy to carry it around. Also, due to the weight there is size limitation especially the terrestrial ones who do not get similar support as the aquatic ones (buoyancy)

Protection

- ❖ Apart from the exoskeleton, the arthropods also possess other structures which aid in their protection.
- ❖ Some such structures are:
 - Wings to fly away in most of the insects.
 - Jointed appendages to escape predators and catch prey efficiently.
 - Fierce mouth parts with poisonous stings (bees, centipedes), venom (spiders) or chelicerae (crabs claws)

Support and Movement

- ❖ Support to the body provided by exoskeleton.
- ❖ Movement is via jointed appendages (limbs). Some have wings to fly and some aquatic ones have the appendages modified to can aid in swimming.



3. Endoskeleton in Vertebrates

- ❖ Vertebrates have internal skeletons (endoskeleton).
- ❖ Hard skeletons of bone and cartilage are inside the body.
- ❖ The endoskeleton provides support, places for muscle attachment and protects the internal organs.
- ❖ All vertebrates share similar bone structure - a skull, a rib cage and a vertebral column.
- ❖ The vertebrate animals are:
 - Fish
 - Amphibians (frogs)
 - Reptiles (snakes, lizards, iguanas and crocodiles)
 - Aves (Birds)
 - Mammals

Advantages of Endoskeleton	Disadvantages of Endoskeleton
➤ Light yet strong and flexible to allow quick escape from predators or to catch prey. ➤ Lighter than the exoskeleton ➤ Can grow as the organism grows (no need to moult)	➤ Endoskeleton cannot be moulted therefore any fatal damage to it is almost permanent.

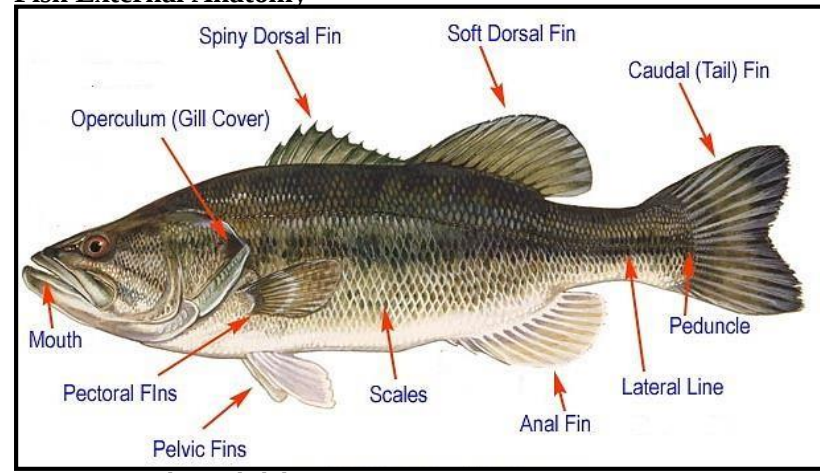
1. Fish

- ❖ All fish are aquatic therefore they do not need adaptive structures which prevent dehydration.

Protection

- ❖ Scales- first line of defence just like our skin.
- ❖ Some have poisons, sharp teeth, camouflaging ability, electric, stings and spines.
- ❖ Operculum (bony gill cover) to protect the tender gills.

Fish External Anatomy



Source: www.kentuckylake.com

Support

- ❖ Buoyancy (upthrust of water) reduces the pull of the gravity experienced by fish.
- ❖ Fish do not need a skeleton as strong as those of terrestrial vertebrates. Sharks have skeleton composed of cartilage which is light-weight.

Movement

- ❖ Fish skeletons are very well adapted for swimming.
- ❖ Most fish propel themselves forward by swishing their caudal fin back and forth. Their dorsal, caudal and fins help keep the fish from rolling. The pectoral, pelvic, and caudal fins steer.
- ❖ Most fish are shape for speed. Their narrow, pointed bodies reduce friction with water.

2. Amphibians and Reptiles

- ❖ Amphibians (frogs) live a part of their life in water and part of it on land. While on land, they need adaptive structures that provide support against the strong pull of the gravity.
- ❖ Likewise there are reptiles capable of both living in water and on land e.g. Crocodiles, turtles and some snakes.

Protection

- ❖ Adult amphibians have no protective covering over their skin because they breathe partly through their skin.
- ❖ This makes them vulnerable to both dehydration and predators.
- ❖ In order to prevent dehydration, amphibians avoid sunlight and live in moist habitats. For example frogs, they mostly come out at night and during the day when it's raining.
- ❖ For protection against predators, amphibians have the ability to camouflage-blend in with the environment. Some amphibians also change the colour of their skin to match the colour of their current environment.
- ❖ Furthermore, some have poison glands. Frogs secrete white toxins near the head region to
- ❖ signal the predators to stay away

Camouflaged Frog



Source: www.dreamstime.com

Frog Changing Skin Colour



Source: www.livescience.com

Fiji Tree Frog



Source: www.fijiguide.com

- ❖ Reptiles have scaly skin which is thick enough to protect them from dehydration and predators.
- ❖ Reptiles have very good camouflaging ability and some can also change skin colour.
- ❖ Other defence mechanisms include:
 - spitting venoms (cobra snakes)



- poisonous bites (some snakes and lizards)
- hissing sounds (snakes)
- sharp teeth (crocodiles and alligators)
- autotomy - lose the tail which will later grow back (lizards)

Support and Movement

- ❖ Tadpoles can swim but when they develop into adult frogs and come to live on land, they use their hind legs to jump or hop.
- ❖ Other amphibians like toads (bigger version of frogs), salamanders and newts can walk; legless caecilians slither like a snake.
- ❖ Land reptiles crawl on their limbs- crocodiles, iguanas and lizards.
- ❖ Aquatic reptiles can swim; turtles have flippers to swim.
- ❖ Legless land reptiles such as snakes slither on the ground.
- ❖ Amphibians and reptiles with limbs support their weight on it. These limbs project to their sides.
- ❖ Such a body design is not very efficient because the weight of the body disables them from standing up or moving quickly. Try standing with your legs bent and out to the sides, like a reptile. Feel how much more muscle exertion this weight distribution requires?

Common Reptiles Found in Fiji

Black and white snake
(Local Name: dadakulaci)



Source: en.wikipedia.org

Pacific Boa (Local Name: Bolo)



Source: www.snipview.com

Crested Iguana (Local Name: Vokai, Vokaivotovoto, Saumure)



Source: www.flickr.com

Green Turtle
(Local Names: Vonudina, Ika du)



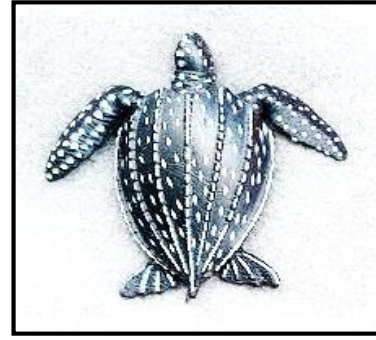
Source: en.wikipedia.org

Hawksbill Turtle (Local Names: Taku)



Source: www.marinebio.net

Leatherback Turtle (Local Names: Taba-i-walu, Tutuwalu, Vonudakulaca)



Source: www.manataka.org

Fijian Copper-headed Skink
(skink = small lizard)



Source: www.ryanphotographic.com

Onoilau skink



Source: www.iucnredlist.org

Rotuman Forest Gecko



Source: www.ryanphotographic.com

3. Aves (Birds)

Protection

- ❖ The main protection in birds is the ability to fly away from danger.
- ❖ It is an effective means of escape but consumes a lot of energy.
- ❖ Many birds also have 'call-out warnings' - special sounds to warn their peers of the danger around. Feathers help protect their skin from dehydration and to keep the body warm.

Support and Movement

- ❖ Birds have wings to fly and hind legs on which it can stand, walk and hop.
- ❖ Adaptations for flight are:
 - Light-weight skeleton
 - Some bones are hollow
 - No teeth
 - Keel- extension on the breastbone to which wings attach.
 - Feathers extend the wing surface area for pushing against the air in flight without adding much weight. These feather extensions are also crucial for adjusting speed and direction while in the air.
 - Stream-lined body structure
 - Some birds keep their reproductive organ tiny and only enlarge it during breeding season.

Did You Know?

There are birds that don't fly such as Penguins, Kiwi birds and Ostriches. These birds protect themselves with sharp claws on the legs or sharp beaks or by running fast (ostriches can run at a speed of 45 miles/hr)

4. Mammals

Protection

- ❖ Have fur/ hair to retain body heat, reduce water evaporation from the skin and protect the skin.
- ❖ Most mammals' fur is coloured to camouflage with the habitat.
- ❖ Others defend themselves with teeth, horns and/or claws.



- ❖ Mimicry is another defence method in which the least dangerous species copies the features of the species that is dangerous to the predator.
- ❖ A few species of mammals have spines or hardened skin.
- ❖ Skunks can spray a burning chemical that stinks horribly.



Source: www.faithfirm.com

Support and Movement

- ❖ Mammals are among the fastest animals.
- ❖ Strong endoskeletons support their weight.
- ❖ Legs are not protruding sideways as in the case of amphibians and reptiles and therefore can run or walk very fast.
- ❖ Well-developed muscles power the movement.
- ❖ Aquatic mammals (whales and dolphins) move by swimming.
- ❖ There are also some mammals which fly such as bats and flying squirrels.

SUMMARY TABLE FOR MOVEMENT, SUPPORT AND PROTECTION IN ANIMALS

	Invertebrates			Vertebrates			
	Cnidarian	Arthropod	Annelid	Fish	Amphibian and Reptiles	Aves	Mammals
Example	Jelly Fish and Hydra corals	Insects, crustaceans	Earthworms	Sharks and Bony Fish	Frog and Snakes	Birds	Bears, dogs, humans, cats
Movement	Swim (muscle contractions)	- Jointed appendages to walk, hop or swim - Wings (insects)	Peristaltic motion created by the contraction of circular and longitudinal muscles with aid from hydrostatic skeleton.	Swim	- Jumping on hind leg (frogs) - Slithering - Crawling	- Flying - Hopping - Walking	- Flying - Hopping - Walking - Swimming - Running
Support	- Buoyancy - Hydrostatic skeleton	Exoskeleton made of chitin	- Hydrostatic skeleton - Bristles to grip the soil when moving	- Buoyancy and Endoskeleton - Streamlined body to swim	Endoskeleton	- Endoskeleton - No teeth - Keel - Hollow bones	- Endoskeleton - Walking limbs not protruding sideways
Protection	Nematocyst(stinging cells)	- Exoskeleton to prevent dehydration - Fierce mouth parts with poisonous stings, venoms, or claws - Fly away	Live under the soil in moist areas to prevent dehydration	- Scales - Sharp teeth - Electric - Stings - Operculum protects the gills	- Live in moist areas (frogs) - Scaly skin to prevent dehydration (reptiles) - poisonous bites - hissing sounds - sharp teeth - autotomy (lizards) - camouflage	- fly away - claws - run fast - call-out signals	- run - walk fast - poisons - sharp claws, teeth or horns - fly away - stinky spray - camouflage - mimicry



SELF TEST

1. How are the support needs of aquatic organism different from those of terrestrial organisms? What are the reasons for these differences?
2. Why do plants have limited movement abilities in comparison to active animals?
3. Plants produce more food than they consume. What may have selected for this over-production?
4. Compare and contrast the support systems of herbaceous and woody plants. Explain the adaptive value of their differences.
5. What disadvantages might climbing plants face because they depend upon other structures for support?
6. How do epiphytes support themselves?
7. Explain turgidity and flaccidity of a cell with reference to osmotic movement of water.
8. Compare and contrast between hydrostatic skeleton, exoskeleton and an endoskeleton. For each type of skeleton, identify an organism which possesses it and the adaptive value of that skeleton to that particular organism.
9. Compare adaptations for protection, support and movement in an earthworm, a cockroach and a rat.
10. Identify problems that humans would face if it had a: (1) hydrostatic skeleton and (2) exoskeleton?
11. Compare methods of protection, support and movement in a fish and a mammal.
12. While most turtle species in the world are terrestrial, sea turtles are more common in Fiji. Sea turtles return to land only to lay eggs. How are sea turtles adapted for movement in their aquatic environment?
13. Describe adaptations of birds which aid in successful flight.

BI 12.1.4.6 SENSITIVITY AND COORDINATION

Organisms (plants and animals) need sensory and coordination abilities to find resources, avoid danger, and to time their reproduction with favorable seasons. The accuracy and speed of an organism's sensory and coordination abilities match the organism's mobility. Sessile organisms, such as hawks, have complex sensory systems and rapid, accurate motor capability.

Organism senses the stimuli that are important to their way of life. For example, plants and photosynthetic protists can sense sunlight direction. Grasshoppers have ears in its abdomen to quicken its reflex to jump and hawks have a vision like a telescope which can locate small preys on the ground far below.

Endocrine vs. Nervous System

- ❖ In most organisms, both the endocrine (glands and hormones) and the nervous system help coordinate body response to stimuli.
- ❖ Stimulus/ stimuli are things that cause a response in organism. For example, the smell of food can be a stimulus to more saliva production in your mouth.
- ❖ The endocrine system uses chemical messenger called hormones to coordinate slow and extended responses such as growth and metabolic rate.
- ❖ On the other hand, the nervous system communicates by rapid electrical impulses for immediate sensory and coordination needs as a vision and movement.

Endocrine System	Nervous system
➤ Consists of glands and hormones ➤ Slow ➤ Long term response ➤ Chemical messenger	➤ Consists of neurons, nerve cells and fibres ➤ Immediate and quick ➤ Short-term response

PLANTS: SENSITIVITY AND COORDINATION

Plant Hormones

- ❖ Plants coordinate responses to stimuli using chemical messengers called **hormones**.
- ❖ Plants produce variety of hormones that diffuse through the plant to coordinate tropisms.
- ❖ Apart from controlling tropisms, hormones also coordinate growth and reproduction in plants.
- ❖ Flowering, fruiting-ripening and falling of leaves in seasonal plants (eg. frangipani) is also controlled by hormones.
- ❖ Plant hormones coordinate their growth and reproductive responses to their environment. If hormones were not there to do this, the roots would be growing randomly with some of it growing up towards the sky; some branches would be flowering and fruiting while others would be dropping leaves.
- ❖ Also, if angiosperms of the same species flowered at different times of the year, their chances of pollination would fall steeply.

- ❖ In Plants hormone may:
 - Induce different responses in different tissues.
 - Induce different responses at different times of development in the same tissue
 - Directly affect the activity or production of other hormones.
 - Induce different responses depending on concentration in a given tissue.
- ❖ The sensitivity of a plant tissue to a given hormone may be altered either by:
 - Changing hormone concentration in the target tissue.
 - Altering receptor sensitivity to that hormone in the target tissue.

Hormones	Role
Auxin	➤ Responsible for cell division and growth in cell size. ➤ Involved in differentiation of vascular tissue ➤ Control cellular elongation ➤ Prevention of abscission ➤ Involved in apical dominance and various tropisms ➤ Stimulate the release of ethylene to enhance fruit development. ➤ Example: IAA (indole acetic acid), IBA (indole-3-butyric acid)
Cytokinins	➤ Promotes cell division in plant roots and shoots, and promote the growth of buds. ➤ Cytokinins increase cell division by stimulating the production of proteins needed for mitosis. ➤ Every time the process of mitosis occurs, a new cell is formed to move to the end of the plant, and this makes it longer or taller. ➤ Affect cell division, delay senescence and activate dormant buds. ➤ Example: Zeatin
Ethylene	➤ Responsible for senescence (aging) processes. ➤ Promotes the ripening of the fruit. ➤ Ethylene also affects many other plant functions such as: - abscission of leaves, fruits, and flower petals; - drooping of leaves; - sprouting of potato buds; - seed germination; - stem elongation in rice - flower formation in some species.
Abscisic acid (ABA)	➤ Maintains dormancy in seeds and buds ➤ stimulates the closing of stomata
Gibberellins (GAs)	➤ Responsible for cell division and growth in cell size. ➤ Initiate mobilization of storage materials in seeds during germination ➤ Causes elongation of stems ➤ Stimulate pollen tube growth

Did You Know?

Plants can communicate.

Plant neurobiology is an emerging field of plant sciences where the researchers are trying to understand the complexity involved in plant communication.

Previously, 'talking tree' research was regarded stupid but in 1983 two researches revealed that willow trees, poplars and sugar maples can warn each other of the insect infestation. The infested trees release chemicals which the neighbouring plants can sense and start preparing its defence mechanisms.

There is an interesting English movie based on plant communication.

Movie: The Happening

Do watch if you get your hands on a copy.

ANIMALS: SENSITIVITY AND COORDINATION

1. Animal sense stimuli and coordinate responses with three types of structures:

(1) Receptors; (2) communication system and (3) effectors.

(1) Receptors

- Responsible for sensing stimuli.
- Organisms have receptors for environmental information useful to their survival.
- ❖ For example, humans have a high concentration of touch receptors on the fingertips.
- ❖ Photosynthetic protists-*euglena* have "eyespot" to sense light.
- ❖ Python snakes can perceive temperature by sight to find prey and all the snakes are highly sensitive to vibrations. Snakes can sense very faint vibrations in both the air and the ground using their inner ear.
- ❖ Sharks have sensory receptors (ampullae of Lorenzini) which detect electric fields created in the waters by other swimming creatures.

(2) Communication system

- Carries message between receptors and effectors.
- Simple and sessile organisms have very basic communication system.
- ❖ For example, hydra has only a nerve net with no processing centre. A vertebrate, by comparison has an extensive neural network with a brain and a spinal cord centre. Most animal use both neural impulses and hormones for communication within the body.

(3) Effectors

- ❖ Are muscles and glands that act out responses.
- ❖ Fast animals require complex nervous systems to keep up with their sensory and coordination needs.
- ❖ Selection pressure for increased speed has led to several major neural developments along the evolutionary trend.
- ❖ These include accurate sensory structures, complex motor ability and the evolution of brains.

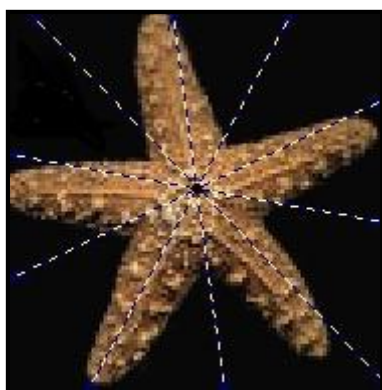
Body Symmetry

1. Asymmetrical Animals

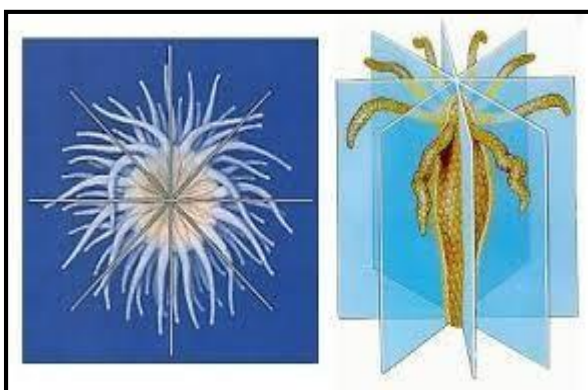
- ❖ No body symmetry.
- ❖ For example, Sponges.

2. Radially Symmetrical Animals

- ❖ Animal can be divided into similar halves by passing a plane through the central axis.
- ❖ These animals have the ability to sense from all directions.
- ❖ Such animals are mostly sessile (do not move) or sedentary (move very slowly) and therefore do not need very complex nervous system.
- ❖ They mostly possess a simple nerve network with no centralized sensing or processing.
- ❖ Example: Cnidarians (jelly fish and hydra) and Echinoderms (star fish, sea urchin etc) as adults.



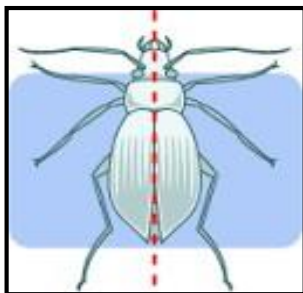
Source: jwilson.coe.uga.edu



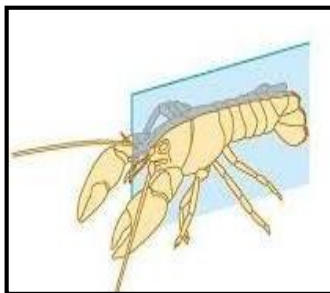
Source: www.pixgood.com

3. Bilaterally Symmetrical Animals

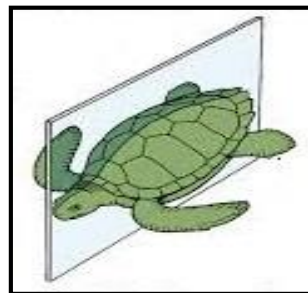
- ❖ Animal can be divided into two (bi= two) matching halves by passing a plane through the central axis.
- ❖ Have left and right sides.
- ❖ The head end is the first to come in contact with food or danger so natural selection favored sensory ability centralized in the head.
- ❖ In turn, this favored the development of nerve centers to process the sensory input.
- ❖ Nerve centralization allowed evolution of increasingly complex animal nervous systems.
- ❖ Example: flatworms, annelids, arthropods, molluscs, vertebrates.



Source: gallery4share.com



Source: www.studyblue.com

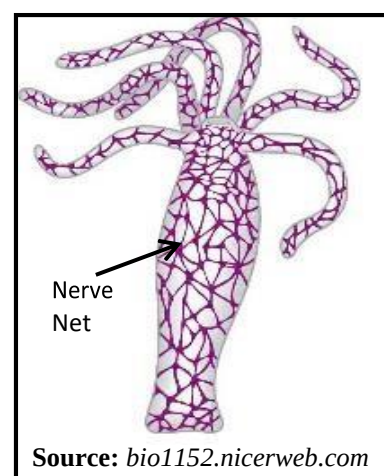


Source: www.mhhe.com

Sensitivity and Coordination in Invertebrates

1. Cnidarians

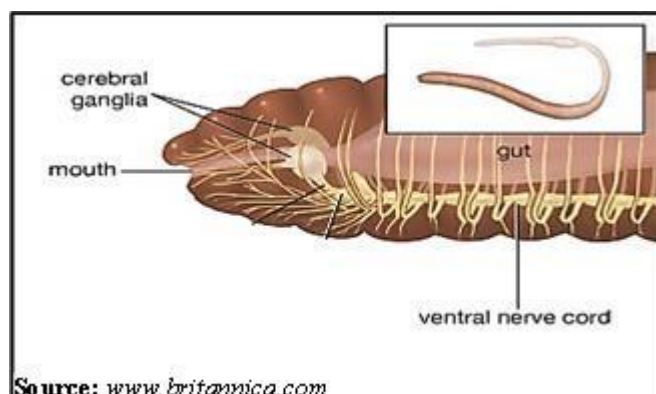
- ❖ Simplest nervous system known as **nerve net**.
- ❖ Cnidarians have simple life which involves stinging of prey and stuffing them into their mouths.
- ❖ They have touch receptors in their skin.
- ❖ When anything stimulates these receptors, a reflex action begins.
- ❖ Reflex action refers to quick responses which do not involve brain.
- ❖ The stimulated sensory receptors signal poison cells to sting the potential prey and tell the tentacle muscles to pull the prey into the mouth.



Source: bio1152.nicerweb.com

2. Annelids

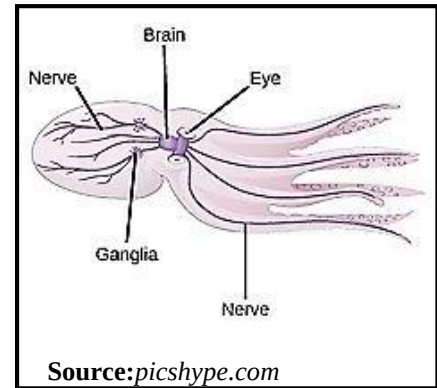
- ❖ Simple bilateral organisms which have a back and a front region.
- ❖ Complex sensory and coordination abilities in comparison to cnidarians.
- ❖ Neurons concentrated into clusters called **ganglia**.
- ❖ Ganglia are connected to each other in chain-like fashion by two nerve cords.
- ❖ Nerve cord is a bundle of neurons that run the length of the organism.
- ❖ Ganglia in the anterior end (cerebral ganglia) functions like a 'mini' brain.
- ❖ This brain processes stimuli and, with the nerve cord, coordinates movements.
- ❖ Sensory abilities limited to light intensity, touch and chemical sensitivity.
- ❖ Earthworms avoid light to prevent dehydration- they need their skin to be moist in order to breath. The touch and chemical sensitivity allows it to search for food and avoid dangers.



Source: www.britannica.com

3. Molluscs

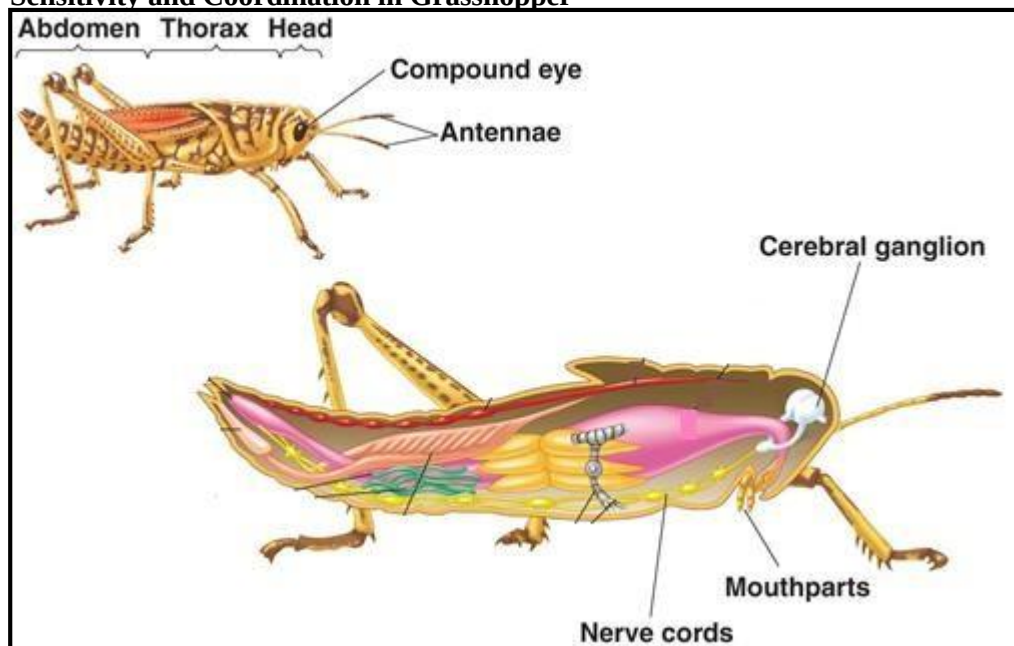
- ❖ Different classes within this phylum greatly differ in terms of the development of their nervous systems.
- ❖ Bivalves (*kai*) and snails are slow-moving – they have a simple nerve network controlled by a brain-like neuron concentration.
- ❖ Squid and octopus are very fast swimmers- they have well developed eyesight and a large and complex brain that allows them to respond very quickly to food and to danger.



4. Arthropods

- ❖ Of all invertebrates, arthropods have the most developed nervous systems.
- ❖ All have a dorsal brain and a ventral nerve cord with ganglia from which lateral nerves extend in each segment.
- ❖ These miniature brains + nerve cord often exert as much control over coordination as the real brain in the head.
- ❖ In arthropods, class Insecta (insects) have the most developed sensory and coordination abilities especially those that can fly.
- ❖ Insects and some other arthropods have compound eyes which help them detect quick movements.
- ❖ The location of other receptors varies with the insect's lifestyle.
- ❖ Most insects have antennae, which often house receptors for sound, smell, taste and touch. Flies have taste receptors on their feet, so they know upon landing if they have found a tasty meal. Grasshoppers have ears in their abdomen section. At the first sound of danger, such as the rustle of an approaching chicken, a jumping reflex begins.

Sensitivity and Coordination in Grasshopper



Sensitivity and Coordination in Vertebrates

- ❖ Vertebrates have the most elaborate nervous system in the animal kingdom.
- ❖ The complex abilities of their nervous systems rest on the three major developments:
 - (1) Well-developed **sense organs**,
 - (2) complex **motor structures** and
 - (3) Centralized **processing and control center**.

(1) Sensing

- ❖ Well-developed sense organs allow vertebrates to take in large amounts of detailed information about their environments.
- ❖ Fast moving animals need powerful sensory organs not only to avoid running into things, but also to find enough food to support their high energy demands.
- ❖ Sense organs that are the most developed, depends on the animal's lifestyle.
- ❖ For example, Birds have sharp eyesight to avoid flying into things. Mongooses have an excellent sense of smell in order to track their prey. Bats discern the precise location of tiny insects by bouncing sounds against them.

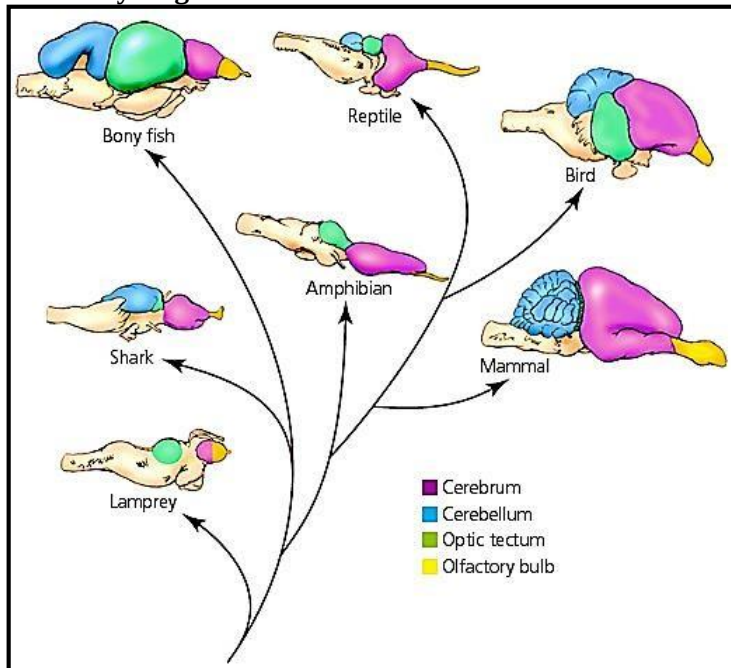
(2) Effect Output

- ❖ The vertebrate's nervous system coordinates dozens of different muscles to make smooth, rapid movements.
- ❖ Simultaneously, the brain directs the heart, diaphragm, stomach walls and other involuntary muscles.
- ❖ The extensive, finely tuned muscular system of a vertebrate works precisely as directed by the brain and spinal cord.
- ❖ At the same time, hormones from the endocrine system manage metabolic rate, emotions, growth and other gradual processes requiring coordination.
- ❖ The brain tells the gland how much of which hormones to produce and in return hormones influence the brain's directions to some extent.

(3) Processing

- ❖ Vertebrates have **central nervous system (CNS)** consisting of a brain and spinal cord.
- ❖ It provides vertebrates with more intelligence and more complex sensory and motor abilities than any other animal group.
- ❖ **Thinking** is done by the cerebrum. The rest of the vertebrate brain is devoted to reflex action such as heart beat, breathing and muscles coordination.
- ❖ The most ancient vertebrates, the fish and amphibians, have tiny cerebrums. Reflexes coordinate nearly all of their actions.
- ❖ The most recently evolved class, the mammals, proportionately has the largest cerebrum.
- ❖ A large cerebrum means greater intelligence. Some birds, reptiles and mammals are capable of complex processes such as memory, learning and even emotion.
- ❖ The 'highest' mammals, such as chimpanzees, humans and dolphins, can think and reason. The cerebrum cover, called the cerebral cortex, has evolved into a complex information processing centre in mammals.
- ❖ The highly developed human cerebral cortex has allowed us to develop the tools and language upon which we have built our entire civilization.

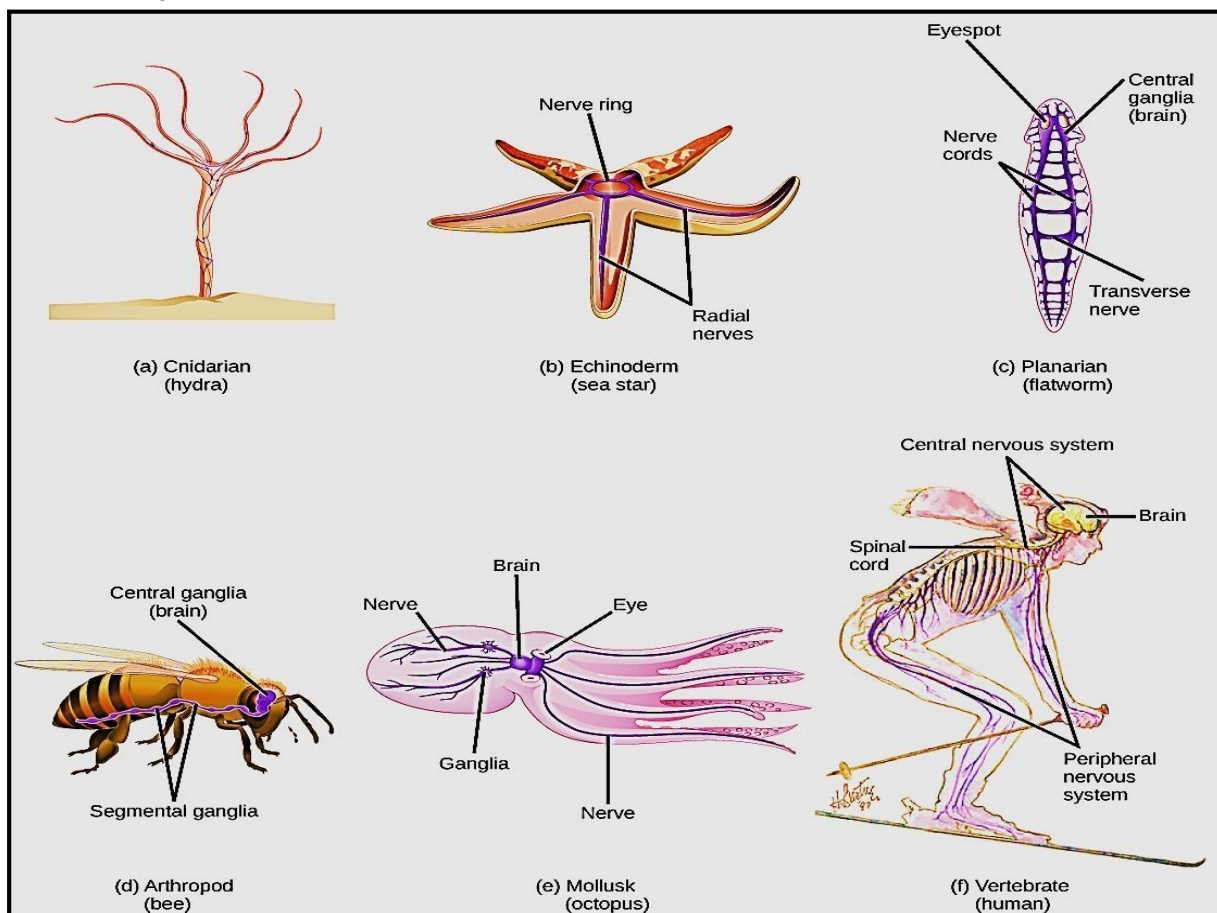
Excretory Organ of Insects



Source: www.thehumanbrain1.blogspot.com

The diagram shows the evolutionary trend observed for the size of the vertebrate brain. The higher animals with more efficient body had a bigger cerebrum. For example: the mammals.

Evolutionary Trend



Source: www.cnx.org

**SELF TEST**

1. Identify the difference between a reflex action and an 'intelligent' action.
2. Describe the trend in evolution of nervous system using the following animals:
(i) cats; (ii) ants; (iii) earthworms; (iv) jellyfish; (v) lizards; (vi) frog and (vii) birds
3. Explain the difficulties that jellyfish would face with bilateral symmetry. How has it overcome that difficulty?
4. Identify some sensory organs of flies (insects).
5. What are some of the differences between the nervous system and the endocrine system?
6. Identify whether the following action is complete by the nervous system or the endocrine system:
 - a. Quickly moving away the fingers after touching a hot pot.
 - b. Growing in height from birth till the end of puberty.
 - c. Release of adrenalin in a dangerous yet exciting situation.
 - d. Scratching your itching head.
 - e. Blinking eyes.
 - f. Feeling sad after being scolded by your teacher.
7. Explain why the sensitivity and coordination ability of parrots will differ from that of an earthworm.
8. Identify the sensory organ/structure that has enabled the following organisms to be well adapted to their environment:
 - a. *Euglena* species (protist)
 - b. Sharks
 - c. Snakes
 - d. Grasshoppers
 - e. Birds
9. Snails and octopus both belong to the phylum Mollusca. Reflecting on the lifestyle of each, explain the difference in their sensitivity and coordination.

BI 12.1.4.7 REPRODUCTION

Survivability and Continuity

Any organism well equipped with the best adapted nutrition, transport, excretion and other body systems is still not regarded successful if it cannot reproduce and pass on its genes.

Organisms have been designed for **survival** and **reproduction**.

All of the body systems (nervous, digestive, endocrine etc.) help the organisms survive. However, for their species to survive, the organisms must reproduce.

Nature selects against organisms poorly designed for survival and reproduction. These organisms have fewer off springs and their genes eventually disappear from the population in successive generations.

On other hand, nature selects for the survival of fittest. These organisms survive well in their environment and also reproduce successfully thus passing their genes over generations.

Evolutionary Trends in Reproductive Strategies

Plant and animals species have developed many strategies for reproduction, all of which attempts to insure survival of the species.

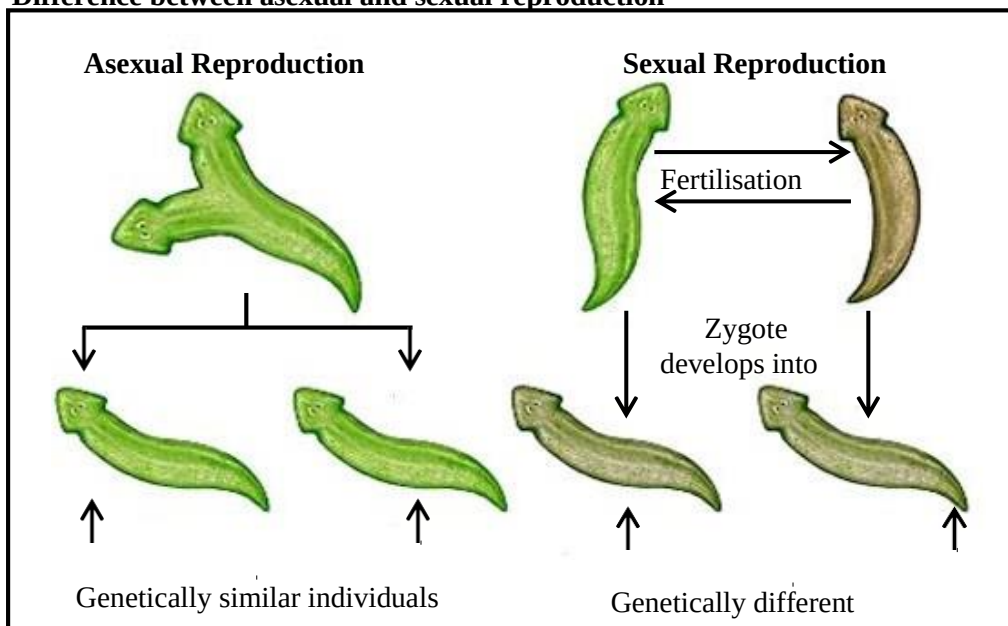
The earlier evolved plants produced many spores or seeds to ensure its dispersal and survival. However, as the higher plants evolved, lesser seeds were produced, several dispersal mechanisms were involved and were enclosed in fruits (angiosperms).

Likewise, the earliest animals produced many eggs thus many offspring but did not provide parental care. Later as the higher animals evolved, lesser offspring were produced but more parental care was provided.

1. Asexual and Sexual Reproduction

- ❖ Some organisms are capable of reproducing asexually.
- ❖ Asexual reproduction involves cell division of a single parent by mitosis to produce genetically offspring.
- ❖ Asexual reproduction produces little genetic variation and therefore asexually produced populations are unlikely to survive severe environmental changes.
- ❖ Asexual reproduction is favoured in stable environments.
- ❖ Changing conditions favour sexual reproduction, where two haploid gametes produced by meiosis come together to produce a unique individual.
- ❖ Sexual reproduction produces genetically varying offspring, at least some of which are likely to have adaptations to survive environmental changes.
- ❖ Evolution shows a slow trend towards sexual reproduction.

Difference between asexual and sexual reproduction



Source: www.slideshare.com

2. Haploid and Diploid Stages

- ❖ When sexual reproduction first evolved, the diploid life stages of organisms were very small. It lasted just long enough to produce new haploid offspring.
- ❖ Mosses and sexually reproducing algae spend most of their lives as haploid organisms.
- ❖ However, as evolution proceeded, diploid life stage in organisms became more prominent. Organisms had longer diploid life stages. Ferns, seed plants and animals spent almost their entire lives in a diploid stage.
- ❖ For example, we humans, one of the highest evolved animals spend our entire life as diploid organism and the only stage that is haploid in our life is our gametes (eggs and sperms) which also unite during fertilization to restore diploidy.

3. Reproduction on Land vs. Water

- ❖ Life began in the sea.
- ❖ Eventually, when the oceans became crowded with competing organisms, natural selection began to favour organisms that could adapt to a land environment.
- ❖ However, terrestrial life required new adaptations for reproductions.
- ❖ On dry land, sperm cannot swim to eggs and embryos need protections from dehydrations.
- ❖ Adaptations for reproductions on dry land evolved as terrestrial organisms evolved.
- ❖ For example, bryophytes (moss) the first land plants still required water for fertilization to occur and therefore, they were very small in size, were low lying and were restricted to moist habitats. As plants evolved, the gymnosperms started producing seeds (cones) which was the reproductive structure and did not require water for fertilization to occur. In the highest evolved plant, that is, the angiosperm, the reproductive structures were enclosed within the flower. There was no need for water for fertilization to occur and the developing embryo was well nourished by the endosperm.

4. Parental Investment in Offspring

- ❖ The more offspring an organism has the less energy it can invest in each.
- ❖ For example, angiosperms could produce many seeds with tiny endosperms or fewer seeds with larger endosperms. Seedlings with tiny endosperms have a low survival rate because they must quickly start producing food for themselves; Seedlings fed by large endosperms have more time to establish roots and leaves before they must support themselves.
- ❖ Generally, the more offspring an organism has, the lower the chances are for the offspring's survival.
- ❖ Natural selections favour organisms that produce the highest number of surviving offspring.
- ❖ Thus, parents must find a balance between having more offspring with less investment for each offspring or have fewer offspring with a greater investment in each.
- ❖ Evolution shows a trend towards lesser offspring and more parental care.
- ❖ The most recently evolved groups of organisms, the mammals and birds, invest more energy in each offspring. They have very few offspring compared to other animals, but their offspring have a high survival rate.



Source: www.countryfile.com



Source: www.imgbuddy.com

PLANTS: EVOLUTIONARY TRENDS IN REPRODUCTION



Source: www.arctic.uoquelp.ca

In plant evolution, **three** trends observed are:

1. Sexual reproduction rather than asexual.
2. Diploid stages of life dominant rather than haploid.
3. Adaptations for terrestrial reproduction such as non-swimming sperm and protected embryos.

Sporophyte = diploid (2n); Example: leaves, roots, stems

Gametophyte = haploid (n); Example: ovules, eggs, sperms and pollen

N = # of chromosomes

1. ALGAE

- ❖ Various reproductive methods.
- ❖ Most reproduce asexually by divide in half via mitosis to produce new algae plants.
- ❖ Some capable of both asexual and sexual.
- ❖ Such algae spend the greater part of their lives in a haploid stage as gametophytes.
- ❖ Examples: Sea grapes (Local Name: Nama); Eucheuma (Local Name: Lumi); Nori (Used in Making Sushi)

Eucheuma (Lumi)



Source: www.bulasamantha.wordpress.com

Sea-grapes (Nama)



Source: www.haisansachphanthiet.com

Nori



Source: www.brokeassgourmet.com & www.imagebasket.net

2. BRYOPHYTES (Greek: bryo= moss; phyta= algae)

- ❖ First terrestrial plants.
- ❖ Lack true roots, stem and leaves.
- ❖ No vascular tissues (xylem and phloem).
- ❖ Male gametophyte known as **antheridia** produces male gametes (sperms) and female gametophyte known as **archegonia** produces female gametes (eggs).
- ❖ Male gametes require water to swim to female gametes.
- ❖ Due to lack of vascular bundles and the requirement of water to complete reproduction, bryophytes are low-lying (small) plants and restricted to moist habitats.
- ❖ The **dominant** stage in a bryophyte is the **gametophyte**, that is, most of its life is spent in haploid stage.
- ❖ Examples: Mosses, Liverworts and Hornworts

Moss



Liverwort



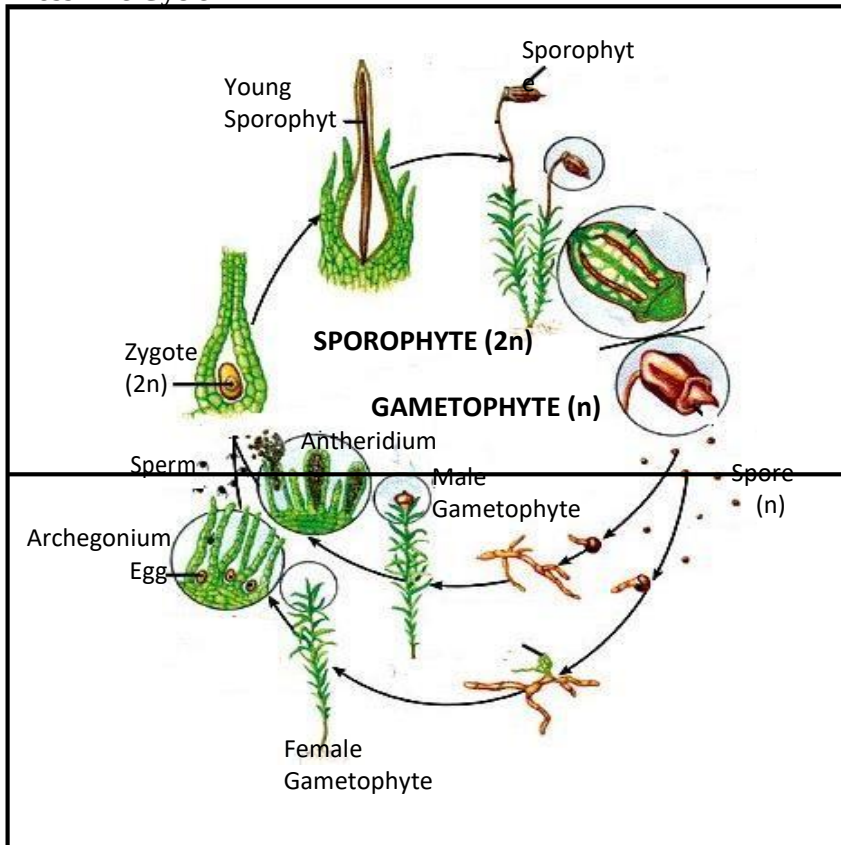
Source: www.saburchill.com

Hornwort



Source: www.ucmp.berkeley.edu

Moss Life Cycle



Source: www.molecularrecologist.com

STEPS:

1. The haploid reproductive cells divide by mitosis to produce gametes.
2. Male gametes swim to female gametes.
3. Fertilisation forms a diploid zygote which grows into a sporophyte. The sporophyte lives on the leafy gametophyte.
4. Cells inside the sporophytes divide by meiosis to produce haploid spores.
5. Wind scatters the spores, which will grow into new haploid moss plants.

SPORE vs. SEEDS

	SPORE	SEEDS
SIZE	▪ Small	▪ Large
PLOIDY	▪ Haploid (n)	▪ Diploid (2n)
STORED FOOD	▪ Less	▪ More
PROTECTION	▪ Not much protected from dehydration	▪ Well protected from dehydration (seed coat)
DISPERSAL	▪ Mostly wind	▪ Wind, water, animals
COMPLEXITY	▪ Unicellular (one cell)	▪ Multicellular (many cells)

3. FERNS

- ❖ First vascular plants- have xylem tissue for water transport and phloem for food transport.
- ❖ Seedless, reproduction using spores.
- ❖ Lack true roots, stem and leaves.
- ❖ Presence of vascular tissue enables it to grow taller than the bryophytes.
- ❖ Male gametophyte- **antheridia**; Female gametophyte- **archegonia**.
- ❖ Water/moisture still required for the male gametes to swim to the female gametes; therefore ferns grow in shady areas.
- ❖ Dominant stage is the sporophyte, that is, most of the life spent in diploid state.

- ❖ Examples: *Athyrium esculentum* (Local Name: Ota); Black Tree Fern (Local Name: Balabala); Equisetum; Lycopodium; Pyrrosia; Selaginella

Ota Fern



Source:
www.bulaislandfood.com

Black Tree Fern (balabala)



Source:
<http://collections.tepapa.govt.nz>

Lycopodium



Source:
www.typicalgardener.wordpress.com

Equisetum



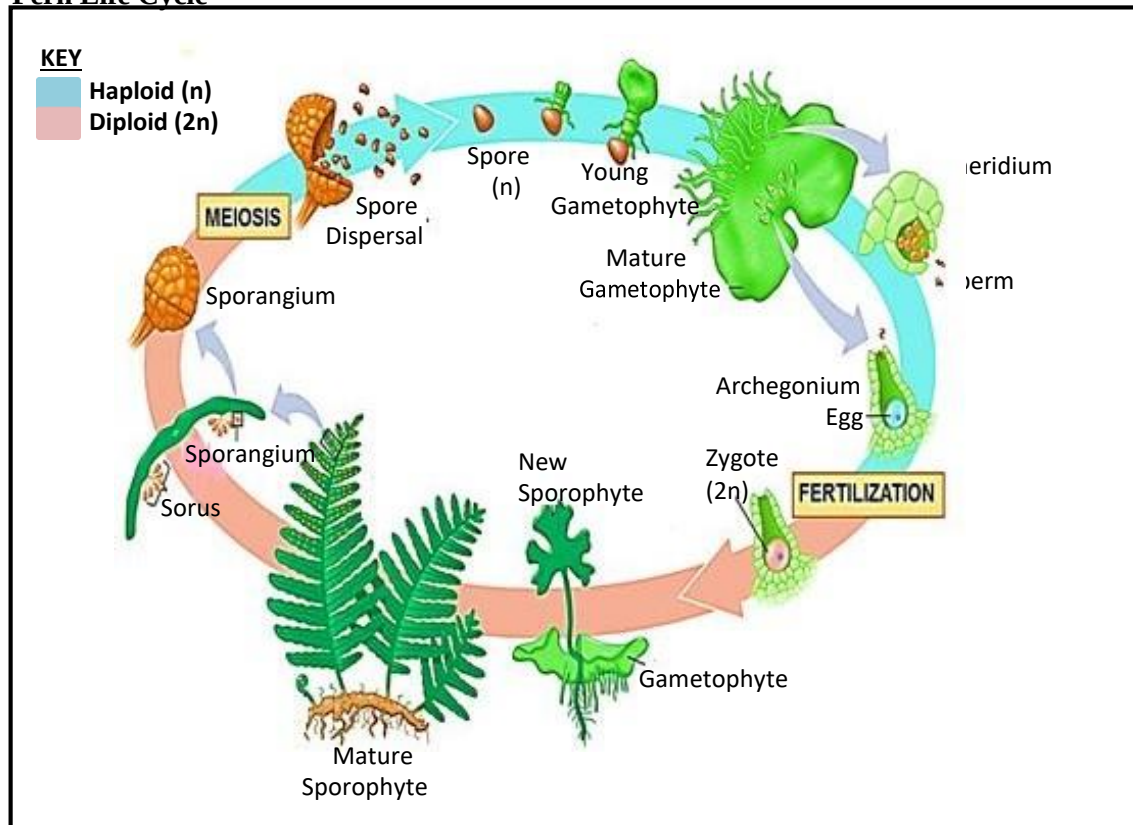
Source: www.gobotany.newenglandwild.org

Selaginella



Source: www.cloudjungle.com

Fern Life Cycle



Source: www.studyblue.com

STEPS:

1. Ferns produce haploid spores by meiosis.
2. Wind scatters the spores.
3. Under the right conditions, a spore divides mitotically to form a tiny, heart-shaped gametophyte.
4. The gametophytes produce eggs and sperms.
5. Fertilisation produces a diploid zygote that grows into an adult sporophyte fern, beginning the cycle again.

SEED PLANTS

- ❖ Seed plants evolved with a solution for terrestrial reproduction.
- ❖ Seed plants do not require water for the sperm/pollen/male gametes to travel to the egg/ovule/female gametes.
- ❖ Seed plants spend their entire life in a sporophyte stage.
- ❖ The only gametophyte stage is the sperm and eggs which are haploid.
- ❖ The two major groups of seed plants are: **Gymnosperms** and **Angiosperms**.
- ❖ Gymnosperms and Angiosperms have slightly different methods of reproduction and seed dispersal.

4. GYMNOSPERMS (Latin: Gymno= naked; Sperms= Seeds)

- ❖ First seed plants.
- ❖ Have vascular tissues (xylem and phloem).
- ❖ As the name suggests, these plants produce ‘naked seeds’ – seeds not enclosed in a fruit.
- ❖ Seeds produced on cones and lay open on the scales of female cone.
- ❖ Small male cones produce many haploid pollen grains.
- ❖ Dispersal of pollen is via wind.
- ❖ When pollens reach the ovules at the tips of the scales of female cones, fertilization occurs.
- ❖ Fertilisation forms diploid seeds.
- ❖ Seed coats protect the embryos.
- ❖ Tissues of the female gametophyte nourish them.
- ❖ When seed falls onto warm, moist ground, it grows into a diploid (sporophyte) adult.
- ❖ The sporophyte, when mature, makes gametophyte producing cones and repeats the cycle.
- ❖ Examples: Conifers (Pines, Christmas trees); Cycads (Sago palms: Local Name: Sago, Sogo, Seko); Ginkgo

Pines



Pine Cones



Cycads



Source: www.riosevergreens.com

Source: www.arkive.org

Cycad (Sago Palm)



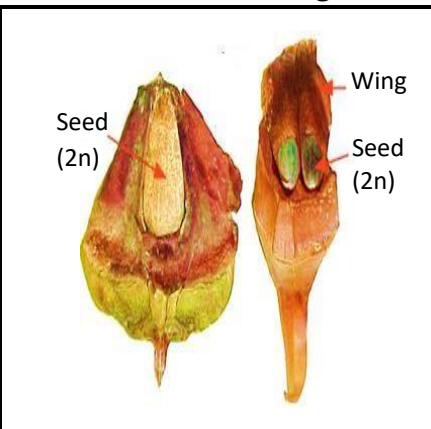
Source: www.htbg.com

Ginkgo



Source: www.bhort.bh.cornell.edu

Section of Cones showing Seeds



Source: www.waynesword.palomar.edu

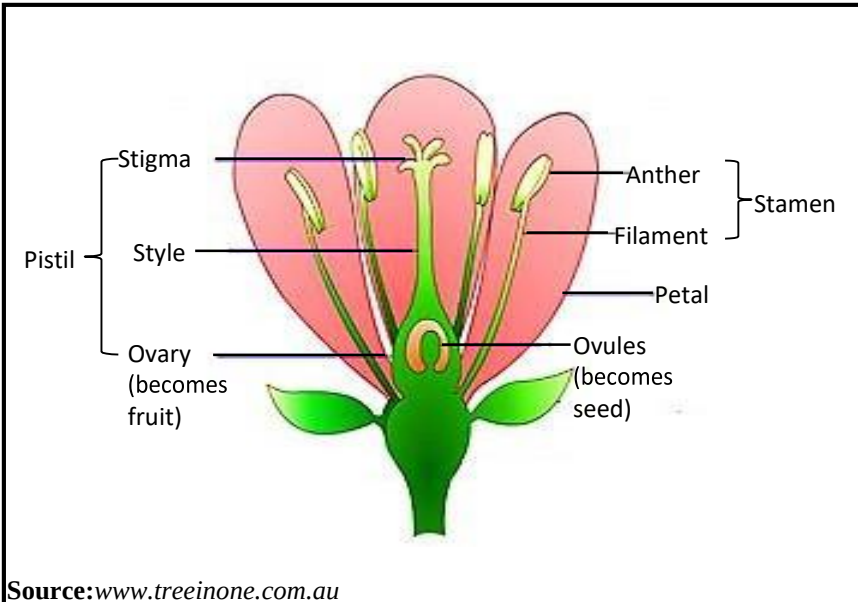
5. ANGIOSPERMS (Greek: Angion = vessels; Sperms= Seeds)

- ❖ Most successful of all terrestrial plants
- ❖ Have vascular tissues (xylem and phloem).
- ❖ There are several adaptations which make angiosperms so successful.
- ❖ Male and female gametophytes reproduced in flowers.
- ❖ Male gametophyte is known as **Stamen** (made of anther and filament). Anther produces the male gametes- pollen grains.
- ❖ Female gametophyte is known as **Pistil** (made of stigma, style and ovary). Ovary produces the female gametes- pollen grains.
- ❖ When an ovule gets fertilized by a pollen grain, a diploid seed forms.
- ❖ **Double fertilisation** in angiosperms is a complex phenomenon. In this process, one sperm fertilizes the egg to produce the diploid zygote and the second sperm unites with the two polar nuclei of the central mega gametophyte (female gametophyte) to form the triploid (3n) tissue which later develops into an endosperm.
- ❖ The ovary become the fruit and protects the seeds.



- ❖ A seed is has 3 parts: (1) plant embryo; (2) a seed coat and (3) a nourishing endosperm.
- ❖ Most angiosperms use animals to **cross pollinate** their flowers, rather than depending on wind pollination.
- ❖ Angiosperms disperse their seeds using: wind; water and animals.
- ❖ Examples: Coconut trees; hibiscus plants; bread fruit trees; and all flowering plants.

The Reproductive Structure in Angiosperms: Flower



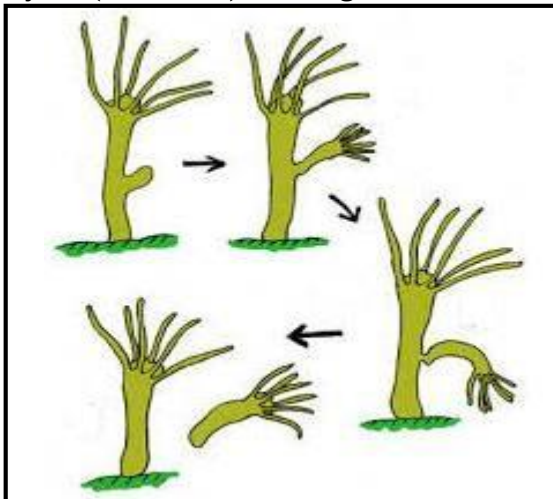
SUMMARY TABLE FOR TRENDS SEEN IN PLANT EVOLUTION

	Aquatic	Terrestrial			
	Algae	Bryophytes	Ferns	Gymnosperms	Angiosperms
Example	- Sea grapes (Nama) - Lumi - Green, Red & Brown seaweed	- Moss - Liverworts - Hornworts	- Ota - Balabala - Equisetum	- Conifers- pines - Sago palms	All flowering plants and trees
Habitat	Ocean, sea, river, drains, ponds, creeks	Moist, shady area on land	Shady areas on land	All terrestrial habitats	All terrestrial habitats
Sporophyte (2n)	- Looks similar to gametophyte - Body known as thallus - No true roots, stems or leaves - Not dominant- not long lived	- Stalk with sporangium on top of gametophyte - Not dominant- not long lived (Note: bryophytes do not have true leaves, stems and roots)	- Structure that looks like leaf, stem and roots. - Dominant- long lived (Note: ferns do not have true leaves, stems and roots)	- Leaves, stems, branches, roots. - Dominant- long lived	- Leaves, stems, branches, roots. - Dominant- long lived
Gametophyte	Dominant	Dominant	Not dominant	Not dominant	Not dominant
Male	Thallus has male and female gametophytes (no specific name given)	Antheridia	Antheridia	Male cones (small)	Stamen
Female		Archegonia	Archegonia	Female cones (large)	Pistil
Water required for reproduction	Yes	Yes	Yes	No	No
Vascular Tissues	Not present	Not Present	Present	Present	Present
Spore/seed	Spores	Spores	Spores	Naked Seeds	Seeds

PROTISTS & ANIMALS: EVOLUTIONARY TRENDS IN REPRODUCTION

- ❖ Simple animals are capable of asexual reproduction.
- ❖ They reproduce by:
 - (1) **Fragmentation**- breaking off pieces of their bodies which grow into new individuals.
Example: Sponges, Flatworms and Sea stars
 - (2) **Budding**- where new individuals bud off from their bodies. Example: Hydra
 - (3) **Regeneration**- modified form of fragmentation. It is the natural ability of organisms to replace worn out parts, repair or renew damaged or lost parts of the body, or the whole body from a small fragment/piece of the body. Example: Sea stars and Flatworms.
 - (4) **Binary Fission**- separation of the body into two new bodies. The organism duplicates its genetic material and then divides into two parts with each new organism receiving one copy of DNA. Example: Protists- Amoeba, Euglena and Paramecium. Animals- Tapeworms

Hydra (Cnidarian) Budding



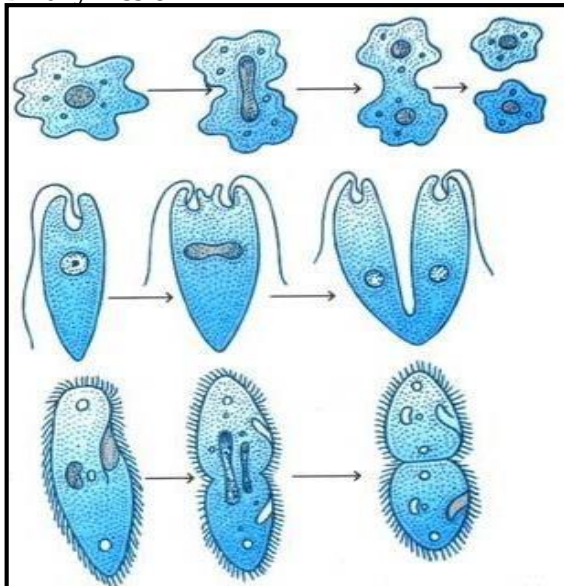
Source: www.taxawiki1314.wikispaces.com

Echinoderm Fragmenting



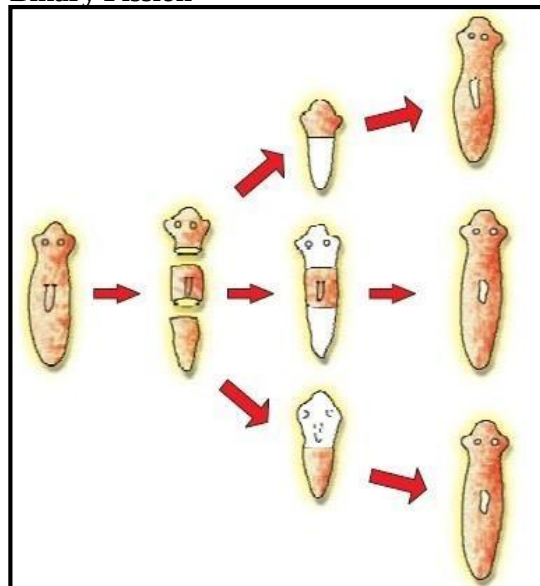
Source: www.gettyimages.com/photos/common-starfish

Binary Fission



Source: www.yourarticlelibrary.com

Binary Fission



Source: www.meritnation.com

- ❖ Complex animals are **only** capable of sexual **reproduction**.
- ❖ Evolution shows trends towards terrestrial reproduction, fewer offspring and parental care.
- ❖ There are different strategies for sexual reproduction amongst animals such as:
 - (1) **External fertilisation**—male gametes fertilise (fuse with) the female gametes outside the body.
 - (2) **Internal fertilisation**-male gametes fertilise (fuse with) the female gametes inside the body.
 - (3) **External development**- the embryo develops outside the mother's body.
 - (4) **Internal Development** - the embryo develops inside the mother's body.
- ❖ Examples of such animals are: arthropods and vertebrates.

1. External Fertilisation

- ❖ Fertilisation occurs outside the body.
- ❖ The male and female parents release their gametes into surrounding water.
- ❖ The sperms swim to the eggs and then fertilises it outside the female's body.
- ❖ The parents do not have sexual intercourse.
- ❖ Examples: most fish, sea worms (*Balolo*) and all amphibians.

Limitations of External Fertilisation

1. Eggs and sperms released in water may not meet and therefore gametes and the energy invested in producing those gametes will be wasted. This problem solved by species staying close together when releasing gametes.
2. This type of fertilisation can occur only in water. Not a problem for fish but for amphibians, they have to go from land to aquatic environment.
3. Eggs released are soft and therefore vulnerable to predation. Therefore numerous eggs are laid to ensure that at least a few offspring will survive. Predators eat most of the offspring either at the egg stage or soon after hatching.

Salmon Fish Eggs



Source: www.marinebio.net

Frogs releasing gametes



Source: www.cathylaw.com

Female Sea worm releasing eggs



Source: <http://seapics.com>



2. Internal Fertilisation

- ❖ Fertilisation occurs inside the body.
- ❖ The male deposits his sperm inside the female.
- ❖ Such fertilization involves sexual intercourse.
- ❖ The sperm swims to the eggs inside the female's body.
- ❖ For this type of fertilisation, water is not a requirement and therefore fertilisation can occur in terrestrial (land) environment.
- ❖ Since, fertilization is internal; fewer gametes are produced to prevent wasting of energy in producing those gametes.
- ❖ Examples: Insects, reptiles, birds and mammals all fertilise their eggs internally.

3. External Development

- ❖ The **embryo** develops outside the mother's body.
- ❖ With external fertilisation, development of embryo is automatically external.
- ❖ With internal fertilisation, development can either be external or internal.
- ❖ After internal fertilization; some animals lay their eggs and the embryos develop externally.
- ❖ Example: Some insects, some fish, reptiles and birds develop externally.
- ❖ The egg contains a yolk, which provides nutrients for the developing embryo.
- ❖ The yellow part of a chicken egg is the yolk, meant to provide food for the embryo in case the egg is fertilized.
- ❖ Eggs of terrestrial animals have **hard** shells to protect the embryo from the dehydration.
- ❖ Reptile egg shells are not hard; instead it is **flexible** but are still **tough** and **leathery** to prevent dehydration.
- ❖ The aquatic animals' eggs have a **jelly-like coating** because dehydration is not a problem for these eggs.

Disadvantage of External Development

- ❖ Embryo extremely vulnerable to predators.

Hard-Shelled Eggs of Birds



Flexible Eggs of Turtles



Source: www.en.citizendium.org

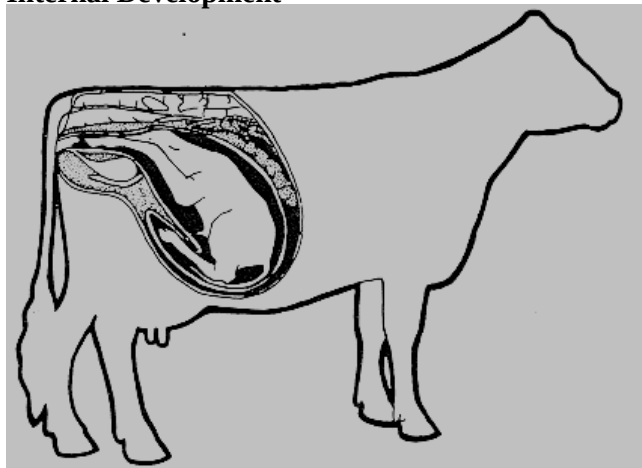
RESEARCH WORK

- Identify how the following animals that lay eggs protect it from being eaten:
 - turtles
 - birds (chicken, pigeons, doves)
 - insects (cockroaches, caterpillars, bees)

4. Internal Development

- ❖ Embryo develops and is protected and nourished inside the mother's body.
- ❖ Internal development provides the protection to the developing embryo from predators.
- ❖ Only mammals have true internal development where the developing embryo is nourished via mother's blood.
- ❖ Few species of reptiles and fish keep their eggs inside their bodies until the eggs hatch. The mothers then give birth to live offspring but the developing embryo is nourished for by the egg yolks and not the nutrients from the mother's bloodstream.
- ❖ Example: Sharks and Rays. The eggs nourish the developing embryo and it hatches inside the mother's body. Baby sharks and rays are given birth to.

Internal Development



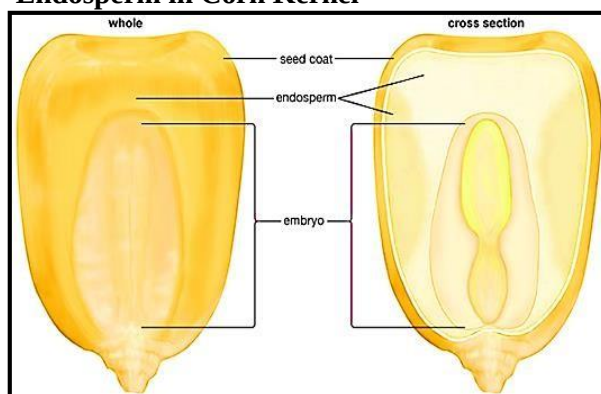
Source: www.nongae.gsnu.ac.kr

Reproductive Success in Plants

Some of the reproductive successes in plants are attributed to:

1. **Double fertilization**- double fertilization in angiosperms leads to formation of endosperm which provides nourishment to the developing embryo.
2. **Seed Dormancy**- a mechanism to prevent germination during unsuitable ecological conditions, when the probability of seedling survival is low. Seeds delayed germination allows time for dispersal and prevents germination of all the seeds at the same time (reduces competition and ensures viability).
3. **Dispersal Methods**- is the movement or transport of seeds away from the parent plant via wind, water and animals. Dispersal methods contribute to reproductive success by:
 - High chances of seed survival when away from the parent plant. Competition with adult plants may also be lower when seeds are transported away from their parent.
 - Allowing plants to reach specific habitats that are favourable for survival.
 - Allowing seeds to avoid adverse environmental effects such as fire or drought.
 - Allowing plants to colonize vacant habitats and even new geographic regions.

Endosperm in Corn Kernel



Source: www.yourarticlelibrary.com

Reproductive Success in Animals

Some of the reproductive successes in animals are attributed to:

1. **Parental Care-** is the investment a parent will put into their offspring, which includes protecting and feeding the young, preparing burrows or nests, and providing eggs with yolk. With evolution of higher animals, the trend observed was lesser number of offspring. Having fewer off springs allowed parents to invest in parental care which encouraged the survival and possible reproductive success of the offspring.

Courtship Behaviour displayed in peacock



Source: www.buzzle.com

2. **Courtship Behaviour-** behaviour by which animals select their partners for reproduction. Mostly, the male initiates the courtship, and the female chooses to either mate or reject, based on his "performance". Many animals have mate-selection courtship rituals. Displays are performed by animals seeking to advertise their willingness to mate, attract a partner and sometimes to warn off rivals. Example: display of a male peacock's tail, and elaborate dancing.

3. **Pair Bonding-** forming a close relationship through courtship and sexual activity leading to production of offspring and/or a lifelong bond. Example: Social and sexual pair-bonding is observed in some human relationships. Other animals which form strong pair bonds are: gibbons, swans, black vultures, wolves, termites and penguins.

Pair Bonding in Gibbons

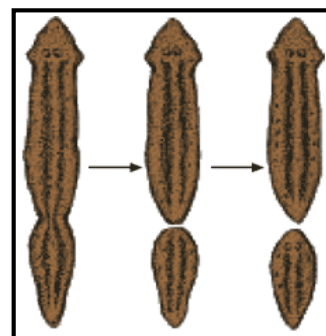


Source: <http://www.mnn.com>

4. **Territorial Behaviour-** when animals actively defend their territory for food, shelter and mate. Territorial behaviour ensures availability of mates and also display of such behaviour by males help attract the females (females are usually attracted towards strong, dominant, powerful males). Example: When dogs urinate (pee) in their surrounding; they are sending signals to other dogs that it is their territory.

**SELF TEST**

1. Explain why female humans produce only two eggs per month whereas female frogs produce thousands of eggs?
2. Turtles and cattle both have internal fertilization but turtles can have as many as fifty to hundred or even more off springs per reproductive cycle whereas cattle can have only a maximum of one or two. Explain why?
3. Explain the trend observed for the sporophyte and gametophyte in plants as they moved from aquatic environment to terrestrial environment.
4. Differentiate a spore from a seed. How is a seed better adapted for life on land?
5. Identify plant groups that require water for reproduction.
6. Read the following descriptions of the life cycles of different plants. State the group to which each plant belongs.
 - a. This plant spends almost its entire life in a sporophyte stage and produces fruits.
 - b. These terrestrial plants spend most of its life as a gametophyte.
 - c. These plants produce and protect gametes in a flower.
 - d. Plant produces naked seeds.
 - e. Terrestrial plant which is seedless, lack true roots, stems and leaves but has vascular tissues.
 - f. These plants produce seeds on cones.
7. Identify the difference between a snake's egg and a Parrot's egg.
8. Explain the difference of how the developing embryo is nourished in lizards and in bats? (Hint: bats are mammals).
9. Describe one advantage and disadvantage of investing parental care in offspring.
10. Birds have to sit on their eggs until it hatches to keep their embryos warm.
 - a. Explain how placental mammals have overcome this problem?
 - b. Identify a reason why birds cannot adopt the technique used by the placental mammals.
 - c. Explain why turtles don't have to sit on their eggs until it hatches? (Hint: something to do with their blood)
11. Use the diagram to answer the following questions:
 - a. Identify the type of reproduction that is occurring in the flatworm.
 - b. Explain how such type of reproduction is advantageous to simple organisms like flatworms.
 - c. Explain why such reproduction is not suitable for higher animals like mammals.



Source: www.glencoe.mheducation.com

12. In vertebrates, what stage of life is haploid?
13. For each of the following organisms, state whether the animal has external or internal fertilisation and external or internal development:
parrotfish, snake, toad, rat, dolphin, mosquito, human, and bulbul.
14. How do bacteria cells reproduce?
15. What is the purpose of egg yolk?
16. Describe one advantage and disadvantage of investing parental care in offspring.
17. Describe the parental care that each of the following animals provide to their offspring:
mynahs, white flies, toads, cows, humans, sea turtles.
18. A sea star may lay millions of eggs in its lifetime. Why don't the seas fill with sea stars?
19. Why do all terrestrial animals fertilise their eggs internally?
20. Describe two problems associated with external development on land.

STRAND 2

YEAR 12

SUB-STRAND 2.1

ORGANISM AND THE ENVIRONMENT



SUB-STRAND 2.1: ORGANISM AND THE ENVIRONMENT

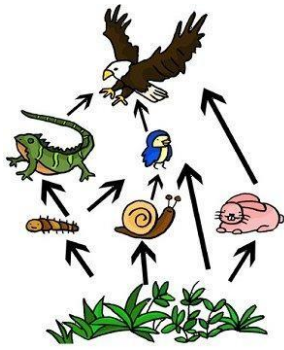
ACHIEVEMENT INDICATORS

At the end of this sub-strand, students should be able to:

At the end of this sub-strand, students should be able to:

- ✓ Examine and explain the stages a population goes through as it increases in size.
- ✓ Analyse the structure of a population in terms age distribution.
- ✓ Differentiate between density dependent and density independent factors.
- ✓ Discuss the factors that limit the population growth.
- ✓ Investigate by carrying out field studies to illustrate the different community patterns.
- ✓ Study and explain some examples of community periodicity shown by plants and animals.

BI 12.2.1.1 POPULATION



Ecology is the study of the interactions of organisms with one another and with their environment. In year 11, the ecological interaction at three levels studied were:

- **Population** - a group of organisms of one species living together in an area at a given period of time.
- **Community** - all the populations of organisms living in an area.
- **Ecosystems** - a community and its environment. In the study of ecosystems, we consider organisms' relationship with one another and with their physical environment.

This year we further explore the patterns in populations and communities.

Population ecology is the study of populations in relation to the environment, including environmental influences on population density and distribution, age structure, and population size.

The features used to describe a population are:

Population size

- Population size refers to the number of individuals in a population.
- Letter 'N' is used to indicate the population size.
- Thus, if there are 12 dogs that live within your school compound, then the population of dogs in your school compound is, $N = 12$ dogs.
- The units of the population are the population being counted.

Population range:

- Refers to the area within which the population is found.
- In the example of dogs given above, the range would be the area of your school compound.
- Since range is an area, the units of the range will be either km^2 or m^2 .

Population density: refers to the number of individuals which may be present in each unit area.

$$\text{Population density} = \frac{\text{Number of individuals (N)}}{\text{Population range}}$$

For example, if there are 400 pine trees in an area of 2 km in length and 100 km in width then the population density of pine trees would be:

$$\begin{aligned} \text{Number of individuals} &= 400 \\ \text{Population Range} &= 2 \text{ km} \times 100 \text{ km} = 200\text{km}^2 \end{aligned} \quad \text{Population density} = \frac{400}{200\text{km}^2} = 2 \text{ trees / km}^2$$

- ❖ Within any population, one will find individuals of varying ages. These are two factors that control the age structure of any population;

- Natality or birth rate
- Mortality or death rate

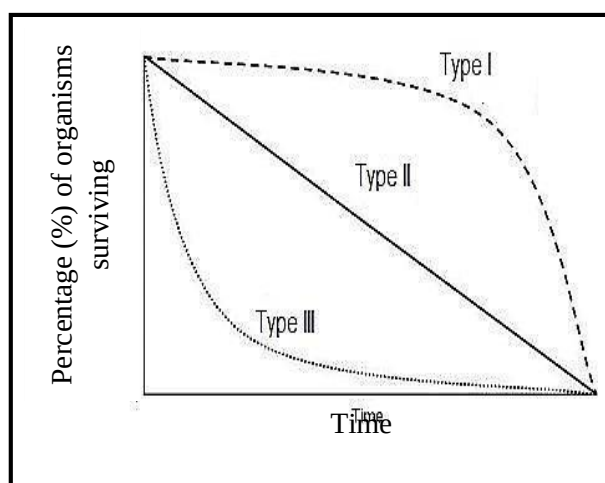
- Some organisms have a very high death rate because they live in areas where conditions are not favourable or they have plenty predators or enemies e.g. mice.
- These types of organisms make up for the high mortality rate by having an equally high natality rate.
- Generally, species that show high parental care (mammals and some birds) live longer than those with no or little parental care e.g. toads and frogs.
- Those organisms that show high parental care make up by producing very large numbers of gametes during reproduction.

Survivorship curves: are useful ways of showing the mortality and natality rate for different populations. Survivorship curve is the 'chance of remaining alive'. There are three types of survivorship curves:

Type I - mortality is low at youth, many individuals survive to reach an old age e.g. humans.

Type II - there is equal chance of dying at any time in life. e.g. insects. Their mortality rate is constant throughout their lives.

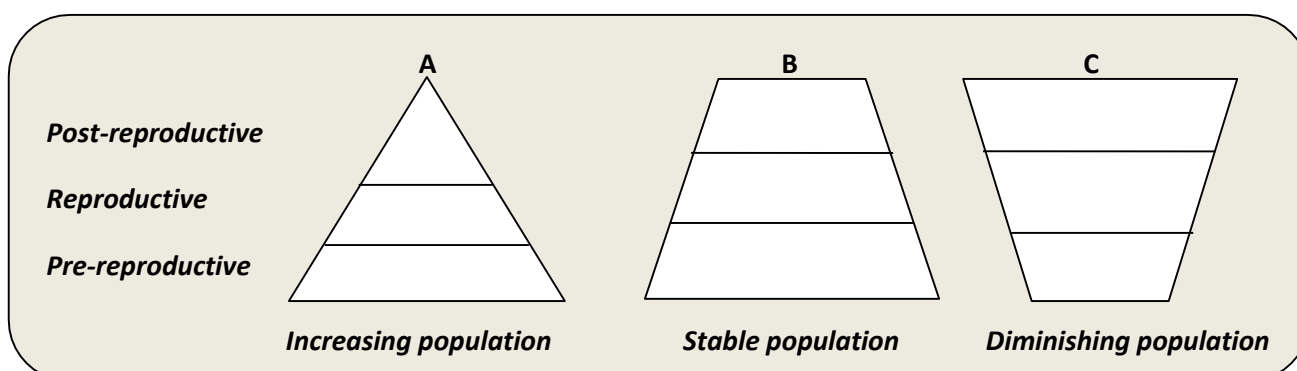
Type III - many individuals die at a young age e.g. fish. Their mortality rate is high in the juvenile stage.



Source: https://en.wikipedia.org/wiki/Survivorship_curve

Age pyramids

- Show information about the number of organisms of a particular age group that is alive in a population.
- This can be used to decide whether the population is increasing or decreasing.
- Generally, the breadth or width of the pyramid indicates the number of organisms in that age group.
- There are three distinct age pyramids that can be identified.

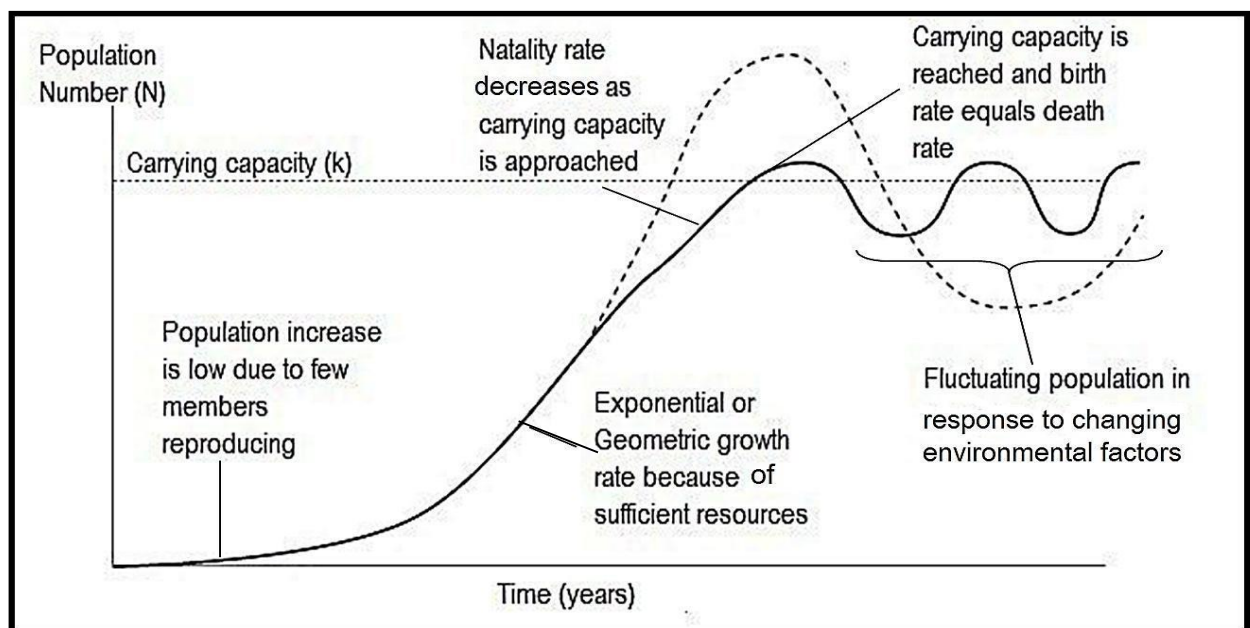
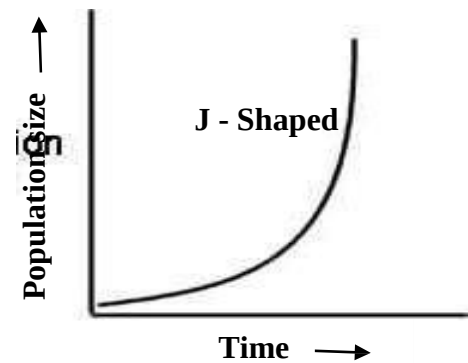


Carrying capacity

- Is the maximum size that can be supported indefinitely by the available resources in the environment in which they live.
- The carrying capacity is designated by the letter ' k '.
- When the population size exceeds the carrying capacity, the population size (N) of the population will decrease as animals move to new habitats or die of starvation because the resources are over-exploited.

Population Growth

- When a species is placed in a new environment where there are sufficient resources, the growth of its population will be representative of an exponential or **J-shaped curve** as shown.
- The population increases rapidly because resources are abundant.
- A population however, cannot keep growing as in the J-shaped graph because resources will become depleted and the N will start to decrease.
- A more realistic graph of natural population growth rate is shown below in the **s-shaped curve** or a **sigmoid curve**.



Population Dynamics

- ❖ Members of a population:
 - rely on the same resources.
 - are influenced by similar environmental factors.
 - have a high likelihood of interacting with and breeding with one another.
- ❖ Populations can evolve through natural selection acting on heritable variations among individuals and changing the frequencies of various traits over time.

Limitations of a Population

- ❖ Populations tend to grow and also shrink with time.
- ❖ An example of population that is increasing continually is the human population while a population which is shrinking is the turtle population.
- ❖ The growth and shrinkage of a population is controlled by many factors.
- ❖ Two such factors are: **Abiotic Factors** and **Biotic Factors**.

Abiotic Factors

- ❖ Abiotic factors are physical conditions or the non-living part of the ecosystem.
- ❖ Examples of abiotic factors include light, temperature, rainfall, atmospheric gases, wind, mineral levels, humidity, soil etc., and earthquakes, floods, volcanic eruptions and storms which have more catastrophic effects on populations.
- ❖ Plants and animals depend on abiotic factors for growth and other processes.
- ❖ Abiotic factors affect a population regardless of the density of the population and are therefore, said to be **density-independent**.

Biotic Factors

- **Biotic factor** is any activity of a living organism that affects another living organism within its environment.
- Biotic factors within a community can affect the populations of organisms but are also essential to the balance of life within the ecosystem.
- Examples of biotic factors include competition, parasitism, predation, diseases and toxic waste.
- These factors are **density-dependent** and usually affect a population in a predictable fashion.

Density – dependent Population Regulation

Competition

- Competition for resources increases as the population increases due to members of the population (members of the same species) having identical resource needs.
- Producers compete for light, space, water, minerals and substrate.
- Consumers compete for space water shelter, breeding sites and food.
- Intraspecific competition strongly regulates population size by favouring the stronger and more adaptable individuals who are able to obtain most of the resources.
- Interspecific competition also keeps a population's size lower due competition for similar resources between different species.
- Interspecific competition can be detected by removing one species, if the population of the remaining species increases, the two species must have been competing for the same resources (Gauze's Principle of competitive exclusion).



Source: www.pinterest.com

Parasitism and Disease

- Parasites and pathogens spread rapidly in a dense population.
- When a pathogen first spreads, both pathogen and host populations usually drop rapidly.
- The most lethal strains of the pathogen and the least resistant hosts die out.
- Eventually, the host and pathogen achieve equilibrium. Source: <http://www.todayifoundout.com/>
- Since the host population supports additional organisms (the pathogens or parasites) with the same amount of resources, the host population size usually is smaller than before infection.



Predation

- Predators often have a good effect upon a prey population, preventing it from over – exploiting its habitat.
- Predator and prey population sizes tend to fluctuate together.
- If a prey population increases their predators have more to eat and so eventually the predator population also increases.
- This shrinks their food supply and, eventually their own population.



Source: <http://www.npr.org/>

Toxic Waste

- Natural waste production limits populations, e.g., the mould *Penicillium* produces penicillin which kills bacteria.
- Algal blooms produce toxic compounds that can kill fish.
- Toxic wastes within a population can limit the population itself, e.g., alcohol produced by yeasts limits yeast production.
- Humans produce toxic waste from sewage and industry.
- This pollution can kill many life forms.



Source: <http://www.earthuntouched.com>

Density- Independent Regulation of Growth

- Any factor that regulates a population's size in a way unrelated to its density is called a **density-independent** factor.
- Natural disasters and sudden environmental change often kill entire populations of organisms, regardless of their density.
- For example, if a fire sweeps through a field, it will kill other small organisms also living in that field.
- Floods, fires, droughts, frosts and cyclones regulate population size independent of population density.

Human Threat to Populations

- ❖ Human population's growth threatens the survival of many wild animal populations independent of their densities.
- ❖ Hunting has reduced whale, tuna and hundreds of other animal population to dangerously low numbers.
- ❖ Additionally, habitat loss to farms and settlements has driven many species to extinction and is pushing still more to the edge.
- ❖ Demand for some animal goods such as ivory and turtles shells actually increases as their source populations become dangerously scarce.
- ❖ Poaching (illegal hunting) threatens tigers, African elephant, rhinoceroses, pandas and sea turtles with extinction.

Factors that limit population size		
	Factors that increase the population size	Factors that decrease the population size
Abiotic	– Favourable light. – Favourable temperature. – Favourable chemical environment.	– Too much or too little light. – Too cold or too warm. – Unfavourable chemical environment.
Biotic	– Sufficient food. – Less predators or ineffective predators. – Few diseases. – Weak parasites. – Ability to compete for resources.	– Insufficient food. – Many effective predators. – Deadly diseases. – Strong parasites. – Inability to strongly compete for resources.



SELF TEST

1. Give two examples of how plants and animals affect their environment.
2. Describe how temperature, light, and soil affect an ecosystem.
3. Which type of survivorship would birds have?
4. Think of a forest ecosystem. Now imagine that a large amount of dust and ash into the air is blocking out sunlight. How might the forest ecosystem be affected if the sunlight is:
 - (i) blocked out for a day?
 - (ii) blocked for a year?
5. Name three density-dependent threats to the human populations.
6. What can we do to prevent a human population crash?
7. Explain why intraspecific competition is more intense than interspecific competition?
8. Explain how algal bloom is caused in water ways? How this eventually leads to the fish and other aquatic life?
9. Explain why outbreaks of diseases are common post a natural disaster like flooding.

10. The population size of fruit bats in Fiji is regulated by many different factors. For each of the population-regulating factors described below, state whether the factors is density- dependent or density –independent.
 - a. Cyclone Kina
 - b. An increase in the number of owls (predatory birds that hunt at night)
 - c. A bacterial disease
 - d. Competition for food from other bats
 - e. A drought

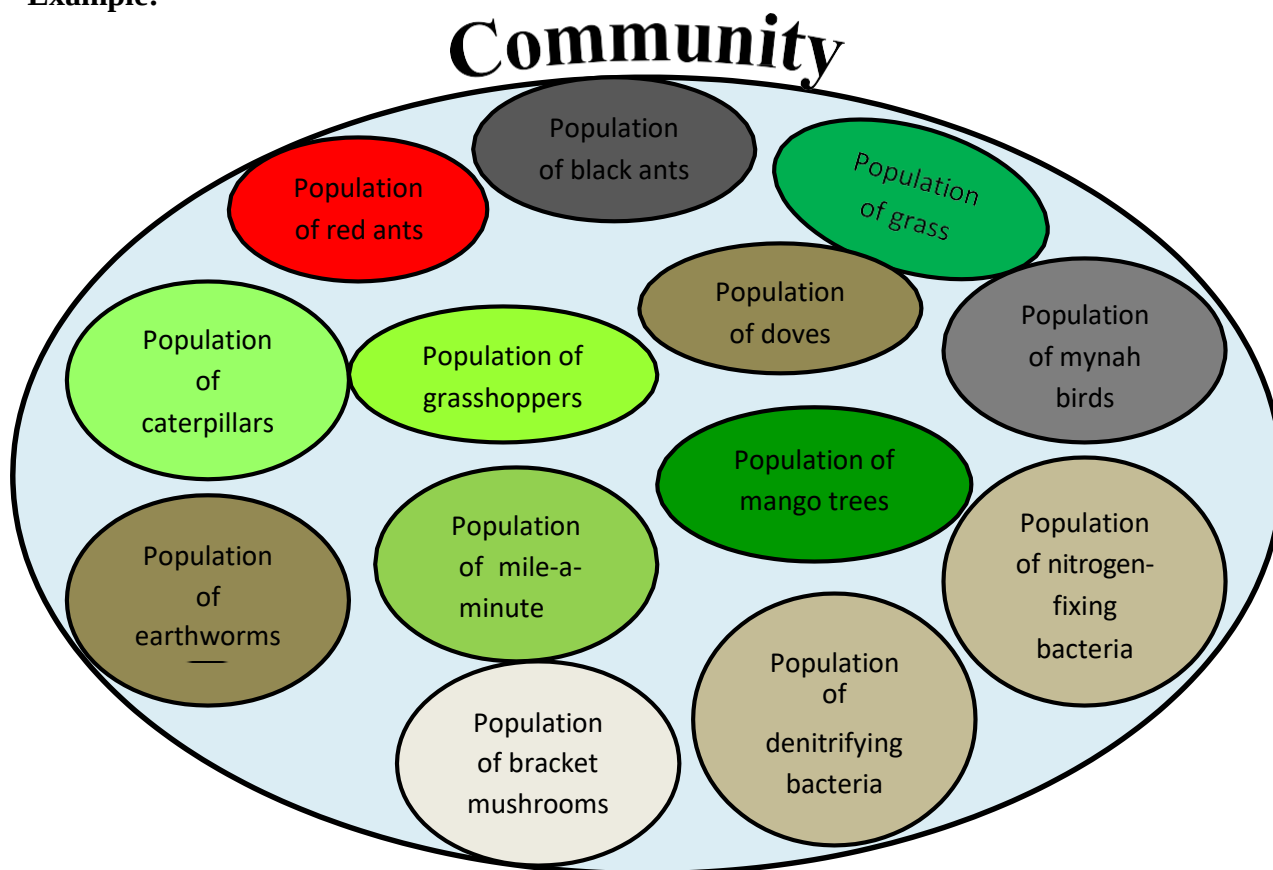
11. In biology, success is defined by the number of surviving offspring an organism produces. However; strains of pathogenic bacteria that reproduce quickly and kill their hosts usually die out. Why?
12. Describe three ways humans have increased the carrying capacity of the earth for our population. How have we decreased it for other populations?
13. Name three density-dependent threats to the human populations.

BI 12.2.1.2 COMMUNITY

Community refers to a group of plant and animal populations that live in a particular area at a particular time and interact with each other. Every member of the community plays a specific role.

Community differs from population in that **population** is made of only one type of species.

Example:



- ❖ The above community is made of:

- Red ants	- Black ants	- Caterpillars	- Grasshoppers
- Earthworms	- Mynah birds	- Doves	- Denitrifying bacteria
- Nitrogen-fixing bacteria		- Grass	- Mango trees
- Mile-a-minute (climbers)		- Bracket mushrooms	
- ❖ These populations play a specific role in the community and in one way or another, interact with each other.
- ❖ The possible types of interaction in a community are:
 - (1) **Competition**- interaction that occurs when individuals of different species compete for a same resource which is limited in supply. This limits the growth and survival of organisms involved. Both the organisms involved are affected negatively. (- / -)

Example: Suppose for the above community, if the red ants and the black ants both prefer to eat same type of food; competition for food when limited supply will drive these two species to fight for resources. This will have a negative impact on both the red and the black ants.

Ecological Niche

- ❖ Niche (pronounced: nitch) is the ecological role a species plays in its ecosystem.
- ❖ It refers to everything about its way of life, particularly its relationship with other organisms and with its physical surroundings (involves both biotic and abiotic factors).
- ❖ This includes the organism's energy sources, habitat, water and minerals, climate preferences and reproductive method.
- ❖ Example: an organism's habitat is its 'home address' and its ecological niche is its 'profession'.
- ❖ For example, an earthworm's niche includes borrowing through the soil eating organic matter. Earthworms prefer a moist, dark habitat, and birds are their main predators. They produce sexually, with internal fertilization, and each individual has both female and male sexual organs.
- ❖ Organisms living in the same community **compete** with each other when their **niches overlap**.
- ❖ Since competition harms both organisms involved, division of resources is favored by natural selection to reduce the niche overlap between species.
- ❖ A division of roles and resources in a community allows a large number of species to live together in the same area.



Examples of Resource Division/ Partitioning

- There are nine different species of fruit-eating pigeons in the rainforests of Papua New Guinea. Why doesn't competition for food drive less competitive species into extinction?

Competition has pushed each pigeon species to evolve adaptations for a slightly different niche. All fruit available in the forests is not the same. Some fruits grow on trees with thin branches, some grow on trees with thick branches. Some fruits are large, some are small. The various body sizes and beak shapes among the different pigeon species adapt them for eating different kind of fruits. The smaller species can land on thin branches that larger pigeons would break. Some species have short thick beaks for cracking nuts, some have hooked beaks for tearing fruit peels while others have sharp beaks for poking through fruit skins. This division of resources reduces competition between the pigeon's species.

Likewise, Fiji has three endemic species of fruit-eating doves. All three eat fruit, insects and caterpillars that they find between the forest undergrowth and tree tops. All three are about the same size and have very similar beaks. With such a large niche overlap, these three species of doves cannot live together. They have survived by spreading across Fiji. The golden dove lives on Viti Levu, Ovalau and Gau while the orange dove makes its home on Vanua Levu and Taveuni and the whistling dove is restricted to the Kadavu and Ono Islands.

Resource division reduces competition, allowing greater population size and diversity in communities. Species that have similar niches share resources in different ways, in different areas, or at different times.

- (2) **Predation**- interaction between species in which the predator kills and eats the prey. In this type of interaction, the predator benefits and the prey is negatively affected. (+ / -)

Example: mongoose kills and eats chicken, therefore the mongoose is a predator and the chicken is the prey.

- (3) **Herbivory**-interaction in which an organism eats parts of the plant or algae. In this relationship the herbivore benefits and the plant is negatively affected. (+ / -)

Example: when cows eat grass they do not kill the plant entirely. The cow benefits by getting food but the grass is negatively affected because the greens are lost and photosynthesis will be affected.

- (4) **Symbiosis** (sym = together; bios = living) - relationship when individuals of two or more species live in direct contact with one another.

Examples of symbiotic relationship are:

- **Amensalism**- relationship where one organism is harmed, the other remains unaffected. (- / 0)
Example: An algal bloom in the river causes death to so many fish and aquatic animals but the algae in no way benefits from it.

- **Commensalism**- relationship where one organism benefits and the other organism remain unaffected. (+ / 0)

Example: barnacles which are sessile organisms, sometimes attach themselves to whales. As the whales swim, the water currents bring in food for the barnacles. In this way the barnacles benefit while the whale remains unaffected.

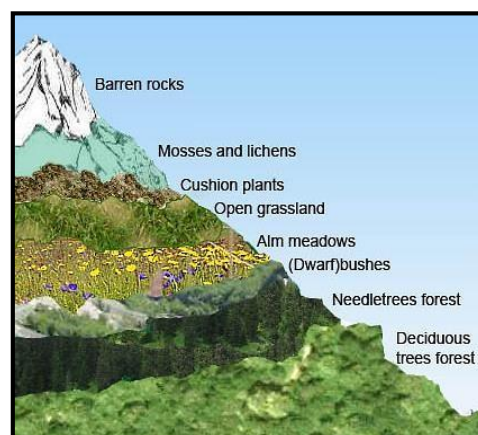
- **Mutualism**- relationship where both organisms benefit. (+ / +)
Example: humans and their pet dogs. The dog receives food, care and shelter from the owner while the owner receives companionship and protection.

- **Parasitism**- relationship where the parasite benefits and the other host is harmed. (+ / -)
Example: Neats and lice (Fijian word: kutu and lice), the parasite, living in human hair benefits by obtaining habitat and food (sucking blood). The host (human) on the other hand gets negatively affected because it looks dirty, results in the loss of blood, causes itchiness and sores.

Community Patterns

1. Zonation

- ❖ The division of organisms into areas, or **zones**, of varying environmental factors is called **zonation**.
- ❖ Different species living in different areas/zones of a community **reduces competition** between them.
- ❖ Species live in different zones according to their adaptations.
- ❖ Zonation is horizontal environmental divisions- side by side.



Source: www.vcbio.science.ru.nl

- ❖ **Example 1:** Next time you go to an undisturbed beach, notice the pattern in which the plants grow from the shoreline. The first type of plants you will notice will be creepers, grass and other low-lying plants. As you walk away from the shore, more to the inland, you will notice plants almost your height and further inland, there will be bigger plants.

Research: Similar to plants, zonation in animals living on the sea-shore can also be observed. When you go to a beach, observe the animals that inhabit the shore. Identify the animals that are found in the different zones.

- ❖ **Example 2:** The stream ecosystem has roughly three zones; (1) wet zone in the stream, (2) damp zone next to it, (3) and dry zone farther away from it. Different organisms are adapted to the zones conditions. In the stream (wet zone) you will find algae. Near the stream banks (damp zone) you will find ferns and mosses farther away (dry zone) you will find herbaceous plants.
- ❖ **Example 3:** Zonation also occurs on the sides of high mountains. The environment at the top of high mountains is normally cold, windy and dry. Conditions at the bottom are more moderate.

2. Stratification

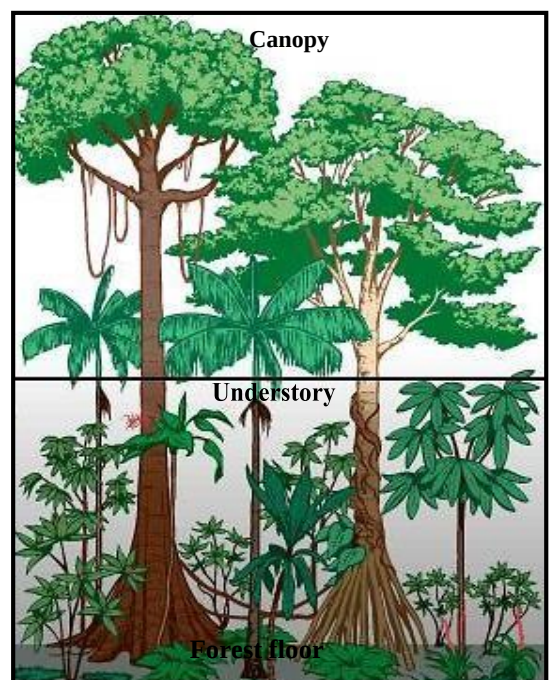
- ❖ **Stratification-** vertical layers of organism in communities.
- ❖ Each layer is known as stratum and different organisms live in the various strata depending on their living requirements.

- Humidity is the amount of moisture in the air.
- The stickiness you feel in your skin during hot weather is due to humidity.

- ❖ **Example 1:** Forest communities often show stratification. The top layer of a forest is called the **canopy**. Canopy receives the highest amount of sunlight and wind and the lowest amount of humidity.

The middle layer of the forest is known as understory. The amount of sunlight and wind in the understory is less than that in the canopy, but the humidity is high. The bottom layer, that is, the forest floor is the darkest and the most humid layer of the forest.

- ❖ Stratification reduces competition between species in two ways:
 - (1) It divides the organisms into separate areas, just like zonation.
 - (2) The many strata create a large number of varied habitats, greatly increasing the diversity and number of organisms the ecosystem can support.
- ❖ Stratification also occurs in the oceans.



Source: <https://daac.ornl.gov>

(3) Succession

- ❖ Succession is the orderly progression of species composition in an empty area of land, from colonizing pioneer species to a stable community.

- ❖ Succession occurs in several stages:

1. A new habitat currently with no form of life is created. Example: A new island created by a volcanic eruption; or by a forest fire; or after deforestation.

2. Pioneer species colonize (inhabit) the newly available habitat. As

Pioneer species

Organisms adapted to growing in exposed, windy areas with intense sunlight, varying temperatures and low fertility soil. Pioneers are usually small, annual plants that produce large numbers of wind dispersed spores or seeds.

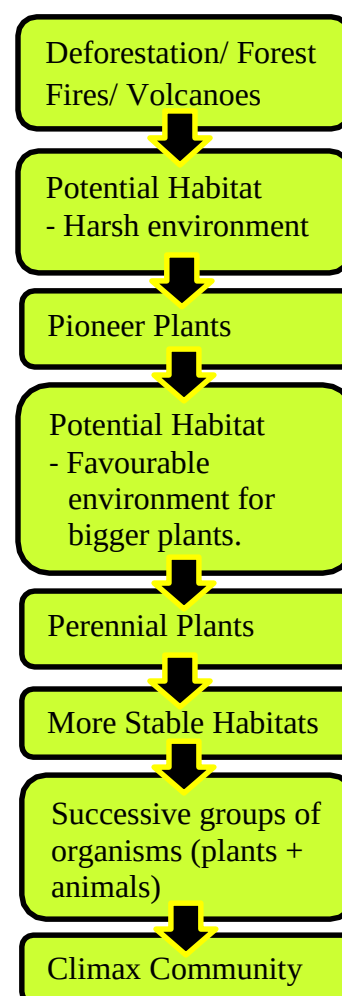
pioneer plants spread over the exposed land, they shelter the soil from the sun, wind and pounding rain. Their roots help prevent erosion. As older plants die and decay, the soil becomes more fertile. Over time, the pioneers create an environment favorable for

larger perennial plant whose

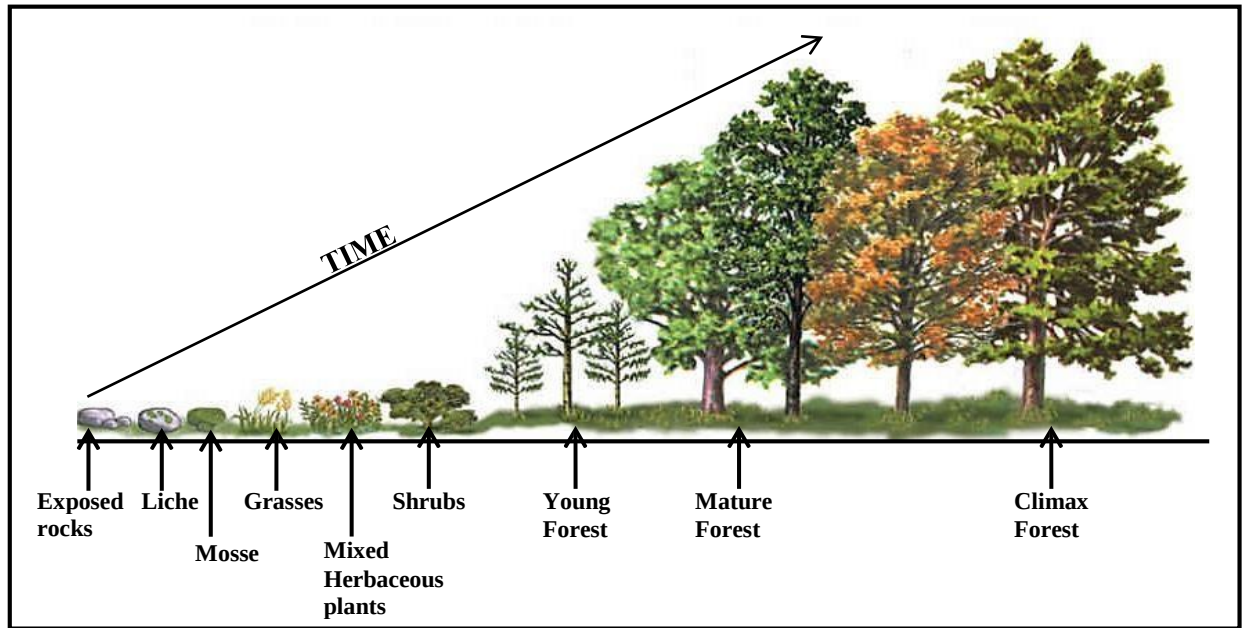
3. Once pioneers have sheltered the soil, the seeds of perennial plants can take root. In moderate habitats, perennials have two competitive advantages over annuals: early growth each year since they live for more than one growing season and a much larger energy store. Over time perennials crowd out the original pioneer species.

4. Eventually, after several stages of successive groups of organisms, the environmental conditions stabilize and the community reaches a stable composition of species called the **climax community**.

- ❖ Succession divides resources between different species with respect to time.
- ❖ In contrast, zonation and stratification divide resources by space.
- ❖ Less dramatic succession occurs after habitat disruptions such as fire, deforestation, bulldozers or even a falling tree. In such cases, the environment is not so harsh and plants grow from seeds or seedling already present. However, one group of species replaces another as environmental conditions change until the community reaches a stable composition of species.
- ❖ The time a community takes to reach a climax composition of species varies greatly.
- ❖ Simple communities, such as grasslands, need only a few years to return to normal after destruction by fire or other disturbance. However, complex communities, such as rainforests and coral reefs, take hundreds of years.
- ❖ Succession in plants shows variation in animals and fungal species inhabiting the place. Smaller organisms are found with pioneer species due to limited food and cover from the harsh



environment. Later with the perennial plants and a richer environment, bigger animals are also supported.



Source: www.intothegardenstrawberries.weebly.com

- ❖ **Example 1:** In 1965, an underwater volcano erupted near Iceland, forming a new island of hardened lava. The pioneers were bacteria and fungi, blown over from Iceland. Flies and seabird were the first to arrive. Within two years, a few small vascular plants began to grow from seeds blown over from Iceland. Two years later a few mosses appeared. The decomposition of dead organisms improved soil conditions leading to variety of plant and animal species which are still increasing.
- ❖ **Example 2:** About 10 million years ago, volcanic eruptions created Viti and Vanua Levu in the same way. A few pioneer species colonized the barren volcanic rock. Today, climax communities of rainforests and grasslands cover Fiji.

Periodicity Patterns in Plants and Animals

- ❖ Most organisms alter their activities according to the time of day and to the time of year.
- ❖ An organism's cycle of activity according to time periods are called **periodicity**.
- ❖ Periodicity divides resources between species since they are using resources at different times.
- ❖ Some common types are periodic cycles observed in organisms are:

(i) Daily Cycles

- ❖ Daily cycle is based on 24 hours.

Example 1: Birds and bats both feed upon fruits, flower nectar and insects. Both of these animal group fly. This is a relatively large niche overlap but the periodic behaviour cycles reduce competition between birds and bats. How?

- Birds are **diurnal** (**active during the day**) while bats are nocturnal (**active during the night**). Species of flowers and insects available at night differ from those available during the day.

Example 2: Other organisms which show daily cycles are **crepuscular** animals which are **active near sunset** such as mosquitoes, frogs, rabbits and crabs.

Example 3: Another example of daily cycle is the **tides**. Daily there are high and low tides.

(ii) Seasonal Cycles

- ❖ Plants have different life cycle.

Example 1: The annual plants germinate, grow, reproduce and die all within one year. They usually begin growth in a new season before other plants. Annuals are adapted for survival in harsh, infertile environments and for wide dispersal by wind to new, unexploited habitats. Perennial plants live for more than one year. Perennials invest in support and energy storage. Normally, they flourish in areas already colonized and moderated by annual pioneer species.

Example 2: Other plants which show prominent seasonal cycles are ivi, duruka and sugarcane.

Example 3: The seasonal behaviours which are observed during winter are:

- Trees dropping their leaves;
- **Hibernation** in animals- hide and sleep through the season; and
- Some birds and mammals change from brown to white fur to camouflage in the snow.

Example 4: The seasonal behaviour in response to high temperature and arid conditions:

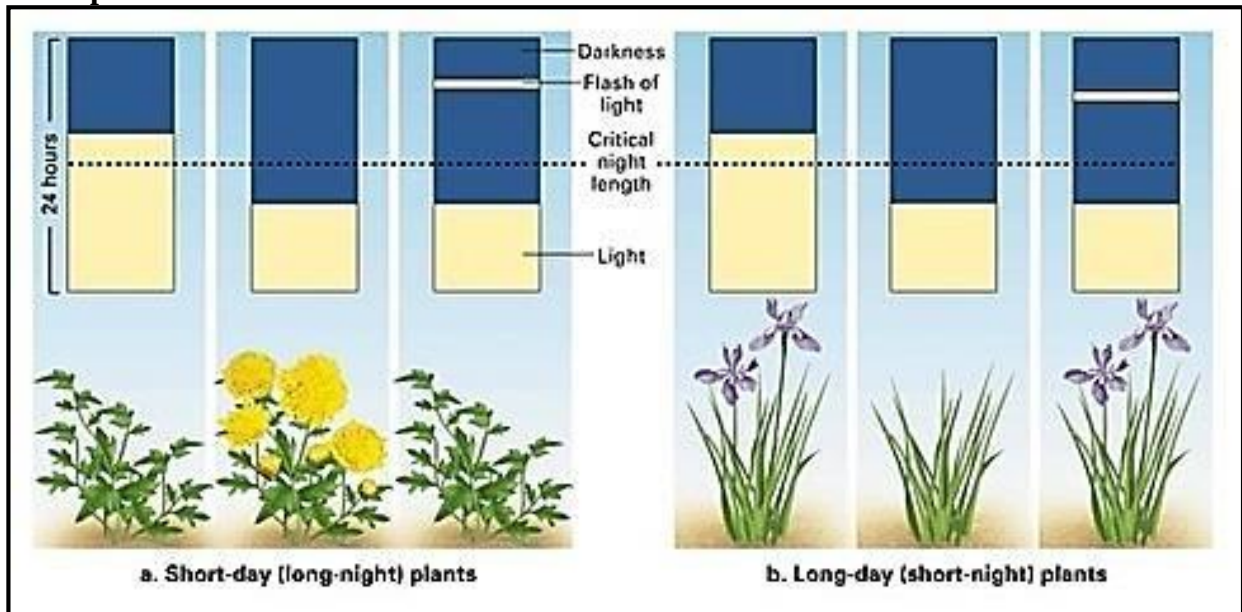
- **Aestivation**- hides and sleeps through the season. Many land crabs spend dry seasons in an inactive state at the bottom of their burrows.

(iii) Photoperiodism

- ❖ Organisms can tell the time of year by the length of the day.
- ❖ Plants and animals time reproduction with the season that provides offspring with the best environmental conditions possible.
- ❖ In cold seasons, the day length is short and in hot seasons the day length is longer.
- ❖ In Fiji, hotter months are November and December while the colder months are around June and July. Think about the length of the day light that you get to see in these months. In June and July, at around 6 pm, it starts getting dark but at the same time in November and December, there is much more light.

Example 1: Some plants only flower when days are long and some when days are short. Some long day plants are oats, peas and wheat. The common short day plants are cotton and rice.

Photoperiodism



Source: www.biologytb.net23.net

Biological Principles on Community Interactions

1. Gause's Principle of Competitive Exclusion

- States that two species with same niche cannot co-exist in the same area for very long.
- The one better adapted to the local conditions will out-number the other.
- The 'loser' species must shift niche, migrate or die.
- **Example:** Two species of flour beetle cannot co-exist in the same jar of flour if forced to be in direct competition. However, if the environment within the flour varies a bit, for example, one part of the jar being warmer or damper than others, then the two species can specialize in these separate zones. This zonation reduces the competition between them so they can both survive.

2. Liebig's Law of the Minimum.

- States that out of all the resource requirements of an organism, one resource will be scarce (limited availability) than the others.
- This resource will be the limiting factor on organism's growth.
- Without more of this resource, the organism cannot take advantage of other resources even if they are plentiful.
- **Example:** Desert plants have enough carbon dioxide and sunlight for photosynthesis. But the scarce resource in deserts is water. If these plants had more water, photosynthesis would be carried out with ease, without having to invest in special adaptive structures and methods to conserve water.

Biological Principles on Community Interactions

3. Tolerance.

- Every organism can survive only within a certain range of physical factors, such as temperature, humidity and light intensity.
- The area between the minimum and maximum conditions in which the organisms can survive is called its range of tolerance.
- Within its tolerance range, an organism functions its best. Outside this ideal range, the organism becomes physically stressed and its activity level drops.
- If the conditions are way beyond the organism's tolerance range, the organism will die.
- **Example 1:** An ideal temperature range for humans to function best is between 12°C to 44°C (without clothes and shelter). If temperature falls below or rises above this range, people begin to feel tired, lazy, frustrated and stressed.
- **Example 2:** Tolerance explains why apple trees do not grow in Fiji, why daisies do not grow in deserts and bananas do not grow in Canada.
- An organism cannot survive outside its tolerance range for any environmental factor.



SELF TEST

1. Describe your ecological niche.
2. What is the advantage of resource divisions which reduce niche overlaps of species living in the same area?
3. Several different organisms are living on the support of a sea dock. Near the high tide line, limpets and periwinkles populate the posts. Deeper in the water, beneath the low tide line, sea anemones are populating.

Limpets



Source: www.en.wikipedia.org

Periwinkle



Source: www.tidings.disl.org

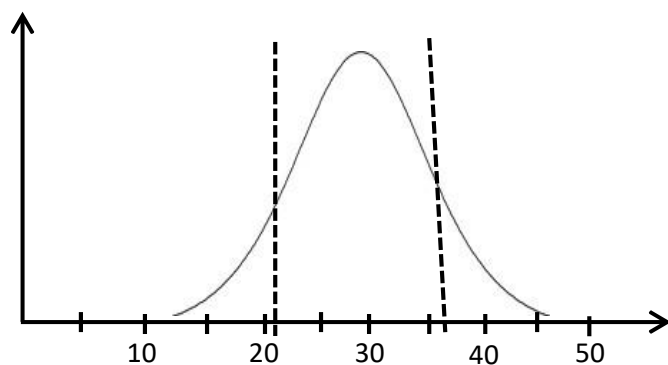
Sea Anemones



Source: www.en.wikipedia.org

- a) What kind of resource division pattern is this?
 - b) Name two ways the environment differs between the top and the bottom of the support posts.
 - c) Why don't the sea anemones also grow at the top of the support posts?
 - d) How are the limpets and periwinkles adapted for living above the high tide line?
4. Compare the environmental conditions in the bottom and along the sides of a drainage ditch. What kind of adaptations would plants living along the sides need as compared to those living in water at the bottom?
 5. Describe two ways in which stratification reduces competition between organisms in a community.
 6. Why do different species live in different strata within forests?
 7. Name an organism you would expect to find living in a forest canopy and one that you would expect to find in the leaf litter on a forest floor. Describe how each of these organisms is adapted to the environment of its strata.
 8. How do pioneer plants affect their environment as they take root in cleared land areas?
 9. Why doesn't tree seedling colonize deserted areas?
 10. Pioneer plant species are outnumbered by perennials in the areas they colonize. How do their species survive?
 11. How does periodicity reduce competition can have for organisms in a community?
 12. Describe advantages that periodicity can have for organisms aside from reducing competition.
 13. Bats pollinate balsa tree flowers. What time does balsa flowers bloom? Explain your answer.
 14. Describe two differences between annuals and perennials.
 15. Choose the resource division pattern (zonation, stratification, succession or periodicity) which best describes each of the following situations:
 - a) Pawpaw tree seedling take root in the shade of tall grasses.
 - b) Bird nest ferns grow in the upper branches of trees.
 - c) Owls hunt during the night.
 - d) Lichens (symbiotic fungi and algae) colonize bare rock.
 - e) Mosses grow over the rocks along the stream and ferns grow on the upper stream banks.
 - f) Fungi grow in the leaf litter on a forest floor.
 16. The orange fruit dove and the fruit bat in Taveuni both live on medium-sized fruits growing on forest trees. How do these two species divide their food resources to reduce competition?
 17. What factors might limit the growth of a cactus plant in a desert?

18. Study the diagram of a snake's level of activity over a range of temperatures.



- What is the snake's temperature tolerance range?
- What is the snake's ideal temperature range? Explain how you know.
- What happens to the level of the snake's activity as the temperature drops below 20°C?

19. Why can't two species that occupy the same ecological niche co-exist?

20. Copy and fill in the following chart.

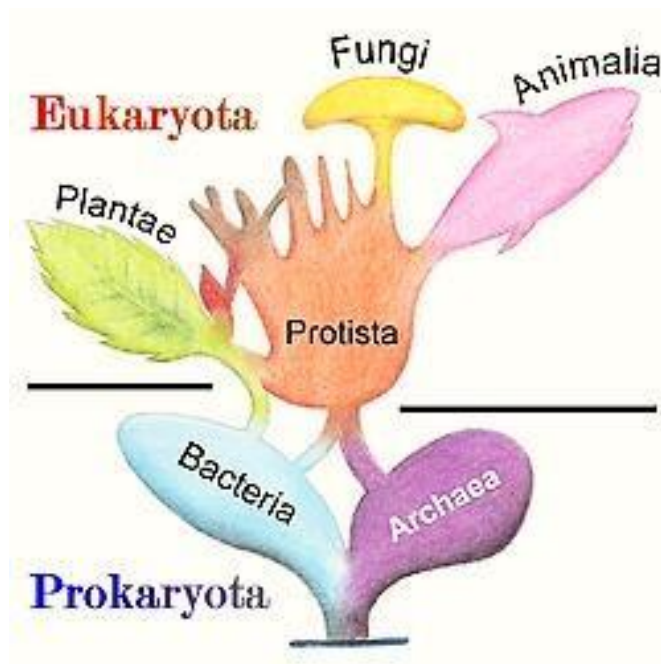
Type of Resource Division	Resource Divided by:	Example
Zonation	(a)	(b)
(c)	Vertical space	(d)
Succession	(e)	(f)
(g)	(h)	Hawks are diurnal, owls are nocturnal.

STRAND 3

YEAR 12

SUB-STRAND 3.1

DIVERSITY OF LIVING THINGS/ORGANISMS



SUB-STRAND 3.1: DIVERSITY OF LIVING THINGS/ORGANISMS

ACHIEVEMENT INDICATORS

At the end of this sub-strand, students should be able to:

- ✓ Research and present on the history of the different classification systems.
- ✓ Study the taxonomic rank of organisms in the three-domain and 6 kingdom system of taxonomy.
- ✓ Describe the three characteristics used to place organisms into domains.

BI 12.3.1.1 TAXONOMY

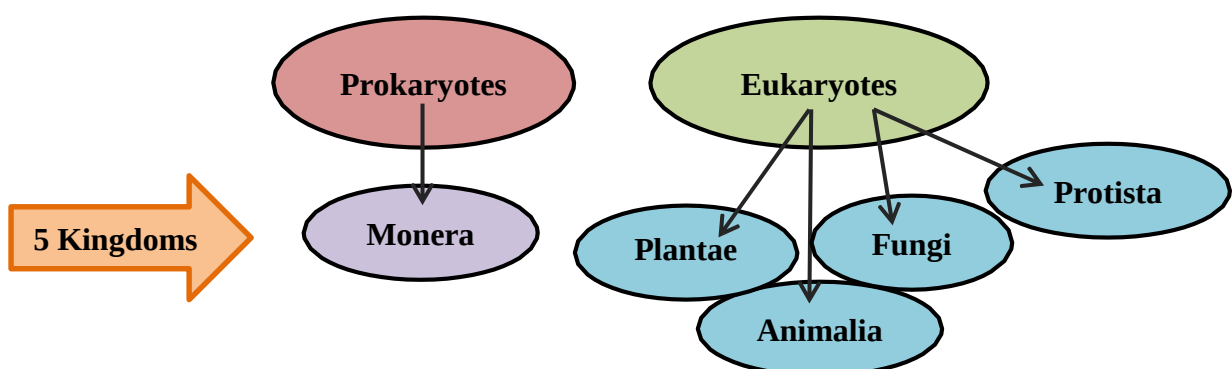
In Chapter 3 of the Year 11 Course book, you learnt about Taxonomy which **categorizes** all living things into one of the Kingdoms based on their similarities. This Year we will briefly study the history of taxonomy and its applications.

- ❖ Classifying organisms into some type of group is known as **taxonomy**.
- ❖ The taxonomic system was first developed by Carolus (Carl) Linnaeus.
- ❖ He identified and differentiated organisms based on physical characteristics that were common to each species.
- ❖ When Linnaeus first developed this classification system in year 1735 there were only **2 kingdoms: Animalia** and **Plantae**.
- ❖ Within each kingdom, he then grouped the organisms into Phylum, Class, Order, Family, Genus and Species.
- ❖ As microscopes got developed more different types of organisms were observed and it was quickly realized that there are organisms which do not fit the descriptions of either Animalia or Plantae.
- ❖ This is when Thomas Whittaker's (1969) **5 Kingdom** system got widely accepted and was used. The Animalia and Plantae remained the same; the three additional kingdoms added were: **Monera** (bacteria), **Protista**, and **Fungi**.
- ❖ While classifying, Whittaker first specified whether the organisms possessed a true nucleus (eukaryotic) or not (prokaryotic). The classification method used then was:
 - Kingdom Monera- prokaryotic and unicellular organisms.
 - Kingdom Protista- eukaryotic unicellular organisms.
 - Kingdom Plantae- eukaryotic, autotrophic organisms.
 - Kingdom Animalia- eukaryotic, heterotrophic organisms.
 - Kingdom Fungi- eukaryotic, heterotrophic organisms which unlike animals break down large organic molecules in their environment by secreting enzymes (saprophytes).

Carolus Linnaeus (1707- 1778)



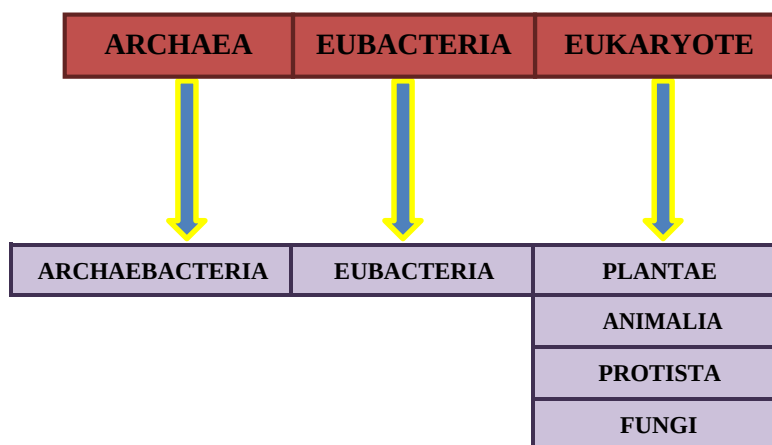
Source: www.radiolab.org



- ❖ With more advance technology such as development of DNA sequencing, electron microscopes etc; the biologists discovered that there were unicellular prokaryotic cells which differed extremely from the bacteria.
- ❖ These organisms had the ability to survive in hot springs, ice lands and other harsh environments.
- ❖ Upon these discoveries, Carl Woese proposed a reorganization of the five kingdom system into three domains. Since 1980s Woese's domain system got accepted and used.
- ❖ Woese split the previous Kingdom Monera into Domain- Eubacteria and Archaea.
- ❖ Currently, Woese's **3 Domain and 6 Kingdom** system is widely used for taxonomic classification.
- ❖ Together with that the Phylum, Class, Order, Family, Genus and Species classification continues to show how similar or different each organism is from another.
- ❖ The widely used classification system today is the **3 Domain and 6 Kingdom** classifications.

- ❖ The **three Domains** are:

1. Archaea
2. Eubacteria
3. Eukaryote



- ❖ The **six Kingdoms** are:

1. Plantae
2. Animalia
3. Fungi
4. Protists
5. Eubacteria (Monera)
6. Archaeobacteria

- ❖ The hierarchy grouping for each kingdom are:

- **Phylum** (animals and bacteria)/ **Division** (plants and fungi)
- **Class**
- **Order**
- **Family**
- **Genus**
- **Species**

Example: Modern Human Classification

Eukaryote	⇒	Domain
Animalia	⇒	Kingdom
Chordata	⇒	Phylum
Mammalia	⇒	Class
Primates	⇒	Order
Hominidae	⇒	Family
Homo	⇒	Genus
Sapiens	⇒	Species

Why Use Classification System?

- ❖ To study and include each organism along with its identification and habitat.
- ❖ To establish the relationship among different organisms and to understand their evolution.

Organisms are classified according to:

1. Cell Type/ Structure

- Whether the cell is prokaryotic or Eukaryotic and then whether it has a cell wall or not.

2. Nutrition

- Whether the organism is autotrophic heterotrophic or saprophytic.

3. Number of cells in their body

- Whether the organism is single celled (unicellular) or multicellular and if multi-cellular then how the cells are organized into tissues.

**SELF TEST**

1. Which 2 kingdoms make up the Prokaryotic cells?
2. Which type of organisms fall in the domain Archaea?
3. What is taxonomy and who was the first person to develop the formal taxonomic system?
4. With development of modern technology, why was the 5 kingdom system quickly changed to 3-domain 6-kingdom classification system?
5. Identify the Carl's hierarchy system that is still used in conjunction with the 3-domain 6-kingdom system?
6. Which three main characteristics of the organisms are used when classifying organisms?
7. What is the difference between Eubacteria and Archaeobacteria?

STRAND 3

YEAR 12

SUB-STRAND 3.2

ENVIRONMENTAL ISSUES AND ECOSYSTEMS



SUB-STRAND 3.2: ENVIRONMENTAL ISSUES AND ECOSYSTEMS

ACHIEVEMENT INDICATORS

At the end of this sub-strand, students should be able to:

- ✓ Explain how the natural greenhouse effect is essential to sustain life on earth.
- ✓ Describe activities that lead to the enhanced greenhouse effect and its effects on the ecosystems.
- ✓ Explore the practices that help to mitigate (reduce) the effects of the enhanced Greenhouse effect.

BI 12.3.2.1 Environmental Issues and Ecosystems

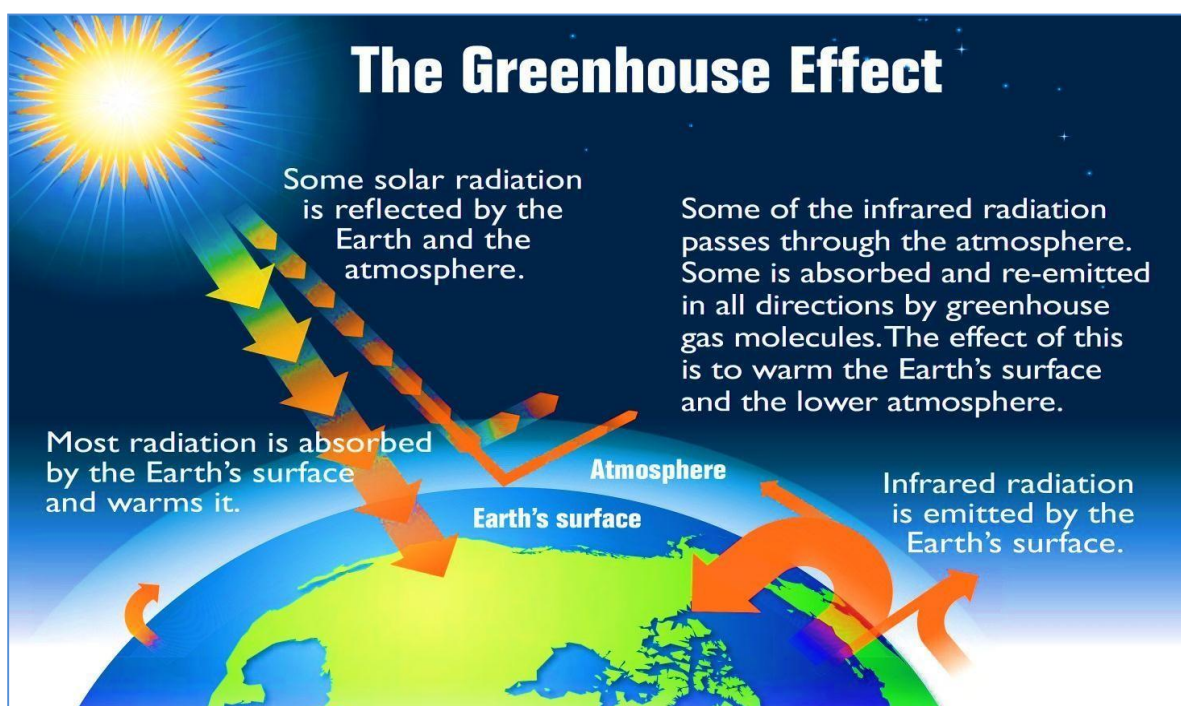


Source: <http://www.shiawisdom.com>

Over the past century, human activities have released large amounts of carbon dioxide and other greenhouse gases into the atmosphere. The majority of greenhouse gases come from burning fossil fuels to produce energy, although deforestation, industrial processes, and some agricultural practices also emit gases into the atmosphere.

- ❖ Greenhouse gases act like a blanket around Earth, trapping energy in the atmosphere and causing it to warm.
- ❖ This phenomenon is called the **greenhouse effect** and is natural and necessary to support life on Earth.
- ❖ However, the build-up of greenhouse gases can change Earth's climate and result in dangerous effects to human health and welfare and to ecosystems.

The choices we make today will affect the amount of greenhouse gases we put in the atmosphere in the near future and for years to come.



Source: <http://img-0.onedio.com/img>