Biology For All

Quality Education for Change, Peace and Progress

Ministry of Education
Curriculum Development Unit

BIOLOGY FOR ALL

(A New Approach To Learning Fifth Form Biology in Fiji Secondary Schools)

Curriculum Development Unit
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PREFACE

As a science, biology needs to be taught with the aim of cultivating and fostering an enquiry approach to learning using the scientific method of investigation and developing the scientific process skills. It should promote discovery learning by exploration and manipulation, to fully comprehend and understand, in order to analyse, apply, evaluate, create and design.

In my years of teaching science, and in interacting with biology teachers, I have noticed how biology learning in secondary schools has become very passive, and according to many students, boring and irrelevant. Students are given a lot of notes and diagrams, very often original and self-designed, and accompanied with excellent explanations by a genuinely concerned teacher. It has also become common practice for students to make their own notes and copy diagrams from the text books, often with no skills in summarizing. This leads to them copy great chunks of notes out of their text books.

This of course has its exceptions, for example, many students love the Social Biology topic taught in form 5 because it provides room for them to share their experiences and they are able to relate to it. So how do I make biology interesting, relevant and nurture the enquiry and discovery learning of students all the time, and still be able to cover the syllabus? If biology falls under the science discipline of learning, how come students learning it at school fail to answer questions involving application, analysis, evaluation and creativity? What has happened to the **scientific method of investigation** and to the development of **scientific process skills** crucial to the growth of scientific minds?

The concern that the teaching of biology was mostly affecting the lower cognitive domain of Blooms taxonomy and that many students were learning biology from a knowledge based – recall situation and were under utilizing their higher cognitive skills (understanding, analyzing, applying or evaluating), led to the need to re-evaluate the method in which biology was being taught and eventually to the writing of this text book.

The results of a survey conducted in October 2009 and reports on the external examinations, also indicated that students were not well equipped when answering questions that involved the use of higher cognitive skills (FSFE and FSLC Examiners' Reports 2006,2008,2009), and when using examples, many lacked the basic knowledge about native and endemic species of Fiji. In addition the report on the Fiji Seventh Form Certificate Examination (2009) prepared by the Examination and Assessment Unit indicated a steady rise in the cases of inconsistencies in the award of internal Assessment marks in the science subjects; a trend first noted in 2004.

This strongly indicated that the practical component of these subjects is not being translated into feasible understanding and learning. It clearly supports the need to revive the identity of Biology as a science with the aim of pursuing and nurturing the scientific method of investigation and the scientific process skills in our students.

PURPOSE and GOALS

Science is made up of facts which are organized into laws and theories. It is cumulative and involves a never ending search for truth. It explains and predicts, demands evidence and has individual and social dimensions. It changes its approach in application and attempts to deal with relevant and changing issues of society. It is utilized by those in power and sometimes abused by those who do not understand its value. However it is seen, science has its limits and students must be made to realize that science cannot solve all the possible problems of society.

This text book provides the opportunity to re-direct the teaching and learning of Biology as a science in Fiji schools with an added dimension of learning about the plants and animals in Fiji and their environments. It aims to equip them with understanding that will help them make sound decisions in relation to associated global changes that will influence them in the future. It attempts to build on students' prior knowledge, utilize collaboration and co-operation amongst students and teachers so that all those involved gain in the process of learning. At the same time it is an attempt to make biology an enjoyable subject to learn and teach.

INTRODUCTION

This text takes students and teachers into a journey of science discovery with a character who acts as a tour guide, the bird called KAKA.

Teaching resources are provided for the teachers use. They are intended to supplement the notes and enhance learning, or in some cases, complement them to produce complete understanding. Teachers are encouraged to build on students' prior knowledge, use local examples as much as possible and promote collaboration and co-operation amongst students, therefore classroom activities and laboratory experiments are expected to be in groups.

The teacher is to take the role of facilitator more than the main distributor of knowledge. The teacher guides questions and investigations from one point to another so that students are able to derive knowledge that they can assess and make decisions about. The teacher nurtures the process and the learning journey of the student, rather than lead them by the hand to their destination. This requires that the teacher takes the journey with them, the difference being, they have the knowledge and experience of having been on it before.

In the book there are a variety of styles being utilized to help the teachers guide students to a thorough understanding of the concepts and facts. The style type is indicated by an icon as shown below:

The content of the topics may not be presented as a complete package and a collaborative exercise or project will need to be done to complete their learning. The extent of the content and achievement indicators is provided in the revised prescription, but teachers are encouraged to nurture students curiosity through the 'Probing Questions' based on real-life and related issues.

Teacher Initiated discussions

with the teacher leading the discussions.

Complementary Activity

where the students and/or with the teacher go through the activity together. Students are to work in groups. This activity should not be used as a substitute for the teacher. Its complete understanding requires that a teacher facilitates the group work. A presentation by the students at the end of the lesson is essential to provide the opportunity for critique by the rest.

Collaborative discussions

where the students are given a resource to go through and expected to derive their own conclusions, which they record and present to the rest of the class. The summary ideas from these are then recorded in the students note books along with other aspects of the theme that comprise their notes. Students are encouraged to record information and make their notes as the lesson proceeds.

Probing Question

where students can carry out short researches using whatever facilities they find most appropriate. It is important that they are given the opportunity to share their findings within the week of the due dates. These aim to cultivate critical thinking and decision making within students.

CAREER OPPORTUNITIES IN BIOLOGY

The interest in Biology fosters positive attitudes and confidence in handling tertiary studies and career possibilities. An early attachment to the subject of biology opens a vast world of careers and interest commitments. These possibilities are provided in Appendix 1 at the back of the book.

Iva Teilai (Mrs)

CONTENT

CHAPTER 1

INTRODUCTION TO BIOLOGY

The word 'biology' is derived from the Greek words *bios* meaning **'life',** and *logia* meaning **'the study of'.** Thus biology is the study of living things. When we think about living things, we generally think of humans and animals. But living things take up an untold number of forms, often behaving in ways that are very strange to us as well.

The female of a certain species of the black widow spider is known to devour its mate after mating; the strongest pup of the sand shark will kill and eat its siblings while still in their mother's uterus; hibernating brown bats can stop breathing for almost an hour during hibernation to reduce their energy needs; the carnivorous pitcher plant will trap and digest insects for its nitrogen requirements, the average bristle cone pine tree can live to almost 1000 years – outliving more than 10 generations of humans!

Scientists have endeavored to categorise the astounding assortment of living things and have been suitably challenged. Today, they have identified five different kingdoms into which all living things are classified: Bacteria (Monera), Protista, Fungi, Animals and Plants.

So what is living?
How are living things distinguishable from the non-living things?
All living things whether they are bacteria, a beautiful ochre-yellow hybrid rose, a rattle snake or an award winning Hollywood actress, are made up of the same chemical elements that non-living things are made up of, and respond in the same way to the laws of nature as non-living things.

The Bristle Cone Pine

Source: rechargebiomedical.com

A pitcher plant

Source: naturephoto-cz.com

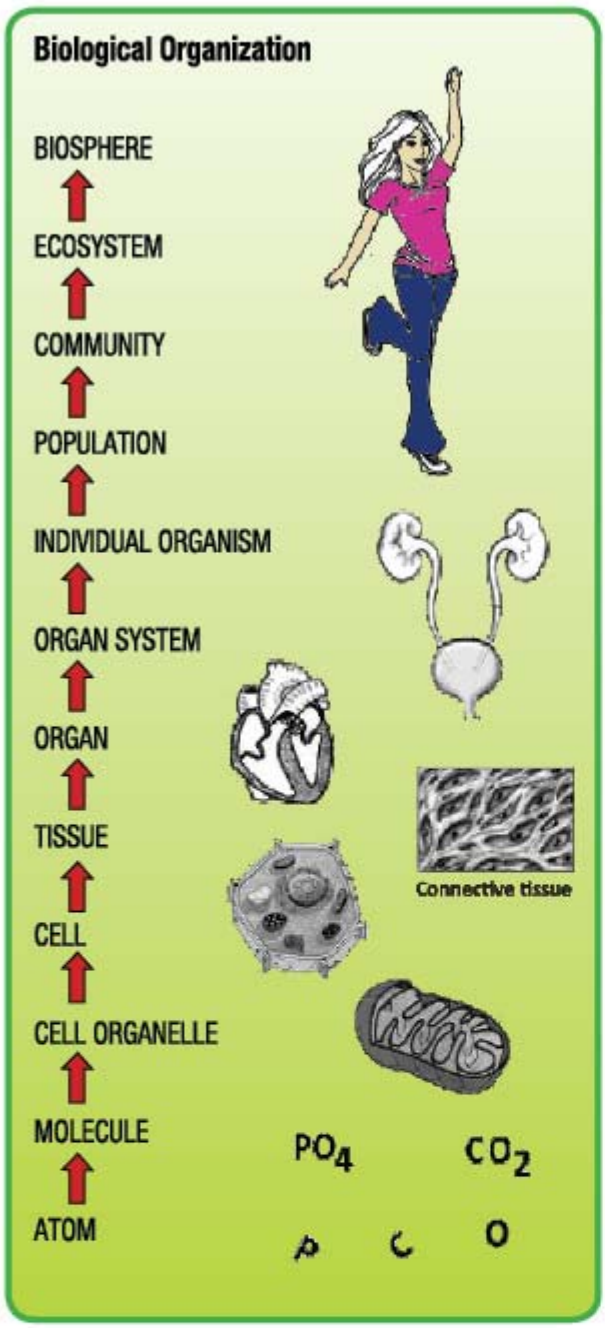
1.1 CHARACTERISITICS OF LIFE

There are seven processes that living things can carry out at one point in their lives that distinguishes them from the non-living. These processes are given below:

M – movement: are able to move because they have bone and muscle acting together;
R – respiration: take in oxygen to break down the food they consume to release energy;
S – sensitivity: are able to react and respond to internal and external stimuli;
G – growth: increase in size with time;
R – reproduce: able to produce more offspring like themselves;
E – excrete: able to remove waste products formed in their cells;
N – nutrition: take in or make their own food, which when broken down releases energy for its use

1.2 BIOLOGICAL ORGANISATION

Living things are organized, forming a complex organization that scientists often refer to as the biological organization of life. It begins with the **cell**, which is the basic unit of life. Cells differ in size and shape, some are microscopic while others are large enough to be seen with the naked eye (see Chapter 2). Many cells together form **tissue** – such as heart tissue or lung tissue, which are specialized to form an **organ**. Thus, the heart which is an organ consists of (specialized) tissue. Many organs make up the **organ system** – thus the heart and blood vessels and the blood make up the transport or circulatory system. Similarly, many organ systems, like the digestive system, are made up of many organs.



Many organs systems make up an **individual organism.** Your body has many organ systems including a digestive system, a respiratory system, an excretory system. Many individuals make up the **population,** and many populations make up a **community.**

A community and its environment make up the **ecosystem** and the global sum of all ecosystems make up the **biosphere,** which is that part of the earth and its atmosphere that can support life.

The study of Biology is vast and varied as life is vast and varied. From the study of microscopic structure of unicellular organisms like bacteria and virus to the global interactions of millions of organisms, biology encompasses them all. It also includes life histories of organisms and collective life histories of all organisms.

The biological themes that this text book discusses, supports those themes that you study in the Form 5 Biology syllabus. These include (1) cell biology, (2) Classification, (3) Plant and Animal (Human) Form and Function, (4) Ecology and (5) Genetics. The information given under these themes in this text is very basic, but it is sufficient at this level. As you progress in to higher forms, you will study these themes and more in greater detail.

1.3 WHY IS BIOLOGY SO IMPORTANT?

The careers of many people are concerned directly or indirectly with many aspects of applied biology. A career in the field of medicine, as agriculturalists, in biotechnology, environmental monitoring and conservation management deal with specialized aspects of biology.

The world around us is dynamic and ever changing. Some changes are a result of abuse of natural resources, some are a result of advances in technology, some are result of a combination of both. All changes, however, affect us in some way because planet earth is our home. Biology helps us to understand these inevitable changes, teaches us how we can cope with these changes, and our part in these changes. The study of biology helps us to understand and appreciate ourselves, and the living organisms that share this great planet with us.

Review Questions

1. What does the word 'biology' mean?
2. Define and give examples of the following terms: ecosystem, community, organ systems, tissue, cell organelle.
3. List some characteristics of living things.
4. Why is biology important?

CHAPTER 2

CELLS

2.1 BRIEF HISTORY

The term **cell** was first used by Robert Hooke in 1665 when observing cork tissue under a simple compound microscope. The image he saw looked like tiny compartments or cavities that used to accommodate monks and also reminded him of cells in a honeycomb. This association led him to call the cavities 'cells'.

The discovery of the cell was only possible with the invention of the microscope. The type of microscope designed and built differed according to the purpose of the work being carried out by the different scientists involved. The major growth in the construction of the microscope happened mostly between 1665 and 1855. Scientists recorded as being involved in this process included

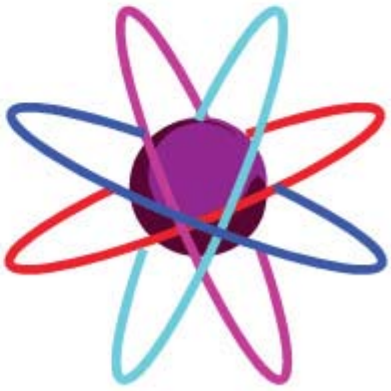
Robert Hooke – 1665
Anton van Leewenhoek – 1674
Matthius Schleiden – 1838
Theodor Schwann – 1839
Rudolf Verchow - 1855

A compound light microscope

This name has since been used to describe the basic structure of all living organisms, although more is now known about its variation in shape and how this is related to its structure and function. It is now common knowledge that the basic structural and functional unit of all living things (animals and plants) is called a CELL. Some organisms are one celled – unicellular, while others multicellular, being made up of many cells.

The invention of the microscope and the work of two scientists, Matthias Schleiden (1938) and Theodor Schwann (1839) led to the postulation of the CELL THEORY which states that:

a. the cell is the basic structural and functional unit of all living organisms
b. all cells are derived from cells that were already in existence.

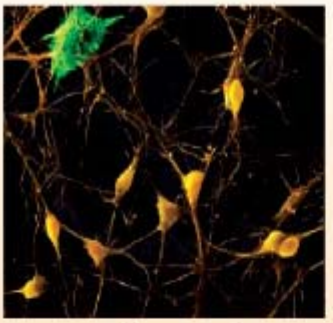


2.2 SIMILARITY AND VARIATION IN CELLS

Although cells are very similar in their basic structure, they vary in shape and size depending on their purpose. This means that there is really no such thing as a 'typical' cell. This can be seen in Figure: 2.1 where the shape and size of the cell is related to its function.

Figure 2.1

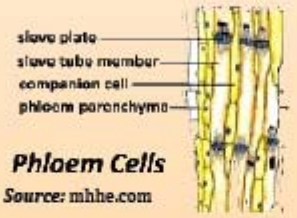
Variety of Cells



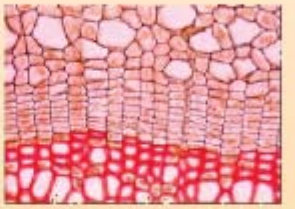
Nerve cells
Source: emc.maricopa.edu

Red Blood Cells
Source: 3dscience.com

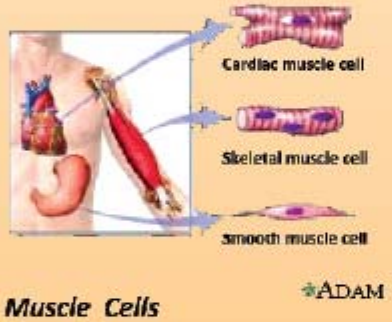
Yeast Cells
Source: historyforkids.org



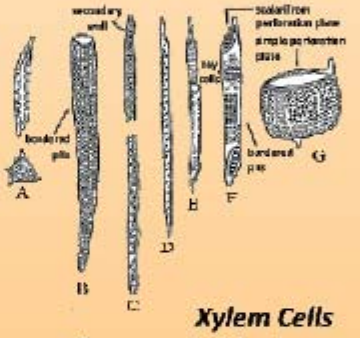
Phloem Cells
Source: mhhe.com



Cambium Cells
Source: biologie.uni-hamburg.de



Muscle Cells
Source: nytimes.com



Xylem Cells
Source: ucmp.berkeley.edu

2.3 MICROSCOPE

Microscopes come in different forms and shapes, providing a variety of strengths and designed specifically for a range of uses. Some types are

1. The Monocular and Binocular light microscopes differ only in the number of eyepieces: one (monocular) or two (binocular). The light microscope is the oldest and simplest of microscopes and the type most commonly used in high school today. Usually having two or more lenses, thus called a compound light microscope, the eyepiece may have a magnification of 10x while the objective lens may be up to 100x magnification in power.

2. A dissecting microscope, sometimes called a stereoscope, is one that is designed to help magnify and examine 3-dimensional objects rather than samples on prepared slides.

3. The Scanning Electron Microscope or SEMs are electron microscopes that use high energy beam electrons projected in a certain pattern. These electrons interact with the atoms that the sample is made of and signals are produced that give information on the properties and characteristics of the sample.

Figure 2.2 **Types of Microscopes**

Monocular Light Microscope

Source: Microscope.org

Dissecting Microscope

Source: digitalsmicroscope.com

Scanning Electron Microscope

Source: microscopesmanufacturer.com

Binocular Light Microscope

Source: milescoscientific.com

2.3.1 HOW THE MICROSCOPE WORKS

2.3.11 Parts and Function:

There are intricate patterns of organization inside the tissue of plants and animals, and there is an entire world of thousands of plants and animals which is invisible to the human eye. We use a microscope to see those animals and plants and to see, what plants and animals are made up of. To be able to have a good look at the world of microorganisms, we must know the parts of the microscope and how to use it correctly.

Given below is a list of the parts of a microscope and their functions:

a. The eyepiece: This is the removable cylinder at the top of the microscope. It contains one set of lenses which can magnify the view of the object.
b. The Tube (Barrel): A hollow cylinder that holds lenses in their correct positions. The upper portion contains the eyepiece (where we look through with our eyes)
c. Nosepiece: is fixed to the base of the tube. The lower part of the nosepiece is movable.
d. Objective Lenses: Interchangeable lenses with different magnifying powers. Usually have Lower Power Lens (Low Power Objective 4x, 5x, 10x) and High Power Lens (High Power Objective 40x, 100x, 400x).
e. Stage and Clips: Stage is the platform on which the slide is placed for observation and the clip holds the slide in position to prevent it from shifting or moving.
f. Diaphragm: (Iris Diaphragm) Controls the amount of light that enters the stage to the objective lens.
g. Mirror: Reflects / directs light through the diaphragm to the specimen and lens system. [In some microscopes, an electric bulb is the source of light]
h. Arm: Provides a place to grasp with fingers and lift the microscope.
i. Base: A heavy lower platform to ensure that the microscope sits well on the surface.
j. Coarse Adjustment Knob: Moves the lens rapidly with respect to the slide. [Used before Fine Adjustment Knob]
k. Fine Adjustment Knob: Moves the tube / barrel slightly with respect to the slide. This should be the ONLY focusing knob used with high power lenses.

2.3.12 Care and Maintenance of Microscopes

Great care must be exercised when using expensive equipment such as the microscope.

a. Use both hands to carry the microscope. [One hand grasps the bottom of the base while the other grasps the arm]
b. Take great care of lenses by ensuring that they are clean. [If dirty, report to the teacher for cleaning. DO NOT attempt to clean the lens using any type of paper or cloth. Lens cleaning paper must be used.]
c. After using the microscope, make sure that the microscope is dried thoroughly, and stored safely in its box/ case, with the lowest objective lens in place.
d. Make sure that the microscope is not left near to the bench edge. [Eg: must be 8cm or more from the bench edge]

2.3.13 Magnification and Resolution

Magnification is simply the enlargement of a specimen under the magnifying power of the eyepiece and objective lenses. The total magnification of the specimen may be calculated as follows:

Total Magnification = eye piece magnification X objective lens magnification

Example: A specimen is seen under 5x eyepiece magnification and 10x Low Power Objective.
Therefore, Total Magnification would be:
Eyepiece magnification = 5x
Objective Lens = 10x

Total Magnification = eyepiece x objective lens
= 5x x 10x
= 50x

The specimen is magnified 50 times.

Resolving Power/Resolution: of a microscope is the ability of the microscope to clearly separate small details present in an object. It is the microscopes ability to distinguish fine detail.

Example: A tiny dot (•) is resolved by the objective lens under high power objective and separates into two dots (• •). The eyepiece then magnifies (enlarges) what is resolved by the objective lens.

2.3.14 How Images Appear?

Points to Remember:

- When the specimen is moved to the right, the image moves to the left and vice versa.
- Moving the specimen up causes the image to move down and vice versa.
- When the letter "**e**" is placed under the microscope, the image appears enlarged and "upside down" (inverted) as shown in the box below:

2.3.15 Steps In Using a Light Microscope

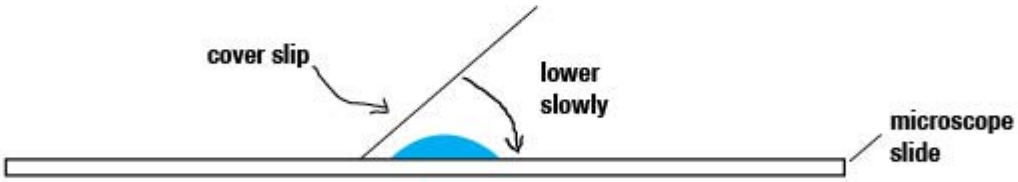
a. Using the coarse adjustment knob raise the nose piece (barrel) of the microscope;
b. Rotate the nose piece until the low power lens clicks into position in line with the body tube
c. Open the diaphragm fully to allow as much light to enter the specimen on stage.
d. Look down through the eyepiece and turn the mirror towards the source of light. [Not directly towards the sun] Adjust the mirror until a circle of white light appears forming the field of view [The microscope is now ready for use]
e. Place the mounted or stained slide at the center of the stage and use clips to fasten.
f. By looking from the side, use Low Power Objective and Coarse Adjustment to bring the lens of the Low Power Objective about 3mm above the specimen. [Be careful not to allow the coverslip to touch the lens]
g. Look through the eyepiece and slowly turn the coarse adjustment until the image comes into view. [Make sure to focus by RAISING the tube NOT LOWERING it]
h. Using Fine Adjustment Knob move the knob SLOWLY back and forth until a clear view is obtained.

Points to note:

- The slide can be moved up or down, right or left in order to get a field of view that encompasses the structures you wish to see;
- Use Fine Adjustment Knob to get a clear view of the specimen. NEVER USE COARSE ADJUSTMENT WHEN USING HIGH POWER [IT MIGHT CRASH INTO THE SLIDE CAUSING IT TO BREAK].
- To observe under HIGH POWER, turn to the high power objective lens while looking from the side.
- Remember there is less light in high power than in low power.

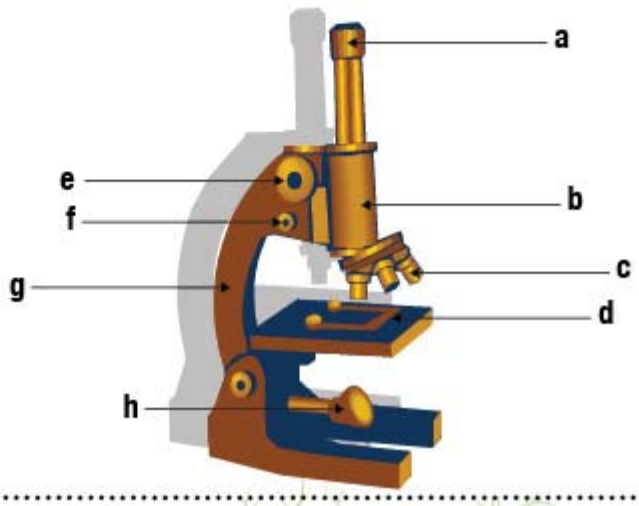
2.3.16 Steps in Preparing a Wet mount

a. Clean a glass slide and a coverslip with water. Hold them by the edges to avoid finger prints. Place the clean slide on a piece of paper or cloth.
b. Place the specimen at the center of the slide and cover it with a drop of water using a dropper.
c. Hold the cover slip at an angle of about 45^0 and slowly lower the cover slip (see diagram below) making sure that no bubbles are trapped. [Air bubbles will spoil the image seen under the microscope. If air bubbles are trapped under the cover slip, wash and dry slide and repeat step (b).]
d. Use focusing techniques in the steps to using a microscope to get a clear image.



Exercise:

Diagram Of A Light Microscope



Label the parts (a-h) of the microscope given above and give their functions.

2.4 CELL STRUCTURE

The cell is the basic unit of all tissues. Therefore, a study of its components and the processes associated with its proper functioning, is an important step to studying and understanding any organism. Since there is a marked difference between plants and animals, the basic parts of their cells will also be different, although all cells have an outer boundary that ensures their internal components are confined within a manageable area. This makes it possible for each cell to function successfully.

The main function of plants is to make food from inorganic compounds found in their surroundings, by the process of photosynthesis. Animals on the other hand, are not able to make their own food but are dependent on plants to provide them with the nutrients they need. This accounts for the differences in the kind and number of internal organelles found in each type.

We will look at the boundary of the cell in more detail later in the chapter, but first let us look at the basic differences between animal cells and plant cells.

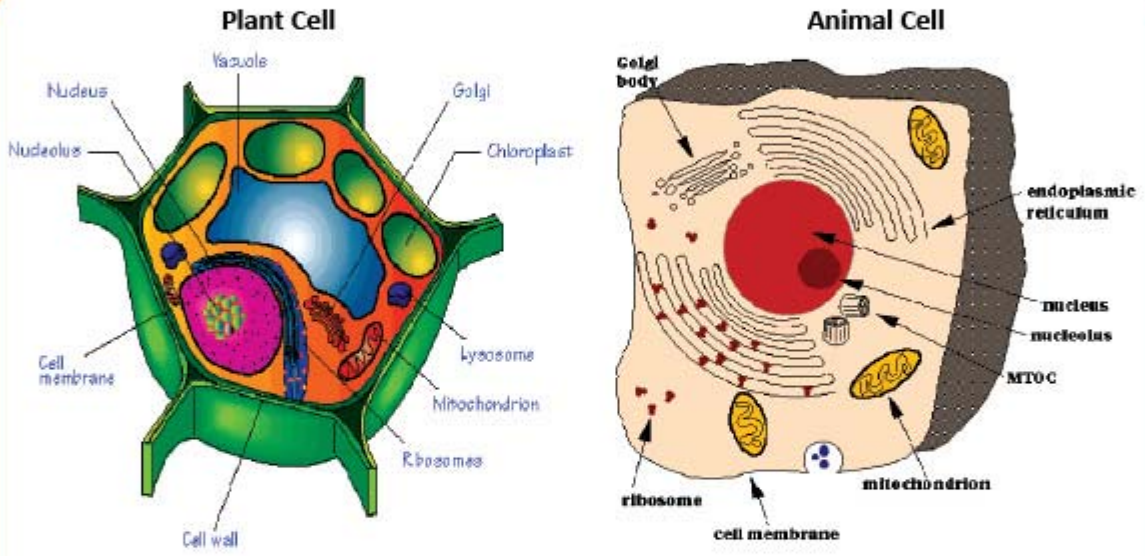


Figure 2.3 A generalized plant and animal cell showing the main features.

Source: www.nclark.net/Biology

GROUP DISCUSSION:

- What are the main differences between animal and plant cells?
- How do these differences influence the internal structure of these cells?

All cells are made of a living material known as PROTOPLASM bounded by an outer CELL MEMBRANE (in animals) and a CELL WALL (in plants). There is a NUCLEUS or central controlling centre, made of a material known as NUCLEOPLASM. The nucleus contains the genetic material called deoxyribonucleic acid or DNA.
The rest of the cell material is called the CYTOPLASM and is made up mostly of water and proteins, and contain the following organelles and structures:

a. VACUOLE which stores dissolved nutrients, minerals and elements such as oxygen and carbon dioxide. They vary in shape and size depending on the function of the cell in which it is found. For example, in plant cells vacuole is relatively large in comparison than in animal cell.

b. MITOCHONDRION or 'power house' of the cell, where energy is produced. It is the site of the respiration reaction.
c. CHLOROPLAST which contains pigments for photosynthesis and is the site of photosynthesis.
d. RIBOSOMES where proteins are made.
e. GOLGI BODIES which act as a temporary storage for modifying and transporting large molecules.
f. LYSOSOMES where nutrients, foreign materials and damaged organelles are digested or broken down.
g. ENDOPLASMIC RETICULUM where large molecules are made or synthesized. Large molecules such as fats (LIPIDS) and molecules derived from fats such as PHOSPHOLIPIDS and STEROIDS are made in the SMOOTH ENDOPLASMIC RETICULUM. Large molecules such as PROTEINS are made in the ROUGH ENDOPLASMIC RETICULUM.
h. CENTRIOLES which form the fibers along which chromosomes move during cell division.

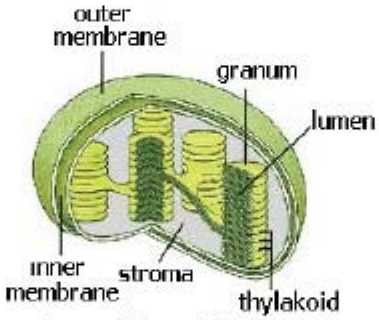
The vacuoles, golgi bodies, lysosomes and endoplasmic reticulum are bound by a single membrane. The other organelles such as mitochondrion, chloroplast and ribosomes are bound by a double membrane and will be studied in more detail in Form six.

Figure 2.4 **Diagrams of Cell Organelles:**

a. Mitochondria

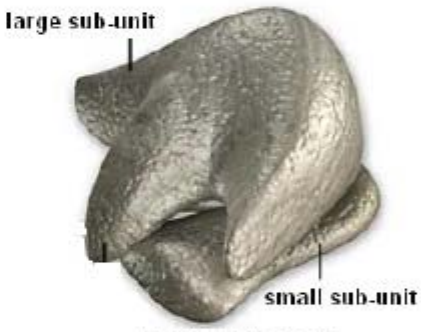
Source: photobucket.com

b. Chloroplast



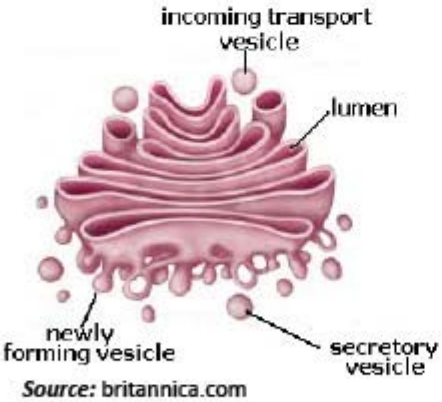
Source: blogger-index.com

c. Ribosomes



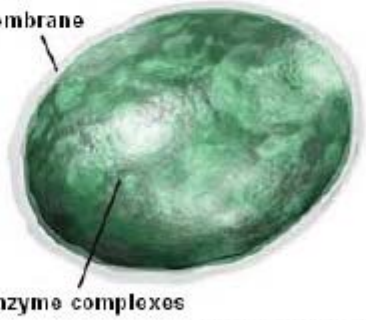
Source: cartage.org

d. Golgi bodies



Source: britannica.com

e. Lysosomes



Source: education.king.edu

f. Endoplasmic Reticulum

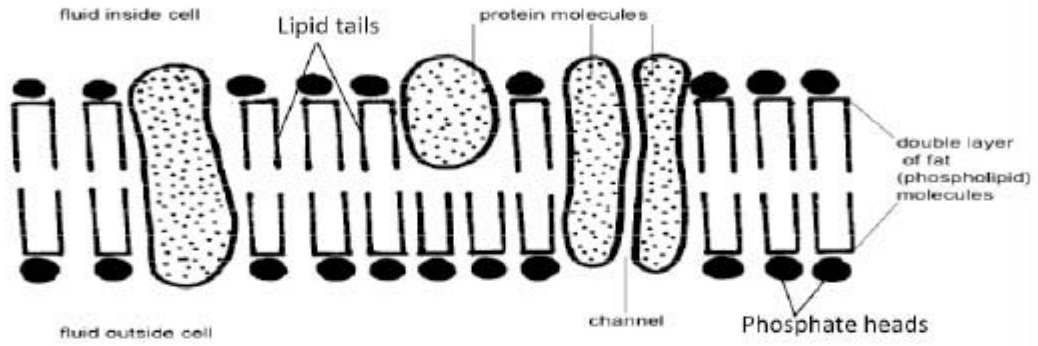
Source: epiehonorsbilogy.wikispaces.co

g. Centrioles

Source: picsearch.com

2.5 THE CELL MEMBRANE

The cell membrane is a thin layer bordering the cell, and controls molecules and nutrients moving in and out of it. The membrane consists of two layers of PHOSPHOLIPID MOLECULES facing each other, a BILIPID layer. Each molecule consists of a phosphate structured 'head' with two chains of lipid molecules hanging from it, known as 'tails'. Each phospholipid layer is arranged such that the heads of each layer are facing outward while the tails are facing inwards.



The Bi-lipid Layer Cell Membrane

Source: dogsresort.com

The structure of the head is such that it acquires a characteristic "**polar**" effect, making it attract water molecules which are also polar. The head end is said to be **HYDROPHILIC** or 'water-loving". The structure of the tail end of the phospholipid layer on the other hand, gives it a characteristic "**non-polar**" effect making it resist or repel water molecules. Thus the tail end is said to be HYDROPHOBIC or "**water-hating**".

2.6 CELL TRANSPORT - MOVEMENT OF MOLECULES ACROSS THE CELL MEMBRANE

The movement of molecules is influenced by the concentration of the internal and external solutions of the cell. The size of the molecules and the presence or absence of a cell membrane which is semi-permeable in nature are also influencing factors. A number of terms used to describe the various types of movement are as outlined as follows:

a. Diffusion: This is when small molecules move from an area of high concentration to an area of low concentration. This process does not require energy and is an example of *PASSIVE TRANSPORT*.


COLLABORATIVE DISCUSSION

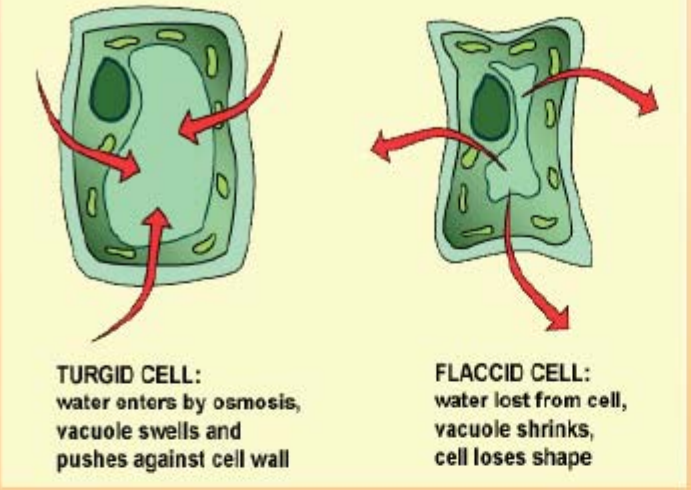
How does the structure of the phospholipid layer influence the movement of water and other polar and non-polar molecules across it?

In an internal environment of high water concentration, as the polar water molecules move towards the polar head, they take with them dissolved ions or dissolved molecules. It is by this method that nutrients enter into, and unwanted substances move out of, the cell.

If however, substances wanting to move across the membrane are non-polar in nature, then they will dissolve in lipids which can easily enter the non-polar "tail" of the phospholipid layer because of their likeness in (identical) nature.

This characteristic property of the phospholipid layer or cell membrane, enables it to transport certain molecules in and out of the cell. It is said to selectively absorb or to be selectively permeable in nature.

b. Osmosis: This is the movement of **water molecules** from an area of low solute concentration to an area of high solute concentration, but across a semi-permeable membrane such as the cell membrane. The movement is regulated by the properties of the cell membrane structure.



In plant cells, for example, the movement of water molecules *into the cell* by osmosis results in a condition known as TURGIDITY. The presence of a cell wall around the cell membrane produces a boundary, causing the cell to swell or become TURGID. When water molecules move *out of the cell* also by osmosis, the process is called PLASMOLYSIS. This results in a condition known as FLACCIDITY, where the cell shrinks and becomes FLACCID.

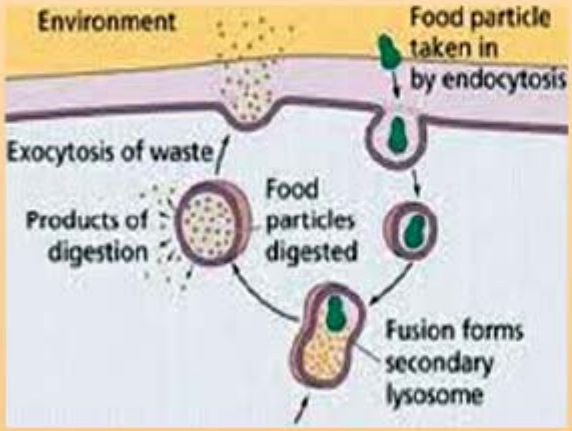
Figure 2.5 Flaccid and Turgid Cells

Source: leavingbio.net

c. Exocytosis: This is the movement of vesicles carrying molecules or particles out of the cell across the cell membrane.

d. Endocytosis: This is the movement of molecules or particles into the cell across the cell membrane. The movement of large molecules into the cell is know as PHAGOCYTOSIS, while the movement of fluids is known as PINOCYTOSIS.

Figure 2.6 Exocytosis and Endocytosis



Source: ww.basisoflife.wikispaces.com

Exocytosis and endocytosis involve the formation of vesicles around the particle of food or unwanted substance that is to be transported across the membrane. The cell membrane curves around the particle or substance until eventually the particle or substance is completely surrounded by the membrane. The phospholipids bi-layer meets and forms a continual layer producing a VESICLE, while the rest of the cell membrane closes the gap and forms a continuous new layer.

In exocytosis, this vesicle moves to the cell membrane and it's contents are expelled out of the cell and into the environment, or in the case of endocytosis, the vesicle is taken into the cell and the food released into the lysosomes to be digested. (Figure 2.6)

The given description of the movement of materials across the cell membrane seems simple and straight forward, and part of the process is. However there exists a variety of different types of protein molecules positioned within the phospholipid bilayer that provide support and protection, and influences the transport process making it specific and accurate.

TEACHER-LED DISCUSSION:

Using the diagram below, provide leading questions to get the students to arrive at the process and definition of

i. DIFFUSION, ii. OSMOSIS and iii. ACTIVE TRANSPORT.

The movement of molecules from one solution to another across the cell membrane produces **three** conditions within the cellular environment;

HYPERTONIC: The concentration of the solution inside the cell is higher than the concentration of the solution outside the cell. Water molecules easily move into the cell.

HYPOTONIC: The concentration of the solution outside the cell is higher than the concentration of the solution inside the cell. Water molecules easily move out of the cell.

ISOTONIC: The concentration of the solution inside the cell is equal to the concentration outside the cell.

When molecules move from an area of high concentration to low concentration, they are said to be moving along (or moving down) the concentration gradient (i.e molecules are moving with the flow of the majority of their kind). No energy is required and the transport process is PASSIVE. Small molecules such as oxygen, urea, carbon dioxide and fatty acids can move directly through the lipid layer of the cell membrane by this method.

e. Active Transport: Sometimes molecules can move from an area of low concentration to an area of high concentration where molecules are moving against (or moving up) the concentration gradient. This is hard work and molecules need energy to do this. Since energy is required, the process is called ACTIVE TRANSPORT and is explained in more detail below.

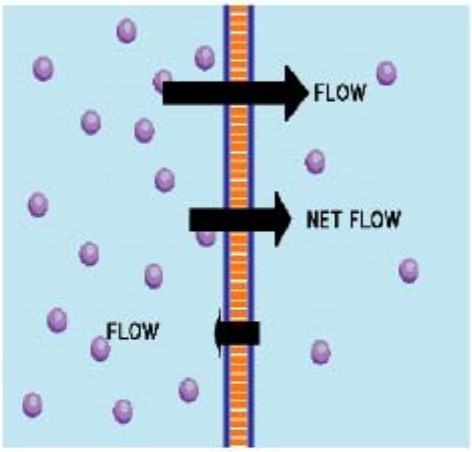


Figure 2.7: Movement of particles across as semi-permeable membrane

2.7 THE ROLE OF PROTEIN MOLECULES

Molecules that are too large need to be assisted when attempting to travel across the cell membrane. Protein molecules embedded in the phospholipids layer are responsible for providing this assistance.

CHANNEL PROTEINS allow water and other small molecules to pass through them to enter or leave the cell by the process of osmosis already described. (Fig 2.7a)

CARRIER PROTEINS help larger molecules such as amino acids to travel across the cell membrane. This process requires energy (ATP) and is therefore ACTIVE TRANSPORT. (Fig 2.7b)

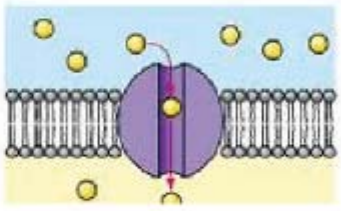


Figure 2.7a: Channel proteins

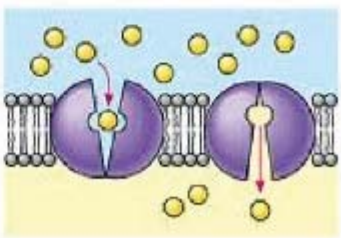


Figure 2.7b: Carrier proteins

Source: kentsimmons.uwinnipeg.ca

2.8 CELL GROWTH

As food and required nutrients enter and waste materials leave across the cell membrane, cell growth perpetuates to a size where the rate of transportation begins to become too slow to maintain the rate of growth. Nutrients and oxygen need to be transported to where they are needed fast enough to produce the desired growth rate.

As the cell grows it reaches a size where the rate of transport cannot maintain the growth rate sufficiently to produce efficient metabolism in the cell. When this happens all internal cellular processes begin to slow down. In order to prevent a slow internal decay of the cell, the cell begins to divide into two smaller fractions or cells.

This process is essential to maintain maximum internal cellular processes. In other words, cell division is necessary to ensure its survival. At the same time, the number of cells is increasing and producing growth of the entire tissue, system and organism.


COLLABORATIVE DISCUSSION

Students are to go through the activity on cubes of different sizes (1 cubic cm, 2 cubic cm and 3 cubic cm). In the process of calculating the surface areas and the volumes and determining their ratios, they should be able to deduce the necessity of cells dividing.

2.8.1 Cell Division

Cells need to divide in order to survive. This process contributes to an increasing number of cells which in turn ensures growth of the organism. This type of cell division which results in an increasing number of cells is known as MITOSIS.

Mitosis produces cells which are identical to each other and to the cell from which they originated. This ensures that stem cells produce stem cells during growth; skin cells produce skin cells etc.

A second type of cell division particular only to sexually reproducing plants and organisms is concerned not with increasing numbers but with increasing variety. This cell division is known as MEIOSIS. It is a particularly important type of cell division because it ensures that a *variety of types of cells* are produced, and therefore, contributes to variation and the progression of the species population, whether it be plant or animal.

MITOSIS

Mitosis occurs in stages taking each cell through from one phase to another, and eventually back to their original phase. All the components of the cell, such as the cell membrane, the cytoplasm, the nucleus, the nuclear membrane and the chromosomes undergo changes. Energy is required for each of these changes, and may often be drawn from other processes that are happening in the same organism or plant.
There are five sequential phases of mitosis and each phase will be described in some detail. It is important however to note at this point that mitosis does not always start at stage 1.

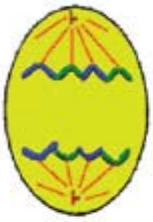
Interphase

- this is the stage between cell division processes. Cells that are not undergoing mitosis are in the interphase stage.

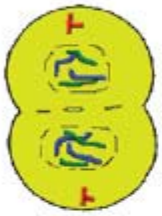
Prophase

- chromosomes shorten and thicken and become visible;
- spindle fibres begin to form outside the nucleus and the centrioles, if present, move to the poles and become the origin for the spindle fibres

Metaphase
- the nuclear membrane disintegrates;
- centrioles complete movement to the poles
- chromosomes are aligned halfway between the two spindle poles



Anaphase
- spindles fibres attached to kinetochores begin to shorten and pull apart the sister chromatids to opposite poles
- this ensures that daughter cells get identical sets of chromosomes



Telophase
- a new nuclear membrane appears and surrounds each group of chromosomes
- cytokinesis (division of the cytoplasm) occurs to produce two daughter cells

(Source of mitosis diagrams: www.biologycorner.com)

MEIOSIS

This important cell division follows very closely the sequential steps outlined in mitosis. The exception is that this process occurs in two major steps; meiosis I and meiosis II. It occurs in this manner because of the purpose of meiosis which is to influence the production of variety in the population of species. As already mentioned, meiosis is essential for the process of sexual reproduction.

When meiosis occurs, it results in the production of non-identical cells with only half the number of chromosomes as its cell of origin. This is the reason for meiosis occurring in two major steps, each encompassing the sequential stages found in mitosis.

Meiosis I – in this type of nuclear division, cells are formed that have only one copy of each type of chromosome. Homologous pairs of chromosome separate independently of each other.

Interphase: the stage in which the cell spends most of its time, and carries out its function, including preparation to undergo cell division. The chromosomes are invisible in this stage;

Prophase I:
The chromosomes duplicate themselves and sister chromatids are held at the centromere. Homologous chromosomes synapse. Spindle fibres form and the nuclear envelope breaks down. Crossing over may occur at this stage because of closeness of chromosome pairs to each other

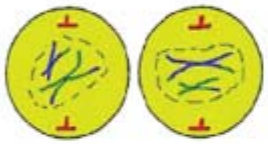
Metaphase I:
Spindle formation is complete and bivalents(two homologues)are aligned at the equator.

Anaphase I:
Homologues with their centromeres intact now separate and move to opposite poles. Cytokinesis begins.

Telophase I:
The spindle fibres dissolve and nuclear envelopes form. Daughter nuclei are haploid. Each chromosome is still duplicated. Cytokinesis results in two distinct cells.

MEIOSIS II

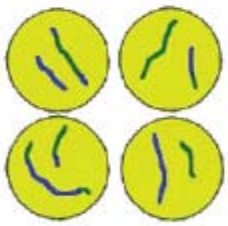
Although, this phase may differ from species to species, it is basically a mitotic division where sister chromatids divide and move toward the poles.



Prophase II
Chromosomes are still duplicated. Spindle fibres begin to form and the nuclear membrane disintegrates

Metaphase II
Spindle formation is complete and duplicated chromosomes are aligned at the equator

Anaphase II
Centromeres divide and chromatids separate. Haploid sets of daughter chromosomes move to opposite poles.



Telophase II
Spindle fibres dissolve and nuclear envelopes reform. Daughter nuclei are haploid and genetically unique. Cytokinesis results in four daughter cells

(Source of Meiosis diagrams: uic.edu)

COMPLEMENTARY ACTIVITY

Create models from simple objects like plasticine, strings, sticks and clay to represent chromosomes at various stages of cell division in mitosis and meiosis.

2.9 COMPARISON OF MITOSIS AND MEIOSIS

Mitosis	Meiosis
• More common occurrence because it allows for growth and repair of tissues in multicellular organisms;	• Occurs only at certain time in the life cycle of sexually reproducing organisms to produce gametes;
• Only one nuclear division after the initial duplication of chromosomes;	• Two nuclear divisions after the initial duplication of chromosomes;
• No pairing of homologues during the process;	• Homologues pair at the equator during the Meiosis I process and allows crossing over to happen;
• Two daughter cells are formed at the end of the process;	• Four daughter cells are formed at the end of the process;
• Daughter cells are genetically identical;	• Daughter cells are genetically unique;
• Daughter cells are diploid.	• Daughter cells are haploid.

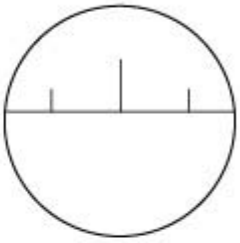
Review Exercises

1. What is a cell?

2. List some cell features that are similar no matter what cell type.

3. Differentiate between the following types of microscopes:
   a. Binocular and monocular;
   b. Compound (light) and electron

4. A transparent millimeter ruler was placed under the microscope at 200x as shown on the right:
   a. Calculate the diameter of the field of view at 400x magnification in micrometers (μm).
   b. If 4 cells were seen along the diameter at 400x magnification, calculate the size of one cell in micrometres.



5. Briefly explain how to prepare a wet mount

6. State the differences between a plant and an animal cell.

7. For each of the following cell organelles, given their feature and/or function:
   a. Lysosomes
   b. Chloroplast
   c. Mitochondria

8. Differentiate between diffusion and osmosis with examples.

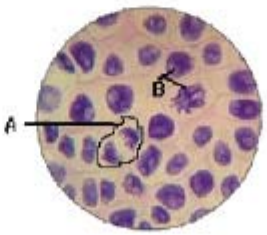
9. A piece of onion epidermis is soaked in a concentrated sugar solution overnight, removed and mounted on a slide. Draw the appearance of one cell.

10. Differentiate between endocytosis and exocytosis with examples.

11. For the following molecules, state the correct transport method across the cell membrane: water, calcium ion, sucrose (against the concentration gradient), droplet of liquid.

12. Summarise the stages of mitosis and meiosis.

13. With reference to the diagram on the right,
    i. what are the structures labeled B'
    ii. what stage of cell division is happening in A.
    Give a reason for your choice of stage



14. List the differences between mitosis and meiosis.

CHAPTER 3

TAXONOMY
(CLASSIFICATION)

Each living organism is identified by a scientific name that is universal. In order for this to be the case, an accepted world wide system of naming must be one that is recognized and used by all biologists. This system of naming is known as BINOMIAL NOMENCLATURE. It was originally proposed by a Swedish biologist by the name of Carl Linnaeus. This system categorises organisms into groups that share the same morphological features. Under this system all organisms in all the main divisions or KINGDOMS are given two names, with both names belonging each to a recognized group, known as GENUS and SPECIES respectively. The key used to identify and classify the organisms is called a DICHOTOMOUS KEY.

All organisms are members of one of five kingdoms; Monera (e.g. bacteria and blue-green algae), Protista (e.g. Paramecium and Amoeba), Fungus (e.g. mushroom, yeast and bread mold), Plantae and Animalia. Within the KINGDOM, each organism belongs to a particular PHYLUM. Within the Phylum, each organism belongs to a CLASS and within the Class, the organism will be a member of an ORDER. Within the Order, the organism will belong to a FAMILY, and within the Family, to a particular GENUS. Within the Genus, each organism will be a member of a particular SPECIES.

The example below illustrates this identification concept.

The crested iguana (local name: Vokai) belongs to the:
KINGDOM Animalia
PHYLUM Chordata
[SUB-PHYLUM Vertebrata]
CLASS Sauropsida
ORDER Squamata
[SUB-ORDER Iguania]
FAMILY Iguanidae
GENUS Brachylophus
SPECIES vitiensis

Thus the scientific name of the crested iguana is ***Brachylophus vitiensis.***

3.1 NAMING ORGANISMS

The scientific name of an organism consists of two parts – the genus and the species. Eg. The crested iguana's scientific name is *Brachylophus vitiensis* – the first part *Brachylophus* is the genus and the second part *vitiensis* is the species. Other examples are:

Battisa violecia:	freshwater bivalve (kai)
Rattus rattus:	rat
Canus domesticus:	dog

Rules for writing scientific names

1. There must be two parts to the name- Genus and species;
2. The first letter of the Genus is always capitalised, the first letter of the species is always in lowercase;
3. When handwritten, the scientific name is always underlined, if typewritten, it is in *italics.*

COLLABORATIVE WORK - A

1. Divide into groups of 4- and collect 20 items from your school compound. Sort out the 20 items into smaller groups, making note of the criteria used for the formation of the groups. Design a dichotomous key that can be used by another group to arrive at the same correct identification.

2. Test the accuracy of the key by having another group use it to identify each of the items collected. The results of their identification can then be matched with that of the group designer. The higher the percentage match, the more accurate the key designed as a separator. Award a point system so that the group with the best designed key gets the most points.

COLLABORATIVE WORK – B

1. Each group is to identify four or five endemic species of plants or animals. The members of each group need to conduct some research to find out the Kingdom, phylum, class, order, family, genus and species of each of their chosen endemic species.

COLLABORATIVE WORK - C

1. Each group is to create a display tray/board consisting of preserved animals of the same species.

3.2 KINGDOMS OF LIVING THINGS

The five most widely accepted Kingdoms are:

Kingdom Monera	e.g	blue-green algae and bacteria
Kingdom Protista	e.g.	*Paramecium* and *Amoeba*
Kingdom Fungi	e.g.	mushrooms and yeast
Kingdom Plantae	e.g.	algae and flowering plants
Kingdom Animalia	e.g.	snails, fish, birds and man

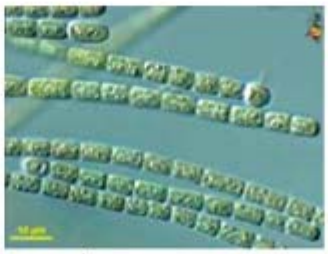
Viruses are considered to be neither living nor non-living and therefore cannot be seen to belong to any of the above Kingdoms. They are generally known for their disease causing nature in plants and animals. The structure and nature of viruses will be studied in greater detail in Form 7.

Understanding why organisms are grouped together helps in understanding how they function. The following information on classification is helpful to know and understand especially if one will be spending a lot of time working specifically with plants or animals.

3.2.1 MONERA

All organisms in this group are microscopic, unicellular and prokaryotic ie. they lack a membrane bound nucleus, and other organelles that are membrane bound. Some members are autotrophic while others are heterotrophic. Some have flagella for movement. The most common examples of monerans are the blue-green algae (cyanobacteria) and bacteria.

Examples of Monerans



Cyanobacteria

Source: quia.com

Bacteria

Source: lanesville.ki2.in.us

3.2.2 PROTISTA

The organisms in this group are mostly unicellular. However, they are eukaryotic i.e. they have a membrane bound nucleus and membrane bound cell organelles. Protists live in aquatic environments and are quite dissimilar in many aspects including feeding modes and method of movement.

Examples of Protozoans

Amoeba

Source: scientificillustrator.com

Trypanosoma

Source: postitart.blogspot.com

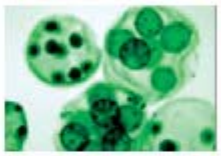
Paramecium

Source: biologinet.galeon.com

Scientists have divided the Protista into three divisions:

1. the protozoans (animal-like protists): are mostly heterotrophic, are motile and are generally categorized according to their mode of locomotion. Some are flagellated eg. *Trypanosoma* is responsible for African sleeping sickness, some are ciliated eg. *Paramecium* and some move by pseudopodia ('false feet') eg. *Amoeba*. One group of Protozoans (the *Sporozoa*) are parasitic and their lifestyles almost always involve spore formation. The human parasite, *Plasmodium vivax*, responsible for the spread of malaria is a sporozoan.
2. the plant-like protists: these photosynthesize like land plants producing food both in the oceans and freshwater bodies.
3. fungi-like protists (molds): these are saprophytic protists living on dead organic matter. They also produce spores. The slime molds and water molds are examples of fungi-like protists.

Plant-like and Fungi-like Protists



Source: bensonapbiology.wikispaces.net

Source: yourdictionary.com

3.2.3 FUNGI

Mostly multicellular, except for yeast which is unicellular, heterotrophic, mostly saprophytic, some parasitic, reproduce by spores, often have more than one nuclei, have a body structure made of **hyphae** instead of stems, roots and leaves. Some fungi are disease causing such as potato blight and ringworm. They are divided into three phyla; Phylum Zygomycota (also known as Phycomycota), Phylum Ascomycota and Phylum Basidiomycota.

Fungi

Source: en.wikipedia.org

Source: richard-seamen.com

3.2.4 PLANTS

This includes the Sub-kingdom Algae which exist in a wide variety of forms from unicellular to large multi-cellular plant-like structures, autotrophic whose main body structure is known as a **thallus.** They lack true roots, stem and leaves and are divided into three broad categories based on the dominant pigment present in them, namely Chloropyta (green algae), Rhodophyta (red algae) and Phaeophyta (brown algae).

Horsetails

Source: en.wikipedia.org

Mosses

Source: agenciazappa.com.org

The rest of the plant kingdom is made of species that are multicellular and whose basic structural unit is the cell whose walls are made of cellulose. They have true roots, stems and leaves and have specialized structures for reproduction.

Source: zonedenial.com

Many biologists differ in the categorizing of plants but the majority agree on the following phyla; Bryophyta (Classes Hepaticeae and Musci) and Tracheophyta which includes all those with a conspicuous and dominant sporophyte generation and vascular tissue with lignified cells. Club mosses and horsetails will be classified with bryophyta at this level although some biologists classify them into phyla of their own; club mosses in Lycopodophyta and horse tails in Sphenophyta.

All other tracheophytes are divided into the phylum Cycadopsida (cycads), phylum Pteridophyta (ferns), phylum Coniferophyta (Gymnosperms) and Angiospermophyta (Angiosperms). The angiosperms are further divided into the Classes Monocotyledoneae and Dicotyledoneae.

Source: lasquetipress.blogspot.com

3.2.5 ANIMALS

The animals are multi-cellular organisms with a high level of tissue differentiation and very highly specialized organ systems. Animals are heterotrophic; they produce haploid gametes and have a very well organized nervous system with well developed and articulately designed sense organs.

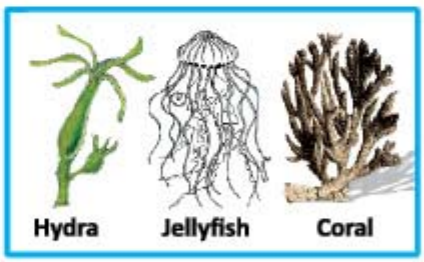
Animals are placed into one of the following phyla:

a. Phylum Porifera (sponges) – These animals have bodies that consist of two cell layers, the endoderm and ectoderm. They do not have mouths but have tiny pores (ostia) on their bodies through which water enters bringing oxygen and food. Wastes are removed through an opening at the top of the sponge called the osculum.

Source: kgs.ku.ed

b. Phylum Coelenterata (Cnidaria) – these animals also have a body consisting of two cell layers. There are two common body forms of the cnidarians which are medusa and polyp form.

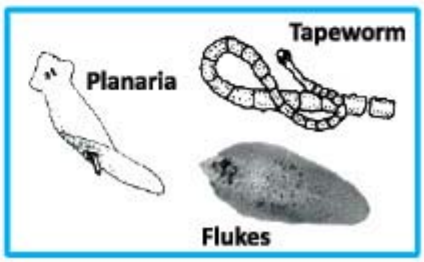
Class Hydrozoa eg. Hydra
Class Scyphozoa eg. jellyfishes
Class Anthozoa eg. corals



Source: scientificillustrator.org

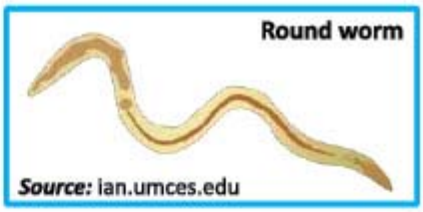
c. Phylum Platyhelminthes (flatworms) - These animals have dorso-ventrally flattened bodies, with one opening to their digestive system

Class Turbellaria eg. Planaria
Class Trematoda eg. the flukes
Class Cestoda eg. tapeworms

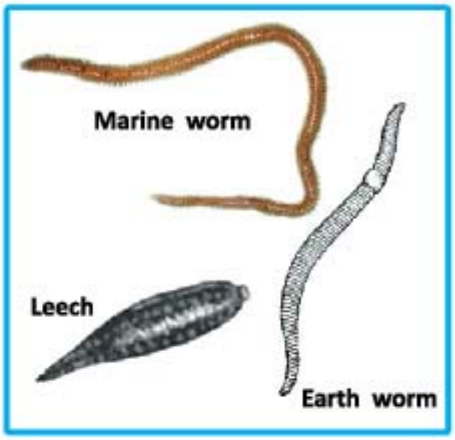


Source: scientificillustrator.org

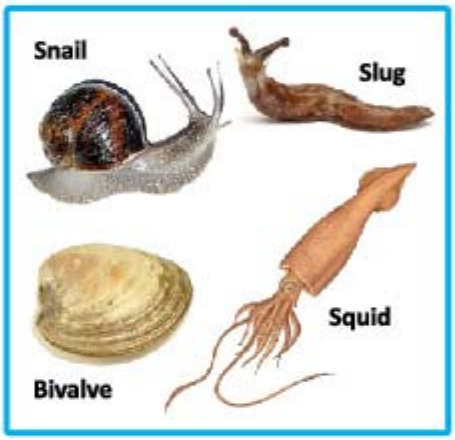
d. Phylum Aschelminthes (round worms) - These animals are mostly parasitic, having both mouth and anus.
Class Nematoda



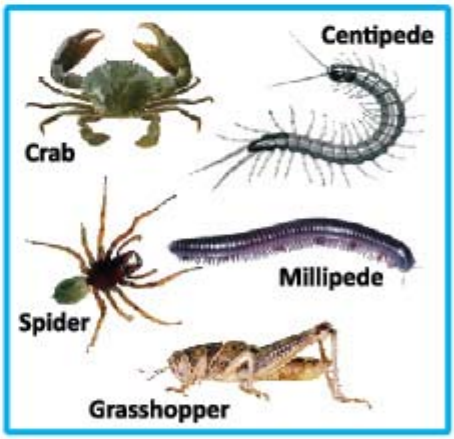
e. Phylum Annelida (segmented worms) - These animals show multiple segments, each segment having the same sets of organs.
Class Polychaeta (marine worms); The famous delicacy *balolo* (*Eunice viridis*) is a classic Fiji example of this class of worms.
Class Oligochaeta (earthworms)
Class Hirudinea (leeches)



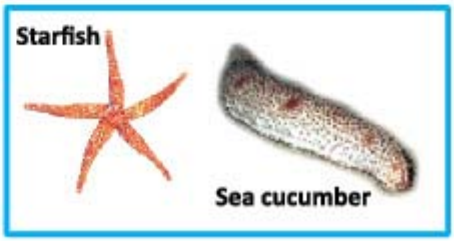
f. Phylum Mollusc
These animals are soft bodied, have a muscular foot, which in some members, like the octopus, is modified into tentacles. May or may not have shells.
Class Gastropoda eg. the snails (one shell) and slugs (no shell)
Class Pelecypoda(Bivalves) –all mollusks with two shells
Class Cephalopoda includes the octopus, squid, nautilus and the cuttlefish.



g. Phylum Arthropoda
These are animals that have 2-3 segments, have jointed appendages and an exoskeleton.
Class Crustacea (crabs, lobsters)
Class Chilopoda (centipedes)
Class Diplopoda (millipedes)
Class Insecta; An endemic Fiji example is the 'nanai' (*Raiateana knowlesi*) and belongs to the order Hemptera and the family Cicadidae. This species is a delicacy in areas of Navosa and Serua.
Class Arachnida (spiders)



h. Phylum Echinodermata
These are spiny bodied animals that includes the starfishes and sea cucumbers.



i. Phylum Chordata

Sub-phylum Vertebrata – members have a backbone (vertebrae)

Class Chondrichthyes – the cartilaginous fishes

Class Osteichthyes – the bony fishes

Class Amphibia eg. toads

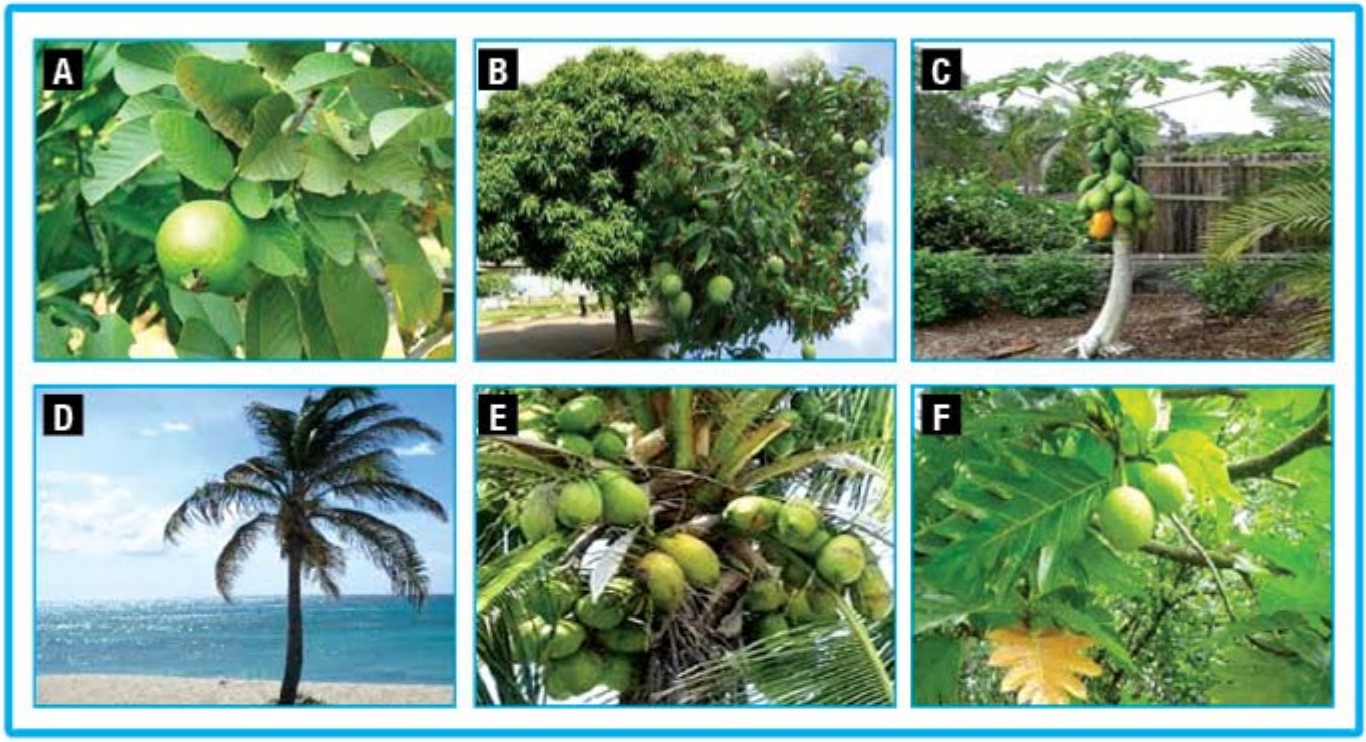
Class Reptilia eg. snakes

Class Aves eg.birds

Class Mammalia eg. Horses

Review Questions

1. Explain the need to classify organisms into groups.
2. Use the dichotomous key given below to identify the following local trees in the box:



Dichotomous Key

1. Bears fruit……..……Go to 2
   Does not bear fruit……palm tree
2. Tree with many side branches……Go to 3
   Tree with no side branches…… ……Go to 4
3. Single seed in fruit……mango tree
   Many seeds in fruit……Go to 5
4. Fruit is soft when ripe……pawpaw tree
   Fruit is hard……coconut tree
5. Seed is small in size……guava tree
   Seed is medium in size……breadfruit tree

3. Name two ways in which the following pairs of organisms may be distinguished from each other:
   a. a snake from a shark
   b. a banana plant from a fungus
   c. grass from a pawpaw tree

4. The scientific names of some local plants and animals are given below. For each example, identify the genus and the species.
   a. Agathis vitiensis (Dakua tree)
   b. Pinus caribeae (Pine tree)
   c. Bufo marinus (cane toad)
   d. Brachylophus vitiensis (Crested iguana)
   e. Chelonia midas (Green turtle)
   f. Tridacna gigas (giant clam)

5. Suggest a reason why birds and mammals have fewer offspring compared to other chordates.

CHAPTER 4

PLANT BIOLOGY

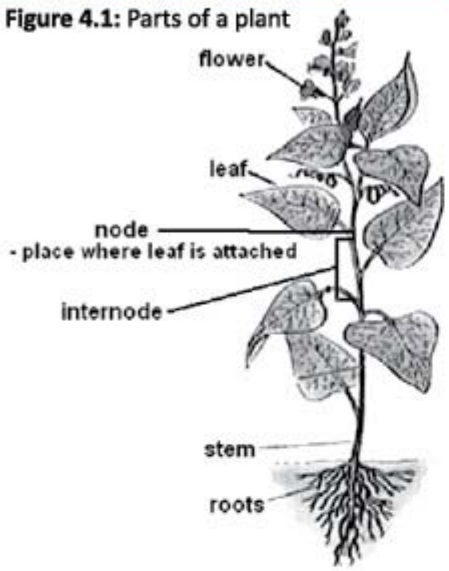


Figure 4.1: Parts of a plant

Source: hnosrodriguez.com.mx

All plants belong to the Kingdom, PLANTAE or PLANT and as evidenced, vary widely in colour, size, structure and adaptation to the environment. Regardless of the variety and diversity that is obvious in most land plants, there are some features that are common to most plants as can be seen in Figure 4.1.

These features include the **roots,** that are responsible for anchorage and absorption; the **stems,** that support the leaves and branches and also transport materials; and the **leaves,** that are responsible for making food for the plant. Flowers are only present in the Angiosperms (the Flowering Plants) and for this group of plants, the flower is the reproductive structure. Also, only the angiosperms produce **fruits.**

The first plants were believed to be aquatic. Today, however, only a very small percentage of plants are aquatic, the vast majority being terrestrial.

Throughout the history of human kind, plants have been very important as a source of food. Cereals and fruits, staples like taro and cassava, and vegetables have been a part of the diet of people the world over.

In order to assist with the identification and naming of plants, scientists have devised a system to organize them into similar groups depending on the presence or absence of certain structures.

The illustration in Figure 4.2 below outlines the main divisions of plants:

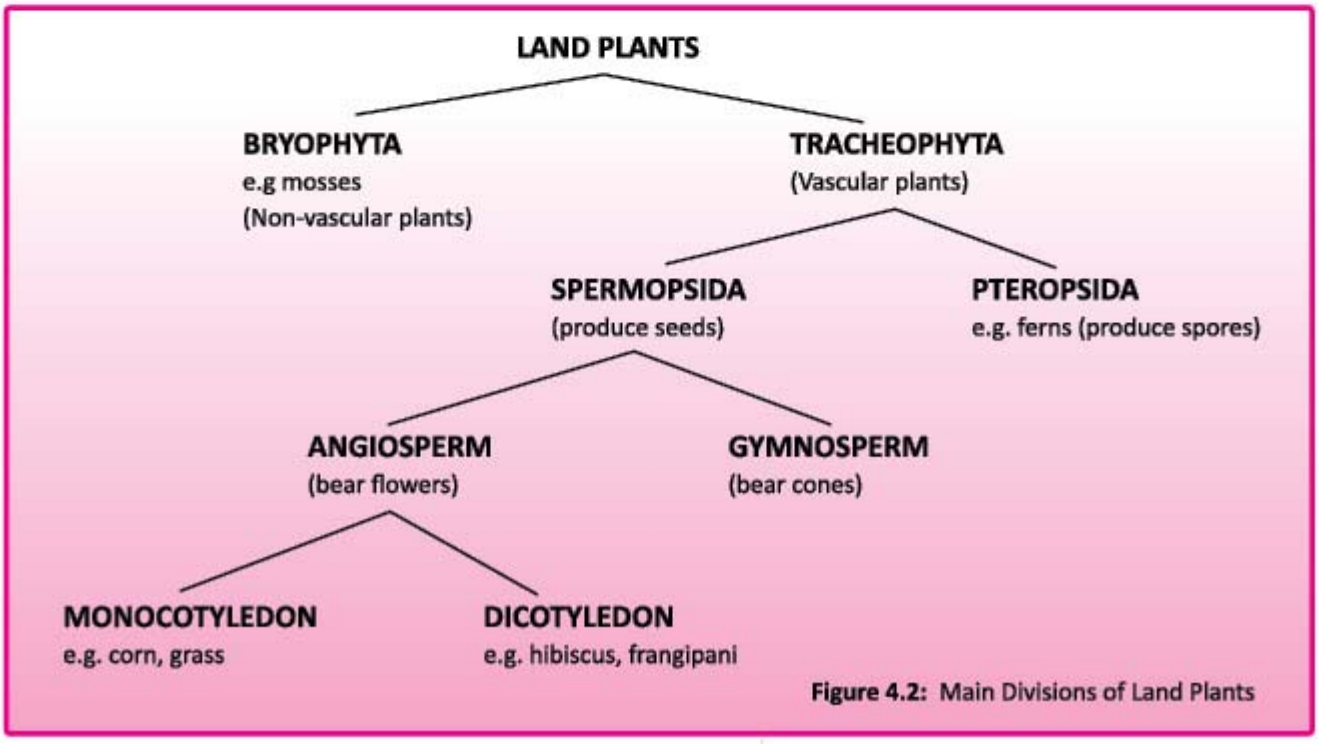


Figure 4.2: Main Divisions of Land Plants

The structure and function of plants discussed in this text book will be limited to those with vascular tissue (Tracheophyta), have seeds as their reproductive structures (Spermopsida) and bear flowers (Angiosperms).

4.1 FLOWERING PLANTS

All flowering plants have three basic parts:

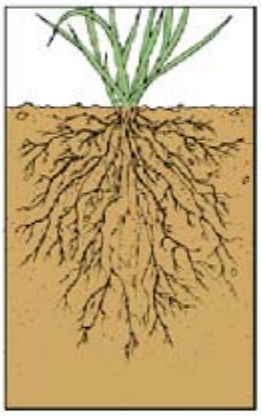
4.1.1 Roots

All flowering plants need to have firm anchorage for two main reasons:

1. To expose their flowers for reproduction;
2. To be able to grow very large and tall.

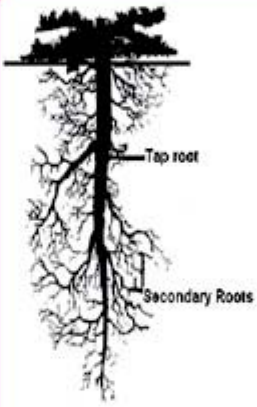
There are three main types of root systems; fibrous, tap root and adventitious root systems. A comparison of the fibrous and tap root systems is given in below. Some plants such as bulbs and rhizomes, have adventitious roots, which grow from the stem (Figure 4.4). The main function of roots is to provide anchorage for the plant. It also serves as an absorber of water and necessary nutrients from the soil to be transported to the stem.

Comparing Fibrous and Tap Roots



- Several roots grow from a germinating seed at the same time, and lateral roots may grow from these
- There are many roots appearing from the stem
- Roots are thin and fairly short in length
- Appear as a web or network of fibres
- There is no recognizable main root
- Are found in most monocotyledonous plants

Source: **pic2fly.com** **Figure 4.3**



- A single root grows vertically down from a germinating seed.
- There is one main root recognizable from the stem
- Main root is larger and stronger than all the others.
- Smaller lateral roots grow from the main root
- Are found in most dicotyledonous plants

Source: **www.ramin.com.au** **Figure 4.4**

As mentioned in Chapter 2, cells dividing in a section of the plant or animal cause growth to occur in that region. In order for roots to grow, there needs to be cell division taking place in the region of growth. Since the top part of the root is firmly anchored, cell division will cause roots to grow downwards or sideways between the soil particles. This indicates that the region of growth and therefore cell division (Zone of Cell Division) is at the tip of the root. This region of cell division at the tip of the root is called the **apical meristem** (Figure 4.6).

Figure 4.4: Adventitious roots on ginger rhizomes

As the root grows into the soil, it is protected from being damaged by the root cap which is a layer of cells found on the outside of the root tip. This layer of cells is continually added from the inside as fast as it is being worn away on the outside through abrasion against the soil as the root grows and burrows deeper into the soil.

4.1.11 Zone of Elongation

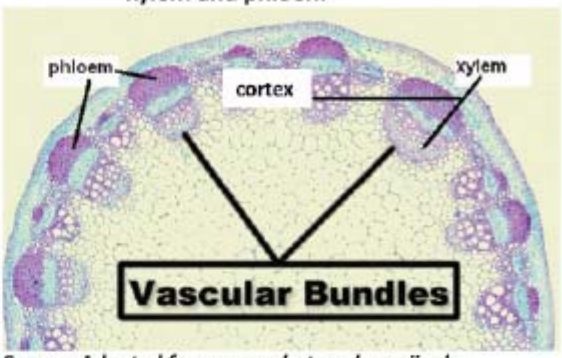
This is the region immediately behind the apical meristem, caused by newly dividing cells absorbing water and developing vacuoles causing them to elongate. This elongation also contributes to the plant becoming longer.

4.1.12 Vascular tissue

This is found in the centre of the root and is made up of phloem and xylem tissues. Figure 4.5 shows the cross section of a root and the position of the phloem in relation to the xylem. Lateral roots grow out from the vascular bundle, pushing their way through the cortex and outer root layer into the soil.

The position of the vascular bundle in the centre adapts the root well to the vertical strain that it could experience while anchoring the plant firmly in the soil.

Figure 4.5: Cross section of the Root showing xylem and phloem



Source: Adapted from www. botany.hawaii.edu

4.1.13 Cortex

This is the region between the vascular bundle and the outer-most layer of cells or epidermis. The cells that make up the cortex are large with thin-walls and loosely packed together. The spaces between them are filled with air. Cells of the cortex may store food material and those nearest to the vascular bundle may regulate water and minerals entering.

4.1.14 Root hairs

These are finger-like projections growing out of the epidermal cells. They grow into the soil and lodge themselves between the soil particles. Root hairs are not found at the root tip, nor in the zone of elongation. They are found beginning in the region just above the zone of elongation.

As the root hairs weave themselves between the soil particles, their cell walls stick to the particles making them difficult to remove. This results in firm anchorage, the minimization of erosion and aids with water absorption.

Summary of Root Parts and Function:

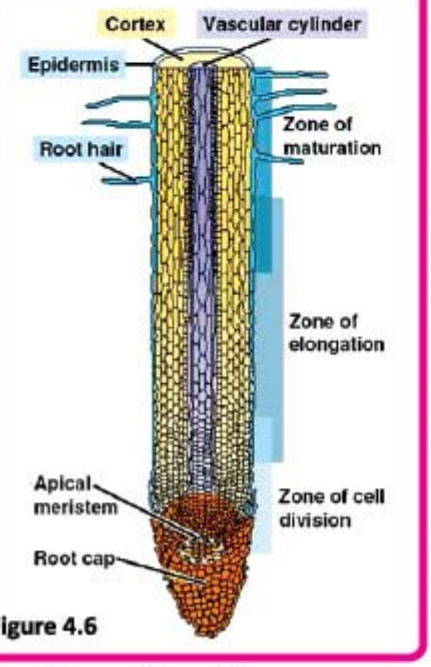


Figure 4.6

Source: **tudbotany.blogspot.com**

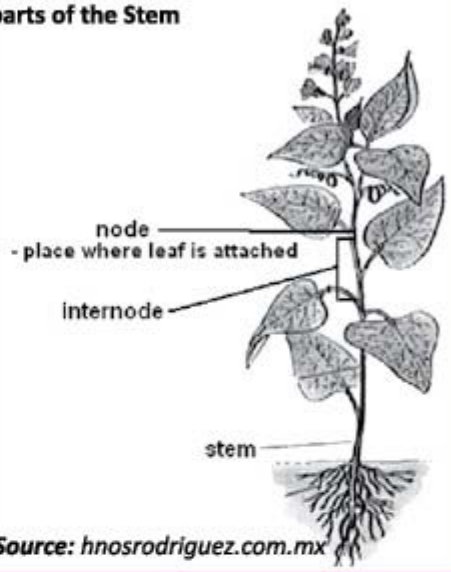
Part of Root	Function
Root cap	Group of loosely arranged cells around the tip of the root, protecting it during growth
Meristem region	This is found at the tip of the root, it is the place where growth takes place
Vascular cylinder	Contains xylem and phloem, the tubes that conduct food and water to and from roots
Cortex	Tissue found between the epidermis and the vascular cylinder
Root hairs	Tubular outgrowth of the epidermal cells that are in contact with soil for absorption
Zone of maturation (or differentiation)	Region where cells have stopped growing and start to differentiate and become specialized
Zone of cell elongation	Region where cells are developing vacuoles and becoming longer. Most growth occurs here
Zone of cell division	Region where new cells are constantly being made

4.1.2 Stems

In most plants, the shoot consists of a stem, which grows leaves, buds and flowers. The stem and the leaves form the most visible part of the plant. It appears in a variety of forms and sizes. Some are small and very short (e.g. carrot) while others are large and tower over others forming forest canopies (e.g. *Dakua*). Some live for a few weeks while others survive for many years (e.g. *Baka* and *Pinus vitiensis).* Some creep horizontally on the various surfaces (e.g. *Wabosucu* or *Mile-a-minute*) while others form food stores under the soil (e.g. onion and dalo).

Stems have **nodes** at regular intervals along its length. A node is the place on the stem where leaves are attached to and branches are formed. The interval between nodes is called the **internode** and a terminal bud will be found at the growing tip of the stem.

Diagram 4.7: Diagram of Different parts of the Stem



***Source:** hnosrodriguez.com.mx*

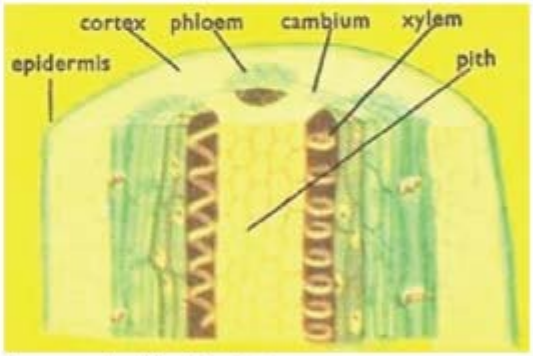
Stems and roots are closely related although they are distinct and separate. The tissues that make up stems and roots are also similar although they each have structural characteristics that distinguish them from each other.

Herbaceous stems are usually green, indicating the presence of **chlorophyll.** There are openings called **lenticels** in the epidermis of woody stems through which air enters. The rigidity of young stems is brought about by the **turgidity** of each cell, the distribution of **conducting tissues** and the opposing effects of **pith** and **epidermal** cells.

4.1.21 Conducting Food and Water

Conducting vessels or tubes (known as vascular tissue), run up and down the length of the stem, taking water from the roots to the leaves and taking food from the leaves to other parts of the plant. The vascular tissue consists of **xylem vessels** on the inside and **phloem tubes** on the outside. They are separated by meristematic cells (**cambium**) or supporting tissue in the case of monocotyledons.

Figure 4.8 Cross section of stem showing different parts



***Source:** daviddarling.info*

Xylem vessels transport water and dissolved minerals from the roots to areas in the plant where they are needed. They are long tubes lined with a substance called **lignin**, whose presence strengthens the xylem for transporting water.

Phloem however, is formed from cylindrical cells and do not have lignin, but have cross-walls called **sieve plates.** Phloem also have **companion cells** which assist by i) providing ATP for active transport and ii) determining the direction dissolved minerals should travel; either to the roots for storage, or to other cells for energy, a process called **translocation.**

The process of water movement up the xylem vessels is influenced by **turgor pressure**, and to a great extent, by the movement of water lost from a plant. This water loss from the leaves is known as **transpiration.**

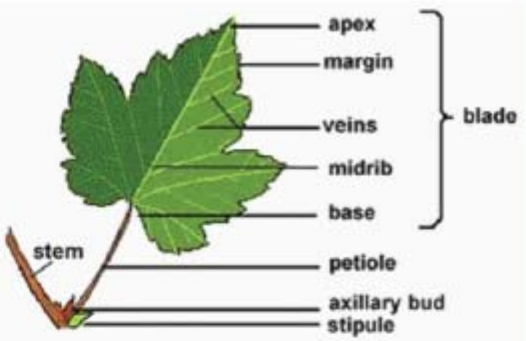
Water lost by transpiration is replaced by a flow of water from the xylem vessels. Water moves in a continuous manner from root hairs through to the xylem in the veins of leaves and to the stomata of the leaves, where it is lost via transpiration. This movement of water is called the **transpiration stream.**

4.1.22 Functions of Stems

Stems are an important part of plants and serve a variety of functions. They

- hold up and support the structures of the shoot;
- space out the leaves so that each receives adequate sunlight and air;
- provide the vessels for the conduction of water from the roots to the leaves;
- provide the vessels for the transport of food produced in leaves during photosynthesis to other parts of the plant where there is need;
- hold up flowers and thereby assist in the process of and/or photosynthesis if they are green.
- act as food stores.

***Figure 4.9** External structure of the leaf*



***Source:** bio.miami.edu*

4.1.3 Leaves

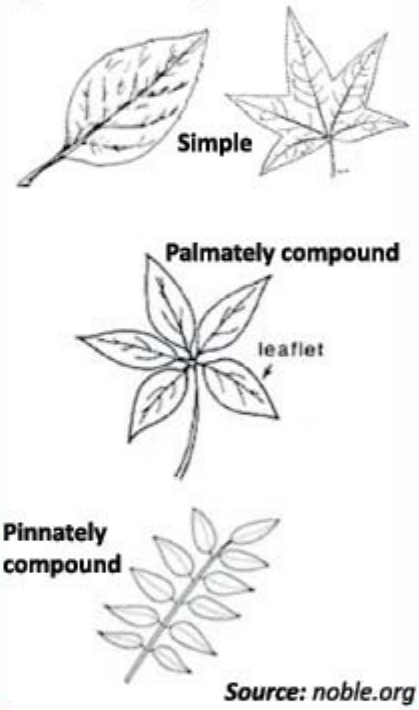
Not all leaves are green, but all leaves have pigments that direct their function. All leaves contain the green pigment **chlorophyll**, which is found in structures contained in the cells of leaves known as **chloroplasts**, along with all the necessary enzymes needed for the process of photosynthesis. Chloroplasts are most abundant in the cells of the palisade layers than anywhere else on the leaf.

Leaves vary in shapes and sizes, many of which are adaptations to the habitat in which they live. However, all leaves have a general external structure as shown in Figure 4.9.

Leaves can be described as

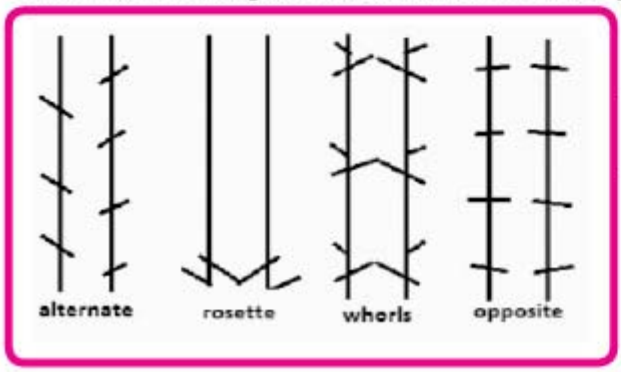
- **simple:** they have only one leaf blade which is undivided. The leaf may have lobes but the lobes do not reach the main vein of the leaf. eg. the hibiscus leaf is a simple leaf
- **compound:** the blade is fully subdivided to form several small joined leaflets. If the leaflets are attached to the petiole at one point (as in cassava leaves), they are **palmate compound,** if they are attached to the petiole at several places (as in coconut leaves) they are **pinnately compound** – Figure 4.10.

Figure 4.10 Leaf Types



***Source:** noble.org*

Leaves can be arranged on the stem in different ways as shown below:

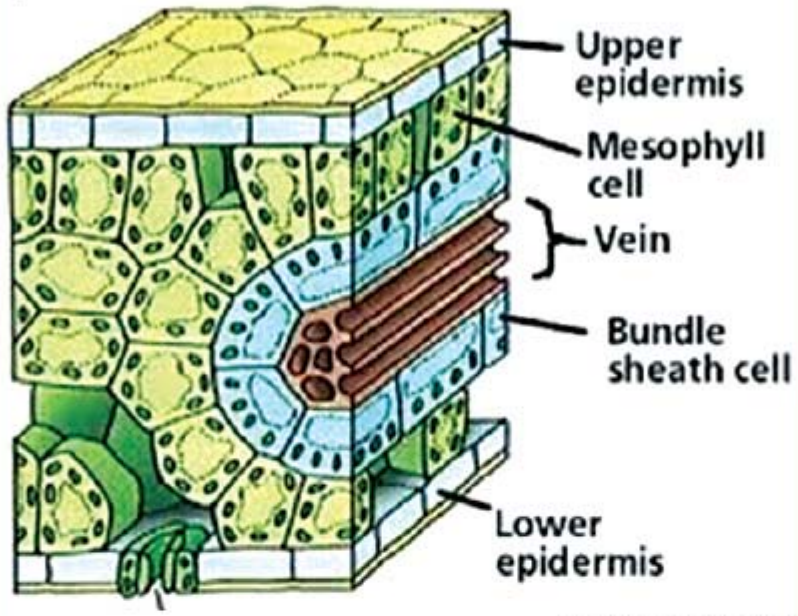


Leaves are highly specialized for the process of producing food from inorganic compounds such as water and carbon dioxide. It captures energy from sunlight on its surface and converts it to chemical energy. The leaf must therefore be well adapted to efficiently utilize the amount of sunlight it captures.

List the different types of adaptive features a leaf has to carry out photosynthesis? Discuss these features and take note of them.

Irrespective of the size or shape, the cross-section of a leaf reveals a structure with layers similar to that shown in Figure 4.11.

Figure 4.11: Cross Section of a leaf



Source: tea.state.tx.us

In a table, note all the different parts labeled in the leaf cross section (Figure 4.11) and explain how each part assists the leaf to carry out photosynthesis. Discuss this with your teacher.

The process of converting inorganic compounds into chemical energy is known as photosynthesis and is shown by the word equation below.

Photosynthesis Reaction

carbon dioxide + water $\xrightarrow[\text{light energy}]{\text{chlorophyll}}$ **glucose + oxygen**

The chemical equation is:

$$6CO_2 + 6H_2O \xrightarrow[\text{light energy}]{\text{chlorophyll}} C_6H_{12}O_6 + 6O_2$$

The glucose molecules formed during photosynthesis are converted into starch in the leaves or transported to the roots of the plants for storage (as it is insoluble in nature). The presence of starch in the leaves is used as evidence of the process of photosynthesis. When photosynthesis stops, the starch in leaves gets hydrolyzed back to sugar. The diagram (Figure 4.12) below shows the movement of gases into and out of the leaf during the processes of respiration and photosynthesis.

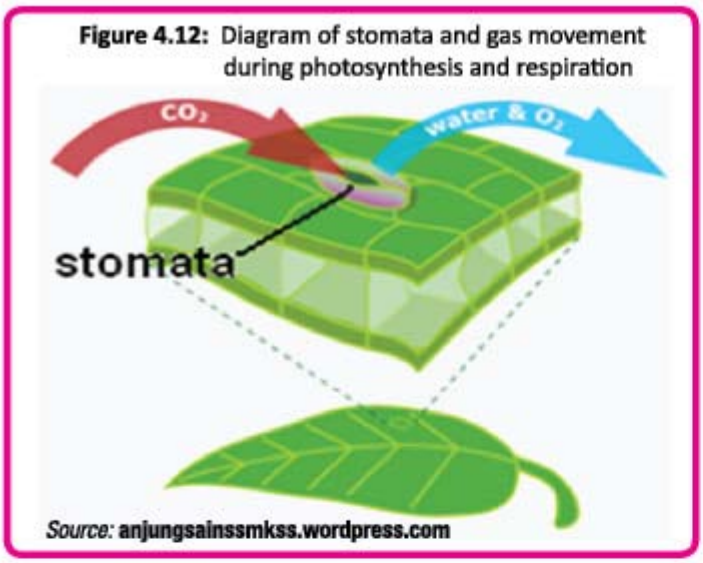


Figure 4.12: Diagram of stomata and gas movement during photosynthesis and respiration

Source: **anjungsainssmkss.wordpress.com**

How can we show that a leaf photosynthesizes?
How can we show which raw materials are needed for photosynthesis?

4.2 GLUCOSE AND ITS USE

When the rate of photosynthesis is high, a lot of glucose is produced and can be used in a variety of ways. Some is used to produce energy (via respiration) in the leaves and flowers for immediate growth, some diffuse out of their production sites and enter into the phloem tubes of the leaf veins, transported to the roots to assist growth or production of protein by being combined with absorbed nitrates, while some are used to form cellulose which build the cell walls and lignin which strengthens the cell walls in woody tissues.

Excess sugar is stored as starch in leaves, stems, fruit or roots. The organ of storage varies from plant to plant.

4.3 Starch and their Use

Plants use food or starch for the same purposes as animals, that is for body building or growth and repair, and for obtaining energy. The rate of energy usage however is not the same.

With the help of oxygen, glucose from starch is broken down into carbon dioxide and hydrogen, which in turn combines with the oxygen, to form water. The energy released is used for plant activities while some is lost to the environment in the form heat energy.

Respiration reaction:
Glucose + Oxygen ⟶ Carbon dioxide + water + energy.

This process of producing energy from the breakdown of glucose (glucose combustion),is called respiration and occurs all the time in living organisms.

Discuss the processes of photosynthesis and respiration during day periods and night periods

4.4 Transpiration

Transpiration is the process by which plants lose water through the leaves to the environment. This process occurs mostly through the leaves of plants and is the reason behind the movement of water through plants. Water lost by transpiration is replaced by water moving in from the root hairs, through the roots, xylem and veins to the leaves. This continuous flow of water is known as the **transpiration stream.**

The rate of transpiration is influenced by the rate of evaporation, and the factors that affect it. These are

a. atmospheric temperature
b. air movement or wind
c. humidity.

Explain **how** these factors affect the rate of transpiration.

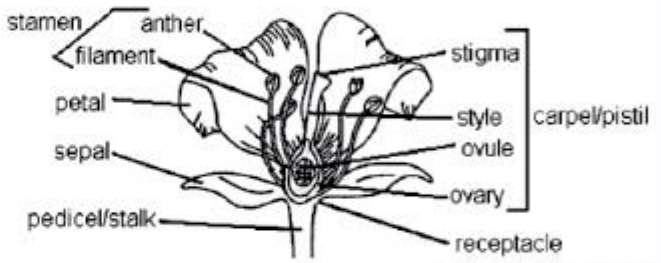
4.5 Reproduction in Plants

4.5.1 Flowers

Flowers are the reproductive structures of a plant. In most flowers, both male and female reproductive organs are found on the same flower. The purpose of flowers is to ensure that sexual reproduction occurs, and that fertilization results in the formation of fruits and seeds.

In flowers a series of morphological changes (that will not be discussed in detail here), cause the nodes to grow closer to each other. Because of the absence of meristematic tissue at the shoot tips to continue normal growth, the close proximity of nodes results in the formation of a compact arrangement of floral parts.In spite of the enormous variation in flower shape, size and colour, all flowers have essentially four sets of modified leaves.

Figure 4.13: Diagram of a Flower



Source: ekcsk12.org

These all grow from the flower stalk or **pedicel,** the tip of which is called the **receptacle.**

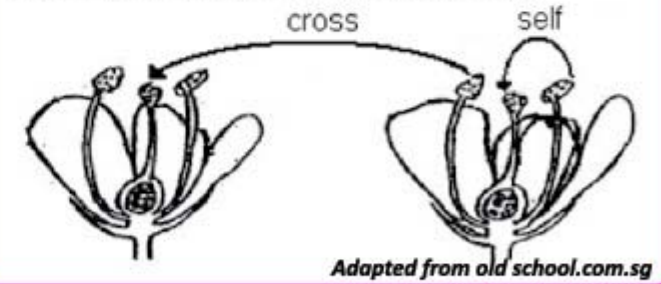
The four sets of modified leaves are the:

1. sepals – green leaf-like structures that protect the flower while it is still a bud. [Collectively they form the calyx]
2. petals – colourful part of the flower, altogether the petals make up the corolla
3. stamen – the male part of the flower consisting of filament and anther
4. carpel (pistil) – the female part of the flower consisting of stigma, style and ovary

4.5.2 Pollination

This is the process where pollen grains from the **anther** at the top of a **filament** are deposited on the **stigma,** the swollen tip of the **pistil.** Both the filament and stigma are usually situated on the inside of the petals. The transfer of the pollen can occur from the anther to the stigma of the same flower **(self-pollination)** or from the anther of one flower to the stigma of another flower **(cross-pollination)** of the same species.

Figure 4.14: Cross-pollination and self-pollination



Adapted from old school.com.sg

Cross pollination produces offspring that have an intermixing of hereditary information which usually increases their chances of survival. Many species have developed characteristics that prevent self-pollination and promote cross-fertilisation. An example is where the anther of the flower is hanging outside the petals, exposing the pollen to be carried by the wind.

Pollen can be transferred naturally by wind, water or by passing animals. Wind, water and passing animals are known as **agents of pollination.**

Pollen can also be transferred on purpose during the process of **artificial selection.** Insect pollinated flowers differ from wind pollinated flowers in many ways. Figure 4.15 shows the general structure of these two types of flowers and the comparison between these two types of flowers are given below:

Figure 4.15: Types of Flowers

Source: sciencequiz.net, nicksnowden.net

Wind pollinated

Source: bbc.co.uk

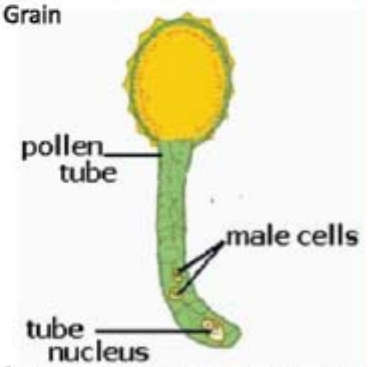
Flower Part	**Wind Pollination** (Grass, mahogany)	**Insect Pollination** (Hibiscus, gardenia)
Petals	Small, unattractive, does not produce nectar or have a scent.	Large, brightly coloured, produces nectar and has a scent.
Anthers	Produces a lot of small, dry and light pollen.	Produces fewer, large pollen grains which are sticky with rough surfaces.
Filaments	Long and often hangs outside the flower.	Short and contained within the flower.
Carpel	The stigma and style are large and feathery.	The style is short and the stigma sticky.

4.5.3 Fertilisation

After a pollen grain has landed on a stigma, it goes through a series of changes to prepare it to send its nucleus down through the style of the flowers pistil. It produces an elongated pollen tube which pushes its way down through the tissue of the stigma. While the pollen tube is growing, the generative cell inside it divides by mitosis to form two sperm cells. The pollen tube paves the way for the two sperm cells to move through the tube to the ovary.

The outer cells of the ovary form one or two protective layers called **integuments** and leaving a small opening called the **micropyle.** The pollen tube connects to the ovary at the micropyle and the two sperm cells or nuclei enter the micropyle one after the other. The first pollen nuclei fuses with the egg nuclei to form a zygote, while the second nuclei fuses with the polar nuclei to form the triploid **endosperm or food store.** This double fusion of sperm with the egg and sperm with polar nuclei is known as **double fertilization.**

Figure 4.16: Germination Pollen Grain



Source: waynesword.palomar.edu

The zygote becomes a multi-cellular organism by cell division and growth. At some stage during growth, the cells form, become different from the original cell or zygote. This process of becoming different is called **differentiation.** The instruction that causes differentiation is found in the original zygote and passed on to new cells during cell division and growth.

The zygote grows into a structure called the **embryo.** Along with other components, this grows into the structure known as the **seed.**

4.5.4 Seeds

A seed is a matured ovule and consists of a tiny living plant which is the embryo (formed during fertilization), stored food and the seed coat. The stored food provides nourishment to the young embryo until it can make its own food by photosynthesis. The food store in the seed is called the **endosperm.**

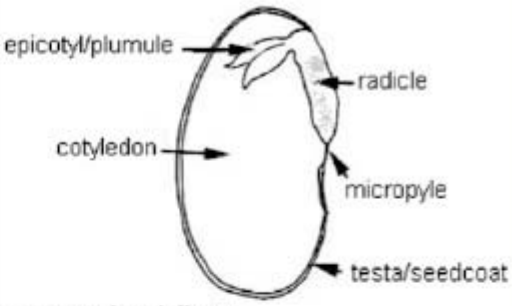


Figure 4.17 Diagram of Parts of a Seed

***Source:** suburchill.com*

The seed of a dicotyledonous plant has two halves called **cotyledons,** or seed leaves. In bean seeds the two halves are held together and covered with a seed coat or **testa.** The testa protects it from desiccation and other danger before it germinates. In bean seeds, there is an inner thin, white covering that is difficult to separate from the testa. Both the thin white covering and the testa developed from the ovule after fertilization.

Near the point of attachment of a bean seed to its pod, is a tiny pore called the **micropyle.** This is the opening where the pollen nuclei enters the ovule for fertilization.

4.5.5 Seed Germination

Between the cotyledons lie two important parts of the embryo; the **hypocotyl** or embryonic stem and the **epicotyl** or embryonic shoot (also known as the **plumule**). The hypocotyl connects the cotyledons to the embryonic root or **radicle.** The epicotyl is made of two tiny leaves folded together and lying above the point of attachment of the cotyledons. Between the two leaves lies a bud that will grow into the **terminal bud** as the epicotyl grows into the shoot.

Before germination, many seeds go through a period of rest, known as **dormancy.** This period may last from a few hours to a few years depending on the season and the prevailing environmental conditions. Drought, excessive heat or cold can increase the period of dormancy.

When conditions are favourable however, dormancy ends and germination begins. The ability of a seed is called its **viability.** During germination, both the hypocotyl and epicotyl undergo rapid cell division and growth and the energy needed for this is supplied by the cotyledons. The oxygen required for the respiration process during germination is very high.

The food stored differs between monocotyledons and dicotyledons. In bean seeds for example, the food stored is in the form of proteins and oils, while in corn kernels (monocotyledon), it is protein and starch. During germination, starch in the cotyledon is first converted to sugar by the enzyme amylase before being used in the respiration process. This accounts for the sweet taste in germinating seeds such as bean sprouts.

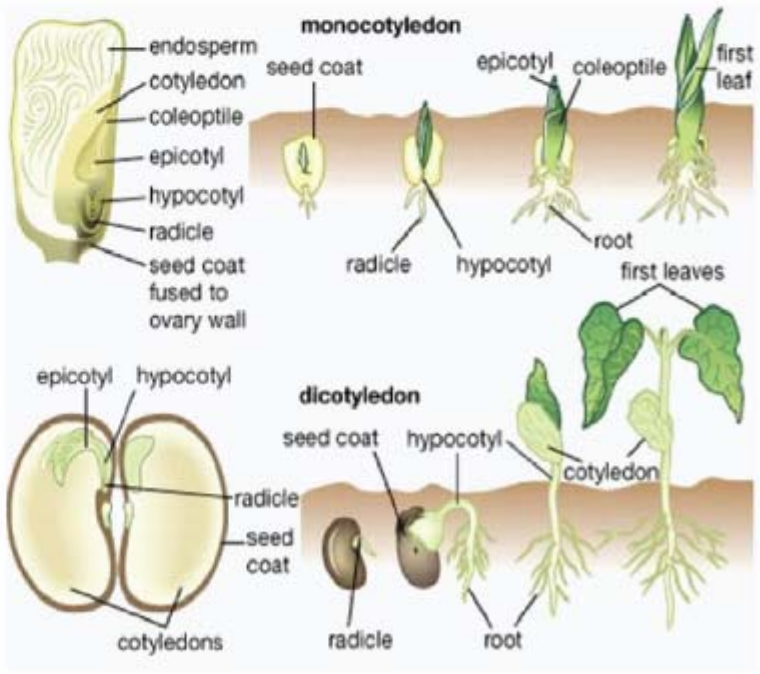


Figure 4.18 Diagram of Germinating Bean Seed

***Source:** m.eb.com*

For successful germination, the right amount of moisture, oxygen and the correct temperature are required. Seeds absorb moisture to soften the testa and cause swelling. However too much water coupled with warm temperatures stimulate fungal growth on the seeds and destroys them.

Investigate the conditions for successful germination in a worksheet.

4.5.6 Seed Dispersal

Dispersing seeds give the chance for the young plants to grow upon germination. When seeds are dispersed and are far from each other, competition for light and space is reduced. It also gives the plant a chance to spread out and exploit new habitats.

As seeds grow, the flower withers and most of the parts fall off as they die. The ovary continues to grow and develop and becomes the fruit with seeds inside it. The function of the fruit is to scatter or disperse ripe seeds over as large an area as possible.

There are four common ways that seeds may be dispersed:

1. Animal Dispersal: hooked fruits catch onto the fur of animals and are carried away. They are either scratched off or fall off; succulent fruit like tomatoes are eaten and the undigested seeds pass through the alimentary canal of the animal and expelled in the faeces.
   Fruits dispersed by animals may have burrs and hooks on the covering, or are fleshy and good to eat.
2. Wind Disperal: seeds dispersed in this way are light weight and feathery, some are shaped like 'parachutes', or they may have wing- like structures. These seeds are caught up by the wind and carried or blown long distances. Winged seeds of mahogany, and parachute shaped seed of the *vutu tree* are dispersed in this way.
3. Water Dispersal: seeds of plants near water ways or on sea shores are usually dispersed by the water. A common water dispersed seed is the coconut which is hollow and fibrous, making it light and buoyant and easy to float. Coconuts float from one land mass to another dispersing the plant.
4. Self Dispersal/Explosion: some seeds in pods are dispersed when the pods crack open and expel them out with a force that will spread them out at some distance from the parent plant. The vaivai tree disperses seeds in this way. Some pea pods split in half by curling up its edges or ends and in doing so ejects the seeds away from the tree.

Figure 4.19 SEED DISPERSAL

4.5.7 Types of Growth and Development

The shoot and root of a germinating plant grows only at the tips (unlike growth in animals). Cell division occurs by **meristematic tissue** in a region known as the **apical meristem.** The outside of this region in the root tip, consists of a layer forming a tough coat or **root cap** which protects the root as it travels down through the soil particles during growth.

The **zone of cell division** is found immediately behind the root cap. Next to the zone of cell division, is the **zone of cell elongation** (Figure 4.6) followed by the **zone of cell maturation/differentiation.** All the growth that takes place in these regions is known as **primary growth,** and results in plants growing up and growing down, or growing in length.

Secondary growth takes place only in woody trees and shrubs and not in herbaceous plants. It occurs because of the cell division in the **cambium** which is the meristematic tissue found between the phloem and the xylem of the **vascular bundles.** This cell division results in the formation of secondary phloem on the outside and secondary xylem on the inside. The phloem does not grow much and is usually thin. As new xylem grows, it pushes the old xylem to the centre of the stem. The old xylem begins to lose its function and the cells harden. Now it has become heartwood or wood and contributes to the strengthening of the stem.

Most plants will reproduce before they die. The period of time from fertilization to the death of the gamete producing stage which then begins an identical series of changes is called a **life cycle.** Life cycles vary in length depending on the species of plant. Those whose cycles are one year long are called **annuals.** Those which complete their life cycle in two years are called **bienniels,** while others which live for more than two years are called **perenniels.**

Suggest the names of plants (native if possible) which flower

a. less than 1 year
b. 1 to 2 years
c. 2 to 3 years
d. 3 to 4 years
e. More than 4 years

4.5.8 Tropisms

Plants are able to respond to environmental stimulus by growth or movement. This growth response is called **tropism** and the direction of the response is related to the direction of the stimulus. The plant may respond to the stimulus – this is called a **positive tropism,** or the response may be away from the stimulus – **a negative stimulus.**
The types of tropism are:

1. Geotropism (gravitropism) – response to gravity. The shoots show negative geotropism, while the roots show positive geotropism;
2. Phototropism – response to light. Plants show positive phototropism;
3. Hydrotropism – response to water. Plants show positive hydrotropism;
4. Chemotropism – response to chemicals. Depending on the usefulness of the chemical, plants will show negative or positive chemotropism;
5. Thigmotropism – response to touch. When bean plants (or like twining plants) touch a pole or fence post or tree trunk, tendrils curl and pull the plant up.

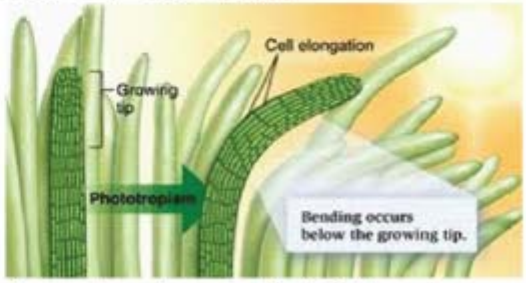
1. Plant and grow about 20 bean seeds to about 1cm in height.
2. Using these seedlings, design a simple activity that will help you to investigate either **geotropism** or **phototropism,** or both.
3. Use control experiments to help you compare the results you obtain.
4. Write down a conclusion to this activity

4.5.81 Phototropism

Both roots and shoots are sensitive to light. Shoots show positive phototropism while roots show negative phototropism. For the plant, shoots being positively phototrophic means that the leaves will always be facing the sun. This is advantageous to the plant because this movement will ensure that photosynthesis is maximized.

There are specific chemicals responsible for this movement toward light. **Auxins,** a group of plant growth hormones, produced in the tip of the shoot cause cell elongation and the resultant bending response toward light. The specific auxin responsible for cell elongation is **IAA** or **indole-acetic-acid.**

Figure 4.20 Phototropism



Source: beyondrepresentationfolie.blogspot.com

When a seedling is exposed to light from one direction, auxins migrate to the darker side causing the cells in that part of the stem to elongate faster than the cells in the lighted side. This unequal growth rate results in the stem bending toward or in the direction of the light (Figure 4.20).

4.5.9 Factors Affecting Flower Formation

All flowering plants have the ability to produce flowers. Two factors that affect flowering are

a. Temperature - In an investigation, biennial seeds were soaked in water, and were placed in a refrigerator for six weeks when they started to germinate. The temperature in the refrigerator was 2° - 5° C. The seeds were then allowed to germinate and grow into plants. These plants produced flowers and seeds both in the same season, instead of in two seasons.

b. Day length or photoperiod - Some plants flower when the day-length is short. These are called short-day plants. Long–day plants flower when the day is long. Experiments on long-day plants showed that they flowered when the nights are actually short, and short-day plants flowered when the nights are actually long.

4.6 VEGETATIVE (Asexual) REPRODUCTION in Plants

In asexual reproduction there is no genetic variation and the offspring are identical to the parent. Vegetative reproduction is a form of asexual reproduction and is when a new plant grows from a segment of the parent plant. Various forms emerge from the plant structure producing a new plant.

The advantage of asexual reproduction is

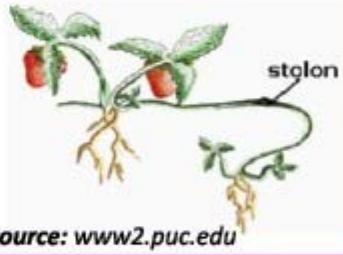
- Only one parent is involved thus it can be faster than sexual reproduction;
- Large numbers of offspring can be produced at one time;
- Offspring are identical and this can be useful in horticulture.

The disadvantage is:

- No genetic variation;
- Identical offspring are more vulnerable to diseases;
- Limited range of adaptations to enable survival.

There are several ways that asexual reproduction can take place:

a. Stolons: These are formed by stems that grow horizontally above ground. New shoots and roots grow out of the nodes. The shoots may grow upwards to form several branches.

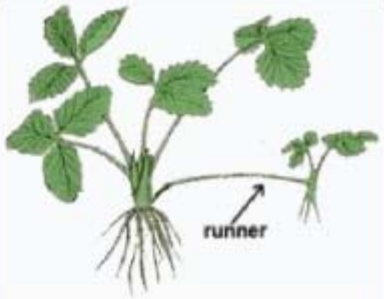


Source: www2.puc.edu

b. Rhizomes: These are like stolons except that they grow just below the surface instead of above it. The new plant remains attached to the parent plant for several years eg. Ginger.

Source: planandplant.com

c. Runners: These are formed when a parent plant sends a shoot above ground. The shoot grows into a new plant and the parent plant dies away eg. paragrass



Source: *gardenpool.org*

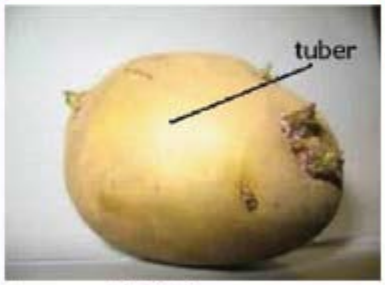
d. Corms: These are stems which are swollen with food, found underground and are short, thick and starchy. Terminal buds of the corms may develop into a new plant eg. taro.


Source: *raygrogan2-ivil.tripod.com*

e. Bulbs: These are large buds found underground with thick, fleshy leaves that are stored with water and sugar eg. onions.

Source: *harvestwizard.com*

f. Stem tubers: These are stems which grow into the soil and their tips eventually fill with stored starch and swell forming a tuber. If the tuber remains dormant it will grow new shoots eg. potatoes.

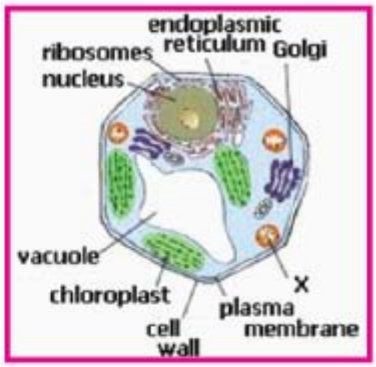


Source: *click4biology.com*

g. Suckers: These form when auxillary buds below the soil surface grow new stems. The new stems become suckers eg. bananas


Source: *palmvrienden.net*

Review Questions

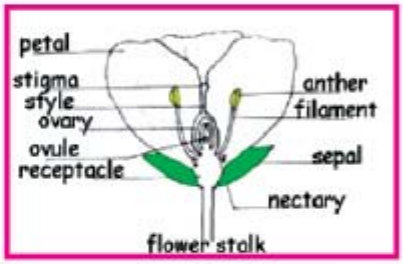


1. Name the vegetative parts of the plant and state their functions.

2. At right, is a generalized diagram of a plant cell.
   i. Name two organelles present in this cell that are not in the animal cell.
   ii. Name organelle X and briefly state its function
   iii. In which organelle would energy be produced from?

3. Fill in the blanks in the table given below

	Photosynthesis
Reactants	(i)
Products	(ii)
Purpose of reaction	(iii)
Organelle where reaction takes place	(iv)



4. The diagram of a simple flower is given on the right:
   i. State the function of the petals, anther, stigma
   ii. In which two flower parts does **meiosis** occur?
   iii. What do the male and female parts of the flower consist of and what specific names are given to the male and female parts?
   iv. Differentiate between insect and wind pollinated flowers.

5. The diagrams on the right show the fruit/seed of two different plants:
   i. State the method of dispersal that would be used by each one.
   ii. For each one, give **two** adaptive features that allow for such a dispersal method as you have mentioned in (i) above.
   iii. State two reasons why seed/fruits need to be dispersed.

6. Given below is a diagram of the upper part of a pot plant which is exposed to direct sunlight near a window.
   i. Name the growth response shown in the diagram.
   ii. Name the hormone that regulates this growth response.
   iii. Which side, M or N, of the plant would have the highest concentration of hormone to allow this response to occur?
   iv. Give **one** adaptive value of such a response.

7. Vegetative and sexual reproduction are common in plants.
   i. Name three kinds of artificial vegetative reproduction methods in plants
   ii. Give two advantages of sexual reproduction over asexual reproduction.

8. Discuss two factors that affect flower formation.

CHAPTER 5

ANIMAL BIOLOGY

All living animals conduct a variety of processes in a coordinated manner to achieve homeostasis or a stable internal balanced environment. These processes function within systems and each system comprises of a variety of organs. When one organ in a particular system has a malfunction, the whole system is affected.

The human body is an example of a combination of systems working in unison and coordination. In this section we will be looking at six of the seven systems that keep the body in homeostatic balance. The seventh system – the Reproductive System has been covered in the Form 4 Basic Science prescription and will only be briefly reviewed in Form 5.

System	Parts	Function
Digestive	Mouth, eosophagus, stomach, pancrease, liver, ileum, colon	Ingestion, digestion, absorption, assimilation and egestion
Circulatory	Heart, vessels, blood	Transporting materials and antibodies
Respiratory	Nose, trachea, lungs,	Gaseous exchange
Excretory	Kidneys, bladder,	Removal of metabolic wastes
Muscular & Support	Muscle, skeleton	Support, movement and protection
Nervous & Endocrine	Brain, nerves, glands, hormones	Control of homeostasis

5.1 DIGESTIVE (FEEDING SYSTEM)

Human beings cannot produce their food like plants. They rely on plants and other animals to provide them with the minerals that their bodies need. Humans can be carnivores (meat eaters), herbivores (vegetable/plant eaters) or omnivores (both meat and vegetable eaters).

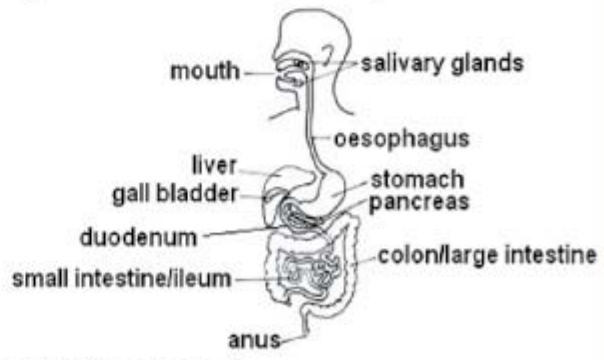
Like all living organisms, human beings have an alimentary canal, a tube beginning with mouth and ending at the anus, with different parts carrying out different aspects of the process. To get the best of the nutrients from the food, humans must be able to break down the food in small enough pieces to swallow, store, digest and absorb. In order to do these successfully, all animals have specially designed structures that function effectively to accomplish the desired task. It is imperative to note that each structure is designed specifically for its role.

As the food travels down the alimentary canal, its breakdown is assisted by various secretions produced in structures called **glands.** The glands, together with the alimentary canal, make up the **digestive system.**

Digestion is the process of breaking down food into smaller particles for easy absorption. There are five main activities involved in the process of digestion. These are

- Ingestion; process by which food is taken into the mouth
- Digestion: this involves two types:

Figure 5.1 The Human Digestive system



Source: hsc.csu.edu.au

1. Mechanical/physical: the breakdown of large food particles into small food particles in the mouth by the teeth
2. Chemical: the breakdown of larger molecules (like starch) in the food into smaller molecules (like glucose) by enzymes

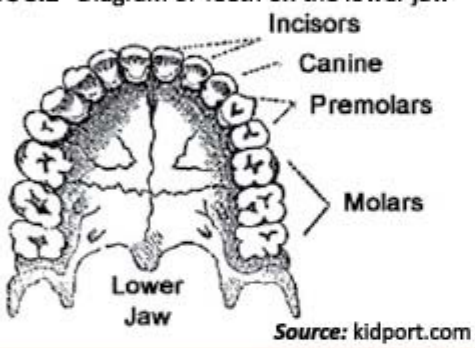
- Absorption: the taking in of digested food material at the ileum
- Assimilation: the use of absorbed materials by cells
- Egestion: removal of undigested food through the anus

5.1.1 Ingestion

This is the process of taking in food and preparing it for digestion. It begins in the mouth where the tongue, teeth and saliva all play an important yet distinct part.

Teeth process food by cutting, tearing and grinding in a very close sequence, with all or only some of the movements, depending on the nature of the food being eaten. Some foods, such as bananas, are soft and need very little cutting or grinding, while other foods, such as meat, may need to be cut, torn apart and crushed before it can be swallowed. The shape and position of teeth in the mouth is such that it carries out the exact kind of function on food at the right time.

Figure 5.2 Diagram of Teeth on the lower jaw



Source: kidport.com

There are three types of teeth:

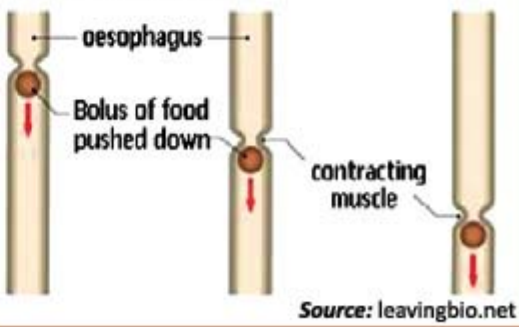
1. Incisors: are located in the front of the mouth and are responsible for biting and tearing food;
2. Canines: are located on the side of the mouth and are responsible for cutting food;
3. Pre-molars and molars: are located at the back of the mouth and are responsible for crushing and grinding food

5.1.2 Digestion

As the food is being crushed it is mixed with saliva which is secreted by the salivary glands situated below the tongue. Chewing, or **mastication,** causes crushed food to form a ball or **bolus** making it easy for the food to enter the throat so that it can be swallowed. Saliva contains the enzyme **salivary amylase** or **ptylin** which acts on cooked carbohydrates and breaks it down first into maltose, and eventually into glucose. Chewed food does not remain in the mouth long enough for all starch digestion to take place, however it remains long enough for starch digestion to begin.

A bolus of food enters the gullet by the combined action of the tongue, the soft palate, the laryngeal cartilage and the epiglottis, each playing an important role in getting the bolus to pass over the trachea without entering it and down the oesophagus. The bolus travels down into the stomach, by the process of **peristalsis** (Figure 5.3). Peristalsis is a wave-like motion caused by the alternative contraction of **circular** muscles and **longitudinal** muscles moving the bolus down until it is deposited into the stomach.

Figure 5.3 Peristalsis



Source: leavingbio.net

In the stomach, both chemical and mechanical digestion occurs. The wall of the stomach is elastic and can be extended enabling food to be stored for some time and released slowly, as more food enters.

The bolus is mixed with **gastric juice** which is secreted from glands situated in the lining of the stomach walls. Gastric juice contains **hydrochloric acid,** the enzyme pepsin, and in the case of young children, the enzyme rennin. Hydrochloric acid provides the acidic medium (and the optimum pH) in which the **pepsin** best functions, as well as destroys many of the bacteria that is taken in with the food. Pepsin acts on proteins to produce peptides, while rennin in young children acts on milk protein by clotting it.

The rhythmic action of the stomach, mix the food and gastric juice producing a creamy liquid called **chyme.** The **pyloric sphincter** at the lower end of the stomach, opens periodically to release the chyme into the first part of the small intestine, called the **duodenum. Pancreatic juice** from the pancreas, an alkaline juice containing sodium bicarbonate partly neutralizes the acidic conditions in chyme. It also contains the enzyme **trypsin,** and together with bile from the liver, enters into the duodenum.

Trypsin acts on proteins to produce peptides, and on peptides to produce **amino acids.** It also contains **lipase** which digests **lipids** into **fatty acids** and **glycerol.**

Bile does not contain enzymes instead it contains sodium chloride, sodium bicarbonate and organic bile salts. These bile salts decrease the surface tension of fats and so emulsifies them, that is, it breaks them down into small particles making them more water soluble easily forming a suspension having greater surface area and open to attack by lipase enzymes. Bile salts are absorbed by the small intestine and returned to the liver.

Summary:

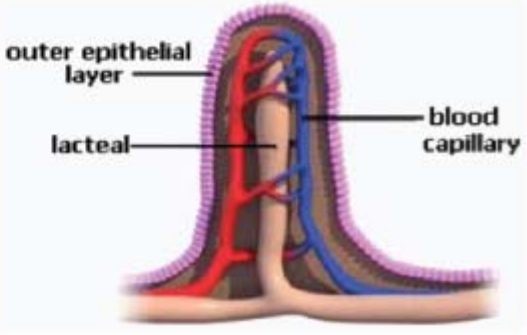
Enzyme	Where it is produced	What it digests	Result of Digestion
Amylase	Salivary Glands	Starch	Glucose
Pepsin & Trypsin	Gastric Glands & Pancreas	Proteins/peptides	Amino acids
Lipase	Pancreas	Lipids/Fats	Fatty Acids and Glycerol

5.1.3 Absorption and Assimilation

Digestion continues and is completed in the **ileum** or small intestine by the pancreatic enzymes. Any unchanged peptides get broken down into amino acids, unchanged maltose and other sugars get broken down into glucose and unchanged fats to fatty acids and glycerol. All food material that is digestible is now in a form that can be easily absorbed into the lining of the ileum.

The ileum is structured for efficient absorption. Its surface is lined with thousands of microscopic finger-like projections known as villi. Each villus is one cell in thickness, has a network of blood capillaries and a singly lymph vessel or **lacteal.** Absorbed molecules of glucose and amino acids pass through the epithelium, into the capillaries and eventually into the **hepatic portal vein** onto its way to the liver. Most absorbed fatty acids and glycerol however, enter the lacteal which eventually enters the **lymphatic system,** a network all over the body, whose contents eventually empties into the blood stream.

Figure 5.4: The Cross section of a Villus



Source: en.labs.wikimedia.org

5.1.4 Egestion

After the products of digestion have been absorbed into the ileum, the undigestible material such as cellulose, vegetable fibre (roughage), bacteria, mucus, dead cells and water then pass into the colon. Most water and some salts are reabsorbed in the colon. The semi-solid waste, called **faeces,** is passed into the **rectum** and stored there until it becomes expelled at intervals through the **anus.** The colon together with the rectum comprises the large intestine.

Undigested cellulose get digested by bacterial activity in the appendix, or caecum in animals such as rabbits or horses.

5.1.5 Malfunctions of Digestion

These cause an imbalance in homeostasis and include;

1. Constipation – this is the condition where bowel movement is not frequent or difficult to pass. Causes of constipation range from insufficient water and/or dietary fibre to lack of exercise and stress, and even ignoring the urge to go to the toilet. Taking regular exercise, drinking at least eight glasses of water a day, eating more fibre and reducing stress will relieve constipation. Seek advice from a family doctor about suitable laxatives for alternative treatment of constipation.
2. Vomiting – this is the condition where the stomach contents are forcefully ejected through the mouth and, sometimes, nose. There are several reasons for vomiting including gastritis or poisoning.
3. Heartburn – this is experienced as a burning sensation in the chest, just behind the breast bone after a heavy meal. Generally, this is a digestive disorder and is caused by stomach acids coming into contact with the oesphagus wall. Several things could trigger a heartburn – smoking, eating certain foods, eating too much too quickly. Although heart burn may suggest serious underlying health issues, generally, one can manage heartburn by eating less and eating slowly, allow ample time for digestion before bedtime and stop or reduce smoking.
4. Mumps – is a painful virus infection affecting the salivary glands, which become swollen and tender. Mumps tends to be more common in children, however, the infection may occur at any age. Drinking a lot of fluids, eating soft foods and gargling warm salt water during the infection stage helps to reduce the pain. An infected person usually has life-long Immunity to mumps.

Summary of Parts of the Human Digestive System and Associated Glands and their functions

Part	Function
Mouth Teeth Tongue	Beginning of the alimentary canal where food enters Physically breaks down food to smaller pieces Manipulates food in the mouth as it is broken down, helps to roll food into a round bolus making it easier to swallow
Salivary gland	Three pairs of glands produces saliva which moistens and softens food making it easier to swallow, the enzyme amylase in the saliva begins starch digestion
Saliva	Liquid substance secreted by the salivary glands containing enzyme amylase
Epiglottis	Located on the top of the oesophagus. Prevents food from entering the trachea during swallowing
Oesophagus	A long tube-like structure connecting the mouth to the stomach. Bolus of food travels through this tube by a wavelike action called peristalsis

Part	Function
Stomach	A sac-like chamber through which food enters and is stored temporarily to be released to the rest of the gut when necessary
Gastric glands	Secretes gastric juice containing pepsin, for protein digestion in the stomach; hydrochloric acid, for killing any bacteria in the food
Small intestine Pancreas	Divided into the duodenum and the ileum Secretes pancreatic juice which contains amylase, for further starch digestion, lipase for lipids/fats digestion and trypsin, for protein digestion
Bile	Green liquid produced by the liver and stored in the gall bladder. It has two functions: • To neutralize the acidic nature of the chyme in duodenum so enzymes can continue digestion • To break up fats and lipids into smaller molecules so that there is greater surface area for enzymes to act – a process called emulsification and is not the same as digestion
Villi	These a small finger-like projections in the wall of the ileum through which digested food is absorbed
Large intestine (or colon)	Receives undigested material that remains after the digested food is absorbed. Water is reabsorbed from this material, now called faeces, which passes into the rectum
Rectum	Located at the end of the colon, holds faeces until it is expelled from the colon
Anus	The end of the alimentary canal. Opening through which faeces is discharged

5.2 THE CIRCULATORY SYSTEM

All living cells need to be fed nutrients and have their wastes removed in order to survive and function well. The circulatory system acts as the transport system transporting oxygen and required nutrients to the cells, and removing carbon dioxide and wastes. This system comprises of three parts:

1. A fluid medium that carries material called **blood,**
2. Tubes through which blood can be transported called **blood vessels** and
3. A pump to provide the push for the blood called the **heart.**

Microscopic and very small organisms depend on a process known as **diffusion** to gain oxygen and small food molecules, and to lose wastes. Large organisms however have a larger body volume and diffusion would simply not be efficient enough. Therefore there is a need to have a transport system to provide efficient transport of vital components to and from the cells.

5.2.1 Blood

This is a viscous, dark red or maroon coloured liquid. On closer examination, blood is seen to be a suspension of cells in an aqueous solution. Adults have about 5 to 6 liters of blood circulating in their circulatory system. There are four components of blood that will be discussed here:

a. <u>The Plasma</u>

The liquid part of blood is called **plasma** and constitutes about 55 % of blood. It is a solution with about 90 % water containing dissolved substances such as sodium chloride, sodium bicarbonate, amino acids and glucose. It also contains the many important nitrogenous proteins such as globulin antibodies, fibrinogen, albumin, urea and hormones, digested food, carbon dioxide and excretory products. Plasma is the medium through which these substances, together with the erythrocytes and leucocytes are transported around the body. When fibrinogen is removed from plasma, the remaining liquid is called **serum.**

The solid component of blood consists of red blood cells (erythrocytes), white blood cells (leucocytes) and platelets (thrombocytes).

b. Red blood cells or Erythrocytes,

These are made in the bone marrow of short bones such as the sternum, ribs and bones of the vertebral column or vertebrae. Each red blood cell lasts for about four months, after which it disintegrates in the liver or spleen. Approximately 200,000 million red blood cells get produced each day, and about the same number get destroyed in the same period of time. There are approximately five to six million red blood cells in a cubic millimeter of blood. Red blood cells are tiny, biconcave shaped discs. They have no nucleus and their shape provides a large surface area on which oxygen can be carried. In the spongy cytoplasm of the red blood cell, is a red pigment called **haemoglobin.** This pigment is a protein containing the element iron in its molecule. The iron has an attraction for oxygen, and in high concentrations of oxygen, a complex called **oxy- haemoglobin** is formed between oxygen and haemoglobin. In low concentrations of oxygen however, the complex easily breaks down and releases the oxygen. In this way oxygen is transported from the lungs to the tissues.

Figure 5.5: Red Blood Cells

Source: rkm.com.au

c. White blood cells or leucocytes,

These are made in the bone marrow, lymph nodes or the spleen. The quantity varies from about 4,000 to 13,000 per cubic millimeter of blood. There are a variety of types of white blood cells; some are irregular in shape and can change their form, but all have a nucleus. Those that can change their shape and move by the flowing action of their cytoplasm are known as **phagocytes.** These can engulf bacteria and ingest them and the dead cells flowing around them.

Some white blood cells produce a chemical that sticks to bacteria, slowing them down so that phagocytes can engulf them. Other white blood cells do not attack bacteria but simply remove their toxins.

Figure 5.6 White Blood Cells

Source: bacteria-world.com

Lymphocytes are another group of white blood cells which are primarily involved in producing antibodies, special proteins that inactivate antigens. Lymphocytes are made in the **lymph nodes** of the lymphatic system. (Antigens are foreign particles or organisms that stimulate the production of antibodies).

d. Platelets also known as **thrombocytes,** are tiny round or oval disc shaped cells with no nucleus, that are produced in the red bone marrow with a life span of approximately 5 to 9 days. There are about 400,000 of these per cubic millimeter of blood. The role of platelets is to clot blood and so prevent the loss of blood and body fluid during an injury.

Figure 5.7: Platelets

Source: fi.edu

Blood is always contained in blood vessels (arteries, veins, capillaries) however some components of plasma are able to pass across the capillary walls and are called tissue fluid or **intestinal fluid.** This fluid can enter into the lymphatic vessels and travel through them as **lymph.** Leucocytes, and especially lymphocytes, can be found in lymph. Although similar in composition to plasma, lymph contains less protein.

Lymphocytes are found at the lymph nodes (located at the arm pits, neck and groin area) in massive numbers during an infection. These are areas where they are stored and where dead pathogens accumulate. Swellings occur in these areas because antibodies are being produced by the reaction of lymphocytes with antigens.

Summary Table:

Blood Component	Function
1. Plasma	Liquid part of the blood and it is the medium through which all materials(except oxygen) is carried
2. Red Blood Cells	Contain the red pigment haemoglobin which carries oxygen
3. White Blood Cells	Responsible for defense. There are two types: a. Phagocytes: engulf and remove foreign material from the cell; b. Lymphocytes: able to produce antibodies that attack specific foreign substances
4. Platelets	Assists in blood clotting

5.2.1.1 Blood Clotting

When a blood vessel has been severed, blood begins to coagulate by forming a blood clot over the damaged vessel, plugging it and reducing further blood loss. A blood clot forms when platelets in the blood congregate and adhere to the site of the damaged vessel, causing other platelets to attach onto them. Fibrinogen, a soluble protein in the blood, is converted to solid fibrin which forms a mesh over this platelet plug further cementing it over the damaged vessel.

5.2.2 The Transporting Vessels

Blood is carried around the body in three major types of vessels.

a. Arteries

These have thick, elastic, muscular walls because they carry blood which is under high pressure. They must be able to resist the high pressure with which the blood is flowing. An example is the **aorta** which carries blood pumped by the left ventricle of the heart to the rest of the body. Arteries divide into smaller vessels called **arterioles** which further divide into smaller vessels called capillaries. The simultaneous contractions of the arteries produce waves which can be felt at places where the arteries come close to the skins' surface such as the wrist and neck. All arteries carry oxygenated blood except the pulmonary artery which carries deoxygenated blood from the heart to the lungs.

b. Veins

These vessels carry deoxygenated blood from body cells back to the heart. Since the blood is travelling under very low pressure, these vessels have thinner walls. Veins have **valves** to prevent the backflow of blood and the action of muscle contractions in the body help to move the blood along the vein. Veins divide into smaller vessels called venules. All veins carry deoxygenated blood except the pulmonary vein which carries oxygenated blood from the lungs to the heart.

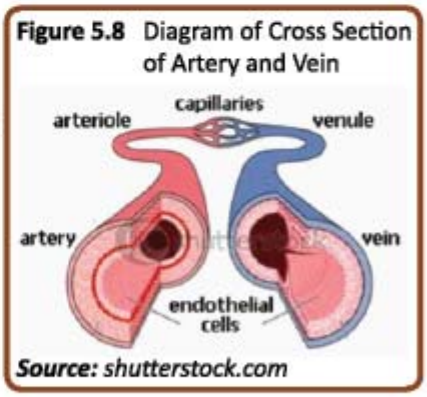


Figure 5.8 Diagram of Cross Section of Artery and Vein
Source: shutterstock.com

c. Capillaries

These are the finest of blood vessels. Their walls are extremely thin (one-cell in thickness) because it is through these walls that diffusion of oxygen and food, to cells, and diffusion of carbon dioxide and wastes, from cells, takes place. The network of capillaries is so dense that all cells are supplied sufficient oxygen and food, and each cells' wastes are removed. Capillaries unite to form venules which further unite to form veins, which then return the blood to the heart.

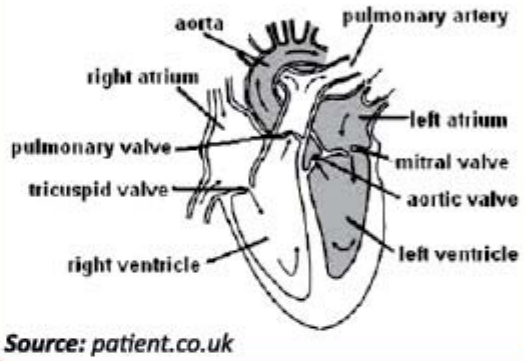
Summary Table:

Blood Vessel	Description and Function
Artery	Have thick elastic walls and carries blood away from the heart to the rest of the body
Veins	Have thinner walls and carries blood toward the heart from the rest of the body. Have valves that prevent blood from flowing backwards or sinking to the lowest part of the body due to gravity
Capillaries	These are very tiny networks that are one cell thick and receive blood from the larger arteries to transport it to the cells

5.2.3 The Heart

The heart is a muscular pump made of cardiac muscle which is involuntary. It beats rhythmically 60 to 70 times per minute but this rate increases with exercise. The heart muscles are supplied with oxygen by blood vessels known as the **coronary** arteries. The size of the heart is about the size of an average mans' clenched fist.

Figure 5.9 Diagram of the Heart



Source: patient.co.uk

The heart is divided vertically into two unequal halves. The left half is separated from the right half by a muscular wall known as the **septum.** Each half is again divided into two creating **four chambers** in total; the left ventricle and right ventricle at the bottom, and the left auricle (atrium) and right auricle (atrium) at the top. The lower ventricles are separated from the upper auricles by **valves** which prevent blood from flowing in the wrong direction. The lower ventricles are also more muscular than the upper atria because they have to pump blood out of the heart. This blood needs to travel under high pressure to enable it to successfully arrive at its designated locations and efficiently carry out the necessary processes of gaseous exchange and transport of nutrients and wastes.

Blood enters into the right atrium from the body, through a vein called the **vena cava.** This blood contains a high concentration of carbon dioxide, the product of cellular respiration. The walls of the right atrium contracts causing this deoxygenated blood to flow through the **tricuspid valve** into the right ventricle. The muscular walls of the ventricle then contract forcing the blood up the pulmonary artery through another valve. This blood then travels to the lungs where the process of gaseous exchange takes place, to oxygenate the blood.

The oxygenated blood then returns to the heart and enters into the left atrium through the **pulmonary vein.** The contraction of the left atrium causes the blood to flow through the bicuspid valve into the left ventricle. The left ventricle has a thicker muscular wall and on contracting, pushes the blood through another valve and out through an artery known as the **aorta.** The aorta carries the oxygenated blood to the rest of the body for cellular respiration.

5.2.4 The Lymphatic System

This system runs alongside the circulatory system and supports it in transporting dissolved substances to, and wastes away from, body cells and tissue. Lymph vessels serve as a system of drainage channels for tissue fluid carrying materials that travel from body cells and tissue but do not return into the blood capillaries. When tissue fluid enters into the lymph vessels, it becomes known as lymph.

Unlike blood capillaries, the walls of the lymph capillaries allow large molecules such as fatty acids, large proteins and bacteria to pass through it. Lymph fluid is filtered at the lymph nodes and re-enters into the blood capillaries.

5.2.5 Malfunctions of Circulation

These cause an imbalance in homeostasis and include:

1. Arteriosclerosis:
   This is a disease affecting the blood vessels caused by the build up of plaque, which could consist of fatty and cholesterol deposits, along the inner walls of the vessel. This deposit causes a decrease in the flow of blood and can eventually cut off the flow altogether. Further, the blood vessels may lose its elasticity, become hardened and break. This very dangerous situation leads to the following:
   a. Stroke:
   Results when the blood flow to any vessel of the brain is cut off or blocked;
   b. Heart Attack:
   Results when the blood flow to one of the vessels leading to the heart is cut off or blocked
   c. Hypertension (high blood pressure):
   Due to plaque build-up in blood vessels, the heart needs to pump harder to ensure blood circulation. In situations where the blood vessel is partly damaged or hardened, this extra force exerted by the heart could result in the blood vessel being ruptured.

2. Varicose veins:
   This is seen most often as thick dark purple lines in the back of the legs. It is a result of valves of the vein not working properly causing blood to collect in the vein and enlarging it.

3. Aneurysm
   This is a balloon-like bulge filled with blood in the wall of blood vessels.
   They weaken the wall of the blood vessel and when they increase in size, the likelihood of it rupturing increasing. A ruptured aneurysm results in hemorrhaging and possible death.

4. Anaemia
   This is the condition where there are fewer than normal red blood cells, or too little haemoglobin and results in not enough oxygen reaching the body cells. The individual with this disorder is pale and tires easily.

5. Leukaemia
   This is a type of cancer of the blood characterized by an abnormally high number of white blood cells.

6. Filarisis

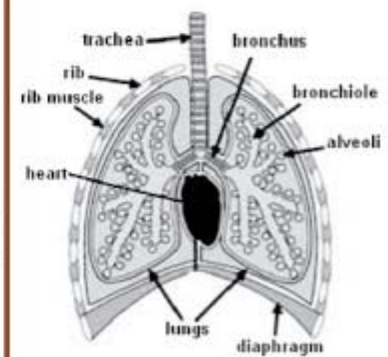
5.3 THE RESPIRATORY SYSTEM

Three processes take place in this system:

1. breathing process,
2. gaseous exchange process and
3. cellular respiration process.

In order to function effectively body cells need oxygen which is transported to cells by the blood. Oxygen is introduced into the body through the respiratory tract and lungs.

Figure 5.10 Diagram of the Respiratory System



Source: homebusinessandfamilylife.com

5.3.1 The Respiratory Tract

Air enters the body through the nose and mouth where it moves into the throat. After leaving the throat air enters a tube known as the windpipe or trachea. The lower part of the windpipe divides into two small tubes known as the bronchi (singular:bronchus) each of which is connected to a lung.

Inside the lungs the bronchi divide into many smaller tubes called bronchioles. At the end of the bronchiole are microscopic air sacs called alveoli.

5.3.2 Movement of Air

Air is normally inhaled through the nose. This is important as the air may contain dust particles that are trapped by the hairs in the nose preventing it from reaching the lungs.

Epithelial cells line the windpipe and the nose secrete a sticky liquid known as mucus. The mucus traps dust, dirt and germs stopping it from getting to the lungs. Microscopic hair present along the windpipe called cilia are responsible for removing mucus. The cilia move back and forth, pushing the mucus towards the nose.

The accumulation of mucus in the passage of the nose will result in sneezing which blows dirt and germs out of the nose.

As air enters and moves through the windpipe it is warmed up and made moist by the addition of water vapour. Air that reaches the lungs is warm and moist.

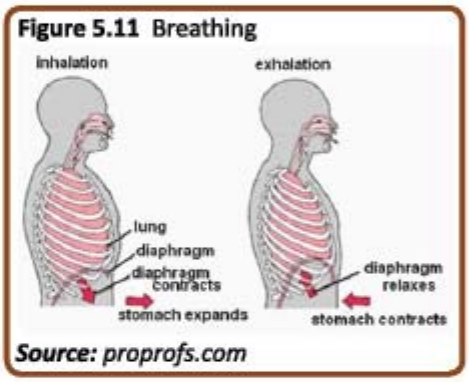


Figure 5.11 Breathing

Source: proprofs.com

5.3.21 Breathing

Breathing is the tidal movement of air into and out of the body. The air enters the body and fills up the lungs every time you breathe in. When you breathe out the used air in the lungs is expelled leaving the body. Breathing takes place without conscious thought. It happens all the time taking fresh air into the lungs and removing the air that the body had used. The ribs and the diaphragm help the lungs when breathing in and out. Ribs have an additional role in that it protects the lungs.

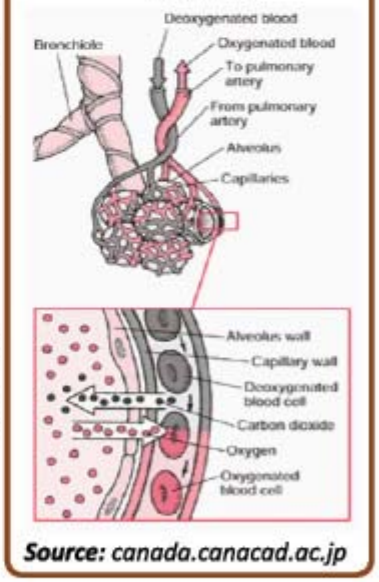


Figure 5.12: Network of vessels in alveoli

Source: canada.canacad.ac.jp

Inhalation

When breathing in, the ribs move up and out while the diaphragm moves downwards away from the lungs. These body movements, increases the volume inside the chest reducing the air pressure inside the lungs. Since pressure of the outside air is higher than air pressure in the lungs it will force air to rush in filling up the lungs causing it to expand or inflate. This is called inhaling or inspiration.

Exhalation

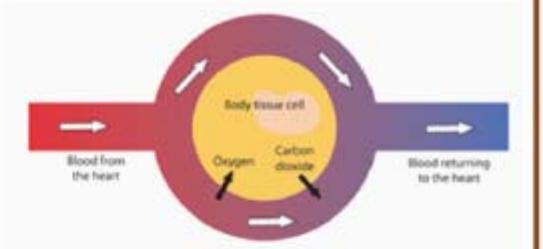
When breathing out the ribs move down and in while the diaphragm moves upwards, toward the lungs. This will reduce the volume inside the body cavity causing the air pressure inside the lungs to increase. Since air pressure inside the lungs is greater than the pressure of the outside air, air will be forced out of the lungs causing it to contract or deflate. This is called exhaling or expiration.

5.3.22 Gas Exchange

Generally gas exchange involves the uptake of oxygen and the removal of carbon dioxide. This is important as oxygen is needed to release energy that the organism needs in order to survive. It also removes carbon dioxide which may poison the body if its concentration accumulates. The gas exchange sites must be thin, moist and have a large surface area. These three characteristics are important as it will allow gas exchange to occur faster. Gas exchange occurs at the air sacs known as the alveoli. These sacs are thin, moist and have

increased the surface area of the lungs. The alveoli are surrounded by a large number of blood capillaries. Capillaries are tiny blood vessels that have very thin walls.
Molecules of oxygen present in the lungs, pass through the thin walls of the alveoli and enters the capillaries where the oxygen joins the haemoglobin in red blood cells. At the same time carbon dioxide is moving from the blood plasma into the alveoli. Movement of the two gases into and out of the alveolus happens by diffusion where it is moving from a region of high concentration to a region of low concentration.

Figure 5.13: Gas Exchange in the Body Tissues



Source: *drtummy.com*

The red blood cells will then take the oxygen to the various cells in the body while carbon dioxide will be removed when air is exhaled.

Another site of gas exchange is at the body cells. When blood arrives at the various body cells oxygen will move out of the blood into the cells while carbon dioxide moves out of the cells into the blood. The plasma will transport the carbon dioxide back to the lungs.

5.3.23 Cellular Respiration

Respiration is a process that occurs in the cells of organisms to release energy. The raw materials for the process are food and oxygen producing energy as the main product and carbon dioxide.

The cell will use oxygen to produce the energy it needs to carry out the many processes it needs to perform in order to survive.

Food	+	oxygen	⟶	energy + water + carbon dioxide
$C_6H_{12}O_6$	+	$6O_2$	⟶	energy + $6H_2O$ + $6CO_2$

Respiration is the last stage of a three step process which begins with breathing the second step is gas exchange and the final stage is respiration.

5.3.3 Malfunctions of Respiration

The following are imbalances in homeostasis in the respiratory system and includes:

1. Asthma: This is an inflammatory disorder of the respiratory tract causing attacks of wheezing, shortness of breath, coughing and tightness of the chest. May be caused by a combination of genetic and environmental factors. Attacks can be prevented by avoiding allergens eg. dust or pollen, and by inhaling corticosteroids.

2. Lung cancer: This is a disease that involves uncontrolled growth in cell tissues of the lung. This uncontrolled growth may be at just an area, or it may spread, or metastasise,to other areas of the body. Common symptoms include shortness of breath, coughing and weight loss.

3. Tuberculosis MTB or TB is a common and in some cases deadly infectious disease caused by various strains of mycobacteria. It usually attacks the lungs but can also affect other parts of the body. It is spread through the air when people who have an active MTB infection cough, sneeze, or otherwise transmit their saliva through the air. Most infections in humans result in an asymptomatic, latent infection, and about one in ten latent infections eventually progresses to active disease, which, if left untreated, may prove fatal. Symptoms include chronic cough with blood-tinged sputum, fever, night sweats, and weight loss. Treatment is difficult and requires long courses of multiple antibiotics.

5.4 THE EXCRETORY SYSTEM

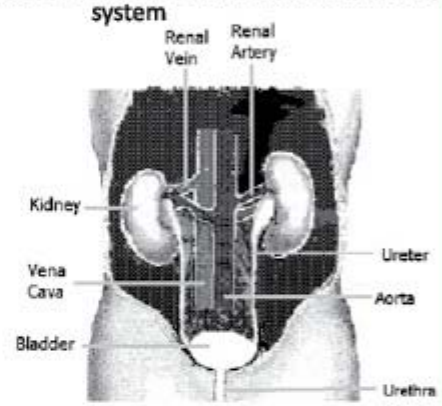
Excretion is the removal of wastes that have been produced by chemical reactions occurring in the body. These chemical reactions are known as metabolic processes or metabolism an example of which is respiration.

Removal of these metabolic wastes is important as it helps to maintain the internal concentration within the cells. If the concentration of these wastes, accumulate it will poison the cell and prohibit the various processes in the cells from occurring. This will lead to the death of cells.

The process of excretion is not the same as the process of **egestion** which is the removal of undigested food. The undigested food moves from the small intestine to the large intestine. Any water present in this waste is reabsorbed as it moves along in the large intestine resulting in the waste becoming a solid. The solid waste then moves into the rectum where it is stored temporarily waiting to be periodically removed from the body. This removal is egestion.

The release of energy in the body also produces carbon dioxide and water. Carbon dioxide is removed from the cells by the blood. The blood takes all the carbon dioxide to the lungs where it is removed from the blood. Air in the lungs is exhaled removing all the carbon dioxide it contains. Some water may also be removed when exhaling.

Fig. 5.14: Diagram of the Human Excretory system



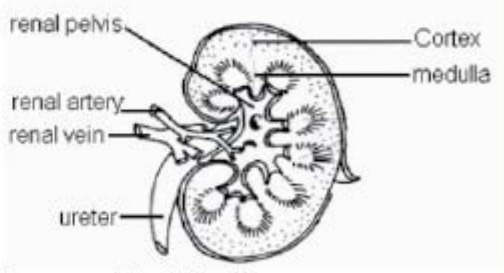
***Source:** comprehensive-kidney-facts.com*

Another important waste material produced by the body is generally called nitrogenous wastes. These nitrogenous wastes are produced from the extra proteins that an individual consumes. The body is not able to store the extra protein it has taken in because of the amine group which is poisonous. This excess protein or amino acids is taken to the liver where it is broken down by a process known as **deamination,** the end product of which is urea.

The urea produced is then taken to the kidneys where it is removed. Since urea is poisonous, a volume of water is needed to dilute it and prevent it from affecting the body. The water dissolves and dilutes the urea forming a solution known as urine which may also contain other dissolved salts and inactive hormones.

Water is an important substance in the body so the body has to ensure that its concentration is maintained. This is another function of the kidney and that is to regulate water concentration which is also known as osmo-regulation. If the concentration of water in the body is high then more water will be lost as urine. A large volume of dilute urine is produced by the kidney. When water concentration in the body is low then less water will be lost as urine. Consequently, a small volume of very concentrated urine is produced.

Fig. 5.15: Diagram of the kidney cross section



***Source:** en.labs.wikimedia.org*

Another way in which water may be lost is as perspiration or sweat. In this instance the water is collected by the sweat gland which is then removed through the pores of the skin. Salt may also be present in the water lost as sweat. Sweating also helps in cooling the body.

The three main excretory organs discussed in this chapter are the lungs, the skin and the kidneys. Only the kidney will be studied in more detail in this section.

5.4.1 Kidney

Each individual has two kidneys. Kidneys are well supplied with blood vessels as it needs to remove urea and maintain the water concentration. The renal artery brings blood to the kidney while the renal vein carries blood back to the heart.

Urine is removed from the kidneys by a tube called the ureter which empties it into the bladder until it is ready to be removed from the body through the urethra.

The kidney is made up of many filter units known as nephrons. Each nephron consists of a capillary network called a **glomerulus** which fits into an invaginated bulb, the Bowman's capsule and a long coiled tubule.

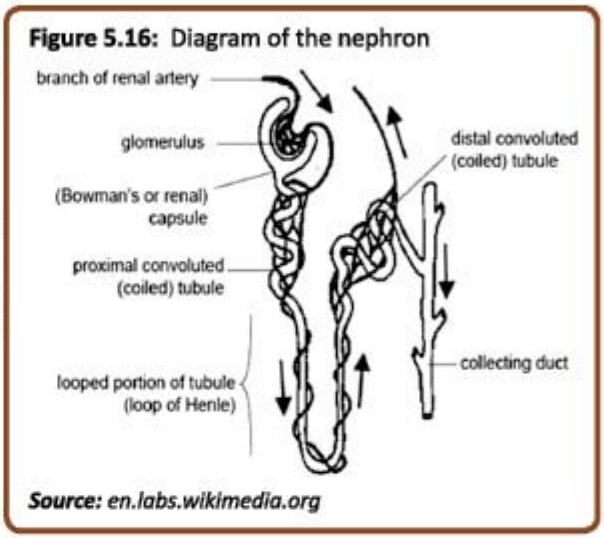


Figure 5.16: Diagram of the nephron

Source: en.labs.wikimedia.org

Renal artery passes the blood into the blood capillaries that are intertwined to form the glomerulus. The high pressure in the glomerulus will force substances out of the capillaries into the Bowman's capsule. Substances that are forced out include urea, water, salts, glucose, amino acids and inactive hormones. Useful substances like water, salt, amino acids and glucose will be reabsorbed as the filtrate moves along the tubules.

All amino acids and glucose would be reabsorbed if the body functions normally. This reabsorption is an active process. The amount of water and salts that are reabsorbed will depend on the concentration in the body.

Urea, water, salt and inactive hormones will be collected at the end of the tubules and it empties into the collecting duct that passes the urine onto the ureter.

5.5 THE SKELETAL AND MUSCULAR SYSTEM (Support and Movement)

The human body is extremely versatile and flexible, making it possible to carry out a whole variety of body movements; walking, jumping, crawling, swimming, doing a split, writing and eating are but a few. All these are made possible because the body has muscles and bones.

The human body has a framework of bones and cartilage held together at joints. This framework is known as the **skeletal system** and gives the body its shape. **Muscles** pull on these bones causing movement. Movement is possible at the joints, where bones meet. Some joints allow greater movement than others. The study of movement is the study of bone and muscle structure, and how they work together or co-ordinate.

5.5.1 Types of Skeleton

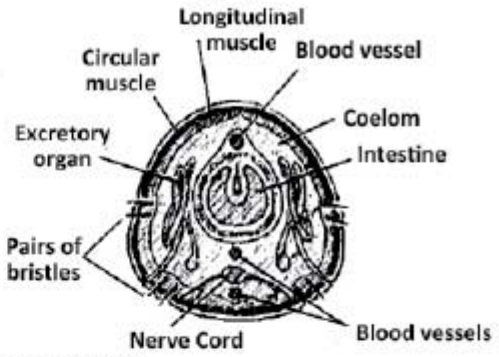
There are three major types of skeletons in animals.

a. <u>Hydrostatic Skeleton</u>
   This is a skeletal system which is based on the presence of a liquid (as the name suggests) instead of bone. The liquid cannot be pushed out of the animal body, therefore when muscles push against it, body movement will occur in a particular direction. Earthworms are animals that move by this method.

An earthworms' body is composed of an internal fluid or **coelom** which separates the gut from the body wall. This is surrounded by two sets of muscles; the **longitudinal muscles** that run parallel to the gut, and the **circular muscles** that run perpendicular to the gut.

When the longitudinal muscles contract the worms' body becomes shortened. When the circular muscles contract, the worm becomes long and drawn out. The contraction of these two muscles happens alternately at different times (in a sequence) creating a wave-like peristaltic movement along its body. The worm is able to grip the substrate on which it is moving by structures found on its dorsal surface known as **setae.**

Figure 5.17: Cross section of the earthworm showing hydrostatic skeleton



Source: dev.cdli.ca

b. Exoskeleton (External Skeleton)
This is skeletal system where there is a bony structure but it is located on the outside of the animals' body. The muscles are connected to the external skeleton which is made of a nitrogenous polysaccharide (repeating units of a derivative of glucosamine) known as **chitin.** This means that all the muscles **have to contract and cause movement from the inside of the external skeleton. Animals with this type of skeletal system include insects and crustaceans.**

Figure 5.18: Exoskeleton of an Arthropod

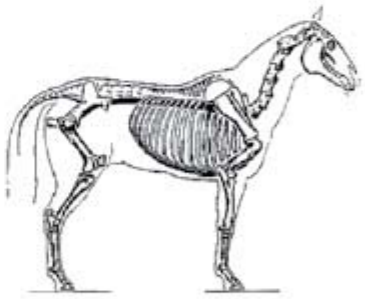
Source: member.cox.net

A common feature of these animals is a process known as moulting. Because the exoskeleton is static, it does not allow the animal to grow to a very large size, without making adjustments to itself. Every so often, their exoskeleton dissolves and is shed to make way for a new one, in order that growing muscle tissue can be accommodated for. In this way growth is not retarded by the presence of the exoskeleton.

c. Endoskeleton (internal skeleton)
This is a skeletal system where a calcareous framework of **bones** are located on the inside of the body. The bones in the framework are held together at the joints. All muscle and cartilaginous tissue are attached to the outside of the bony framework.

This arrangement allows muscles and bones to function independently yet contribute corporately to the smooth co-ordination of an animals' body. Animals that have a bony endoskeleton include fish, amphibian, reptiles, birds and mammals.

Figure 5.19: Endoskeleton



Source: netfuture.org

Functions of the Skeleton

The skeleton has several functions:

1. It provides a support for the human body and attachment site for muscles;
2. It holds up the body thus allowing rapid movement;
3. It gives shape to the body;
4. It provides protection to important organs e.g. the cranium protects the brain, the bones of the vertebrae protect the spinal cord;
5. The bones that make up the skeleton act as levers. Movement results from the action of muscles on these

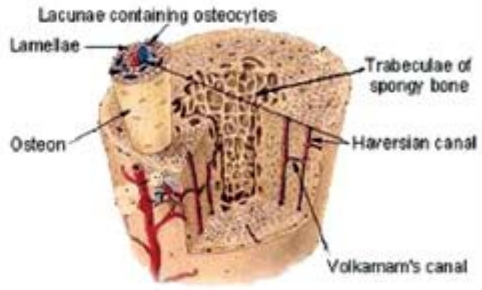
bones;

6. Some bones produce red and white blood cells e.g. sternum and ribs. Bones store the elements calcium and phosphorus.

5.5.2 The Structure of Bones

When in the embryo stage, the skeleton develops as cartilage. The cartilage then grows (ossifies) into bone. Bone and cartilage are made of a type of connective tissue, where the cells are surrounded by extra-cellular (non-cellular) matrix. There are several kinds of cells found in connective tissue but those that produce cartilaginous matrix are known as **chondrocytes,** while those that produce bone matrix are called **osteocytes.**

Figure 5.20: Internal Bone Structure



Source: *curehandpain.com*

Cartilage matrix is flexible and changes into hard bone matrix with the deposition of calcium, a process known as **ossification,** the source of calcium being calcium carbonate and calcium phosphate.

The range of shapes and sizes of bones in the human body varies and is mostly related to their function. However there are generally four types of bones: long bones, short bones, flat bones and irregular bones.

Long bones have bone marrow inside them where red blood cells are made. They have a skin covering called a **perosteum.** Their ends have spongy bone cells which contain nerves. Outside the **spongy bone cells** is a covering of **cartilage,** which acts like a cushion preventing the erosion of bones during rubbing. Long bones whose inside/ middle section is thicker, are known as **compact bone.**

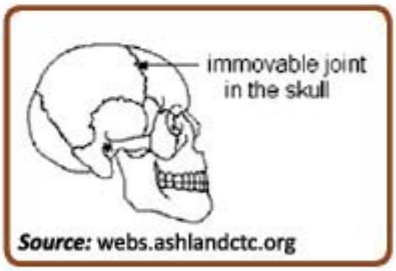
Short bones are those such as, the carpals and metacarpals found in the hands. The bones of the skull and the scapular or shoulder blade are **flat bones,** while bones of the vertebrae and ribs are **irregular bones.**

5.5.21 Joints

This is where two bones meet and hold together by connective tissue known as **ligament.** To avoid the abrasion of bones as they come into contact, the outlying tissue at the point of contact is covered with cartilage.

Like bones, joints also differ in structure and function.

1. Immovable joints cannot be moved such as the bones that make up the skull. Here the bones are held together with cartilage.

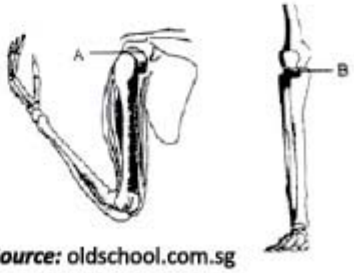


Source: webs.ashlandctc.org

2. Ball and socket joints such as those found at the shoulders and hips, allow movement in all directions. At the shoulders the *humerus* and *scapula* joint allows the arm to rotate, while at the hips the *femur* and *pelvis* allows the leg to rotate.

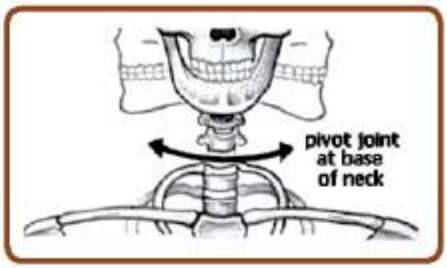
3. Gliding joints are where the bones easily glide up and down, and from side to side, such as those found in the ankles and wrists.

4. Hinge joints are like those found in the elbow and knee, where the bones move backwards and forwards. Movement is only in one direction.



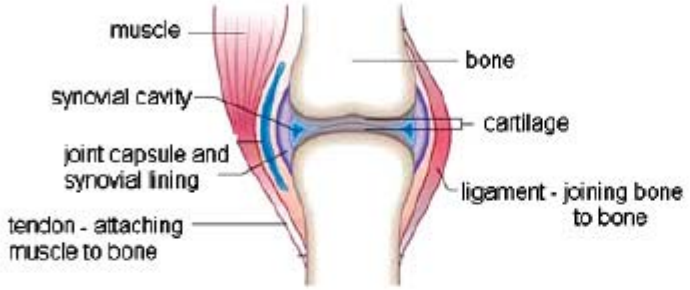
Source: oldschool.com.sg

5. Pivot/swivel joint is found between the first two vertebrae (the **atlas** and **axis**) allowing the neck to be able to rotate.



At all these joints there will be **ligaments** holding the bones together, **cartilage** acting as a shock absorber, **tendons** holding muscles to bones and **synovial fluid** which is a liquid that lubricates the joints.

Figure 5.21: A typical Joint



***Source:** mananatomy.com*

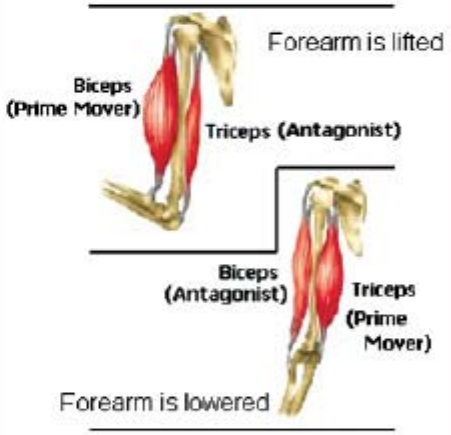
5.5.3 The Types of Muscles

There are three types of muscles; skeletal, striped or striated muscle, smooth muscle and cardiac muscle.

a. Skeletal muscle is voluntary, that is they are under voluntary control and are usually attached to bones. They support the body and their contraction results in movement, releases energy that maintains the body temperature and assists in the flow of blood and lymph in their respective vessels. These muscles work very quickly and with a lot of strength but they also get tired very quickly.

   Skeletal muscle has a stripe or striated appearance due to the arrangement of the protein filaments components. Because the study of muscles known is mostly about striated muscle, it will be discussed in this section to explain the contracting role of muscles.

Figure 5.22: Antagonistic Pairs of Muscles



***Source:** mananatomy.com*

b. Smooth muscle is involuntary, that is it cannot be controlled by the will. They are found in parts of the body where their function is absolutely essential, and their lack of contraction would certainly cause a stand still that would result in death. Examples of places where they are found are in the gut and bladder. Smooth muscle work slowly but do not get tired easily.

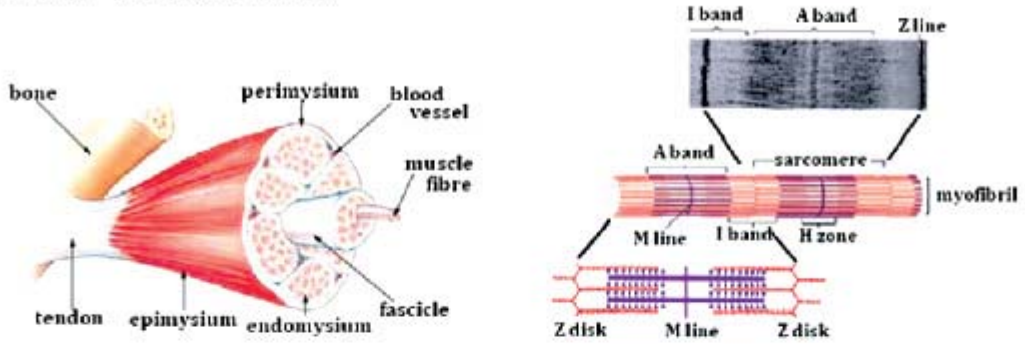
c. Cardiac muscle is a special type of involuntary muscle (cannot be controlled) found only in the heart. It contracts quickly in rhythms without stopping.

Muscles work by contracting and when they do so, they get shorter. When they relax (the opposite action to contraction) they resume their normal size. Muscles act in **antagonistic pairs,** meaning that they work in opposing directions; when one contracts the other relaxes. If they are attached to bone, they pull on it when they contract.

5.5.31 The Structure of Muscles

Striated or skeletal muscle is found held together in bundles and bound by a thin sheath of connective tissue known as **fascia.** The fascia extends into tendons at the ends connecting the muscle to bones.

Figure 5.23 Structure of Muscle



Source: weightrainer.net and smbiology.blogspot.com

The muscle bundle consists of **fibre bundles** also bound and held to other bundles by connective tissue. Within one fibre bundle are **myofibrils** which in turn are composed of **myofilaments** known as **actin filaments** and **myosin filaments.** Actin are thin filaments of protein, while in comparison, myosin are much thicker protein filaments. The arrangement of these two myofilaments produces the striated appearance.

The contracting unit of a myofibril is known as a **sacromere.** During contraction, actin myofilaments slide towards each other causing the sacromere to shorten while the actin and myosin filament lengths remain the same.

On relaxing, the actin myofilaments move back to their original positions.

5.5.32 Movement (Joints and Muscle)

How does movement occur?

Joints facilitate movement. Structures such as wings, legs and arms enhance the movement initiated or made at the joints.

1st order movement – e.g nodding of the head. Here the load and effort are on opposite sides of a fulcrum with forces acting in the same direction

2nd order movement – e.g tip-toeing of the foreleg. Here the load and effort are on the same side of the fulcrum (with effort acting in the upwards direction) but are acting with opposing forces.

3rd order movement – e.g lifting a cup using the fore-arm. Here the load and effort are on the same side of the fulcrum (with the effort acting downwards at the elbow joint) but are acting with opposing forces.

5.5.4 The Human Skeleton

The framework of the human skeleton is divided into two major sections.

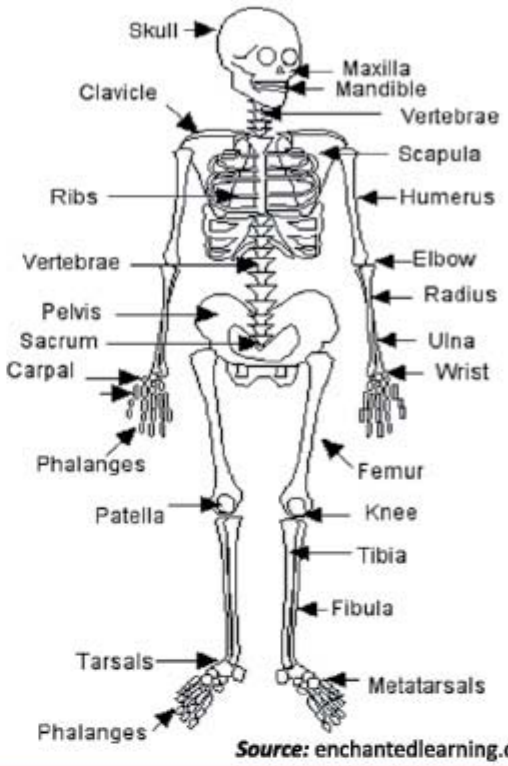
a. The axial skeleton comprising of the

i. skull
ii. rib cage and
iii. vertebral column

b. The appendicular skeleton consisting of the

i. girdles (pectoral and pelvic)
ii. limbs (arms and legs)

Figure 5.24: Human skeleton



Source: enchantedlearning.com

5.6 MALFUNCTIONS OF THE SKELETAL SYSTEM

These cause an imbalance in homeostasis and include;

1. Where the bone is affected
   a. Rickets – this is caused by a shortage of vitamin D during the infancy stage causing deformation of bony tissue. Its evidence is seen in the bow-legged shape due to the bending of the knees.
   b. Fractures – where bones break or split and need to be rejoined
   c. Osteoporosis – thinning of bone tissue and loss of bone density over time. Symptoms occur late in the disease and include bone pain and tenderness.
   d. Osteomyelitis –infection of the bone or the bone marrow. Symptoms include local swelling, warmth and redness.

2. Where the muscle is affected
   a. Strain: injury to muscle where the muscle fibres tear as a result of overstretching. Symptoms include pain, stiffness and discolouration.
   b. Sprain:injury of the joints caused by overstretching. Symptoms include swelling and sometimes bruising.
   c. Muscular dystrophy:this is a hereditary muscle disease that weakens the muscle. Symptoms include progressive muscle weakening, defects in muscle proteins.

3. When joints are affected
   a. Arthritis: a form of joint disorder that involves the inflammation of one or more joints
   b. Slipped Disc: a medical condition affecting the spine where there is a tear in the outer fibrous ring of the vertebral column.

5.7 Caring For Bones

Bones are made of cells specially designed to contain calcium carbonate and calcium phosphate. Food rich in calcium and phosphorus include milk, cheese, eggs, beef and sardines. Vitamin D is essential for the absorption of these minerals, and is found in foods such as fish liver oil, ox liver, egg yolk and margarine. Vitamin D is also produced by the body when the skin is exposed to ultra violet light rays from the sun.

5.8 THE NERVOUS AND ENDOCRINE SYSTEMS (Sensitivity and Co-ordination)

Like all organisms, humans have an enormous ability to make sense of their surrounding and respond accordingly, to the extent, that they are able to change the environment to their advantage. This extraordinary ability is possible because of the structure of the nervous system and the association relay centres that enable information to be processed and retained for long periods of time. This characteristic has made human beings the most influencing agent in the development and changes existing on, and above (in the case of satellites) the planet earth.

The sensitivity and co-ordination system is controlled by two separate but inter-related and inter-connected systems; the **nervous system** and the **endocrine system.** Each utilizes specialized cells or organs and functions in response to different stimulus. The nature of their response also occurs differently.

5.8.1 The Nerve Cell

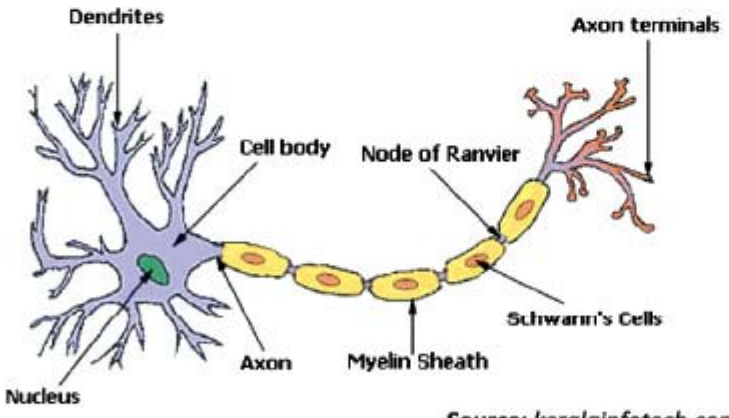
Cells that make up this system are of two types; those that transmit nerve impulses known as nerve cells or **neurons** and those that nourish and support them known as **neuroglia.** For the purposes of simplicity only transmission through neurons will be dealt with.

Each neuron consists of an elongated arm of protoplasm stretched from the main cell which contains the nucleus and other organelles. The elongated arm is called an **axon,** the main cell is called the **cell body** and the minute fibres extending from the neuron are collectively known as the **dendrites.** This cell structure

1. is an adaptation to enable fast transmission of information, in the form of electric impulses, along the cell and
2. ensures efficient and immediate response to all forms of stimuli

The myelin sheath acts as an insulator protecting the axon from infiltrating disturbances that could slow down the transmission of the impulse. The myelin sheath is formed by specialized cells known as **Schwann cells.**

Figure 5.25: A typical Neuron



Source: keralainfotech.com

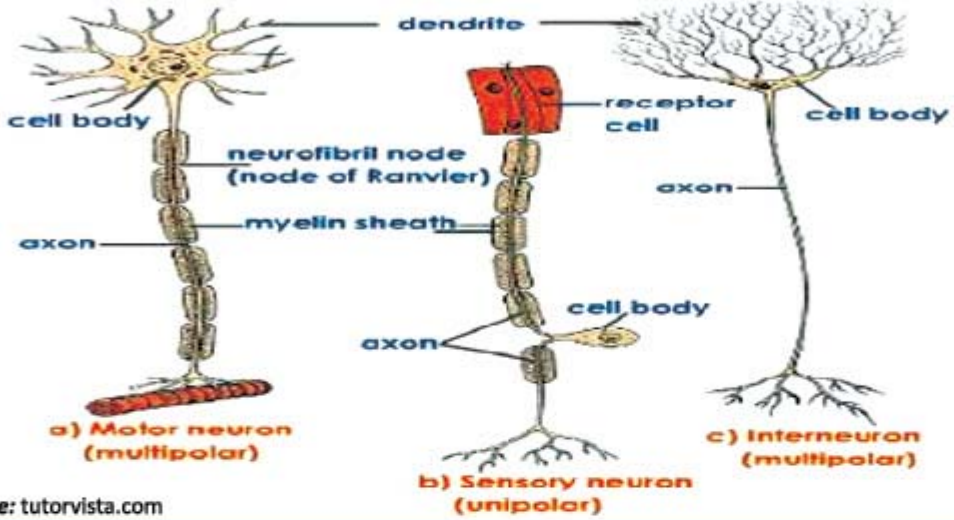
The table below shows the part of the neuron and its function:

Name of Part	Function
Dendrite	Network of fibres receiving impulses
Axon	Conducts impulses toward the brain or spinal cord
Myelin sheath	Helps to speed up the nerve impulse travelling along the neuron. Done by protecting or insulating the impulse from deflect from the short possible route
Cell body	Contained in nervous system and received impulses from short network fibres called dendrites
Schwann cells	Forms the cells of myelin sheath
Dendron	Conducts impulses from sensory receptor to the cell body

There are three types of neurons; **motor neurons, sensory neurons** and **interneurons.**

- Sensory neurons receive impulses from sense organs such as the eye, ear, skin, tongue and nose and transmit them to a relay centre.
- Motor neurons however, transmit impulses from a relay centre to a motor causing a response to be made.
- Inter-neurons convey messages or impulses between neurons and are located in the central nervous system.

Figure 5.26: Three types of Neurons



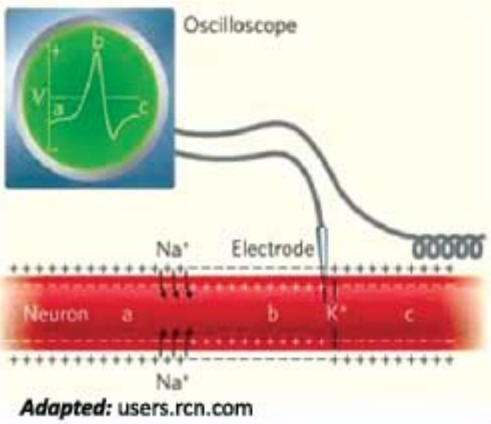
Source: tutorvista.com

5.8.2 The Nerve Impulse and Transmission-How Impulses travel Along a Neuron.

Axons conduct impulses which get transmitted along the neuron. The conduction of an impulse involves a difference in the distribution of sodium ions, Na , and potassium ions, K, on the either side of the plasma membrane of the axon. When there is no conduction, the inside of the axon is negative and is the result of the presence of a high concentration of potassium ions, while the outside of the axon is positive because of the presence of a high concentration of sodium ions. This charge difference, or electrochemical change, causes a **polarity** to exist within the axon, and the polarity is maintained by the action of a membrane protein known as the **sodium-potassium pump.** The sodium-potassium pump is always active as there is a natural tendency for the ions to diffuse from an area of high concentration to an area of low concentration.

The condition of there being no impulse conduction is known as the **resting potential,** that is where the inside is negative and the outside is positive. When measured on an **oscilloscope,** the value of the inside negative pole is -65 mV while the outside positive pole is +40 mV.

Figure 5.27: Oscilloscope graph



Adapted: users.rcn.com

The rapid change in polarity across the axon membrane is known as the action potential. The action potential is an all-or-none phenomenon and will happen if the change in polarity is above a certain threshold.

The strength of a stimulus determines the frequency of the action potential rather than its size. Therefore a strong stimulus will cause the action potential to be arrived at more often than a weak stimulus.

The achievement of an action potential is closely followed by two events. Firstly, sodium gates along the axon membrane open, allowing sodium ions to enter changing the polarity and resulting in

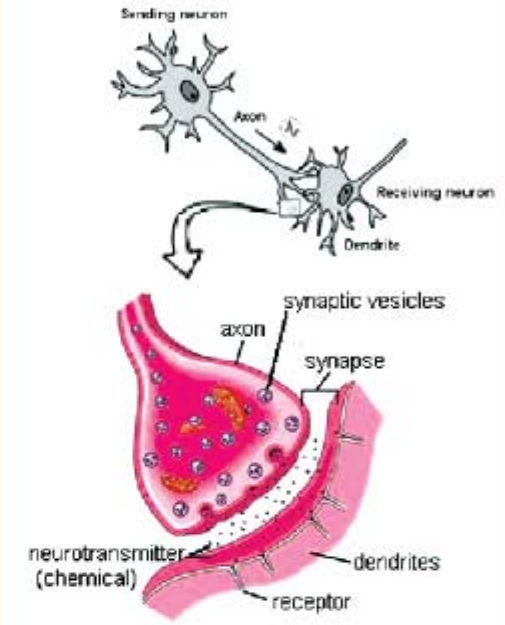
a **depolarization.** Secondly, the potassium gates open allowing the potassium ions to travel out of the axon, again changing the polarity and resulting in a **repolarization.**

As the action potential travels along a neuron, successive portions of the neuron are depolarized and repolarized imitating (likened to) an electric impulse (current) created because of the differing concentrations of sodium and potassium ions on either side of the axon membrane. To ensure that electric impulses do not go backwards, the sodium and potassium gates remain closed for a short period immediately after.

5.8.3 Transmission Across A Synapse

Impulses travel along a neuron in the manner described above until it arrives at the axon bulb. In the axon bulb there are neurotransmitters located in synaptic vesicles. One such neurotransmitter is the chemical acetylcholine. On the arrival of an electric impulse, calcium gates are opened and calcium ions enter the bulb stimulating the vesicles to move to the edge of the presynaptic membrane. When the presynaptic membrane merges with the postsynaptic membrane, the vesicles open by exocytosis releasing the neurotransmitters. The neurotransmitters travel across the **synaptic cleft** and diffuse into the postsynaptic membrane.

Figure 5.28: Impulse traveling through Synapse



***Source:** scienceblogs.com*

In order to ensure the continuity of transmission across the synaptic cleft, the neurotransmitters have to be destroyed or inactivated immediately after they have initiated an action potential in the postsynaptic membrane. This destruction is carried out by certain enzymes. For example, the neurotransmitter acetylcholine is inactivated by the enzyme acetylcholinesterase.

The destruction of the neurotransmitters in the postsynaptic membrane is important to lower its concentration and therefore encourage its diffusion across from the presynaptic membrane. Drugs that affect human response by slowing it down directly intervene with the destruction or inactivation of neurotransmitters after it has arrived at the postsynaptic membrane, thus slowing down transmission across the synaptic cleft and as a result, slowing down the whole body response.

5.8.4 The Nervous System

The complexity in the nervous system is enormous and in-depth knowledge is not possible for the Form 5 level, however it will be described as simple as possible to provide a basic foundation for future specialized study. Put simply, the human nervous system consists of two broad systems; the peripheral nervous system and the central nervous system.

1. **The Peripheral Nervous System (PNS)**
   This system consists of the nerves and ganglia that connect the central nervous system to the rest of the body. It is responsible for the communication between receptor organs and the central nervous system, and between the central nervous system and the effector organ such as an organ or muscle.

The PNS consists of two other systems:

   a. The **somatic nervous system** is associated with voluntary receptors and includes the nerves that take messages from receptors such as skin, to the CNS. Some of these may be **reflex actions.**

b. The **autonomic nervous system** controls involuntary functions in the body such as heart beat, breathing and peristalsis. It consists of two chains of ganglia on either side of the spinal cord. The ganglia are connected to each other as well as to the spinal cord and brain. The autonomic nervous system is divided into two divisions:
   i. the **sympathetic** division which involves responses that are made during periods of stress, and
   ii. the **parasympathetic** division which is associated with responses made during periods of relaxation.

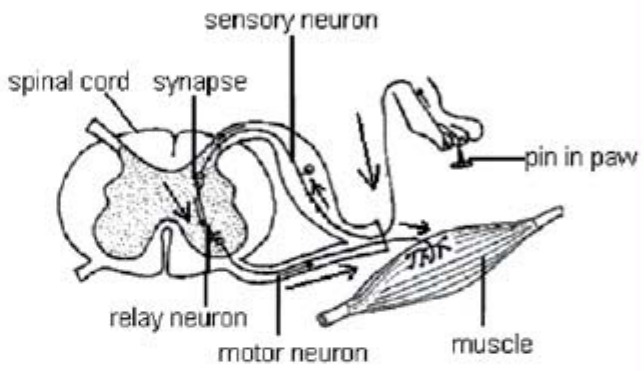
5.8.41 The Reflex Action

This is an automatic reaction to a stimulus often occurring very suddenly. It is a response that would directly or indirectly result in the protection of the individual who displayed the reflex response.

The direction of impulse transmission along a reflex arc is shown below.

Another example of a reflex action is the response shown when a person touches a hot plate and jumps back screaming as he lets go of the plate. In this example, the skin receptors in the fingers receive a heat stimulus. An action potential is created and transmitted along a sensory neuron to a synapse. It then travels across the synaptic cleft to an interneuron or association neuron. The impulse then travels through another synapse to the motor neuron ending at the muscle which contracts and pulls the hand away from the hot plate. While at the interneuron transmission can be sent to other places via the appropriate neurons as well as to the brain. Other places may include the vocal cords causing the person to shout in pain.

Figure 5.29: Cross-section diagram of a simple reflex arc



***Source:** en.wikibooks.org*

2. The Central Nervous System (CNS)

This system is made up primarily of the **brain** and the **spinal cord** which interprets sensory messages from the sense organs before co-ordination of the response, in order to maintain homeostasis.

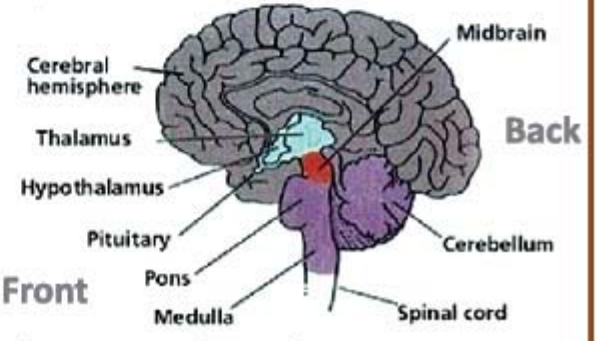
a. **The Spinal Cord**

This is a mass of nerve cells arranged in a hollow tube running through the vertebral column and begins at the base of the brain. The cell bodies of the nerves are found on the inside of the column, while the nerve fibres run up and down on the outside. The function of the spinal cord is to conduct messages to and from the brain, and to make it possible for reflexes to integrate.

b. **The Brain**

This is the specialized end of the spinal cord, weighing about 1.3 kg in an average adult human. It is covered by a number of membranes called **meninges,** and is protected by a **skull.** The brain also has approximately 125 mL of **cerebrospinal fluid (CSF)** circulating around inside it. The CSF serves as a shock absorber, and circulates nutrients to brain cells.

Fig. 5.30: Cross-section diagram the brain



***Source:** emc.maricopa.edu*

5.8.5 The Sense Organs

Accurate, specific and detailed human response is possible because the body is equipped with an elaborate communication network that enables it to pick up, collect and separate signals from a broad range of sources in its environment. Before a stimulus is processed and associated, the body must be alerted of its presence and collected by a receiver or **receptor.** The human body has an elaborate system of very efficient and highly effective receptors each designed to respond to different types of stimuli.

Stimulus in the form of light is received by the eyes (optic receptors), stimulus in the from of sound is received by the ears (auditory receptors), stimulus in the form of chemicals and molecules is received by the tongue in the case of taste, and by the nose (olfactory receptor) in case of smell. Stimuli in the form of pressure (touch), sensations (pain, itchiness, ticklish) and temperature (heat, cold) are received by receptors in the skin (tactile receptors)

5.8.51 The Sense of Vision and the Structure of the Eye

The Structure of the Eye

The human eyes are very complex receptor organs. Within each eye is a lens system for focusing light onto a surface (retina) containing receptor cells **(rods** and **cones**) that converts the light rays into electric impulses. These impulses are then transmitted to the brain by appropriately designed nerves called **optic nerves.**

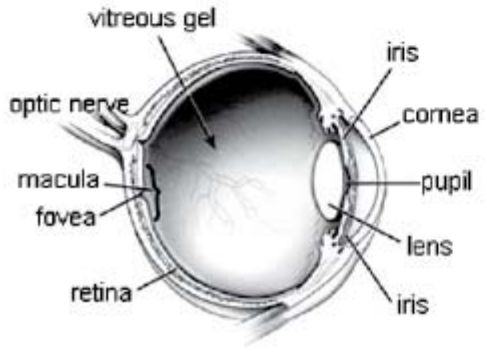
The eyeball itself is made of a tough, white outer tissue known as the **sclera** filled with clear fluid. The front visible section of the sclera is called the **cornea** and is protected with a thin transparent epithelium layer known as the **conjunctiva.** An extension of the conjunctiva also forms the inner lining of the eyelids. When the eye is closed it is completely protected from light and foreign matter.

The amount of light entering the eye is regulated by a diaphragm called the **iris** which consists of two sets of muscles; **circular** muscles and **radial** muscles. These muscles form the perimeter of a space known as the **pupil.** The pupil is the window through which light travels in order to enter the eye. The alternate contraction of these muscles causes the pupil to change in diameter.

When light intensity is high the pupil decreases in diameter and it increases when light intensity is low. Suggest reasons for this.

To enter the eye, light passes through the conjunctiva and the fluid called the **aqueous humour,** before entering the pupil and lens. It then travels through the **vitreous humour** before finally landing on the retina. An image falls on the retina stimulating sensory cells which form patterns of impulses that are sent to the brain through the optic nerve. The appropriate centre in the brain interprets this pattern as information that can be understood and comprehended.

Figure 5.31: The Human Eye



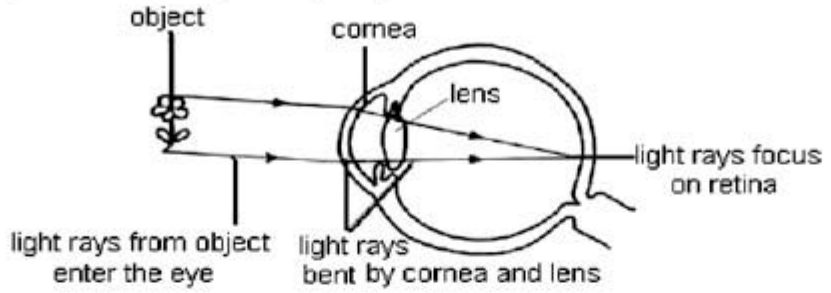
***Source:** visionloss.biz*

Vision

The translation of the object being looked at by the eye onto an image in the retina is made possible by the property of light to bend as it travels from one medium to another. This property is called **refraction.** When the image forms on the retina it is not real (virtual), extremely small in size (diminished) and upside down (inverted). However after it is transmitted to the brain and processed it is registered and recognized by the person as real, the same in size and the correct way up (erect).

The rods and cones (named according to their shape) on the retina, respond differently to light. The cones detect coloured light while the rods are active to the presence and absence of white light. Rods are active in conditions of dim light enabling objects to be seen even in the dark.

Figure 5.32: Light rays forming images on retina.



***Source:** en.wikibooks.org*

Each eye can see objects within a 100° range however each eye can only fully comprehend the detail of an object if its image falls on the spot known as the fovea. This covers a range of about 2°. For example, when you are reading this book, the image of each word or group of words falls on your fovea one at a time as you go through the sentence. However the diagrams, colour, bold headings etc. can still be seen because their image still falls on your retina though not on the **fovea.**

Another important area on the retina is the **blind spot.** It is the place where the optic nerve leaves the retina and there are no sensory cells. When an image falls on the blind spot the brain does not register it and it cannot be seen. Experiences will show that sometimes when we are hurriedly looking for our pen or rubber, we just can't seem to find it at first glance although it was always there on the desk.

Finding your Blind Spot

1. Hold this page at an arm's length from your face.
2. Close your left eye and focus on the cross with your right eye. The circle will appear fuzzy in your peripheral vision.
3. Slowly move the page toward you (while focusing on the cross with your right eye).
4. At some point, the circle will disappear from your peripheral vision.
5. Measure the distance from the page to your eye.
6. Now repeat with your left eye.
7. What do these distances tell you? Write an explanation for this phenomenon.

Accommodation

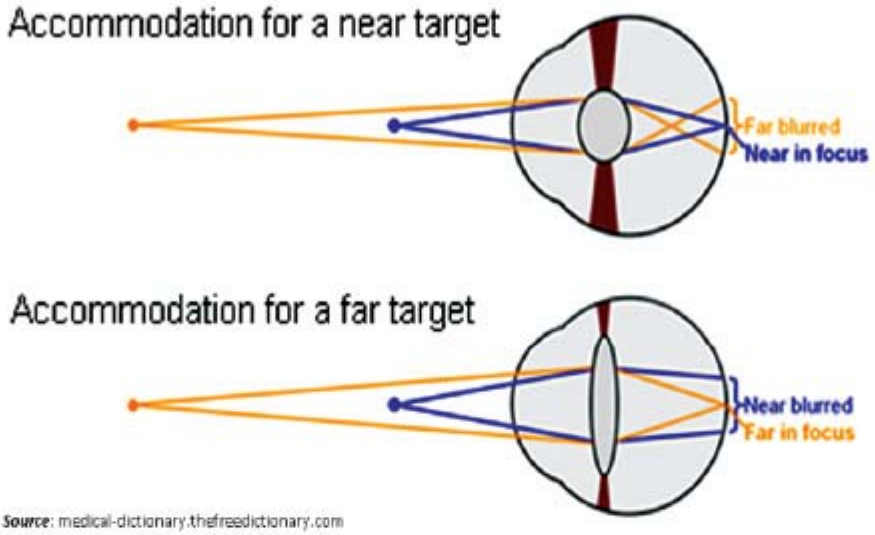
For the eye to serve its role as a sensory organ, receiving stimuli from the environment which is successfully interpreted to aid survival, the image of any object must fall on the retina in a consistent and continuous fashion. For this to happen, the eye must continuously rearrange the position or status of its internal lens.

The lens is held permanently in place by ligaments which attach it to the ciliary muscles of the eye, therefore it cannot move its position. However, it can change its thickness to enable it to bend light more or less, depending on the position of the object being looked at. The alteration of the thickness of the lens is controlled by the contraction and relaxation of the ciliary muscles and it accommodates the eye to see objects clearly irrespective of their distance. This ability of the eye is known as **accommodation.**

Each eye sees a complete picture of an object and two impulses are sent but the brain co-ordinates the images so that only one picture is seen. Each eye sees a slightly different version of the object and the correlation of the two images produces a sensation that enhances the three dimensional property of the object. This is the stereoscopic ability of the eye, which also comes into effect when making judgements concerning distances.

Figure 5.33a: The Accommodation Process

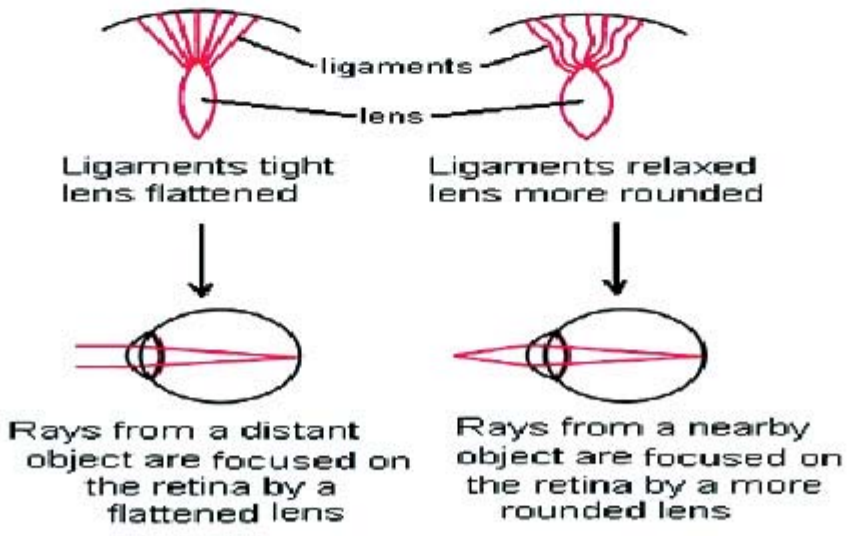
i. Diagrams of the ciliary muscles relaxing and contracting and the lenses changing in shape



Source: medical-dictionary.thefreedictionary.com

Figure 5.33b: The Accommodation Process

ii. Diagrams of rays from far and near objects, going through lenses of the eyes and falling on the retina. (Accommodation for distant objects and accommodation for near objects)

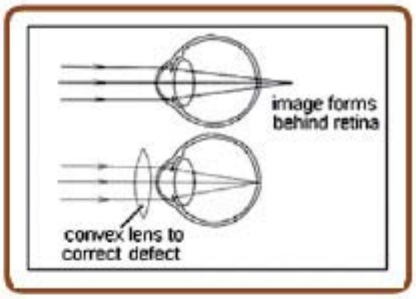


Source: sapdesignguild.org

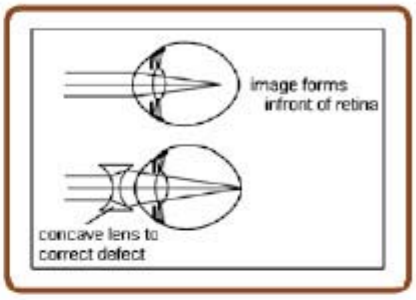
5.8.52 Malfunctions of the Eye

The two most common defects of the eye are:

a. Far or Long sightedness (hypermetropia)
This is a condition where a person can focus on things that are far away but not on close-by objects. This defect is caused by an imperfection in the eye where the eyeball is too short and the lens is not rounded enough to focus properly on objects. To correct this defect, a convex lens is used in spectacles or contact lenses



b. Short sightedness (myopia) – The lens is too curved causing light rays from an object to be bent too much. This results in the image not forming on the retina but in front of it. The ciliary muscles are too relaxed and not contracted enough preventing the lens from being pulled out and made long and thin. To correct this defect, a biconcave lens is used to delay the converging of the rays and therefore enabling them to fall on the retina.



Other defects include:

c. Astigmatism – This is a condition resulting from the cornea or the lens being irregularly curved, or sometimes the lens does not change shape uniformly. When this happens the person can focus on light in one plant but not another. This is a refractive error and causes blurred vision.

d. Cataract – this is a clouding over the lens as a result of protein breakdown. The clouding varies in degree and progresses slowly. Eventually, it could block light from entering the eye and cause loss of vision. Some factors that speed up cataract formation are diabetes, eye inflammation or injury.

5.8.53 The Sense of Hearing and the Structure of the Ear

The Structure of the Ear

The ear is made up of three major parts; the **outer ear,** half of which can be seen, the **middle ear** and the **inner ear.** The outer ear consists of the external pinna and a canal (auditory canal) which ends at the ear drum. The middle ear has three small pieces of bones which link the ear drum to the inner ear. The middle ear communicates with the throat through a narrow tube – the Eustacian tube.

Sound Perception

Sound waves collect on the **pinna,** a flap of skin and cartilage, which then funnels the waves through the **auditory canal** to the **ear drum,** a thin membrane separating the outer ear from the middle ear. The ear drum is sometimes referred to as the **tympanic** membrane. When the sound waves reach the ear drum, the ear drum vibrates and send the vibration to the middle ear.

The middle ear is an air filled cavity containing a chain of three tiny bones – the malleus (hammer), the incus (anvil) and the stapes (stirrup) collectively known as **ossicles.** The sound vibration is carried through the ossicles until it reaches the **oval window** and the **inner ear.**

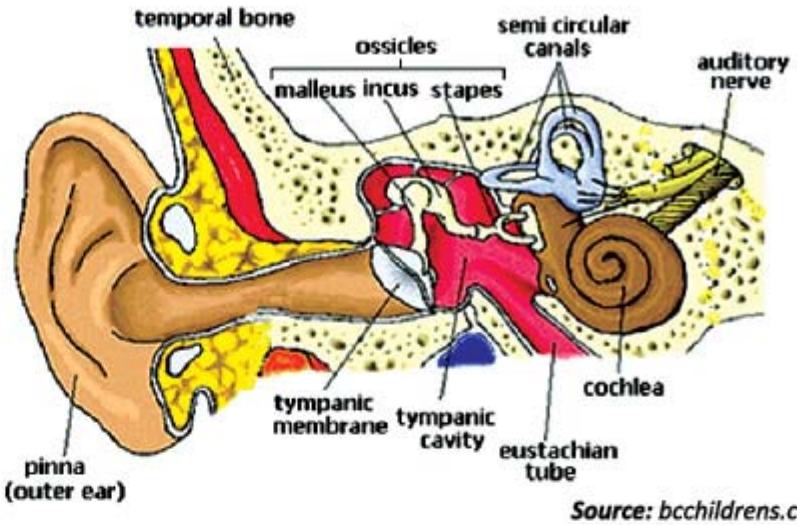
The inner ear is a fluid filled chamber that contains two main structures:

i. The **semi-circular canals** which are concerned with balance;
ii. The **cochlea** concerned with sound perception.

The sound vibration is picked up by the cochlea and transferred to the **auditory nerve** which transmits to the brain. The brain interprets the vibration as sound.

The cochlea is a fluid filled coiled structure that is lined with fibres. The **pitch** of the sound we hear depends on which fibres are stimulated by the vibration. If the fibres at the end of the cochlea are stimulated, the sound is low pitch, if the fibres at the beginning of the cochlea are stimulated, then a high pitch sound is heard. The **volume** of the sound depends on the number of fibres are stimulated. Many fibres being are stimulated is interpreted by the brain as a loud sound.

Figure 5.34: Diagram of the Human Ear



Source: bcchildrens.ca

5.8.54 Malfunctions of the Ear

Several things can affect the perception of sound:

a. Too much wax secreted by the ear can obstruct sound waves from reaching the eardrum, thus reducing the accuracy of perception;

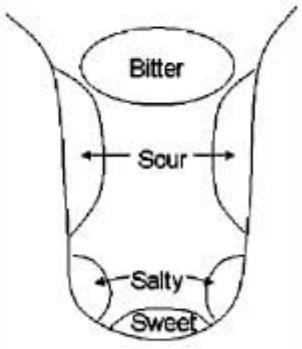
b. Air pressure on either side of the eardrum must be balanced to allow the tympanic membrane to vibrate freely. When there is a pressure imbalance, as when ascending or descending a steep slope, then pressure must be equalized. This is made possible by the clearing eustacian tube which connects the middle ear and the throat. If this tube is blocked by infection, sound reception can be affected.

5.8.56 Response to Chemicals and the Nature of Chemoreceptors

The Sense of Taste

There are four basic tastes that can be detected by the tongue: sour, sweet, bitter and salt. For each taste type, there are different groups of taste receptors to identify it. The variety of tastes that humans can savour is a result of the many receptors that are being stimulated in differing combinations and differing degrees.
Different people have taste buds that vary in their sensitivity to different chemicals so that some people find some tastes agreeable while others may find the same taste unpleasant.

Figure 5:35
Taste areas of the tongue



Source: qi.com

The Sense of Smell

This is sometimes referred to as the **olfactory** sense. Although humans can detect many types of smells, the categories of smell are not so easily analysed as taste. However, olfactory receptors are especially sensitive and will respond to very low concentrations of chemicals in the air.

The Sense of Touch and the Nature of Tactile Receptors

The skin is the largest sense organ of the body and contains different receptors that are perceive touch, pain, pressure and temperature. If the pain receptors are stimulated perhaps by cutting the skin, then nerve messages are sent to the brain which registers the stimulus as pain.

Skin receptors have a characteristic of adapting to stimulus. This means, the receptors can 'get used to' repeated stimulation. Touch receptors adapt quickly and thus, we do not continually 'feel' the clothes on our bodies, while pain receptors adapt more slowly and we continue to feel pain from a cut long after it has happened.

5.9 MALFUNCTIONS OF THE NERVOUS SYSTEM

These cause an imbalance in homeostasis and include;

1. Alzheimer Disease:
   is an irreversible, progressive brain disease that slowly destroys memory and thinking skills, and eventually even the ability to carry out the simplest tasks. Alzheimer's disease is the most common cause of dementia among older people. Dementia is the loss of cognitive functioning—thinking, remembering, and reasoning—to such an extent that it interferes with a person's daily life and activities.

2. Parkinson Disease
   a brain disorder that leads to tremor and difficulty with walking, movement, and coordination. Although not a normal part of aging, Parkinson's occurs most often among people 60 and older, and the risk increases with age.

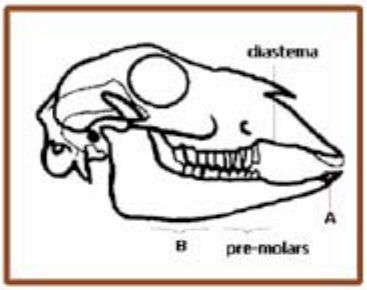
3. Drug Abuse or Substance Abuse, is a disorder that is characterized by a destructive pattern of using a substance that leads to significant problems or distress. That substance could be alcohol, prescribed drugs like valium or illegal substances like nicotine and marijuana.

Review Questions

1. Complete the following table of digestive enzymes.

Enzyme	Produced by	What is digests	Product of digestion
(i)	Stomach	Protein	Amino acid
Lipase	Pancreas	(ii)	Fatty acid/glycerol
Amylase	(iii)	Starch	(iv)

2. The diagram (right) shows the jaws of a rabbit, a mammal which feeds on plants.
   i. Name the type of teeth labeled A and B.
   ii. What function do teeth B perform and how is their structure suited for this function?
   iii. Suggest a function for the large gap (diastema) between the front and back teeth.



3.

List A	List B
i. cartilage	A. causes body movement
ii. ligaments	B. attach muscles to bones
iii. tendons	C. smoothens space between bones
iv. synovial fluid	D. holds cartilage together
v. skeletal muscle	E. bones held by immovable tissue
F. links bone to bone	G. joins sternum and ribs allowing flexibility in breathing

4. The table below shows a survey of red blood cells count of groups people living at different altitudes.

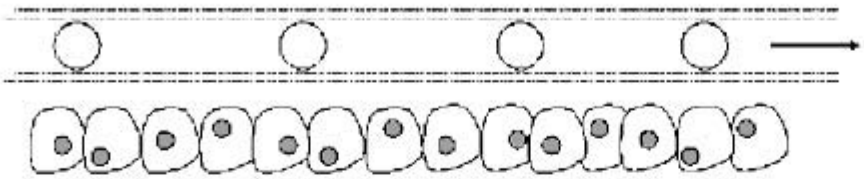
Height above sea level (m)	Red blood corpuscles per mm^3 blood
0	5 000 000
400	5 570 000
1 500	6 500 000
1 800	7 000 000
4 400	8 000 000

   i. Name the pigment that is responsible for the colour of blood
   ii. Where is this pigment found and what is its function?
   iii. What difference is observed between the blood of people living at sea level and those living in high altitudes? Suggest a reason to account for this observation.

5. i. What is a pulse?
   ii. Give one reason why pulses can only be felt at certain points.
   iii. How does the heart respond to strenuous exercise?

iv. Why is there more blood returning to the heart when you run than when you rest?

6. Study the diagram given below which is the relationship between part of the blood system and the tissue cells.



i. Name the fluid found in the area labeled A.
ii. State three substances that pass from the blood capillary to the tissue cells.
iii. Name two gases dissolved in Area A.
iv. If Cell B were invaded by germs, how would the body react to protect against infection?

7. In the dialysis machine, the blood of the patient flows on one side of a partially permeable membrane and the dialyzing fluid flows on the other side. The dialyzing fluid has the composition and the concentration equal to that of the plasma of a normal person.
i. What process causes the excess water from the patient to pass into the dialysing fluid
ii. Name an excretory product, other than water, which will pass out of the blood into the dialyzing fluid?
iii. Name the process by which this (in (ii) above) occurs?

8. The nephron is the filtering unit of the kidney.
i. Complete the table below of the processes that take place in the nephron.

Process	**Place it occurs**
(i)	Loop of Henle
Filteration	(ii)
(iii)	Collecting tube

9. i. What is meant by the term synapse?
ii. How does a message in the nervous system cross the synapse?
iii. Synapses are readily affected by drugs and poisons. Why?
iii. Differentiate between the nervous and the endocrine systems

CHAPTER 6

ECOLOGY

Ecology is the study of relationships of living things (organisms) and their interaction with their environment. The environment is made up of both living things known as biotic factors and non-living things known as abiotic factors or physical factors. An organism can be studied at different levels. These levels are called biological levels of organization (see Chapter 1). The level starts with the atom and the highest level an organism can be studied at is at the biosphere.

Study the following basic terms defined below that are important for understanding the concepts of ecology:

- An **organism** is a living individual that belongs to a certain species. Thus any living thing whether plant, animal or fungus may be referred to as an organism. Examples of organisms are a rat, a donkey, a fern tree or an earthworm.

- A **species** is a group of individuals of the same kind that are able to interbreed and produce fertile offspring. Similar organisms that may interbreed but produce sterile offspring are probably of different species. This definition, however, is limited as it does not include fossils, dead organisms and asexually reproducing organisms. Thus, in these cases, similarities in characteristics are used to classify organisms. Also, within a species, organisms vary in their physical appearances – look around at how different people are. Thus there is always disagreement when dividing similar organisms into different species.

- Individuals of the same species living together in an area at a particular period of time make a **population.** Thus, all the coconut trees in your school compound are a population, all the dogs in Sevuka Place are a population.

Figure 6.1: A rocky shore community

***Source:** redbubble.com*

- **community** is made up of the different populations in an area. The individuals in a population interact with each other and with individuals of other populations within a community. Communities can vary in size eg. there is a community of organisms on a decomposing leaf, and there is a community in a large lake. In any place where organisms can live, one will find a community and it will be defined by the boundary that surrounds it, and named after its most noticeable feature. Thus examples of communities include the rocky shore community, a community on a hibiscus plant or a rotting tree trunk community.

Figure 6.2: A coral reef ecosystem

***Source:** eoearth.org*

- An **ecosystem** is made up of the community of organisms, interacting with each other, and their physical environment, within which they also interact. Ecosystem may be simply described as an organism and its environment. The environment can be divided into living things (biotic factors) and non-living things (abiotic or physical factors). The biotic factors include all organisms of the same species and those of other species in the area. Physical environment will include factors like light intensity, humidity, temperature

and soil type. Examples include a rainforest ecosystem – this involves all the plant and animal life found in the rainforest, and the temperature, humidity and rainfall components of the rainforest and how these affect living things in the rainforest. A coral reef ecosystem includes all the fish, corals, sponges, algae and other living things living amongst the coral, and physical factors of water temperature, salinity, tidal movement and sunlight.

- A **habitat** is the address of an organism, where an organism lives. Obviously, an organism will only be found in a habitat where it can tolerate the environmental conditions, thus organisms are very particular about their habitat.

- Within an environment, factors like temperature and humidity fluctuate and vary daily. Some factors change rapidly like wind speed, others change at a slower rate. To live successfully in an area, an organism must be able to endure these changes. This ability is called **tolerance.** IF the factor in question is temperature, then there is a **range** of temperatures within which an organism will survive. Above or below this range, and the organism will die or must move away from this area. Within the range is an **optimum temperature,** this is the best temperature that the organism can survive in.

- An **adaptation** is a characteristic or feature that an organism has to help it survive. Eg. a thorn is an adaptation of a lemon tree, it keeps herbivores from eating it.

As the study progresses, other ecological terms will be used and defined.

6.1 POPULATIONS

As defined earlier, a population is a group of organisms of the same species living in a given area at a given period of time. There are certain features of a population that can be used to describe a population.

a. Population Size

This refers to the number of individuals in a population. Ecologists have designated the letter 'N' to indicate population size. Thus, if there are 12 dogs that live within your school compound, then the population size of dogs in your school compound is N = 12 dogs. Remember that the units of population are the organism being counted.

b. Population Range

This refers to the area within which the population is found. In the example of the dogs given in (a) above, the range would be the area of your school compound. Because range is an area, the units of range are the units of area like km2 or m2.

c. Population Density

This refers to the number of individuals which may be present in each unit of area.

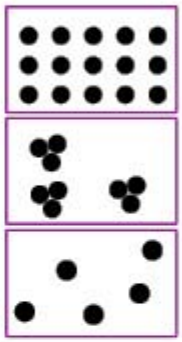
$$\text{Population Density} = \frac{\text{Number of individuals (N)}}{\text{Population Range}}$$

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

Number of individuals	=	400
Population Range	=	2km x 100km
	=	200km2
Density is	=	400
		200
	=	**2 trees/km²**

d. Population Distribution

This refers to the way that individuals in the population are spread out within its range, and this can vary greatly. Within a population, individuals may be distributed in three ways:



i. Uniform Distribution: where the individuals are evenly distributed throughout the area.

ii. Clumped Distribution: where individuals are found in groups or clusters in the area.

iii. Random Distribution: where individuals are distributed haphazardly or unevenly throughout the area

What do these population distributions indicate about the environment and the resources within the environment?

e. Age of populations:

Within any population, one will find individuals of varying ages. There are two factors that control the age structure of any population:

i. natality or birth rate

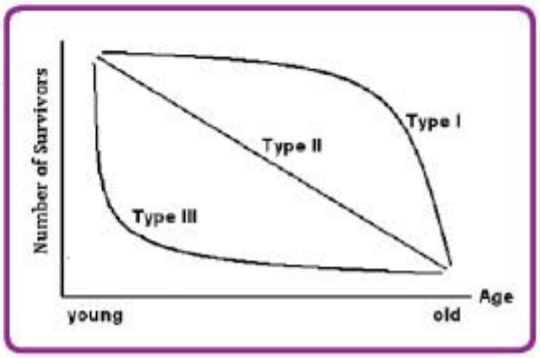
ii. mortality or death rate

Some organisms have a very high death rate because they live in areas where conditions are unfavourable, or they have plenty of enemies eg. 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 little or no parental care (toads and frogs). Those organisms that show high parental care make up by producing very large numbers of gametes during reproduction.

Survivorship Curves are a useful way of showing mortality and natality rates for different populations. Survivorship is the 'chance of remaining alive' There are three types of survivorship curves, shown on the same axis in the diagram at right:

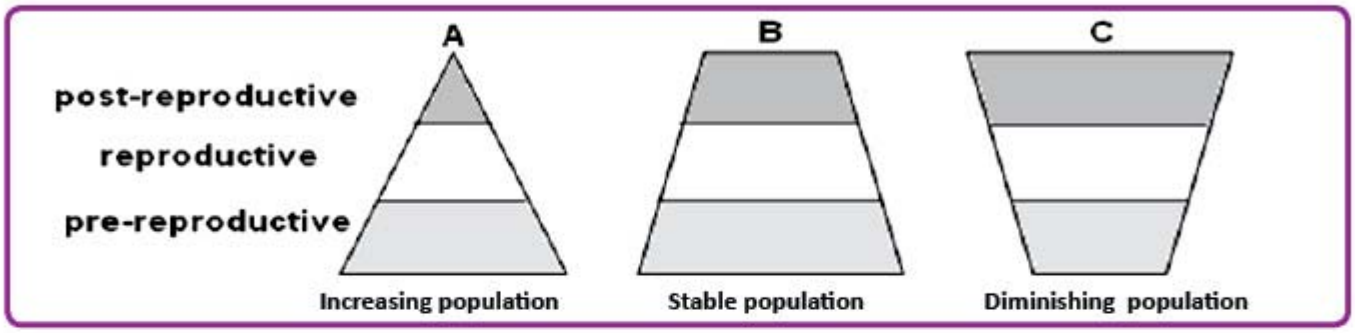
Type I - mortality is low at youth, many individuals survive to reach an old age eg. humans

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



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

Age pyramids show information about the number of organisms of a particular age group that is alive in a population. They 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:

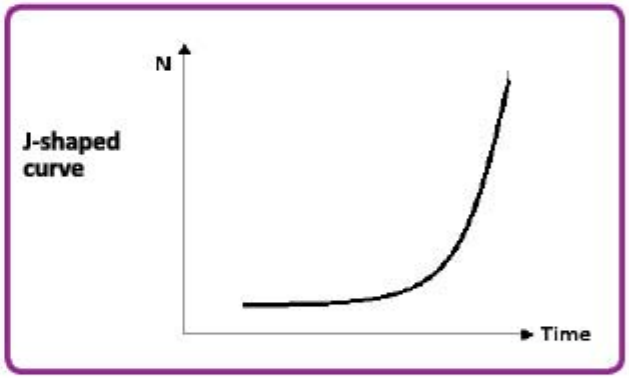


f. Carrying capacity

This refers to the maximum size of a population that can be supported indefinitely by the resources in the environment in which they live. The carrying capacity is designated by the letter 'k'. When population size exceeds the carrying capacity, the N of the population will decrease as animals move a new habitat or die of starvation because the resources are overexploited.

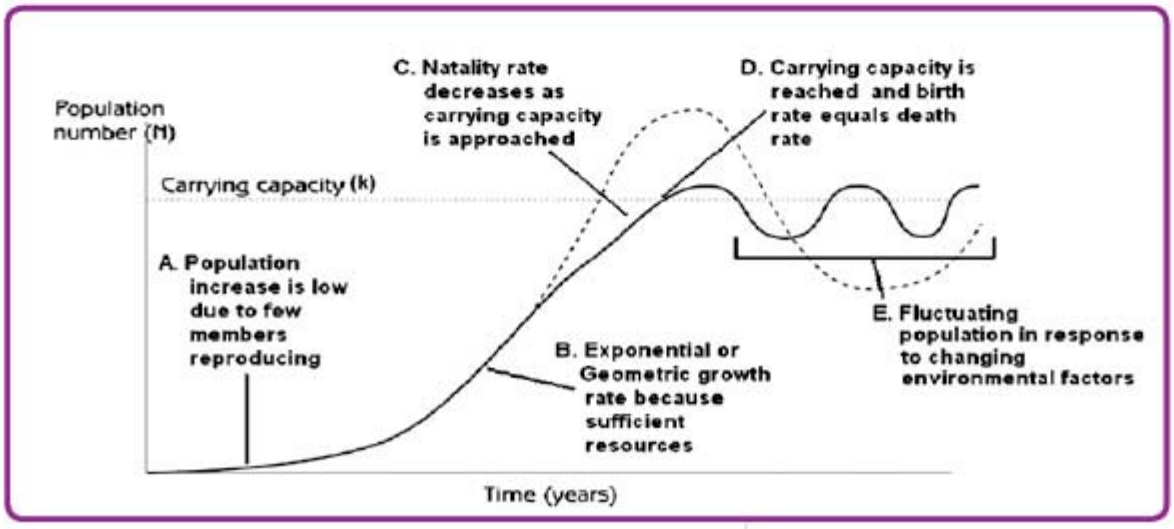
g. Population Growth

When a species is placed in a new environment where there are sufficient resources, the growth of it's population will be representative of an exponential or J-shaped curve as shown below. 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 rates is shown below in the **s-shaped** curve or a **sigmoid curve.**



h. Estimation of Population Size

When populations are small in size, it is easy to make a direct count of the individuals to state the size of the population. However, in nature, populations can be large and varied, always changing in number and quite difficult to make direct counts. Thus, in order to estimate the size of a population, **samples** must be taken.

There are some points to note when samples are taken:

- Sample size must be representative of the population;
- Samples must be taken over the range of the population – not just at one area;
- Many samples must be taken.

There are several methods that can be employed to estimate population size:

1. Direct count: used for small populations, this method involves counting the individuals of the population directly;

2. Mark and Recapture: used for populations that are highly motile eg. turtles and bird. In this method, individuals are captured, tagged or marked and released into the environment. At a later date, another sample is caught and the number of marked samples are counted. The size of the population is estimated using the following formula:

Figure 6.3: A Tag on a turtle

Source: *sareptiles.co.nz*

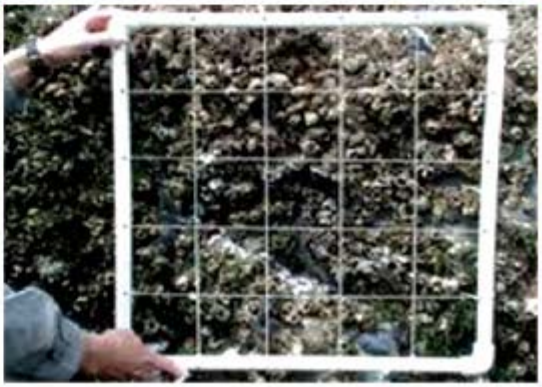
$$\text{Size of population} = \frac{\text{Total number in 1st sample} \times \text{Total number in 2nd sample}}{\text{number of marked animals recaptured in 2nd sample}}$$

3. Transects: This is a line marked out with string which is stretched across the range of the population. It is divided into intervals of known distance – done by tying knots on the string. Generally used for estimating percentage cover of certain species eg. grass. A 'yes' mark is given if the species being sampled is found under the knot on the string, and a 'no' mark is given if the species is not found. Percentage cover is estimated by the following formula:

$$\text{Percentage cover} = \frac{\text{number of 'yes' marks}}{\text{total number of marks}}$$

4 Quadrats: A quadrat is a sample of known area within which all the species present are counted (see picture on the right). To use this method, mark out on the area to be sampled the different places where the quadrat is to be placed. Then place the quadrat and count the number of individuals of the species being sample within the quadrats. Estimate population size by using the formula:

$$\text{Population Size} = \frac{\text{number of quadrats} \times \text{total sample area}}{\text{total area of quadrats}}$$



Source: depts.washington.edu

5. Observation: This method is reserved for very rare species unlikely to be found using any of the above methods. In this case, estimating its population size will have to rely on observations and recorded sightings.

6.2 COMMUNITIES

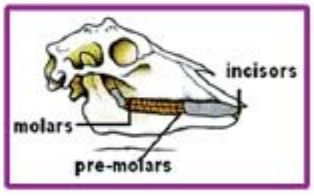
A biological community is the group of all plants and animals living in an area within an easily recognized boundary. Communities vary greatly in size. Organisms in a community can be grouped according to its feeding pattern. There are three main groups namely producers, consumers and decomposers. These groups are the feeding or trophic levels:

a. **Producers** are made up mainly of green plants which produce their own food (organic substances) from inorganic substances through the process of photosynthesis. They are also known as **autotrophs.** There are several adaptive features that plants have that allow them to photosynthesize. These adaptive features include:
   i. the presence of chloroplast which contains chlorophyll the green pigment that traps light energy from the sun;
   ii. xylem – water transporting tubes in the leaf that bring water for the process of photosynthesis;
   iii. stoma – which are openings in the leaf which allows carbon dioxide from the air to enter the leaf;
   iv. spongy mesophyll layer - in the leaf that allows gases to circulate within the leaf;
   v. palisade layer that is close to the upper surface of the leaf – ensures that maximum amount of sunlight is trapped for photosynthesis;
   vi. transparent cuticle layer - means sunlight can penetrate easily and reach the chloroplast

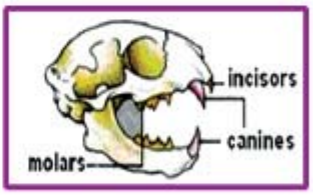
Figure 6.4: A green plant

Source: theflorister.com

b. **Consumers** are organisms that depend on other organisms for their food. In order to obtain organic substances (food) the consumer needs to feed on other living things. Some important consumers include:
   i. Herbivores are consumers that eat plant tissues like leaves, bark and plant sap. Adaptive features will vary depending on the food source of the herbivore. Mouthparts in particular will help in identifying herbivores. Cows for instance have prominent molars which are flat and wide for chewing and breaking down the tough cellulose cell wall of plant material that it feeds on. Grasshoppers and other insects that are herbivores have strong sharp and serrated mandibles for tearing the plant tissues.



   ii. Carnivores are consumers that feed on other animals. Animal tissues that each may feed on varies and likewise its adaptive features. Features in carnivores include: the presence of sharp canines for tearing flesh, having shape incisor teeth for cutting food, and molars that grind food. Some carnivores like dogs have carnassial teeth on the side of their jaws for cracking bones.The carnivore needs to be very quick and have a keen sense of smell and sight.

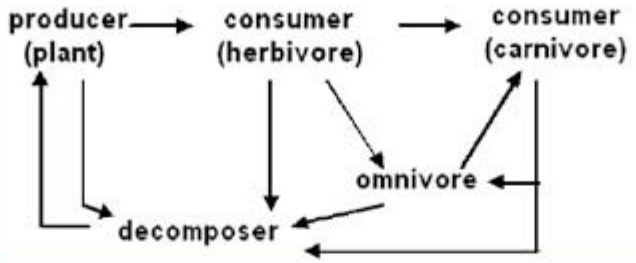


   iii. Omnivores are those consumers that feed on both plant and animal material. Adaptive features in omnivores are much more general.

c. **Decomposers** are organisms that help to break down dead plant and animal matter. The most common groups of decomposers are the bacteria and fungi. Decomposers are important in recycling of nutrients which will enrich the soil.

Many communities depend on the relationship and interactions of producers, consumers and decomposers as can be seen in the diagram below:

Figure 6.5: Interactions of organisms in different trophic levels



6.21 Community Relationships

The feeding relationship in a community can be shown by using a simplified diagram known as the food chain. When writing a food chain, remember the following rules:

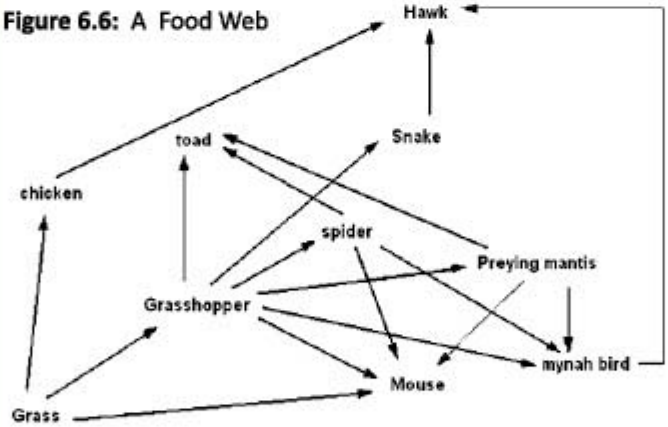
- The arrow ⟶ means 'is eaten by;
- A food chain always begins with a producer/green plant;
- Each link in the food chain is a trophic level;

The example below shows a cabbage that is eaten by an aphid that is eaten by a bird.

cabbage $\xrightarrow{\text{eaten by}}$ aphid $\xrightarrow{\text{eaten by}}$ bird

Food webs are made up of many interacting food chains and shows, a more accurate picture of the relationship between organisms in a community. An example of a food web in a grass land area given in Figure 6.6.

Figure 6.6: A Food Web



Organisms in a community are able to interact with individuals of the same species or with those belonging to a different species. Both intra-specific (within species) and inter-specific (between species) relationships may benefit, harm or have no effect on the organisms involved in the relationship.
The following are examples of community relationships:

1. Mutualism is a relationship where both organisms benefit. An example of this is the relationship between the bacteria that lives in the gut of herbivores. The bacteria help the herbivore to digest cellulose that is found in the cell wall of plant cells. Without the help of the bacteria, herbivores will not be able to obtain any useful nutrients from plants. The bacteria benefits in that it gets a place to live in and food. Another mutualism example if the sea anemone and the clown (picture above). The clown fish is protected among the tentacles of the sea anemone while fanning its fins and providing better water circulation for the anemone.

Source: blackspvbiology.com

2. In commensalism, one of the organisms in the relationship will benefit while the other is not affected. Barnacles on the shells of mollusks (right) have a habitat where they live. The mollusk is not affected by the presence of the barnacle.

Source: affordablehousinginstitute.org

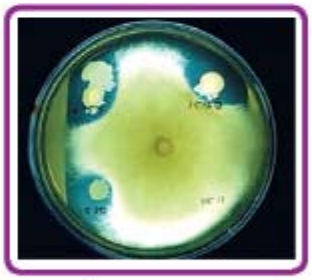
3. Exploitation is the relationship where one organism harms another, but it itself benefits. An example of exploitation is parasitism where an organism (the parasite) lives within or on another organism (host). Ecto-parasites e.g. ticks (pictured) and mosquitoes live on the external body surface of the host while endo-parasites live within the host e.g. tapeworms and hookworms. The parasite gains nutrients from the host organism. The parasite will use the nutrients in the host but will not kill the host. Parasites benefit from this relationship while the host is being harmed. Exploitation also involves herbivores feeding on plants, as in cows grazing on grass.

Source: npic.orst.edu

4. Predation is a relationship where one benefits while the other is harmed. Hawk feeding on chickens is an example of predation. The hawk is known as the predator while the chicken is the prey. The predator has to hunt, kill and feed on the prey. In this relationship the predator benefits while the prey is harmed. Scavengers are different from predators in that it feeds on animals that are already dead e.g. flies. The scavenger does not hunt and kill its food source.

Source: en.wikipedia.org

5. Antibiosis (Amensalism) is a relationship where one organism produces a chemical that destroys another organism, but it itself is unharmed or unaffected by that chemical. The Penicillium fungi produces penicillin that decreases the survival of other bacterial colonies around it, but the fungi is not affected by the penicillin.



Source: aspnet.org

6. Competition is a relationship where the organisms have to compete with each other for a certain resource for instance land, light, food, minerals, etc. Competition occurs between organisms of different species (inter specific) as well as those of the same species (intra specific). Since the needs are more similar in organisms of the same species competition will be more intense.

Source: jerome.guillaumot.com

Fiji has many examples of the community relationships described above. Some of the endemic and native plants and animals in our country are being threatened as they live in relationship with introduced species and with the onset of human development. The table below shows relationships involving some of these:

Relationship	Species Involved	Effect of Relationship
Mutualism	Flower and the insect (pollinator)	The insect visits the flower to obtain nectar for food, and carry off pollen grains to another flower for pollination. Thus it help to reproduce the flowering plant
Commensalism	Old man's beard lichen *(Usnea),* Cup fungi and a Green algal species	The fungi feeds of the photosynthetic products of the algae, which has a place to stay on the fungi
Parasitism	The use of host trees (any canopy tree) by the epiphytic vuga *(Metrosideros collina)*	The vuga obtains its nutrients from the host tree, in a relationship that eventually ends in the demise of the host tree species.
Antibiosis	Relationship occurs between leeches and frogs	The leech is attached on the juvenile frog causing the frog to develop a malformed limb.
Predation in a forest ecosystem	The Small Indian mongoose *(Herpestes javanicus)* and native invertebrates or the occasional bird nest (eggs or chicks).	The mongoose searches out, catches and kills invertebrates or the young of birds for its food.
Competitive interaction	Cane toads and Fiji ground frogs	Compete for space and food items (especially for flying insects like moths).
Exploitation	Humans harvesting rare and threatened insect species like the **nanai** *(Raiateana knowlesi)* or the giant Fiji longhorned beetle *(Xixuthrus heros).*	The **nanai** and beetle populations will begin to diminish

6.2.2 A Seashore Community

Fiji is a Tropical Coral Ecoregion, one of 238 Ecoregions established by World Wide Fund. Each Ecoregion type is selected from a biogeographic realm and ocean basin so that the Global Ecoregions analysis ensures balance and representation in a global biodiversity strategy.

There are 26 major habitat types that "describe different areas of the world which share similar environmental conditions, habitat structure, and patterns of biological complexity, and that contain similar communities and species adaptations."

"In order to represent the unique fauna and flora of the world's continents and ocean basins, each major habitat type was further subdivided by **7 biogeographic realms** *(Afrotropical, Australasia, Indo-Malayan, Nearctic, Neotropical, Oceania, Palearctic)."*

The ecoregions representing the most distinctive examples of biodiversity for a given major habitat type were identified within each biogeographic realm. They were chosen for their species richness, endemism, high taxonomic uniqueness (e.g., unique genera or families, relict species or communities, primitive lineages), extraordinary

ecological or evolutionary phenomena (e.g., extraordinary adaptive radiations, intact large vertebrate assemblages, presence of migrations of large vertebrates) and global rarity of the major habitat type

Given this uniqueness, it is important that the diversity of the Fiji seashore community be understood so that an attempt be made to conserve and protect it in its contribution to the global biodiversity strategy.
The Inter-tidal zone is the area of the shore that is covered by water at high tide and exposed to air at low tide. The inhabitants of this community are mainly marine organisms which must have a high tolerance for exposure to sunlight and high temperatures, fluctuations in salinity and high risks to predation and exploitation by other population species. Organisms that live in the inter-tidal zone have developed a wide variety of structural, behavioural and physiological adaptations (see Section 6.31) that equip them to survive under these conditions.

Seashore Community

Source: ypte.org.uk

Like all biological communities the inter-tidal zone needs to be protected and sustained as much as possible. The way it is treated when it is being used is very important because in respecting it we are helping to sustain it for the future of generations to come.

Group Work

Discus and develop the following issues:

1. some global issues that are affecting our coastal shores, and therefore the inter-tidal zone
2. some guidelines to follow when you go out to explore the inter-tidal zone so that it can be left in the same condition that you found it. These guidelines can be recorded under the headings; care of sea creatures, dangers in the zone, collecting sea shells, time of visits and tides, waves and wind, litter.

Conditions of the Inter-tidal Zone

Organisms in the intertidal zone must be able to adapt to highly variable and often harsh conditions. Those organisms found in the high intertidal must cope with the large range of environmental conditions as they are exposed the longest when the water recedes at low tide. Some of the environmental conditions are discussed below:

Tides

The daily rise and fall in sea level that occurs twice a day is known as the tide. This tidal movement is the result of the interplay of the earth, moon and sun as the moon revolves around the earth, and as both the earth and the moon revolve around the sun. The gravitational and centrifugal forces of these components influence the body of water on the earth creating tides.

The magnitude of the gravitational force exerted by the moon on the earth will be greatest at points on the earth that are nearest to the moon. At these points the water will bulge away from the earth towards the moon. Because the earth is rotating there will be an equal but opposing force (the centrifugal force) exerted at the points furthest from the moon also causing water to bulge away from the earth.

Therefore at any one time, there will be two places on the earth experiencing high tide and two places experiencing low tide as illustrated in the Figures 6.7 and 6.8. This means that along most coasts there are two tides per day.

Since

(i) the earth and the moon are spinning in the same direction and
(ii) the moon moves1/28 of its rotation around the earth in one day,

the moon will be closest to a particular point on the earths surface at a different time each day. The earth makes a complete rotation relative to the moon in 24 hours and 50 minutes. This is known as a lunar day and the tides are approximately 50 minutes later from one solar day to the next. (A solar day is determined by the rotation of the earth relative to the sun).

Student Activity:

1. Working in pairs, hold hands and spin around together to understand the effect of centrifugal force.
2. Use your local newspaper to gather the times of the high tide and low tide for a period of one month. Draw a graph of the data and discus the pattern seen.
3. Draw an eclipse on the floor of the classroom and get the students to take up positions of the sun, moon and earth to enhance understanding of formation of tides.
4. Read up accounts of shipwrecks or other events influenced by the tides.
5. Find evidence on the shore of the location of the high tide line.

If this system was restricted to only the moon and the earth, each high tide will be of equal magnitude. However the sun also produces a gravitational force on the earth. Because the distance is further from the earth, the tide generated by the suns gravitational force is only 0.45 of that generated by the moon.

When the sun, moon and earth are in line and the moon is full or new, the combined gravitational force created causes the "bulge" in water level to increase in size and the "trough" to decrease in size. This results in extra high and extra low tides. These tides are called **spring tides** (Figure 6.7)

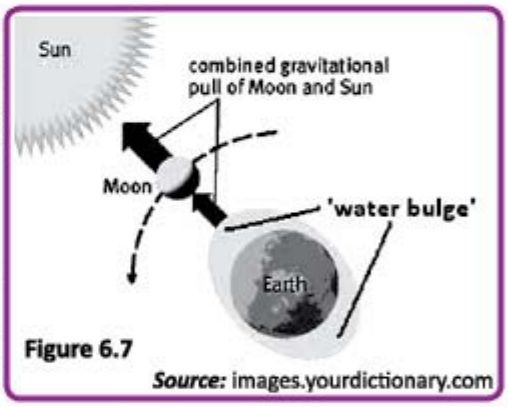


Figure 6.7
Source: images.yourdictionary.com

When the moon is in the first or third quarter, the sun's gravitational pull acts at right angles to the moon's gravitational pull and counteracts the effect of the moons gravitational pull. This flattens the bulges causing tidal variations of low magnitude. These are called **neap tides** (Figure 6.8)

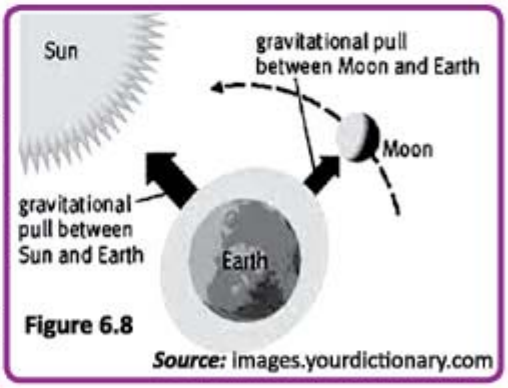


Figure 6.8
Source: images.yourdictionary.com

The height of the tide also varies throughout the year as the orbit of the moon around the earth and the earth around the sun are not circular but elliptical. When the moon is closest to the earth, it is said to be in **perigee** and the tide producing force is 20 % higher than the average. When the moon is furthest from the earth, it is said to be in **apogee** and the tide producing force is 20 % lower than the average.

Having explained the reasons for the existence of tides, their frequency and range will vary depending on geographical location, the shape of the coastline, its degree of exposure or confinement and various local factors such as wind speed and climate.

6.31 Conditions of the Inter-tidal Zone

Life in the inter-tidal zone is mostly governed by the rise and fall of the tides. At high tide there is oxygen, food and a lot of water but at low tide the animals are exposed to air, sunlight, rain, high probability of desiccation and predation.

Abiotic Conditions

1. **Temperature and Desiccation**

   Oceans have relatively stable environmental conditions. The cumulative land mass of the Fiji Islands in comparison to the massive ocean cover surrounding the islands is very small. Therefore the temperature of the open coastal waters is relatively stable all year around and variations may be quite small, and occur over very short durations. The ocean temperature is affected to a large extent by ocean currents that stem from the major water masses such as the Peruvian Current, the Australian Current and the West Wind Drift.

   Air temperatures on the other hand are influenced by the North West and South East Trade Winds. Inter-tidal organisms are exposed to cold and dry atmospheric air on one extreme to hot, moist air at the other extreme. These variations may not be large enough to kill the organisms but they may weaken their condition, allowing death by other means.

2. **Salinity and Dissolved Oxygen**

   On hot days, evaporation from tidal pools may result in an increase in salinity. In contrast, on rainy days, tidal pools may become diluted decreasing salinity. Tidal organisms have to adapt to changes in salinity.

   When water temperature increases oxygen solubility decreases, meaning that the dissolved oxygen available to inter-tidal organisms may be limited. Again the organisms have to adapt to the varying situations of oxygen availability.

   Salinity and oxygen content is influenced by ocean currents from the equator and polar region.

3. **Wave Action**

   Waves dislodge, smash and tear up plants and animals found on the inter-tidal zone. Wave action can also displace rocks and coral that in turn damage the organisms.

   The height and strength of wave action depends on the exposure or protection of the coast line. Tidal zones may be extended on an exposed shore.

Biotic Conditions

Predation is an important feature on the intertidal zone affecting the survival of a wide variety of organisms. Apart from the organisms that prey on others within the zone, other terrestrial predators (e.g. birds such as the 'belo' and small mammals) come down from above the high tide line to feed on the marine organisms and algae that are now exposed and easier to find.

For the intertidal creature, obtaining enough food is more difficult during low tide. Seaweeds have problems photosynthesizing because of the difficulty of gaseous exchange in the absence of water. Sea creatures that obtain food by filter feeding such as mollusks, face a shortage of plankton during low tide and gills are only effective when their surface is kept moist. The removal of waste products by excretion into surrounding water may need to be put on hold until high tide.

Organisms are also faced with the difficulty of moving from one place to another and some respond to the drying up of their feeding structures under the action of the sun and wind by ceasing all feeding. This means that extended periods of exposure during low tide could result in starvation for some of the organisms.

Adaptations

Although a difficult place to live for many creatures, it provides a refuge from predation and competition. The varying and stressful conditions have imposed limits in their distribution. Their special adaptations allow them to live in a habitat where their competitors and predators cannot survive. Their special adaptations can be structural, behavioural and/or physiological.

1. Structural

The inter-tidal organisms have a variety of structural adaptations including the presence of a shell or exoskeleton that helps retain water and reduce water loss, provides a barrier against changes in salinity and prevents excessive physical disturbance.

Source: pleasantridge.k12.ca.us

The colour and shape of the shell may be important in the absorption or reflection of the suns' rays providing a natural internal temperature control for the organism.

The body shape of many intertidal organisms gives them a low profile that helps them move easily under rocks and into crevices preventing them from being swept away by wave action. Seaweed have holdfasts for anchorage while mussels secrete attachment fibers. Barnacles cement themselves to a rock and limpets use suction to stay stuck.

Source: naturalhistory.museumwales.ac.uk

Algae such as Neptune's necklace *('nama')* retain water in their leaf-like structures, have thick cuticle and *'lumi'* grow in a fluffy mass providing a cool and sheltered environment that slows down dessication.

2. Behavioural

This adaptation involves movement or action. At high tide, these organisms will crawl around in search of food, but as low tide approaches and the water recedes, they move under rocks, or burrow into the substrate or crawl into crevices in order to avoid desiccation. Some mollusks do not seal up their shell but use a 'sealing plate' that they return to after grazing during high tide. They use a grinding action to seal the lower edges of their conical shells and stay in that position till the tide comes in.

3. Physiological

This adaptation involves the internal functions of cells and organs Many intertidal creatures have high tolerance levels to the subjective changes. Some species of limpets and chitons can survive water loss up to 70% of their water content and some plants can lose up to 90% of their moisture and still survive. Some organisms have a stronger stress response of making proteins that help in the recovery form temperature stress. This response is similar to the immune response that aids in the recovery from infection.

6.3 ECOSYSTEMS

All communities and their environment make up an ecosystem. Ecosystems vary in size – small as in an aquarium to the large as in tropical rainforest, and structure – species composition, type and distribution of abiotic resources and the range of conditions. Together, all the world's ecosystems make up the biosphere.

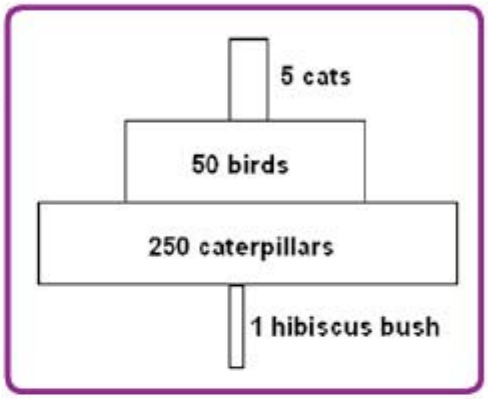
The function of an ecosystem is determined by the processes of

i. Energy flow
ii. Mineral cycles

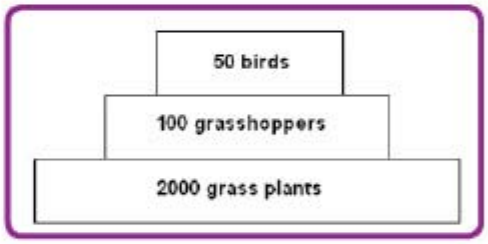
6.31 Ecological Pyramids

Ecological pyramids are made up of trophic levels of a food chain. The producer **must always** be the base of the pyramid, the next box is always the herbivore, then the carnivorous consumers.

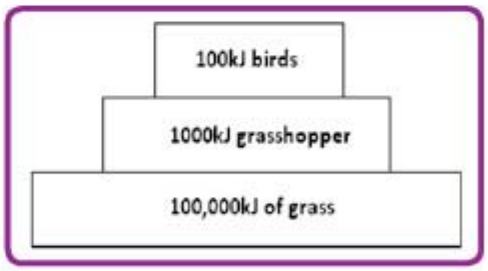
a. Pyramid of numbers: shows the number of organisms that is present at each trophic (feeding) level. The producers are always at the base of the pyramid then the herbivores on the next level followed by other consumers in that particular food chain.



b. Pyramid of biomass: shows the amount of biomass present at each trophic level. This biomass is normally measured after the water has been removed. This pyramid can never be inverted.



c. Pyramid of energy: shows the amount of energy present at each trophic level. The producers which are at the bottom of the pyramid always have the greatest amount of energy and it decreases along the food chain. It is assumed that only about 10 per cent of the energy is passed on to the next level.



6.32 Energy Flow

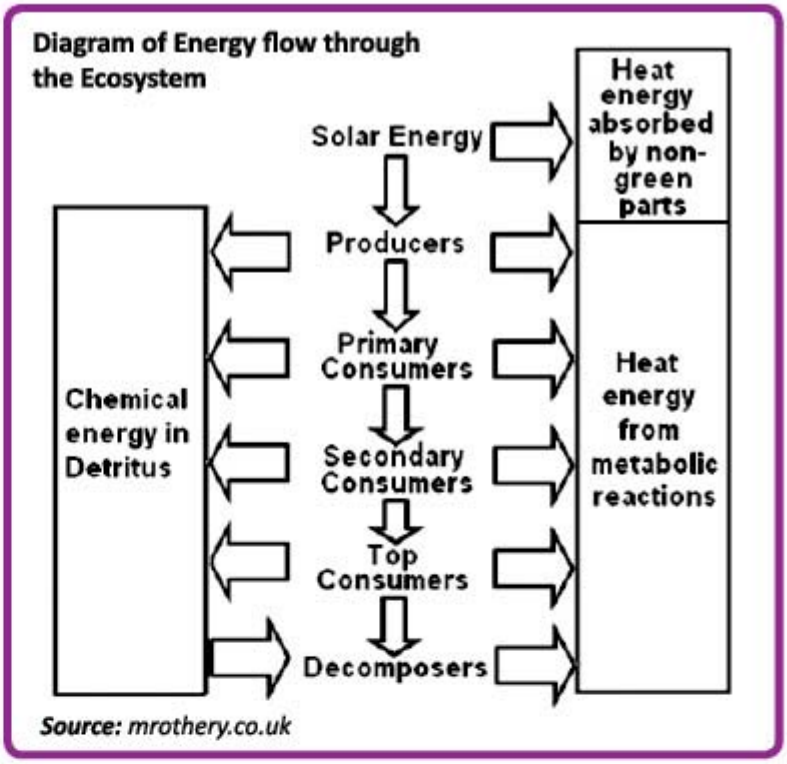
Organisms use nutrients (minerals or matter) and energy in order to live. In the ecosystem, **nutrients are recycled** while energy in an ecosystem is not recycled. **Energy flows** through the ecosystem.

Minerals are important as it is needed to form certain substances or structures needed by an organism for its survival. The concentration of minerals in an ecosystem is constant and therefore needs to be recycled.

The main source of energy in any ecosystem is the sun. This energy is converted by plants into chemical energy and stored in the substance it produces during photosynthesis. Plants are important in that they are the only organism capable of using light energy from the sun converting it into a form of energy that can be used by other organisms. When plants are eaten the energy is passed on to the herbivores and from there it is transferred to the carnivores.

Organisms produce energy by oxidizing the digested food in the different cells. This energy is needed to enable organisms carry out processes necessary for its survival. As the organism uses energy it is turned into heat and leaves the body of the organism and escapes from the ecosystem. Energy is lost as heat at each trophic level leaving less energy for the next level. Producers must constantly bring fresh supplies of energy into the pyramid.

Nutrients, however, as stated earlier, have to be recycled through the ecosystem. They are lost at each trophic level through death, excretion and decay but re-enter into the ecosystem through the decomposition of organic material, some in gaseous form (like carbon dioxide), and some as solid substances which are absorbed from the soil by plants. Examples of common cycles will be discussed in the next section.

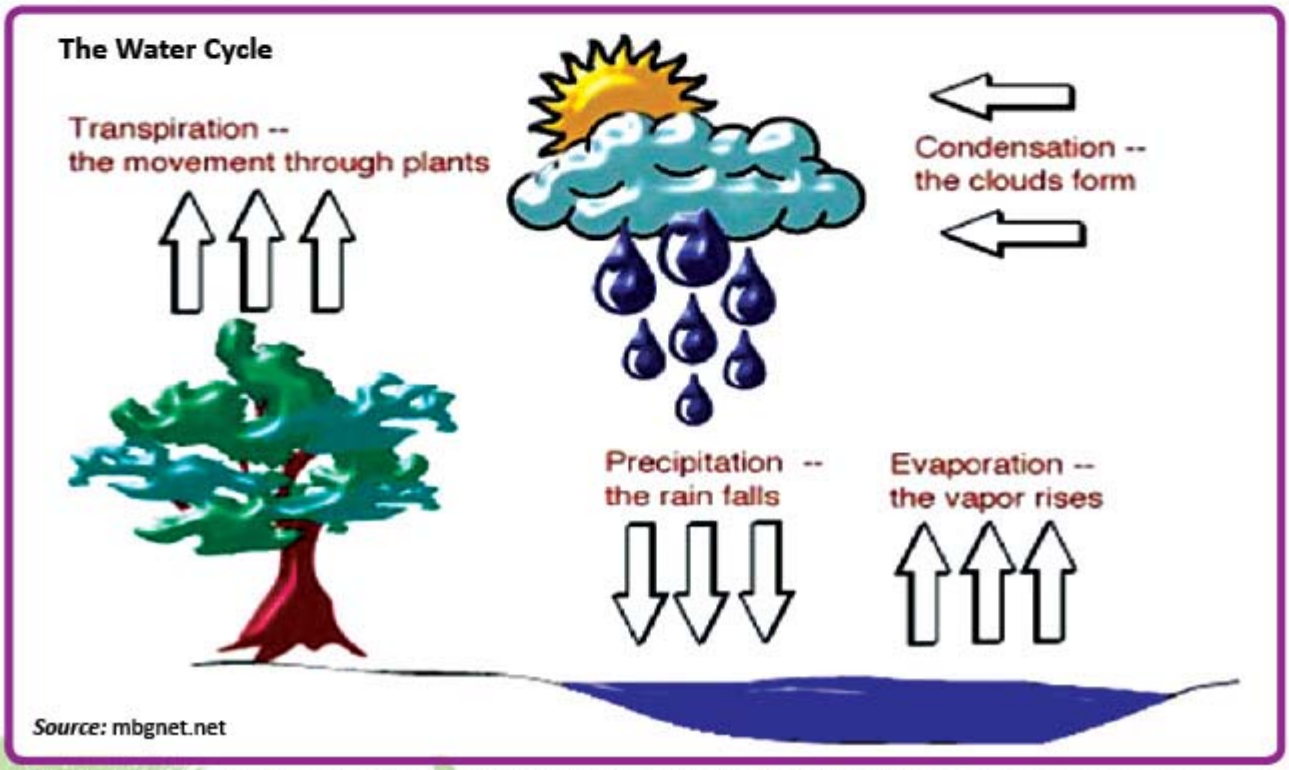


6.33 Nutrient Cycles

The common nutrients in the ecosystem include oxygen, hydrogen (recycled in the water cycle), nitrogen, carbon and phosphorus. They are required by plants and animals for metabolism and growth.

Water Cycle

The water cycle mainly involves the physical environment. When rain falls (precipitation), water accumulates in a water bodies (oceans, ponds) from where it evaporates, then condenses forming clouds. Water is also removed into the atmosphere through transpiration from leaves.



Carbon Cycle

Carbon is an important element since it is the backbone of all organic substances. All organic substances have carbon atoms forming the skeleton structure e.g. carbohydrate, lipid. Glucose is a carbohydrate and is made up of 6 carbon atoms, 12 hydrogen atoms and 6 oxygen atoms thus the formula $C_6H_{12}O_6$.

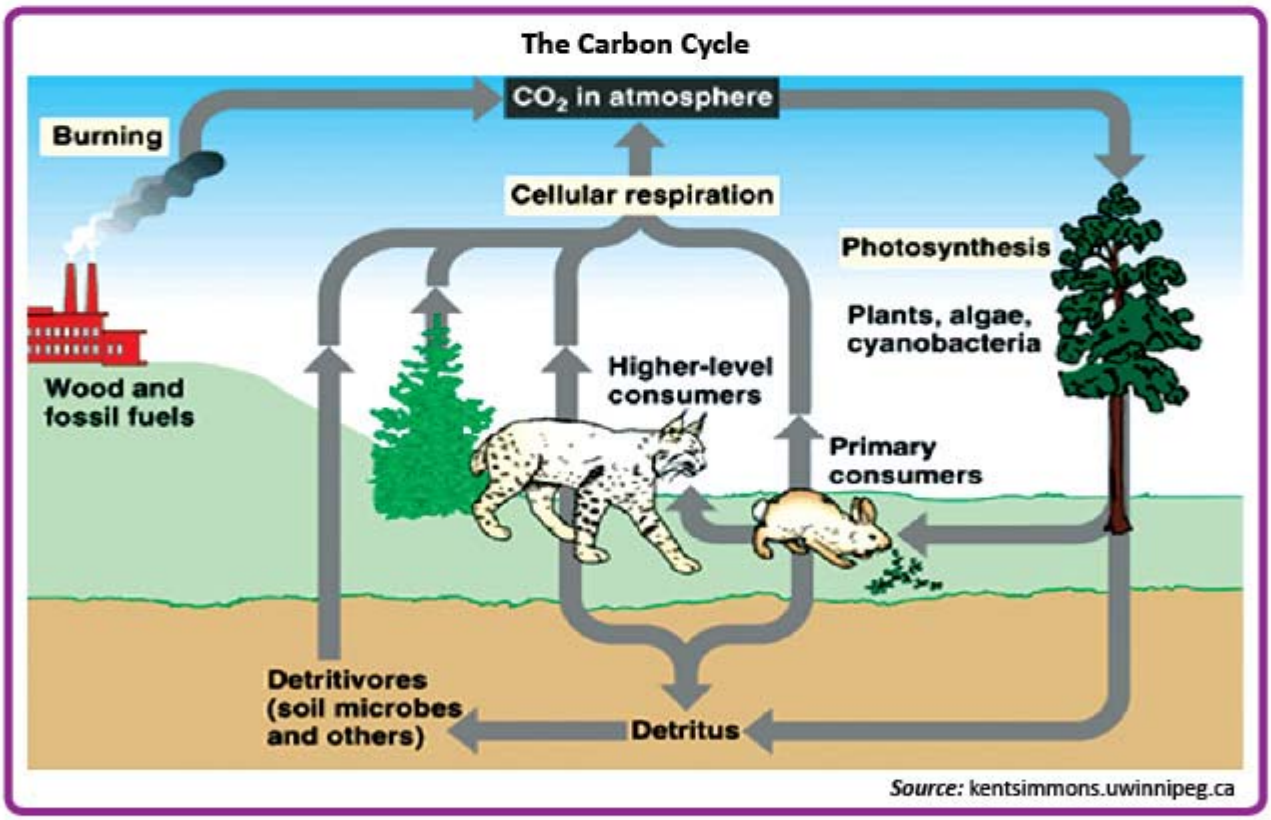
The main source of carbon is the carbon dioxide in the atmosphere. This is used by plants during photosynthesis to form organic substances mainly carbohydrates e.g. starch.

$$CO_2 + H_2O \longrightarrow C_6H_{12}O_6 + O_2$$

When plants are eaten the carbon in plants is passed on to the herbivores. From herbivores the carbon will be passed along the food chain.

Carbon is released back into the atmosphere as carbon dioxide when organisms release energy. This process is important and is known as respiration, given by the following equation:

$$O_2 + C_6H_{12}O_6 \longrightarrow CO_2 + H_2O$$

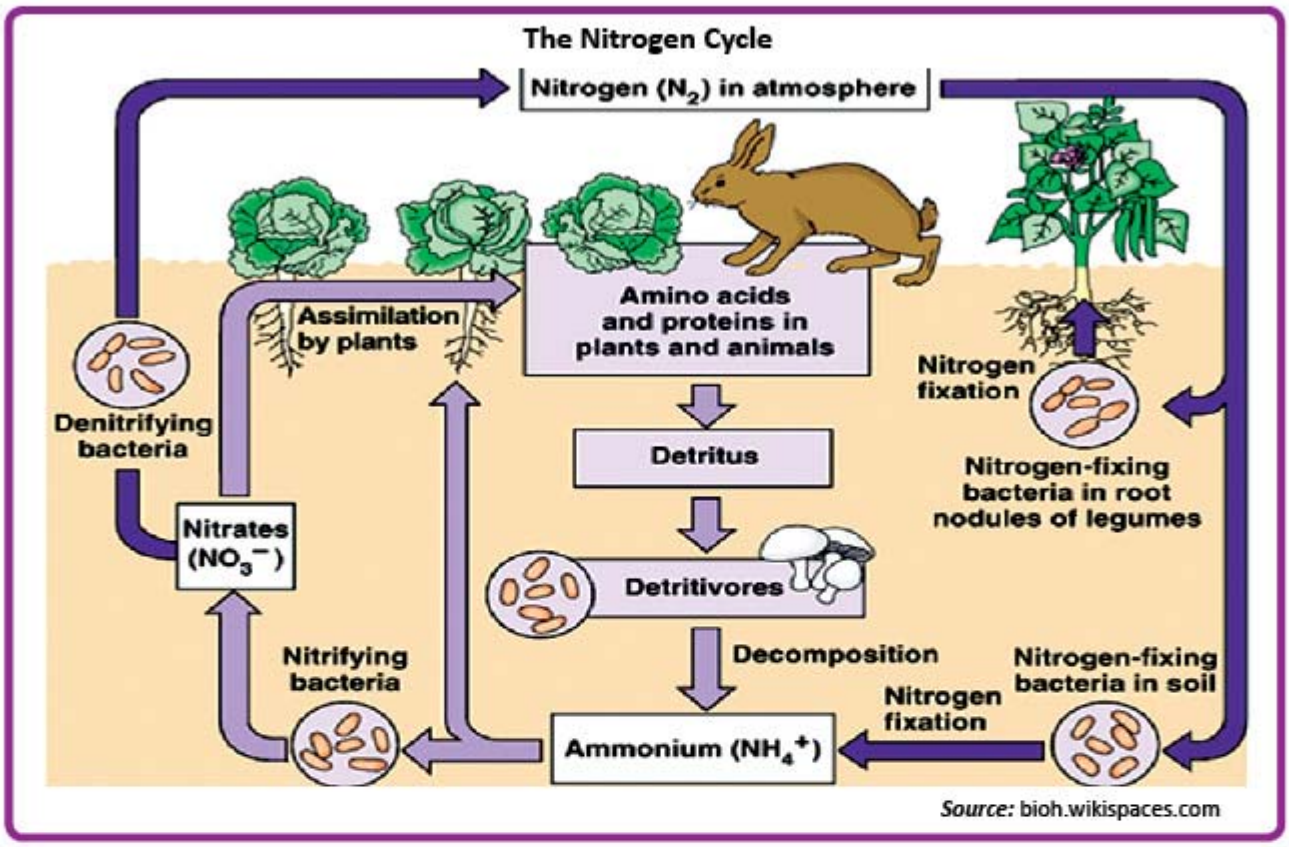


Student Activity

1. What is a carbon foot-print?
2. In a group, discuss ways of determining the following:
   - measure your carbon foot-print;
   - reduce your carbon footprint (called carbon–offsetting);
3. What is carbon trading?

Nitrogen Cycle

Nitrogen is an important mineral in that it is needed to form amino acids the monomer or building blocks of protein. Plants make its protein by using the nitrogen that is present in nitrates. Plants absorb the nitrates from the soil and use it to produce proteins. The plant protein is changed into animal protein when herbivores feed on plants and it is passed along the food chain.



Death and decay of plants and animals is one way for the nitrogen to return to the soil. Bacteria decompose the dead plant and animal producing ammonia. This ammonia is changed into nitrite then nitrate by nitrifying bacteria. The nitrates are ready to be absorbed again by plants for the cycle to repeat itself.

Animals are also able to pass nitrogen to the soil is through the excretion of nitrogenous wastes like uric acid, urea and ammonia. These substances will be converted into ammonia then nitrite and later on nitrate.

Air consists of about 78 per cent of nitrogen gas but plants cannot use this unless it is changed into nitrate. The change from nitrogen in the air to nitrate is called nitrogen fixing. Nitrogen is changed into nitrates by nitrogen fixing bacteria that may live freely in the soil or in association with a plant as in leguminous plants. Lightning is also able to change nitrogen into nitrates.

Nitrate can also be changed into nitrogen in the air through a process called denitrifying. This change from nitrate to nitrogen in the air is carried out by denitrifying bacteria.

Student Activity

Article or Investigation on some aspect of Nitrogen Use or Overuse or Abuse

Review Questions

1. Write the correct example in the list into the box:

List of examples

A. orchids on a tree
B. Goat and cow
C. Nitrobactor in legumes
D. Fleas on a dog
E. Mongoose and chicken

Relationship	Matching example (corresponding letter)
Parasitism	
Predation	
Mutualism	
Commensalism	

2. In the box below is an example of a food chain:

Dalo leaves → caterpillar → bird → cat

i. In the space below, draw a pyramid of biomass for this food chain.
ii. What is a food web?

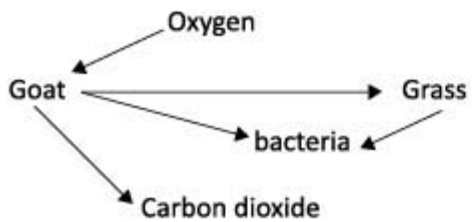
3. The scientific name of the common dog is correctly written as
   A. *canis domesticus* C. *Canis Domesticus*
   B. *Canis domesticus* D. *canis Domesticus*

4. The blue starfish *Linckia laevagata* is an echinoderm. To what genus does it belong?
   A. *Linckia* C. sea stars
   B. echinodermata D. *laevagata*

5. Which of the following is not recycled in a biological system?
   A. energy C. carbon dioxide
   B. phosphorus D. nitrogen

6. Which of the following is the best definition of the term ecosystem?
   A. all living things in a given area
   B. all genes and species in an area
   C. all living things in an area and how they interact with their environment
   D. all the different types of abiotic fators operating in an area

Refer to the diagram on carbon and oxygen cycle to answer Questions 5 and 6.

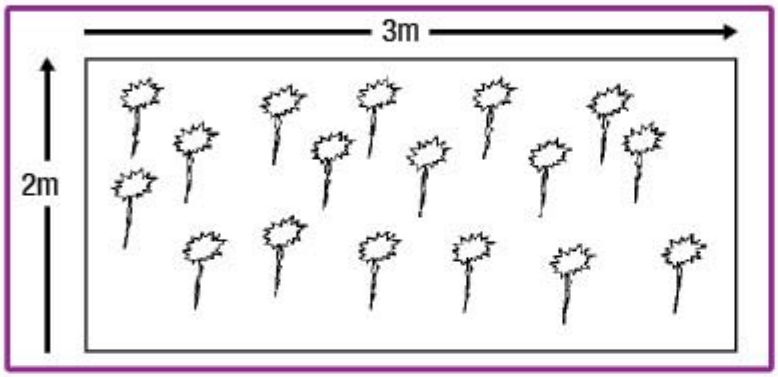


7. Identify the producer, herbivore and decomposer in the above diagram:

	producer	herbivore	decomposer
A.	grass	goat	bacteria
B.	goat	grass	bacteria
C.	bacteria	grass	goat
D.	grass	bacteria	goat

6. Which products from the consumers of the food web are used by the producer?
   A. carbondioxide and water
   B. carbon dioxide and oxygen
   C. water and oxygen
   D. water and nitrogen

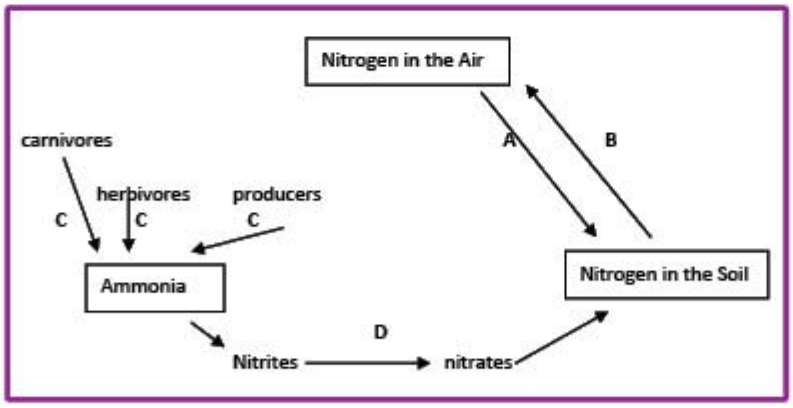
Consider the following diagram to answer Q7 and 8.



7. The 'N' for above coconut tree population is
   A. 2 B. 3 C. 6 D. 18

8. The population density is
   A. 3trees/m2
   B. 6m2
   C. 18trees/m2
   D. 18 trees

7. Below is the diagram of the Nitrogen cycle:



i. Name the bacteria responsible for Process A:
ii. Name Process B:
iii. Explain and name what is happening in C.
iv. What type bacteria is responsible for Process D?
v. Why is nitrogen important to plants and animals?

CHAPTER 7

GENETICS

Genetics is the study of inheritance and variation within biological systems of sexually reproducing individuals. It is the study of how all species are able to retain characteristics particular only to their kind over many generations. It is also the study of why in every generation there is enormous variation within each species regardless of the millions of individual members present. The study of genetics also helps one understand how there can be so much order in the midst of an extensive variety of living things on the planet.

In order to understand how inheritance takes place, we must look at the processes of fertilization and sexual reproduction. Sexual reproduction produces new individuals from a single cell or **zygote.** This zygote is nourished and the single cell multiplies resulting in the growth of the entire individual. Instructions are provided so that different parts of the mass of cells 'differentiate' or become different from other parts. The instructions to enable this to occur are contained in the **chromosomes** of the original cell or zygote and were first inherited from the cells that created it.

In order for muscle cells for example, to form new muscle cells, the instructions to design muscle cells must first be contained in the original muscle cell, but be in a form that can be copied into the new cell. Cells make exact copies of themselves by the process of mitosis. The instructions contained in the chromosomes were passed from cell to cell during mitosis.

Considering that a cell needs to divide (in two) in order to increase in quantity, the chromosomes need to multiply or make a copy of themselves so that one copy remains in the original cell while its duplicate is transferred into the newly formed cell. This way each cell present is equipped with the same set of instructions, and therefore a muscle cell is able to divide into two new muscle cells and not into blood cells or bone cells, and so on. The process of chromosomes duplicating, or making exact copies of themselves is known as **replication.**

The information influencing hereditary is contained in the structure of **genes** which are found on the structure of chromosomes. The gene is therefore ***a piece or length of DNA*** that codes for a specific trait (characteristic or feature). In other words, **chromosomes are made up of coils of DNA, and genes are segments of DNA.** However, the structure of a chromosome is such that genes are found scattered unevenly along it with areas in between that do not consist of genes at all.

7.1 GENES

Before looking at the structure of the chromosome, let us look at genes to help us understand their structure and then later, how they fit into the chromosome structure. When observed under an electron microscope, a chromosome is seen to have a pattern of bands of varying in widths along its length as shown in Figure 7.1. These bands locate the position of genes on the chromosome and are darker in appearance.

Figure 7.1
Dark bands on a chromosome

Genes are a sequence of nucleotides part of, and continuous with, the chromosome on which they are found. The gene was known as the 'sequence of nucleotides that code for one protein'. This however was confusing because some proteins were made up of more than one polypeptide. This led to a change in definition so that the **gene is now defined as the sequence of DNA, or segment of DNA, that codes for the formation of one polypeptide,** irrespective of what the polypeptide is designed to create.

It should be mentioned here, that three words often associated with the term gene, are the terms ***allele, cistron*** and ***locus.*** It has already been mentioned that the locus is the location, or point of existence, of the gene on the chromosome. The term cistron was used interchangeably with the term gene and coded for a specific functional protein however **not all genes are cistrons** even though **all cistrons are genes.**

The term allele is the most relevant of the three, in as far as hereditary is concerned. Genes that occupy the same loci on corresponding strands of a homologous chromosome are known as allelomorphic genes or alleles. In other words, an allele is a form of a gene.

The ***gene for any human trait or characteristic is represented in two loci on any chromosome, because of its homologous nature.*** One gene would be located on one strand of the chromosome, while its complementary pair would be located on the other strand. The two genes could be of the same form, or of different forms.

> For example: Eye colour is a human trait that is coded for on one of the 23 pairs of chromosomes found in the human cells' nucleus. From experience we know that there is more than one eye colour found amongst members of the human species. This means that the gene for eye colour would be found in both of the two loci on the homologous chromosomes, specific for eye colour.

For simplicity, letters are often used to represent genes coding the trait. Therefore if letter B represents the colour brown, and b represents the colour blue, there can be three possible combinations of the eye colour alleles; BB, Bb and bb. **B and b are two different forms of the same letter, or they are alleles of the same gene.** The combination of alleles is the influencing factor determining the **final appearance (phenotype)** of the trait (character). Other traits in humans include Dimpled Cheeks, Tongue Rolling, Ear Lobe, Hitchhiker's Thumb, Widows Peak hair etc.

When working with genetics problems, it is normal to represent dominant genes by a capital letter (eg: B) and recessive genes by a small letter (eg: b) of the same kind. The use of the same letter is consistent with the concept of the same gene, while the two different forms of that letter denote the alleles.

Formation of ear lobes in humans for example, is dominant to the absence of ear lobes. If the allele for the presence of ear lobes is represented by the letter L, then the absence of ear lobes will be represented by the letter l.

N.B. When writing the genotype, the capital letter for the dominant allele is always written in front of the small letter representing the recessive allele.

As already mentioned in a previous section, the *human genome consists of 23 pairs of chromosomes.* A photograph or diagram of all these paired chromosomes is called a ***Karyogram.*** Each of these pairs, contain many different genes, as many as (20,000 in one homologous pair). The plan to map the entire human genome started as early as 1985 by American scientists. This area of study is called gene mapping.

7.2 MITOSIS and MEIOSIS

[Section 2.5 discusses the two cell division processes of mitosis and meiosis in detail.]

Each species of plant or animal has a specific number of chromosomes in the nucleus of their cells. The specific number of chromosomes defines the species. For example, human beings have 46 chromosomes and in all human cells the number of chromosomes is 46. In garden peas the number of chromosomes is 14, while in mice it is 40.

Mitosis occurs in all parts of an animal or plant producing new cells for growth and repair where **the number of chromosomes is retained.** However, mitosis **does not occur in reproductive organs where eggs or sperm, or**

gametes, are produced. This is because **gametes have only a half of the number of chromosomes** to ensure that after fertilization, the complete number is restored.

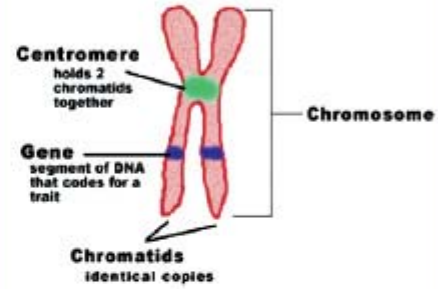
The type of **cell division that halves the number of chromosomes is known as meiosis.** In humans the only cells that have half the number of chromosomes (i.e. 23) are the gametes. The human genome shows that there are 23 pairs of chromosomes. Of these **22 pairs** are **autosomes** while one pair is called the **sex chromosome** as it contains information that determines the sex of the individual.

7.3 CHROMOSOME STRUCTURE

Chromosomes are found inside the nucleus of a cell and each chromosome is made up of two parallel strands. A single strand in a pair is known as a **chromatid.** The chromatids are held together by a **centromere.** The position of the centromere varies between pairs; in some, very close to the top, in others, nearer the middle and in the rest, exactly in the middle.

The pairs of chromosomes are also of different lengths from each other. However the two chromatids in any pair are of the same length and are known as a **homologous pair.** They are homologous meaning that both chromatids in the pair have, at the same distance from the same end (known as the **locus**) the gene for the same trait, whatever the trait might be. Since there are many genes located on a single pair of chromosomes, there will also be many loci (plural for locus), but each pair of loci is the same distance from the same end of the chromosome and carrying information about the same genetic trait, thus the term **homologous pair.**

Figure 7.2 Chromosome structure



Source: biologycorner.com

Chromosomes are extremely long, tightly coiled protein polymers covered with a protein coat to form condensed structures. When uncoiled and pulled out, a chromosome reveals a very long double stranded molecule called deoxyribonucleic acid (DNA) often described as a **double helix.** The double helix can be straightened out like a ladder, where each strand consists of repetitive units of **nucleotides** whose nitrogenous bases are held together by hydrogen bonds. The bonded nitrogenous bases make up the 'rung' of the ladder while the continuous sugar and phosphate make up the 'backbone' of the ladder. The two strands are complementary to each other (Figures 7.4 and 7.5).

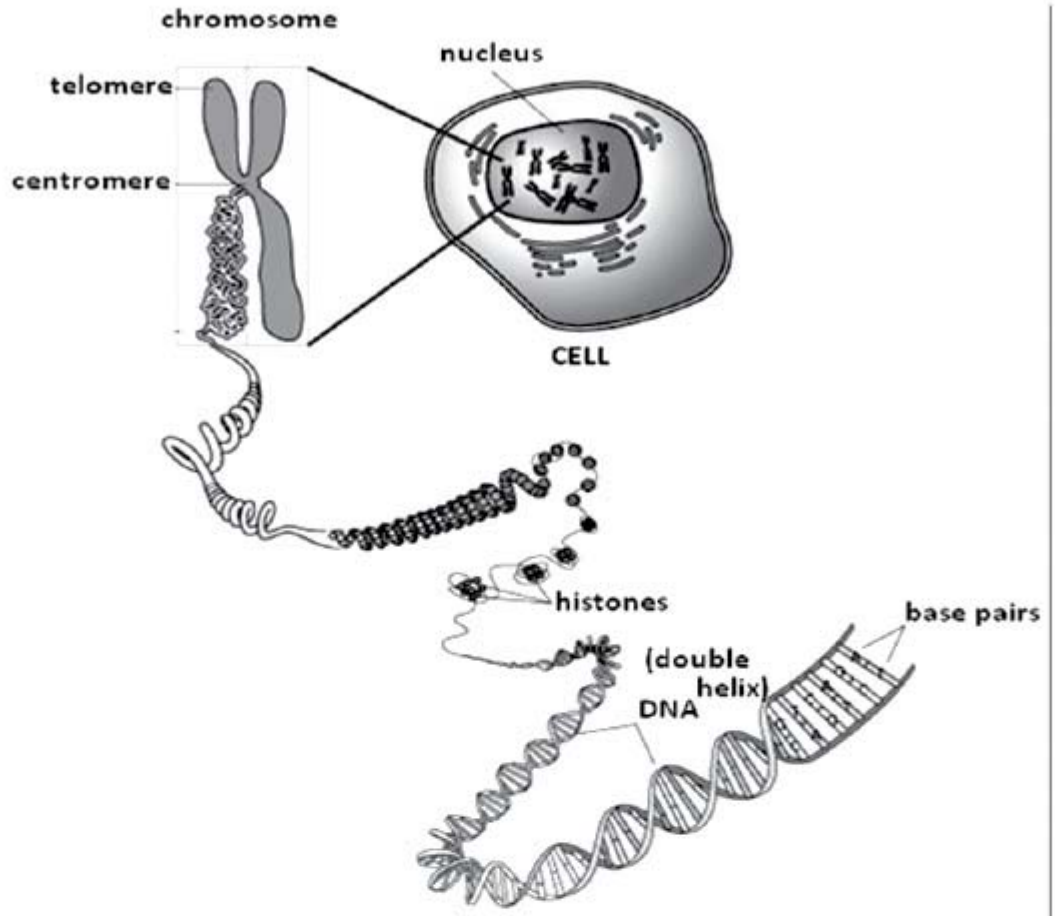
Figure 7.3 Homologous chromosomes

Source: bioap.wikispaces.com

The structure of the double strand shows that one strand of the backbone is aligned or pointing in one direction, while it's complementary strand is pointing in the opposite direction. This orientation is crucial for a couple of reasons, one of which is the rapid process of replication. The almost instant multiplication of cells (and their chromosomes) is crucial to the well being of the tissue and organ systems and therefore to the survival of the human body. The details of this process will be discussed later in this section.

The first attempt to unravel the structure of DNA was carried out by Rosaline Franklin and Maurice Wilkins in 1953, using a method known as X-ray diffraction. However, it was James Watson and Francis Crick who discovered the structure using mathematical calculations on information previously determined by other scientists.
Analysis of the DNA molecule reveals that the distance between the two strands is 20 Angstroms, while the distance between two nucleotides is 3.4 Angstroms (an angstrom is 1×10^{-10}m).

Figure 7.4

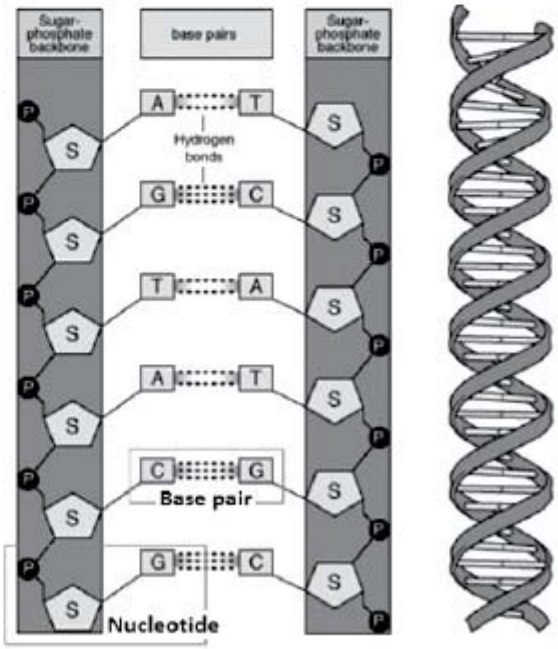


http://www.accessexcellence.org/AB/GG/chromosome.html

It was also found by analysis that the nitrogenous bases had a molecular structure that was cyclic but that there were four types. Two of the nitrogenous bases were composed of one ring or cycle and are referred to as **pyrimidines,** while the other two were made up of double ringed structures classified as **purines.** The two pyrimidines are called Cytosine and Thymine, while the two purines are called Adenine and Guanine.

To maintain the specific nature and role of DNA and in so doing maintain its efficiency (and therefore that of the chromosome), it is imperative that the structure of DNA is retained at all costs. This means that at no time must the distances between the two strands be altered. To retain this distance, the bonding that holds the two strands together must always be between a double ringed structure and a single ringed one. This explains why adenine is always bonded to thymine and cytosine is always bonded to guanine in every DNA molecule.

Figure 7.5 DNA Structure



This also leads to what is known as Chargaffs' Rules on DNA structure as given below:

Chargaff's Rules

1. the number of pyrimidine molecules always equal the number of purine molecules,
2. the number of adenine bases always equals the number of thymine bases, and
3. the number of cytosine bases always equals the number of guanine bases.

There is another nitrogenous base that falls into the category of the pyrimidines but is only found to be present in the nucleus during the formation of proteins. This base is called uracil and will be discussed further in the section on protein synthesis.

7.4 PATTERNS OF INHERITANCE

The combination of alleles determines the **genotype,** and this dictates the outward appearance of the organism or **phenotype.** The study of genetics and inheritance is the study of the combination of alleles and the prediction of the resulting phenotypes. The possible alternatives and combination of alleles is determined from a working table or a grid known as a punnet square.

Different patterns of inheritance are observed depending on whether one is studying a single factor or a multiple of factors. The outcome of the inheritance is also determined by the relative strengths of the alleles. In most cases, one allele is more expressive than the other. This is a case of complete dominance. In other cases the two alleles of the same gene are equally expressive; a condition known as **incomplete dominance.** Sometimes there is a complete dominance and incomplete dominance together, so that every combination produces a variety of expressions or patterns of inheritance. This is called **codominance.**

In the case of complete dominance, the allele which is more expressive is said to be **dominant** while the one that is less expressive is said to be **recessive**.

When the two combined alleles expressing a trait are the same, the situation is known as **homozygous** whether both alleles are dominant or recessive. When the genotype is homozygous (eg: BB or bb) the individual plant or animal is said to be pure-breeding. However, if the genotype occurs where one allele is dominant and one is recessive, the situation is **heterozygous** (eg: Bb).

It can be seen that the different combinations and cases produce a variety of phenotypes in individuals of a species. This variation is enhanced by the processes of gamete formation and fertilization.

7.4.1 Variation

"The difference in characteristics between members of the same species is called variation". This simply means that no two individuals of the same species are exactly alike.

Continuous variation: This occurs when every member of a species show a certain characteristic but not to the same extent. Example – Height [Individuals may be between a certain height range but not all are exactly the same height].

Discontinuous variation: This occurs when organisms must either have OR not have a certain characteristic. Example – Blood Group [Individuals either have A, B, AB or O and no other blood type]

Are All Variations Inherited?

Heritable Variations: Those which are inherited from parents and passed on to succeeding generations, example: Eye colour, height, tongue rolling etc.

Non-Heritable Variation: Those that are not inherited but caused by the environment. The characteristics are said to be acquired (not inherited), example: Scars, lost limb etc.

It is obvious from observations that inherited characteristics or traits are influenced to some extent by environmental factors such as food, exercise, living conditions and so on. Body weight for example, may be determined by a gene on the chromosome but its final outcome will be affected by the amount and quality of food consumed. The birth of a mentally defective child may be the result of inherited factors or, it may be the result of the mother having caught Rubella when she was pregnant or some accident may have happened to cause the unborn foetus to receive insufficient oxygen.

The influence of the environment in comparison to the influence of hereditary genes on human traits, is constantly being investigated. ***Identical twins which develop from the same fertilized cell have identical chromosomes and are genetically the same and of the same sex.*** Study of their similarities and differences therefore, provide very useful information about how the environment influences hereditary. **Fraternal twins** on the other hand **develop from two different fertilized cells and need not be of the same sex.**

In animal research stations identical twin calves are useful for finding out which farming methods work best. The study of identical twins, brought up in different home environments, also provide very useful information for determining the extent to which the environment influences inheritance.

What Happens When Genes Change Their Character?

The events that happen to chromosomes in the nucleus of a cell during mitosis or meiosis occur at extremely rapid rates. Often the speed alone causes certain chromosome components to end up in the wrong positions, or genes to be repositioned. This may cause **a gene to change into a new form giving rise to offspring with characteristics that deviate from the expected outcome.** A change of this kind is called a **mutation.**

Mutations occur all the time at a rate that is thought to be once in every 10,000 to 100,000 gametes. If we take the lowest of these, (i.e 10,000) and if we assume there to be 20,000 genes per gamete then we can expect one gamete out of every five to be carrying a newly mutated gene.

Although factors such as the speed of replication often results in chromosomal mistakes and eventually in the genes created, ***there is an inbuilt system designed to cover up the apparent effect of the mutated chromosome up to a certain level. Beyond this level the effect of the mutation becomes too great and displays itself in one form or another. The effect of the mutation may be as small as the formation of a 'junk' polypeptide or as big as the absence of a limb in an unborn foetus.***

Gene mutations do occur without apparent cause, but it is now known that there are a number of **factors which encourage the formation of mutant genes.** Some of these factors include **high energy radiation such as ultra-violet (UV) light, X-rays, cosmic rays, radioactive chemicals and certain drugs, pesticides and some food additives.** One such drug, **thalidomide,** was widely used for a number of years, as a sleeping pill in West Germany in the 1960s. Thalidomide interfered with the formation of limbs and many babies born during that period did so without arms, depending on the exact time the pill was taken.

Other diseases and **abnormalities caused by mutated genes are albinism, haemophilia, sickle-cell anaemia** and **colour-blindness.**

Albinism – caused by a recessive gene mutation resulting in failure to produce the pigment for skin colour called melanin. A person with this abnormality is often very light–skinned with white hair and pinkish eyes. They have difficulty coping with bright sunlight and need to protect their eyes from the sun's rays.

Haemophilia – caused by a recessive gene mutation that interferes with the formation of the protein thromboplastin, which is required for clotting blood, or for converting liquid blood to a gel that closes a wound and prevents blood loss. A person with haemophilia often refrains from active sports, lives a quiet life and is very careful to avoid injury.

Sickle-cell anaemia – caused by a recessive gene mutation that interferes with the formation of the haemoglobin molecule and distorts its shape resulting in its inability to combine with oxygen which is necessary for the effective process of gaseous exchange and cellular respiration. A person with sickle cell anaemia is often weak, lacking energy and subject to attack by many other disease causing micro-organisms.

Although extensive research has been done and the effects of sickle-cell aneamia have been controlled in countries such as Africa where it is widespread, its eradication has not been possible because of its resistance to malaria causing organisms.

Colour-blindness – caused by a recessive gene mutation that interferes with the functioning of cone cells in the retina of the eye, disabling it from distinguishing between the colours red and green. A person who applies to become an airplane pilot is always tested for colour-blindness, because of their crucial responsibility in ensuring safety when they are piloting a plane. It is important that they see 'red' for red, and 'green' for green to avoid making mistakes.

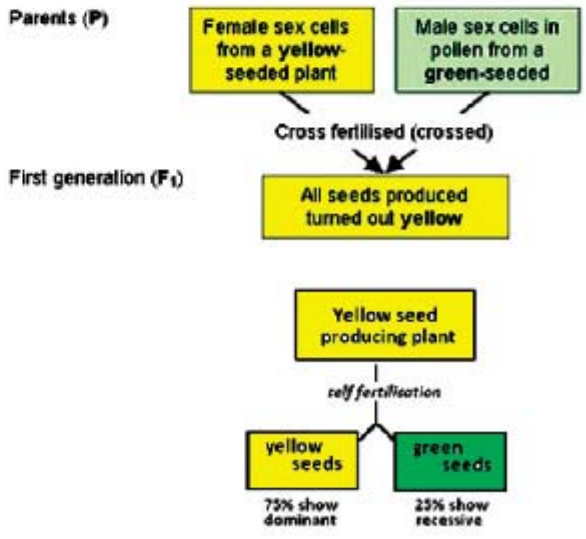
7.5 GREGOR MENDEL – FATHER OF GENETICS

The first recorded study of how traits are inherited was carried out by an Austrian monk named Gregor Mendel (1822-1884). He is known as the father of genetics and he studied inheritance by growing garden peas, and keeping records of the inheritable traits such as **colour and shape of the peas.** He **bred pure-breeding (homozygous)** smooth seed plants with pure-breeding wrinkled seed plants, for example, and then used the results to determine how the factors of seed texture were passed on from parent to offspring.

In his study Mendel observed that several traits were consistent with garden pea plants. These included seed colour (green or yellow), stem length (long or short), pod colour (green or yellow) and seed shape (round or wrinkled). The cross between two pea plants involving only one trait such as seed shape is known as a **monohybrid cross.** If the cross **involved two traits** then it would be referred to as a **dihybrid cross.**

The following illustrations and examples of Mendels' experiments will help you understand the various types of inheritance, the variation that results and the mechanism of inheritance by genes.
The success of Mendels' findings and his contribution to the basics of genetics was due to his excellent scientific process skills. Mendel used garden peas because the appearance of the male flower could be differentiated

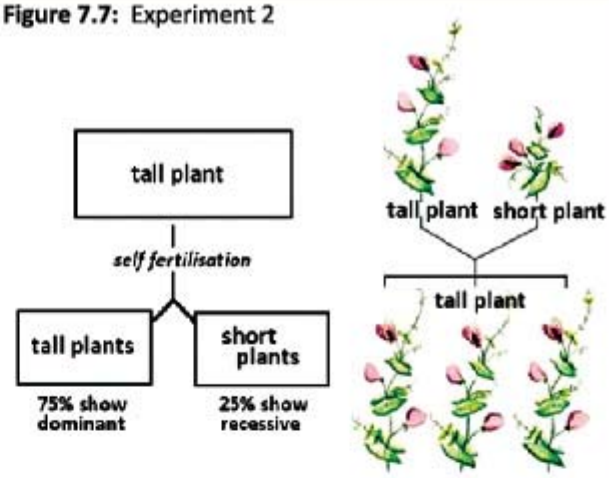
Figure 7.6: Experiment 1



Source: saburchill.com

from that of the female flower and the flowers could cross pollinate or self pollinate.

Figure 7.7: Experiment 2



Experiment 1: (Figure 7.6)
When Mendel pollinated a flower that normally produced green seeds with pollen from a flower that normally produced yellow seeds, all the offspring produced yellow seeds. Mendel then took pollen from one of these offspring and pollinated another flower from the same batch of offspring. He discovered that some of the resulting seeds were green while others were yellow. In fact, out of 8023 seeds, 6022 were yellow while the rest (2001) were green.

Experiment 2: (Figure 7.7)
When Mendel pollinated a flower of a pea plant that normally had tall stems with the flower of a normally had short stems, he found that all the resulting offspring had tall stems. However when he cross pollinated two of these offspring flowers he obtained 787 tall stemmed plants and 277 short stemmed plants.

In both cases the parents had contrasting traits but the offspring or first generation (F1) of plants showed only one trait. In the second generation (F2) the original traits of the parents, reappeared.

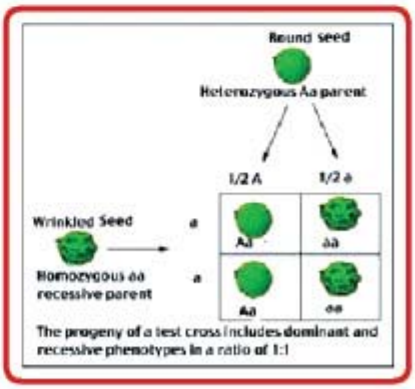
With the knowledge of homozygous and heterozygous gene pairs and an understanding of chromosome behaviour when gametes form, it is possible to understand how traits are passed on from one generation to the next.

STUDENT ACTIVITY

1. What scientific methods would Mendel have carried out to obtain such precise and reliable results that they formed the basis of the outcome of predictions and expectations in all genetic and hereditary work since then.
2. What does the term pure bred mean?
3. Calculate the genotype and phenotype ratios in the following crosses
   a. Pure bred green pods (GG) with **pure bred** yellow pods (gg).
   b. Pure bred purple flowers (PP) with pure white flowers (pp).
4. What would be the genotype and phenotype of the children of a man who is homozygous for the presence of ear lobes, with a woman who is homozygous for absence of ear lobes? Assume ear lobe presence is dominant over its absence.

7.51 Test Cross

The combination of genes of a particular trait is not often obvious from observation because of their conspicuous position in the chromosomes. That is to say that the genotype of an organism is most often not possible to determine from its phenotype (physical appearance). In the case of complete dominance, a test cross can be carried out to determine whether an individual is homozygous dominant or heterozygous because it is not possible to tell from the phenotype of the organism. The genotype of a homozygous recessive individual however is easily detectable because the phenotype will expose it.



In the case of Mendels' garden peas, for example, of the 6022 yellow seeds produced from the cross between a pure breeding green (yy) seed plant and a pure breeding yellow (YY) seed plant, some were homozygous dominant (YY) while others were heterozygous (Yy). The genotype of each seed could not be determined from its appearance. The

genotype of the green seed plant however, was certainly homozygous recessive (yy) because it was not yellow. In order to determine the genotype of the yellow seed, pollen from the flower of a yellow seed plant was then used to pollinate a flower of a green seed plant. The results of the possible offspring genotype from this pollination are shown in the diagram below.

a. Yellow seed (YY) X green seed (yy).

		Yellow Seed Gametes	
		Y	Y
Green Seed Gametes	y	Yy	Yy
	y	Yy	Yy

Genotype : 100% Yy
Phenotype: 100% yellow

b. Yellow seed (Yy) X green seed (yy)

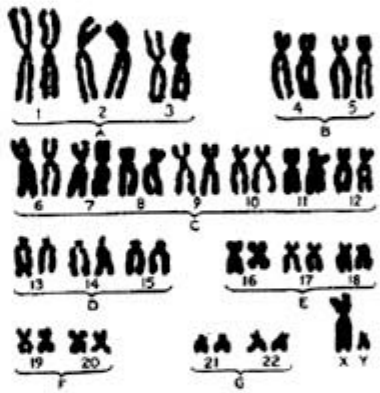
		Yellow Seed Gametes	
		Y	Y
Green Seed Gametes	y	Yy	yy
	y	Yy	yy

Genotype: 50% Yy, 50% yy
Phenotype: 50% yellow
50% green

7.6 DETERMINATION OF SEX

A very obvious feature that everybody has is their sex. A human being is either male or female and this difference is found in one of the pairs of chromosomes in the human genome. In fact this chromosome is the 23rd pair which may not have the same appearance as the other 22 pairs. In the first 22 pairs both chromosomes in the pair have the same length, but in the 23rd pair, sometimes one of the chromosomes is shorter than the other. At other times, the lengths are the same. The difference in the lengths indicates the sex of the person.
Careful studies have shown that the chromosomes in the cells of boys are different from those in the cells of girls.

Figure 7.6: Human Male Karyotype



Source: context.info

All males have one X and one Y (XY) chromosome as components of their 23rd pair, while all females have two Xs (XX).

The 23rd pair of chromosome is known as the sex chromosome. In every individual, one of each pair comes from the mother and one comes from the father.

The following punnet square illustrates this concept.

Answer the following questions using the punnet square above.

		Female Gametes from Mother	
		x	xy
Male Gametes from Father	x	XX daughter	XX daughter
	y	xy son	xxy son

a. What process separates the sex chromosomes in the body cells into male and female gametes?
b. How many kinds of male gametes are there? female gametes are there?
c. What is the chance of a child being a boy? a girl?
d. Which parent is responsible for determining the sex of a child? Explain your answer.
e. In some families all the children are of the same sex. Suggest a reason for this.

7.61 Sex Linked Traits (Traits Influenced by Sex Chromosomes)

It has been mentioned earlier that genes are found on chromosomes and this includes the sex chromosomes. However, only the X chromosome is able to carry a gene or allele. This means that males who have XY will show indications of the presence of certain alleles on their X chromosome because their Y chromosome is unable to carry the allele.

Certain inherited diseases are found to be more common in males than in females. These include red-green colour blindness and haemophilia, The allele responsible for red-green colour blindness for example, is a recessive one found on the X chromosome of the sex chromosome. If this recessive allele is inherited by a male child, then it will be carried on the X chromosome, as the Y chromosome is not able to carry it. The male child will definitely be colour blind as the allele cannot be obscured by another allele.

In a female child however, a recessive allele for colour blindness carried on the X chromosome can either be enhanced by the presence of another colour blindness allele on its X chromosome pair. On the other hand it can be obscured by the presence of a dominant allele which would code for normal colour vision, found on the second X chromosome.

In female children however there is another X chromosome which may carry an allele that can mask the effect of the colour blindness allele found on the first X chromosome. Female offspring therefore cannot exhibit the disease unless both alleles found on the X chromosomes are recessive.

Genes carried on the human sex chromosomes, many of which are associated with diseases and disabilities are known as **sex-linked genes.**

In the case of colour blindness, the genotype expression can be written as:

$X^C X^C$	female with normal vision
$X^C X^c$	female with normal vision
$X^c X^c$	colour blind female
$X^C Y$	male with normal vision
$X^c Y$	colour blind male

7.7 NATURAL AND ARTIFICIAL SELECTION

Natural Selection: Theory proposed by Charles Darwin which explains how organisms adapt to changes in the environment and are, able to pass these better adapted genes to the next generation through reproduction.

Organisms which are better adapted, survive and breed. This is called the "Survival Of The Fittest" principle.

Examples of natural selection at work include:

1. Giraffes having longer necks due to the shortage of plant material at lower levels and thus resulting in Giraffes reaching out to the higher branch levels.

2. Darwin's Finches have different beak types to help them survive based on the different food types available on the island, and where they live.

Artificial Selection: Carried out by humans in order to produce a breed of organisms with the most useful characteristics. Example: Better producing wheat varieties, cows producing larger quantities of milk etc.

Designing Organisms With Desirable Traits

1. **Selective Breeding** – This is the process of selecting a few organisms with traits that can be used for producing offspring in the next generation with a mixture of traits considered to be beneficial.

2. **In-breeding** - This is the process of crossing two closely related individuals with similar sets of alleles or crossing two individuals with identical sets of alleles. This is common amongst plants that are first colonizers because of the low chances of fertilization during the colonization period.

3. **Hybridisation** - This is a process done on two genetically different individuals to mix the desirable traits from each parent. Cloning can then be done on the offspring (known as hybrids) to produce individuals identical to the hybrid.

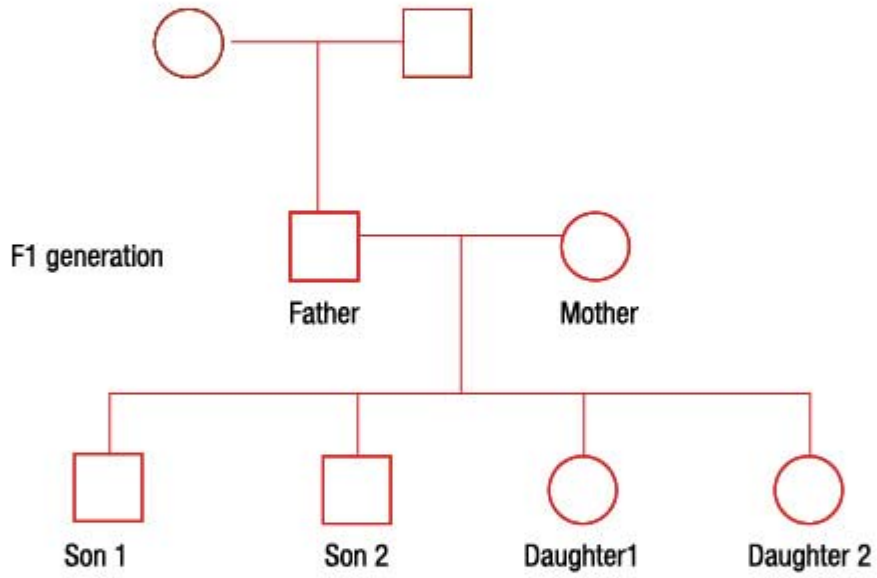
4. **Genetic Engineering** – This process uses bacteria (known as a **vector**) to reproduce the desired segment of a DNA molecule. This desired section is removed (or cut) by a process using enzymes. At the same time, the DNA of a bacterium is also cut making it possible to insert the desired segment. The sticking of the desired segment onto the bacterium DNA is also done by enzymes. The newly formed bacterium DNA is known as a **recombinant DNA** and can then be multiplied by cloning. The method used to carry out this process is known as **Recombinant DNA Technology.**

Review Questions

1. Match the terms in List A with their correct description in List B.

List A	List B
i. alleles	A. foreign substance that causes an immune response
ii. haploid	B. causes gradual body breakdown
iii. antigen	C. the various forms of a gene for a trait
iv. pure-breeding	D. a piece of DNA that codes for one protein
v. degenerative disease	E. cell that has half the number of chromosome
	F. homozygous for every trait

2. In humans, the gene for blue eyes (b) is recessive to the gene for brown eyes (B). The diagram below represents part of a family tree in which some members have brown eyes and some have blue eyes.



i. Using symbols above, write the genotype of the mother.
ii. What is the genotype of the grandfather?
iii. What is the ratio of individuals with brown eyes to those with blue eyes in the F2 generation?
iv. Assume that Daughter 2 wants all her children to have blue eyes.
Explain what the genotype of her future husband needs to be to enable her to have blue-eyed children?

b. Haemophilia and colour-blindness are two examples of sex-linked diseases
   i. Define sex-linked disease.
   ii. Why does a sex-linked disease rarely show up in a female, but nearly always shows up in a male?

c. Blood groups in humans are an example of multiple alleles, controlled by three alleles IA, IB and IO. IAIB are co-dominant and both are dominant to IO. The four blood group phenotypes: A, B, AB and O result from the various combinations of the three alleles.

The following tale shows the possible genotypes for each phenotype.

Phenotype	Genotype
Blood type A	I^AI^A or I^Ai^O
Blood type B	I^BI^B or I^Bi^O
Blood type AB	I^AI^B
Blood type O	i^Oi^O

i. What does the term co-dominant mean?
ii. Tavita has blood type O. His sister Donna has blood type AB.
Give the genotypes of their parents.

d. In tomatoes, trim leaf (T) is dominant to crinkled leaf (t).
A pure-bred trimmed leaf tomato plant (P1) was crossed with a pure-bred crinkled leaf tomato plant (P2).
i. Define pure-bred.
ii. Give the genotypes of the parents, P1 and P2.
iii. Give the genotype and the phenotype of their offspring – the F1 generation.
iv. Complete the punnet square below to show the cross between two F1 individuals.

X	**T**	
		Tt
t		

vi. What percentage of tomato plants will have crinkled leaves?

e. 'Survival of the fittest' is important in natural selection.
i. Define 'survival of the fittest'.
ii. State one difference between 'artificial selection' and 'natural selection'.

f. i. State two causes of genetic variation.
ii. Why is genetic variation important?
i. What does the term co-dominant mean?

CHAPTER 8

SOCIAL BIOLOGY

The phrase ***'social biology'*** refers to the **scientific study of the social behaviour of animals,** and based on the idea that animal behavior is a result of evolution and natural selection. Therefore behavior that is observed in animals is behaviour that has evolved and has become advantageous to the animal, it is an adaptation and useful, if not essential, for the animal's survival.

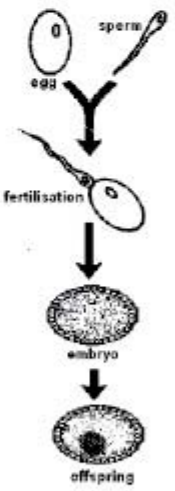
Animals show many types of social behavior – newly dominant male lions will kill cubs that are not sired by them, this will eliminate offspring that poses any competition to their own; wolves and fish form social groups or packs to hunt and ward of predators; ants, wasps and bees are highly social animals and form societies or colonies within which all activities occurs, from feeding to reproduction.

This section of the syllabus, although still called 'social biology' has been greatly reduced as many of the content is addressed in other subjects (like Family Life Education) or other levels of Biology and Basic Science. In Form 5, under the topic of social biology, the human male and female reproductive systems and their functions will be briefly reviewed, and the topic of **Personal Health** will be investigated in some detail. **First Aid** will be briefly included under Personal Health.

8.1 THE HUMAN REPRODUCTIVE SYSTEMS

The process of reproduction is a basic characteristic of living things. An individual who does not reproduce will not die because of it. However, a species that does not reproduce is headed for extinction. Reproduction ensures that new individuals are added to the population to replace those that die due to selection pressures (disease or predation) or old age. The male and female reproductive systems and there functions are covered in Form 4 Basic Science, thus will be presented here as revision. Also, in this section of reproduction, only sexual reproduction will be discussed.

Figure 8.1 Basic Reproduction



Although there are a variety of ways that organisms reproduce, the basic pattern remains the same, as shown in Figure 8.1. A sperm produced by the male parent is placed inside the female body to fertilise the egg produced by the female parent. Sexual reproduction involves the fusion of male and female gametes. Gametes carry half the number of chromosomes of the parents, and upon fusion, will form an individual that will now have the full set of chromosomes (aka - chromosome complement), of the species.

The advantage of sexual reproduction is that the offspring produced will show considerable variation to its siblings, although they are from the same parents. This variation is of great significance to the species, because in any given population, some individuals will be stronger or healthier, or will have features that make them slightly better adapted to their way of life.

8.1.1 THE MALE REPRODUCTIVE SYSTEM

The male reproductive system has basically two main functions:

i. To produce sperm
ii. To deposit the sperm into the female reproductive tract.

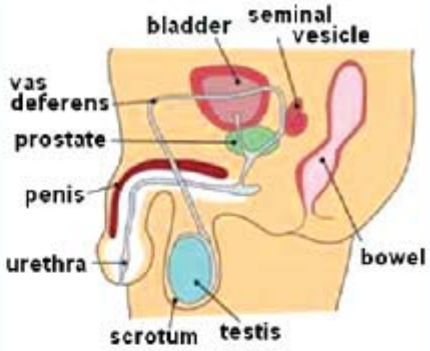


Figure 8.2
The Human Male Reproductive System

Source: shropshireivf.nhs.uk

Sperm are produced in two testes or (testicles). Within the **testes** are coils of tubes in which the sperm are formed. As much as 20-30 billion sperm are produced each month and are if not released will disintegrate and be absorbed into the body. The optimum temperature in which sperm can only be produced is around 34°C, which is why the testes are in the **scrotum,** a body cavity suspended outside the body.

The **penis** is the organ that transfers the sperm into the female body. It consists of spongy tissue which when filled with blood cause the penis to become erect. The end of the penis is called the **glans** and is covered with a fold of skin called the **foreskin.** During circumcision, this foreskin is removed surgically.

The **prostate gland** and **seminal vesicles** produce **seminal fluid (semen)** which is ejaculated from the penis during sexual intercourse, and carries the sperm keeping them nourished and alive and active.

In addition to producing sperm, the testes also produce male hormones **(androgens),** the common one being **testosterone.** These hormones are responsible for the **secondary sexual characteristics** observed in adolescent males and include growth of facial and pubic hair, deepening of the voice and development of the muscles.

8.1.2 THE FEMALE REPRODUCTIVE SYSTEM

The female reproductive system is a bit more complex than the male reproductive system, and is located in the body cavity. Apart from producing the female gametes and hormones, the female reproductive system must also be prepared to receive and carry an embryo/foetus to full term (nine months) and deliver it.

Figure 8.3
The Human Female Reproductive System

Source: chakras.org.uk

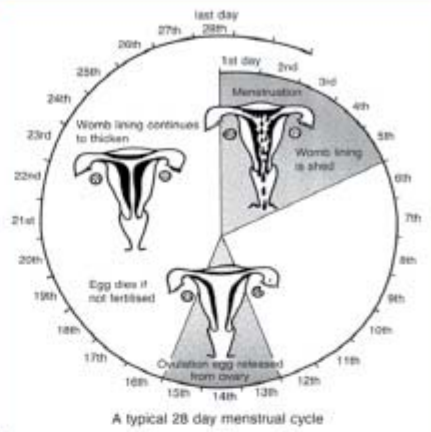
The sperm that are deposited in the **vagina** during intercourse, swim past the **cervix** which is the opening of the **uterus** or **womb,** through the uterus and into the **fallopian tube** or **oviduct** where fertilisation takes place.

The two **ovaries** which produce eggs are located on either side of the uterus and low in the body cavity. Eggs are already present in the ovaries at birth, and at puberty, about 30 000 are in each ovary, however, only about 400-450 are released during the life of the female – one every month for about 35 years.

Like the testes, the ovaries produce the female sex hormones. These hormones are **oestrogen,** which are principally responsible for the development of the female secondary sexual characteristics which include growth of body hair, development of breasts, widening of the hips and commencement of **ovulation,** which is the release of a ripe egg from the ovary every 28 days. With the commencement of ovulation, will come **menstruation.** Oestrogen and another hormone, **progesterone,** are responsible for controlling the menstrual cycle.

8.1.2.1 The Menstrual Cycle

Once every month, progesterone causes the uterine lining to thicken and become well supplied with blood vessels. This thick lining is known as the endometrium and is laid in preparation to receive an egg if one is fertilized. In the case of non-fertilisation, the unfertilized egg and the disintegrated endometrium pass out through the vagina. This is the process of menstruation (or having a period / menses) and may last from 3 to 5 days.

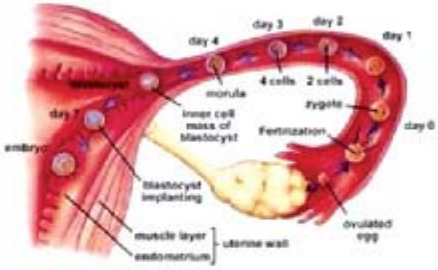


A typical 28 day menstrual cycle

Source: period symptoms.jpg

The first day of a menstrual cycle is the first day of a period. Ovulation usually occurs around Day 14 of the menstrual cycle. Around Day 5, the Follicle Stimulating Hormone (FSH) causes the growth of a follicle (a fluid-filled outgrowth) in the ovary, which contains the egg. As the follicle matures and ripens in readiness for release, oestrogen production increases and inhibits further FSH production, and causes continuing build-up of the endometrium.

When ovulation (release of the egg from the follicle) occurs, the follicle now begins to form a **yellow-body,** which secretes oestrogen and progesterone. If the egg is unfertilized, then the yellow bodied endometrium and unfertilized egg is released as menses or a period. Oestrogen levels also start to decrease and this means FSH production is no longer inhibited and the cycle is repeated.



Source: bioserv.fiu.edu

8.1.2.2 Fertilisation

If sperm are present in the oviduct during ovulation, the chance of fertilization occurring is very high. Healthy sperm that have entered the fallopian tube may survive up to 5-7 days after ejaculation. Once fertilization has occurred, the zygote begins dividing as it travels toward the uterus where it implants itself in the walls of the uterus.

The yellow body continues to mature and produce more oestrogen to prevent further egg releases and cause more thickening of the endometrium. This is the reason for the cessation of the monthly period during pregnancy.

8.1.2.3 Embryonic Development

The structure that is now embedded into the uterus has divided into several hundred cells, but has not grown. Growth comes when food and oxygen is obtained from the mother, and this ball of cells quickly develop into the embryo and its associated structures; placenta, umbilical cord and embryonic membranes.

5 weeks: Limb buds, eyes, the heart, the liver and rudiments of all other organs have started to develop in the embryo which is about 1cm long

14 weeks: Growth and development of the offspring, now called a foetus, continues during the second trimester. The foetus is about 6cm long

20 weeks: By the end of the second trimester (about 24 weeks), the foetus is about 30cm in length

Figure 8.4:
Stages of Foetal Development

***Source:** nursingcrib.com*

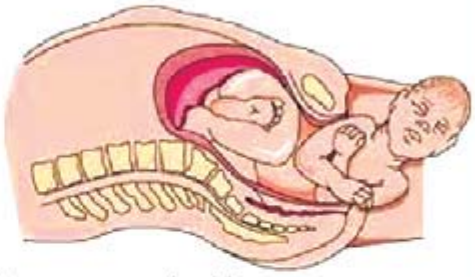
Growth is quite rapid and within a few weeks (about 8 weeks), the embryo is now called a foetus. The limbs and organs have formed and its facial features are recognizable. Not only does the foetus rely on nutrients from the mother for nourishment, but metabolic nitrogenous wastes and carbon dioxide are also removed by the mother. The fetal heart circulates blood within the foetus, and through the umbilical cord to the placenta where exchange of materials takes place between the blood vessels of the mother and the foetus.

The foetal blood circulation is always separate from the mother's circulation. As the foetus grows, it is surrounded by the **amnion,** a protective fluid-filled sac that serves primarily to cushion and protect it against mother's movement or external shock.

8.1.2.4 Childbirth

The period of pregnancy **(gestation)** for humans is 40 weeks or 9 months. A few days before birth, the foetus usually turns in the uterus to face downwards, its head just above the cervix. A foetus that has not turned into this position is said to be in a **breech position** and this means that its feet and buttocks are at the cervix, in order to exit the womb first instead of the head. There are options to correct this position of the foetus, as giving birth to a breech baby is risky.

Figure 8.4: A baby exits from the birth canal



Source: womenshealth.gov

During **labour,** the amnion ruptures and the fluid contents are released. This is known as **'breaking of the waters'.** As labour progresses, the cervix and vagina **dilate** (become larger) in preparation for birth. This dilation is felt as **contractions** that continue to intensify until the foetus is expelled from the womb through the birth canal. The baby remains attached to the placenta by the umbilical cord, which is then cut. The placenta or **afterbirth,** as it is now called, is expelled in the same way as the foetus within a few minutes to an hour after birth.

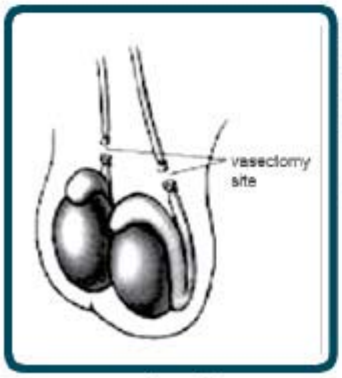
8.2 FAMILY PLANNING

Family Planning issues will be very briefly addressed in this section. Planning a family is a very important decision, and is to be made by married couples. There are a lot of factors that need to be considered when planning a family and generally, it must result in the family being happy and together. A couple may choose to use birth control as a way of ensuring success in their family planning efforts, and this section will discuss some of these birth control (or **contraceptive**) methods.

Sterilization

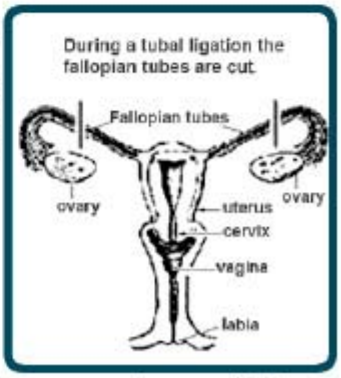
This involves permanent surgery to prevent any further pregnancies.

In men, the operation is called vasectomy, and involves the severing of the vas deferens so no sperm is released during ejaculation.



Source: mmhc-online.com

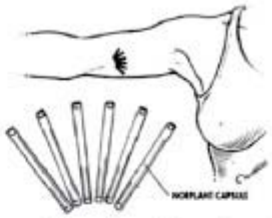
In females, the operation is called tubal ligation and involves the cutting and tying of the fallopian tubes so that during ovulation, eggs will not meet the sperm. Sterilization is the most effective form of contraception and is recommended only if the couple do not want any more children



Source: vasectomymedical.com

Injections and Implants

These are chemical implants that are in rod shaped containers and are inserted usually in the upper arm. The implants slowly release progesterone into the body preventing ovulation, as the body 'believes' that it is pregnant. Implants usually work up to 3 years and is about 99% effective.



Source: *facweb.northseattle.edu*

Birth Control Pills

These work the same way as the implants and injections, except that in the pill, the hormone is ingested. Contraceptive pills come in packages of about 28 pills per card (see diagram on the right), one pill to be taken everyday. Pills prevent ovulation from taking place.

Source: *en.wikipedia.org*

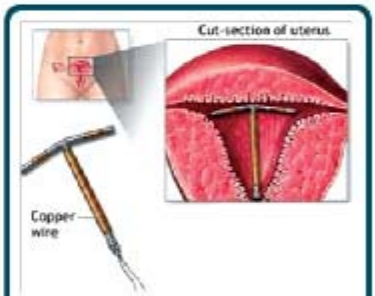
Condoms

Are rubber covers that fit closely over a man's erect penis and any sperm that is released during intercourse is kept within the condom. This is the only method that is thought to prevent the spread of STI's. A new condom must be used all the time.

Source: *Columbia.edu*

Intra-uterine device (IUD)

This is a T-shaped piece of plastic that is inserted into the uterus to keep the fertilized egg from implanting itself onto the uterine wall. As long as the woman has the IUD in place, she is protected from being pregnant. They are about 98% effective. There are some side effects including having a heavier period for a longer time, and sometimes are painful.



Source: *umm.edu*

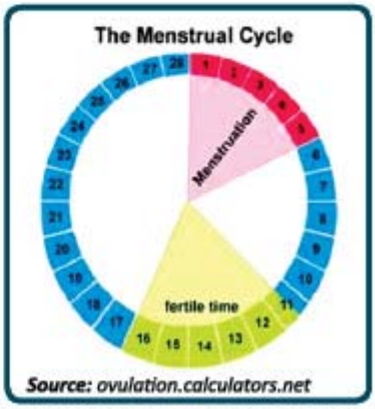
Diaphragm with spermicide

Is a bowl shaped cover that fits over the woman's cervix. It is usually filled with a spermicide (sperm killer) cream to ensure and improve its efficiency as a contraceptive. The diaphragm is inserted before intercourse and removed 6 hours after for best protection. This method, if used properly, is about 92-96% effective

Source: *healthylifecarenews.com*

Rhythm Method

This is the natural method where the woman monitors her menstrual cycle to engage in intercourse only during her 'free' days. These 'free' days are her non-fertile times, the times when she can have sex and the chance of falling pregnant is very low. The diagram (on the right) shows the 'fertile times' (in green) and these are the times that she should **not** engage in sexual activity. This effectiveness of this method depends on how carefully it is practiced, and regularity of menses. If these are monitored carefully, then this can be up to 85% effective.



Source: *ovulation.calculators.net*

Withdrawal

This involves the male pulling his penis out of the vagina before ejaculation, ensuring that most of the sperm is released outside the body. This method is not very effective as pre-ejaculation fluid may contain sperm that is able to fertilise the egg.

No method

This is the least effective as most couples get pregnant within the year

8.3 PERSONAL HEALTH

This section discusses the need to eat well in order to keep healthy. We will investigate the different nutritional contents of different types of food and look at different types of diseases, some of which result from unhealthy eating habits. Human beings consume a great variety of different foods. However, all foods have only a few of different nutrients that the body needs. These nutrients include carbohydrates, proteins, lipids (fats and oils), minerals and vitamins, fibre, or roughage, and water. A **balanced diet** is one that includes all the nutrients in the right amounts. Thus in general, one must eat a variety of foods in order to have a well balanced diet.

Carbohydrates

These are an important source of energy, and most are in the form of starch. When consumed, carbohydrates may be used up by the body immediately, or they may be stored for later use. Humans store excess carbohydrates in the form of **glycogen** in the liver, and when blood sugar is low, glycogen is converted to glucose by the hormone **glucagon** (secreted by the pancreas). Foods rich in carbohydrates include cereals, rice, and root-crops.

Lipids

Fats (like butter, lard and dripping) are found in animals while oils are found in plants (coconut oil, peanut oil). At room temperature, fats will solidify but not oils which remain in liquid form. Lipids are very rich in energy and any excess is usually stored under the skin. This layer of fat helps in insulating against the cold and mammals like whales, (although they do not have fur), are able to live in cold water because of the fat storage layer under their skin.

Proteins

These are essential in the diet as they are needed for body building, and repair and maintenance of cells. Many hormones and all enzymes are proteins and they are responsible for controlling the numerous chemical reactions in our bodies. Proteins consist of many amino acids joined together. There are only about 20 naturally occurring and known amino acids. But their number, type and sequence in a protein molecule results in a very large number and variety of proteins.

Vitamins and Minerals

Although these two groups of nutrients are required in minor quantities, a deficiency in any one could result in a deficiency disease and even death. Minerals play vital roles in maintenance of our bodies; calcium is essential for building bones and teeth, iodine is needed for the production of thyroxine; iron is needed for the formation of haemoglobin; zinc functions in cell and energy metabolism for growth and development, in cell signaling systems and in the immune system.

Vitamins, like minerals, although in needed in small quantities are still essential. They play important roles in controlling cell reactions and some act as co-enzymes, without which the enzyme is unable to catalyse reactions effectively. Lack of Vitamin C causes a disease called Scurvy.

These diseases caused by these two groups of nutrients will be discussed later in the chapter.

8.3.1 Malnutrition

The shortage of any food type or nutrient in the diet results in a condition called **malnutrition,** and can lead to a variety of deficiency diseases. A general lack of food (starvation) results in **marasmus** and is characterized by a ballooned belly and the exposure of an oversized head in children. There is tissue and muscle wasting and the skin appears dry. A deficiency in protein leads to a condition called **kwashiorkor.** This is characterized by weakness, stunted and slow growth and peeling skin, thinning hair and loss of teeth.

Types of diseases

Diseases may be generally classified into three categories;

a. A **deficiency disease** is a disease caused by the lack of a certain type of food or nutrient in the diet. Table 8.1 presents a list of these types of diseases, what their causes are, and the foods that contain the type of nutrient that is deficient;
b. **Communicable/Infectious/Contagious diseases** are those that are result from a **pathogen** (a disease causing organism like a virus or bacteria) and spreads easily from one (sick) person to the next through coughing, sneezing or even talking, or a vector (carrier), like a fly or rat. Some examples of infectious diseases are influenza, the common cold, mumps, chicken pox and scabies;
c. **A non-communicable diseases (or NCD)** is a medical condition or disease which is non-infectious. NCDs are diseases of long duration and generally slow progression, they are degenerative. They include heart disease, stroke, cancer, asthma, diabetes, chronic kidney disease, osteoporosis, Alzheimer's disease, cataracts, and more. Some of these diseases are discussed in the Chapter 5.

Table 8.1 Types of deficiency diseases

Mineral/Vitamin	Function/Need	Food sources	Deficiency
Calcium	For strong bones and teeth	Dairy products like milk, cheese	Weak bones
Iodine	For production of thyroxine	Salt, seafoods	Goiter-swelling of the thyroid gland
Iron	To make haemoglobin	Red meat, liver	Anaemia–lethargy and tiredness due to lack of oxygen
Magnesium, Sodium and Phosphorus	Used in cellular respiration, osmoregulation,	Grains and milk, leafy vegetables	Weakness, paralysis and even death
Potassium	Regulation of the heartbeat and protein synthesis	Bananas, raisins, prunes, avocados Salmon	Fatigue and muscle weakness
Vitamin A (retinol)	Vision and healthy skin, cell growth, bone development	Green and orange vegetables cod liver oil	Night blindness, cannot see well in the darkness

Mineral/Vitamin	Function/Need	Food sources	Deficiency
Vitamin B_1 (thiamine)	For healthy skin, hair, eyes and liver	Oatmeal, rice bran, vegetables, eggs, cauliflower,	Beriberi, weakness, paralysis then death
Vitamin B_2 (riboflavin)	In cellular respiration	Dairy products, bananas, green beans, asparagus	cracks and sores at the corners of the mouth, eye disorders, inflammation of the mouth and tongue
Vitamin C (ascorbic acid)	Growth and repair of tissues in all parts of the body	Citrus fruits and vegetables and liver	Scurvy – bleeding gums and leaky capillaries
Vitamin D (Cholecalciferol)	absorption of calcium, assists in bone growth and the integrity of bone and promotes strong teeth	Fish, eggs, liver, mushrooms	Rickets – soft bones that bend and break easily, muscle twitching

Research

Find out about the following common diseases that exist in Fiji. For each one, state the symptoms, the cause and preventative measures. Some are already discussed in this text, others are not.

a. Diabetes
b. High blood pressure
c. Tuberculosis
d. Sexually Transmitted infections
e. Heart diseases
f. Typhoid fever
g. Cancer
h. Dengue fever
i. Malaria
j. Intestinal worms
k. Leptospirosis
l. AIDS

8.4 Disease and the Immune System

The immune system is an arrangement of organs, tissues and cells that work together in the human body to ensure defense and protection from pathogens, microorganisms and foreign bodies that cause illness. Everyday, there is a constant attack from pathogens on our immune system. We must therefore ensure that our immune system is not weakened, especially by our life-styles and diets, to the point where it is unable to function effectively.

General defense

There are many ways in which the body prevents itself from illness. Our first line of defense consists of our skin, mucus and cilia that keep out or trap pathogens attempting to enter the body. Phagocytes, or white blood cells, make up our second line of defense and surround and trap any pathogens that have managed to go past the first line of defense and enter the body. Any foreign particles are identified and the phagocytes will rid of them through endocytosis. The immune system is the third and final line of defense.

Immune response

When phagocytes (second line of defense) are unable to overcome the pathogens, then the lymphocytes are alerted. When it is necessary for the immune system to be 'activated', the signal that is given for the immune system's to react is called an immune response'.

Memory lymphocytes

Some lymphocytes have the 'experience' of having encountered an antigen (a foreign molecule that, when introduced into the body, triggers the production of an antibody by the immune system) during a vaccination or an earlier infection. These lymphocytes are called memory lymphocytes. Thus they 'remember' the antigen and a second encounter will trigger a faster and stronger immune response.

Immunization

This is the process by which an individual's immune system becomes prepared to defend against an agent (known as the immunogen).

When this system is exposed to molecules that are foreign to the body, it will coordinate an immune response, but it can also develop the ability to quickly respond to an ensuing encounter. The process involves the injection of a vaccine which consists of dead bacteria or a weakened form of virus. Lymphocytes multiply quickly to attack these foreigners, and memory lymphocytes remain, ready to protect in the case of a second encounter.

8.5 First Aid

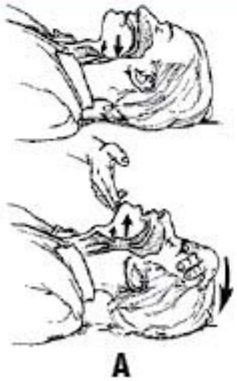
This is the first help or initial care that is given to the injured or sick. It is usually administered by non-medical but trained personnel until proper medical help arrives. Sometimes, in minor cases, the victim may not need any help beyond the first aid treatment, and in other cases, the first aid treatment will save the life of the victim. First Aid involves a series of simple but sometimes life-saving techniques, and designed to be performed with minimal equipment.

Research

Find out the First Aid treatment for the following cases:
cuts and scrapes, nosebleeds, burns, choking, fractures, asthma, poisons and shock.

Certain skills are considered indispensable to the provision of first aid and are taught universally. Particularly the "ABC"s of first aid, which focus on critical life-saving intervention, and must be given before the treatment of less serious injuries, especially if the victim is unconscious. ABC stands for

i. **A**irway: attention must be given to the airway to ensure that there is nothing blocking it, and that is clear. Choking is a life threatening emergency;
ii. **B**reathing: once the airway evaluation is complete, then the First Aider must check that there is adequacy in breathing. Otherwise, rescue breathing ('Kiss of Life', Mouth-to-mouth resuscitation) must be rendered;
iii. **C**irculation: when the breathing evaluation is complete and the patient is breathing, check circulation by checking pulse rate. If the patient is not breathing, then trained First Aiders would begin applying chest compression in an attempt to start the heart beating.


A


B


C

Review Questions

1. Match the disease in **List A** with its deficiency or symptom in **List B.**

List A		List B	
i.	Anaemia	A.	Swollen neck
ii.	Kwashiorkor	B.	Leaky capillaries, bleeding gums
iii.	Rickets	C.	Dehydration
iv.	Scurvy	D.	Protein
v.	Goitre	E.	Vitamin D
		F.	Tiredness due to lack of oxygen

2. List two natural defenses of the human body against pathogenic micro-organisms

3. Name the disease described below **and** suggest a preventative method against the disease.

   i. Patient I: have leaky capillaries and bleeding gums
   ii. Patient II: gets tired easily due to lack of oxygen
   iii. Patient III: passes urine frequently and has sores that take a long time to heal

4. i. Which organ of the body does tuberculosis (TB) directly affect?
   ii. Explain how the concern over cramped conditions can be a contributing factor to the workers contracting the disease.
   iii. How are children in Fiji protected against TB?

5. Oestrogen and Testosterone are hormones that play vital roles in the development of secondary sexual characteristics in humans and other mammals.
   i. Name the organs that produce these hormones.
   ii. State the functions of the hormones in question.

6. Name the family planning method that
   i. involves surgical operation and is the most effective.
   ii. gives protection against sexually transmitted infections.

7. i. Which organ of the body does tuberculosis (TB) directly affect?
   ii. Explain how the concern over cramped conditions can be a contributing factor to the workers contracting the disease.
   iii. How are children in Fiji protected against TB?

8. AIDS is considered to be more dangerous in comparison to any other sexually transmitted infection.
   i. Why is this so?
   ii. State two factors that contribute to the spread of AIDS.
   iii. What is the effect of the AIDS virus on the immune system?
   iv. State two preventative measures against AIDS.

Glossary

Action potential: a state of flow of impulse or voltage
amylase – enzyme for breaking down starch to sugar
Angiosperm – the group of seed bearing plants that produce flowers as their reproductive structure
Annelida – segmented bilaterally symmetrical worms with two openings in their digestive system
annuals –plants that live for only a year
Anther: the part of the flower that produces the male cell or pollen grains
Apical Meristem – meristem tissue found in the tips of roots and stems
Apogee: the point in the orbit of an object (as a satellite) orbiting the earth that is at the greatest distance from the center of the earth
Arthropoda – the largest phylum in the animal kingdom where the organisms have 2 or 3 body segments, paired jointed appendages and a tough exoskeleton
Artificial selection: or selective breeding is a process of breeding plants and animals for certain traits
Aschelminthes (Roundworms) – unsegmented bilaterally symmetrical worms with two openings in their digestive system
Asexual reproduction – mode of reproduction by which offspring arise from one parent only
Autotroph – produces own food eg. Green plants
bienniels – plants that live for 2 years
Binomial Nomenclature – the naming (nomenclature) using two names (binomial), the genius and species
Biosphere – the part of the earth and its atmosphere inhabited by living things
Breathing – inhalation and exhalation air through the nose
Bryophyte – part of a group that includes mosses and liverworts. These plants have no true roots, stems and leaves i.e. no phloem and xylem in roots stems and leaves
Bulb – a short stem with fleshy leaves or leaf bases
Cambium – the layer of cells in the vascular tissue that lies between the xylem and phloem. It is responsible for the cell division to produce new xylem cells
Carpel – another name of the pistil of very simple flowers
Cell division – the process by which a parent cell divides into two or more daughter cells.
Chlorophyll: green pigment in plants that trap light energy
Chloroplast – cell organelle that
Chordata – bilaterally symmetrical organisms, most having a backbone and a spinal cord
Cnidaria (Coelenterata) – a group of radially symmetrical and multicellular marine organisms with double layered body wall and tentacles
Coelom – a fluid filled body cavity completely surrounded by mesoderm
Companion cells – specialised cells adjacent to the sieve tube cells in the phloem of flowering plants
corms – a short, vertical, swollen underground plant stem that serves as a storage organ used by some plants to survive winter or other adverse conditions such as summer drought and heat
Cortex – the unspecialized tissue in plant stems and roots between the vascular bundles and the epidermis
cotyledon – seed leaf fro embryonic plant, providing nutrient molecules for the developing plant before its mature leaves begin photosynthesis
Cross pollination: when pollen from the anther from a flower is transferred to the stigma of another flower of the same species
Cytosis: an active transport mechanism for the movement of large quantities of molecules into (endocytosis) and out (exosytosis) of cells.
Deamination – removal of the amine group from a molecule
Depolarization: a change in a cell's membrane potential, to become more positive or less negative
Dichotomous key – a key used to identify organisms using two features or characteristics
Dicotyledon – the group of flowering plants that typically have two (di) cotyledons (seed leaf)
differentiation – specialization in early embryonic cells

dormancy – period in an organisms life when growth, reproduction and other activities are temporarily stopped
double fertilization – complex fertilization mechanism in flowering plants involving the fertilization of egg and one sperm cell to give a 2n zygote, and the fertilization of 2 polar nuclei to give the 3n endosperm
Echinodermata – radially symmetrical marine invertebrates with spiny skin and most having tube feet
Ecology – is the study of relationships of living things (organisms) and their interaction with their environment
embryo – produced from a zygote, the early developmental stage of a plant or animal
Endosperm – nutritive tissue in a seed
Epidermis – The single-layered group of cells that covers plants' leaves, flowers, roots and stems
Epithelial cells – cells that line cavities and other structures in the body
Fertilization: the joining together of male sperm and female egg to form a zygote
Fibrous roots – also known as adventitious root that thin and moderately branching from the end of the stem
Filament – the stalk like part of flower that holds up the anther
Flower – the reproductive structure of the flowering plant
Food chain – shows which organism is eating what
Food web – network of inter-linking food chains, made up of more than one food chain
Fungi – a group of multicellular organisms (except yeast) which lack chlorophyll and are heterotrophic and saprophytic (feed on dead organic matter)
Gas exchange – occurs between blood vessels and cells in the alveoli (lungs) and blood vessels and body cells, where oxygen is exchanged for carbon dioxide
Genus – a taxonomic group that consists of similar species
germination – new growth by a seed or any reproductive structure
Gymnosperm – the non flowering plants. Group of plants that produce cones as their reproductive structure
heartwood – found in the centre of the stem, it is the hard wood made up of dead sap cells
Herbaceous stem – plants like hibiscus that are soft stemmed and usually die down at the end
Insect pollination: when pollen is transferred from anther to stigma during pollination by insects
Integument – is the covering layer over the seed
Internode – space on the stem between the nodes
Invagination – to fold inward or to sheath
Kingdom - largest taxonomic group where organisms are classified according to cell structure, tissue structure, nutritional requirement and developmental patterns
Latent infection – A lingering infection that may lie dormant in the body for a period of time but may become active under certain.
Lateral roots – roots that growth outward or sideways from the main root
Lenticels: gaps found in the stems of woody plants through which gases enter and leaves
life cycle- is a period involving all different generations of a species succeeding each other through means of reproduction
Lignin – an organic substance that, with cellulose, forms the chief part of woody tissue.
Meristem – the tissue in most plants consisting of undifferentiated cells (meristematic cells), found in zones of the plant where growth can take place
Micropyle – an opening on the surface of the ovule through which the pollen tube enters
Mollusca – soft bodied and often hard shelled organisms that have a head and a muscular foot
Monera – a group of microscopic unicellular organisms that do not have a nuclear membrane
Monocotyledon – the group of flowering plants that typically have one (mono) cotyledon (seed leaf)
Neap tide: A tide that occurs when the difference between high and low tide is least; the lowest level of high tide.
Node – the place (scar) on the stem where a leaf attaches
Oscilloscope: a measuring instrument that measures or observes constantly varying signal voltages
Pedicel – stalk of an individual flower
perennials – plants that live for more than two years
Perigee: the point in the orbit of an object (as a satellite) orbiting the earth that is nearest to the center of the earth

Petals – usually colourful modified leaves that surround the reproductive parts of the flower
Phloem – specialized tissue for carrying food
photoperiodism – physiological responses of organisms to length of day or night
Photosynthesis – the process by which plants make food
Pistil – the female part of the flower consisting of stigma, style and ovary
Pith – the soft, spongy central cylinder of parenchymous tissue in the stems of dicotyledonous plants
Platyhelminthes (Flatworms) – unsegmented bilaterally symmetrical worms with one opening in their digestive system
plumule – embryonic plant shoot that bears young leaves
Pollen grain – the male gametophyte in the seed plant
Pollen tube – tube that germinates from the pollen grain and acts as a channel conducting male sex cell to the ovary
Pollination: the process whereby pollen from the anther is transferred by a pollinating agent (like insects or wind) to the stigma
Polypepetide: a protein
Porifera – a group of non-motile marine organisms with a double layered body wall
primary growth – growth in length of stems and roots occurring in vascular plants
Protista – a group of unicellular organisms that have membrane bound organelles
Protoplasm – the living contents of a cell that is surrounded by a plasma membrane
radical – a young root
Respiration – oxidation of food (glucose) within cells (mitochondria) to release oxygen
Respiration – the process by which living cells oxidize food to release oxygen
Resting potential: a state of no impulse or voltage flow
Rhizomes – is characteristically a horizontal stem of a plant that is usually found underground, if separated into pieces, each piece may be able to give rise to a new plant
rhizomes – root-like underground horizontal stem
Root cap – layer of cells found covering the root tip preventing it from being damaged as it grows into the soil
Root hairs – outgrowths from root epidermal cells
Roots – Found in vascular plants, it is the organ that typically lies below the surface of the soil, and responsible for anchorage and absorption of water and minerals .
runners – type of stolon that exist above ground and are produced by many plants eg strawberries, as a type of asexual reproduction
secondary growth – growth in width in vascular plants
seed coat – covering around the embryonic sporophyte and stored foods ina mature seed
seed – mature ovule that contains an embryo with store food enclosed in a protective coat
Self pollination: when pollen from the anther is transferred to the stigma of the same flower
Sepals – protective leaflike structure enclosing the flower when in bud
Sexual reproduction – mode of reproduction involving fusion of male and female gametes
Sieve plate – perforated end wall of a sieve tube cell
Species – organisms of the same kind that are able to interbreed and produce fertile offspring
Spermopsida – the seed producing plants
Spring tide: The exceptionally high and low tides that occur at the time of the new moon or the full moon when the sun, moon, and earth are approximately aligned
Stamen – the male part of the flower consisting of anther and filament
Stem – the above ground structures that have vascular tissue and that support leaves and flowers
Stigma: the part of the flower that receives the pollen grain during pollination
stolon – modified, horizontal stem of plants found just above ground. New plants may be produced where nodes of the stem are in contact with the soil
Stomata – openings found on leaf surfaces by which water is lost
suckers – Offshoots are lateral shoots that are produced on the main stem of a plant

Symptomatic infection – an infection where there is an obvious expression of lack of health

Synaptic Cleft: space between neurons through which nervous impulse travels

Tap root – an enlarged, somewhat straight to tapering plant root that grows vertically downward. It forms a center from which other roots sprout laterally

Taxonomy – is a discipline of identifying and classifying organisms according to certain rules

Tracheophyta – vascular plants that have xylem and phloem tissue for conduction of water and food

Translocation – conduction of soluble food from one part of the cell to the other

Transpiration – the process by which plants lose water through their leaves

Trophic level – a feeding level in the food chain

Turgidity – the state of being turgid, as when water enters a cell making it appear swollen

Turgor pressure or turgidity is the main pressure of the cell contents against the cell wall in plant cells and bacteria cells

Vascular tissue – phloem and xylem tissue for conduction of water and food

Wind pollination: when pollen is transferred from anther to stigma during pollination by wind

Xylem – specialized tissue for carrying water

Zone of elongation – Area in plant roots where recently produced cells grow and elongate prior to differentiation

Zone of maturation – area in plant roots where cells differentiate and serve such functions as protection, storage, and conductance

Zygote – initial cell formed upon fusion of sperm cell and egg

Appendix I: The main biology career areas with some examples:

1. **Agriculture:** educator, manager, agronomist
2. **Animal Biology:** anima nutrition
3. **Anatomy / Physiology:**
4. **Bioinformatics / Biotechnology** –
5. **Biochemistry**
6. **Botany;** plant biologist, botanist
7. **Cell Biology:** microbiologist
8. **Conservation/ Ecology –** management and research in all area
9. **Science Consultancy –** in all areas
10. **Ecology**
11. **Education:** teacher, researcher, writer
12. **Environmental Science –** eco-farm manager,
13. **Forest Management –** forest ranger/assistant
14. **Forensic Science:** police officer (forensics)
15. **Fisheries –** hatchery assistant/manager, fisheries officer
16. **Genetics:** geneticist, research technician
17. **Geology:** geologist
18. **Marine Science:** marine biologist
19. **Medicine/Medical Science:** physiology, radiography, hemotology, lab technician
20. **Microbiology:**
21. **Natural Resources:** rock scientist, geologist, farmer
22. **Nutrition:** dietition
23. **Pathology:** pathologist
24. **Pharmacology:** pharmacy technician
25. **Science Research:** tertiary lecturer,
26. **Soil Science:**
27. **Sustainable Development/Management**
28. **Toxicology:**
29. **Veterinary Medicine:**
30. **Wildlife Studies**
31. **Zoology**