INTEGRATED SCIENCES

FOR TTCs

YEAR ONE

STUDENT'S BOOK

OPTIONS: Languages Education (LE)

&

Social Studies Education (SSE)

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FOREWORD

Dear Student- teacher,

Rwanda Basic Education Board is honoured to present to you this Integrated Science book for Year One of Languages Education (LE) & Social Studies Education (SSE) Options which serves as a guide to competence-based teaching and learning to ensure consistency and coherence in the learning of Integrated Science subject. The Rwandan educational philosophy is to ensure that you achieve full potential at every level of education which will prepare you to be well integrated in society and exploit employment opportunities.

The government of Rwanda emphasizes the importance of aligning teaching and learning materials with the syllabus to facilitate your learning process. Many factors influence what you learn, how well you learn and the competences you acquire. Those factors include the instructional materials available among others. Special attention was paid to the activities that facilitate the learning process in which you can develop your ideas and make new discoveries during concrete activities carried out individually or with peers.

In competence-based curriculum, learning is considered as a process of active building and developing knowledge and meanings by the learner where concepts are mainly introduced by an activity, a situation or a scenario that helps the learner to construct knowledge, develop skills and acquire positive attitudes and values. For effective use of this textbook, your role is to:

- Work on given activities including laboratory experiments which lead to the development of skills;
- Share relevant information with other learners through presentations, discussions, group work and other active learning techniques such as role play, case studies, investigation and research in the library, from the internet or from your community;
- Participate and take responsibility for your own learning;
- Draw conclusions based on the findings from the learning activities.

I wish to sincerely extend my appreciation to the people who contributed towards the development of this book, particularly REB staff who organized the whole process from its inception. Special gratitude goes to teachers, illustrators and designers who diligently worked to successful completion of this book.

Dr. MBARUSHIMANA Nelson
Director General of Rwanda Basic Education Board

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I wish to express my appreciation to all the people who played a major role in development of this Integrated Science book for Year One of TTC, Languages Education **(LE)** & Social Studies Education **(SSE)** Options. It would not have been successful without active participation of different education stakeholders.

I owe gratitude to different Universities and schools in Rwanda that allowed their staff to work with REB in the in-house textbooks production project. I wish to extend my sincere gratitude to lecturers, teachers, tutors, illustrators, designers and all other individuals whose efforts in one way or the other contributed to the success of writing of this textbook.

Finally, my word of gratitude goes to the Rwanda Basic Education Board staff particularly those from the Curriculum, Teaching and Learning Resources Department who were involved in the whole process of in-house textbook writing.

Joan MURUNGI,

Head of Curriculum, Teaching and Learning Resources Department

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UNIT 1: HEALTHY NUTRITION

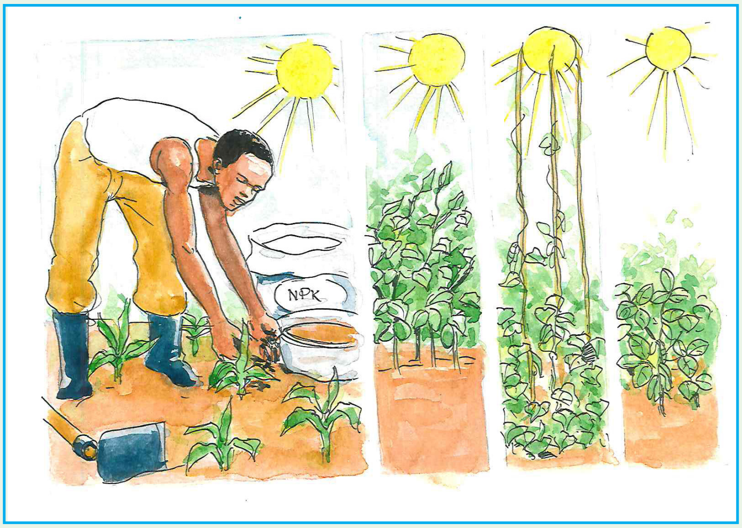
Key unit competence: **Explain the concept of the integrated science, prepare and serve a healthy diet**

Introductory Activity

1. Observe the illustration above and respond to the related questions
   a) Name the components of meal in these families above
   b) What main food groups are they eating?
   c) Compare that menu with yours, you daily have in family
   d) Is it a must to favor what kind of meals in your family. Why?
2. Predict what you are going to learn in this unit

1.0. INTRODUCTION TO INTEGRATED SCIENCE AND FOOD GROUPS

Activity 1.1



Observe the illustration below and answer the questions:

1. From your observation, describe the importance of the NPK/ organic manure to the plants on the figure above
2. Elaborate the consequences, to be observed when the plant didn't get the minerals
3. What is the implication of the sun to the growth of the plants?
4. As a farmer, what are the subjects have you studied that contribute to get the required knowledge and skills in order to get good crops from the plant above?

1.1. INTRODUCTION TO INTEGRATED SCIENCE

1.1.1. Definition and rationale of integrated science

human survival depends on knowledge through the exploration of the environment. Science provides knowledge while technology provides ways of using this knowledge. It is therefore very important to be aware of the global dimension of science needed in our lives in order to effectively deal with every day situation. The word "integrated" means "to restore the whole, to come together, to be a part of, to include." Integrated science is a subject which incorporates the knowledge base of all the science fields, both physical and life sciences and these science fields are included in one subject as a whole "integrated science" in that the fields of science are not segmented. It is a subject which offers experiences which help people to develop an operational understanding of the structure of science that should enrich their lives and make them more responsible citizens in the society.

Hence, integrated approach of learning science is appropriate as science knowledge is a tool to be used by every person to effectively deal with real world problems and life.

For examples, when you are studying digestion process of animals, you will need the knowledge of chemical processes. Another example, in describing the physics of light, we show how this applies to the inner workings of our eyes, which, in turn, are sensitive to visible light in great part because of the chemical composition of our atmosphere.

1.1.2. Interconnection between science subjects

The purpose of science is to produce useful models of reality which are used to advance the development of technology, leading to better quality of life for man and the environment around him.

There are many branches of science and various ways of classifying them. One of the most common ways is to classify the branches into social sciences, natural sciences and formal sciences.

Social sciences deal with the study of human behavior and society. Examples of these are psychology and sociology. Natural sciences deal with the study of natural phenomena, for example lightning, motion, and earthquakes all which can be observed and tested.

Examples of these are physics, chemistry and biology. *Formal sciences* deal with mathematical concepts and logics. An example of this is mathematics.

Note:

- Chemistry mainly deals with the study of salts, acids and their reactions. For a physicist to understand the working mechanism of chemical cells, help is sought from a chemist. On the other hand, the reasons behind the various colours observed in most of the chemical reactions are explained by a physicist.
- Petroleum products are dealt with by the chemist, but the transportation of such products make use of the principles of physics.
- In Biology, the study of living cells and small insects by a biologist requires magnification. The concept of magnification using simple or compound microscope is a brain child of a physicist. A good physicist needs to have good health.

1.1.3. Relationship between sciences with other subjects

The concepts of science and other subjects might be expanded or explainable in broader senses than you might have been exposed to, this should then predict not only the interconnection senses already known, but should also predict much broader interconnections. This might be useful to you and our future civilization.

Science is about observation and experimentation of things in the physical and natural world. If there no creative ideas, no destructive ideas, just more ideas of the same things that exist can this be healthy? There is such a thing as **inductive reasoning** not just **deductive reasoning.**

Now, science is the practical application of scientific knowledge. So we could have science as a conservative subject, or we could have science as a creative (conservative and destructive) subject, then leading to smaller or larger sets of science.

Note:

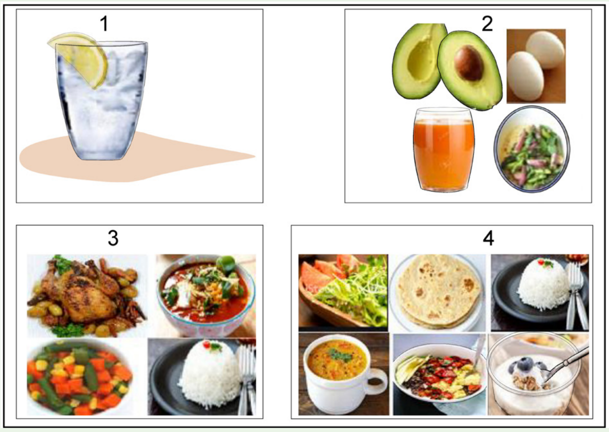
- In Geography, weather forecast, a geographer uses a barometer, wind gauge, etc. which are instruments developed by a physicist.
- In Agriculture, the water sprinkler, insecticide sprayer, etc. make use of the principles developed by physicists.
- In History, the determination of age fossils by historians and archaeologists use the principle developed by physicists.
- In games and sports, accurate measurement of time, distance, mass, and others uses instruments developed by physicists.

Application activity 1.1

1. Write a paragraph to convince someone that science is related to other subjects. Use clear examples to support your arguments and reasoning**.**
2. How can you describe the interconnections between science and technology, using at least three specific examples?
3. Why does science tend to be a “self-correcting” way of knowing about things?
4. What is likely being misunderstood by someone who says, “But that’s only a scientific theory”?

1.2. FOOD GROUPS

Activity 1.2



Observe four plates of food above, analyze them and determine at which time do you like to take each one of them?

1. Compare the nutrients in the plates of food above.
2. From your observation of above images, identify the main food groups for each plate
3. If recipes above represent day diet of a family, is it a healthy diet? Explain you reason
4. If recipes above represent day diet of a family, is it a healthy diet? Explain you reason

Food nutrients include **macro** and **micro nutrients**. Macro nutrients are needed by the body in large quantities. They include proteins, carbohydrates and lipids while the micro nutrients are needed in small amount and they include mineral salts and vitamins.

The foods that we eat contain different types of nutrients. It is therefore essential that we know the components of the food that we eat in order to live healthy lives. There are three main food groups such as: **energy giving foods, body building foods and protective foods.**

Energy giving foods are necessary to provide energy for cell metabolism. They include: carbohydrates and lipids. Some energy giving foods include potatoes, banana, rice, maize etc.

Body building foods are needed to promote growth and tissue repair.

These include proteins and can be found in the meat, eggs, fish, milk, beans, cassava leaves, etc.

Protective foods allow a good functioning of the body, and protect the body against some deficiency diseases. They include minerals and vitamins. The minerals can be found in fish, beans, kitchen salt and mineral water; and vitamins are found mainly in vegetables and fruits.

Food nutrients

Food contains mainly two classes of nutrients, organic and inorganic. The inorganic nutrients include mineral salts like calcium, phosphorous and others like water. The organic nutrients include proteins, carbohydrates, lipids and vitamins.

The materials that an animal's cells require but cannot synthesize are called essential nutrients. There are four classes of essential nutrients: essential amino acids, essential fatty acids, vitamins, and minerals.

1.2.1. Functions of food nutrients

a. Minerals

Mineral are also called micronutrients because we require them in very small quantities. They constitute about 1% of an organism by weight. Even though they are required in a very small amount, they are nonetheless essential for human body processes.

Table 1.1: **Principal minerals**

Calcium (Ca^{2+})	Iodine (I^-)
Phosphorus ($H_2PO_4^-$)	Chloride (Cl^-)
Nitrogen (NO_3^-)	Manganese (Mn^{2+})
Sulfur (SO_4^{2-})	Fluoride (F^-)
Potassium (K^+)	Zinc (Zn^{2+})
Sodium (Na^+)	Cobalt (Co^{2+})
Iron (Fe^{2+} or Fe^{3+})	Chromium (Cr^{2+} or Cr^{3+})
Magnesium (Mg^{2+})	Molybdenum (MoO_4^-)

Classification of minerals

The classification of minerals is based upon their requirement rather than on their relative importance. Mineral nutrients are needed in a precise small amount. The five major minerals needed in human body include

calcium (Ca^{2+}), **phosphorus** ($H_2PO_4^-$), **potassium (K^+)**, **sodium (Na^+)** and magnesium **(Mg^{2+})**. Mineral nutrients are grouped into two groups of mineral salts: the **macronutrients** or major elements and the **micronutrients** or trace elements.

Macronutrient or major elements are minerals needed by humans in a relative large amounts (greater than 200 mg/day). Their examples include nitrogen (NO_3^-), phosphorus ($H_2PO_4^-$), sulfur (SO_4^{2-}), calcium (Ca^{2+}), sodium (Na^+), chlorine (Cl^-), magnesium (Mg^{2+}), and iron (Fe^{2+} or Fe^{3+}). Micronutrients or trace elements are those which are needed in minute amounts (a few parts per million). Examples include manganese (Mn^{2+}), iodine (I^-), zinc (Zn^{2+}), molybdenum (MoO_4^-).

Human body requires mineral nutrients to survive and to carry out daily functions and processes. Minerals keep humans healthy and have key roles in several body functions. Humans receive minerals by eating plants that absorb minerals from the soil and by eating meat and other products from animals, which graze on plants. The deficiency of mineral nutrients results into body functional disorders and diseases. Most are found in the blood and cytoplasm of cells, where they assist basic functions. For example, calcium and potassium regulate nerve and muscle activity

Table 1.2 **Minerals required, sources, function and deficiency**

Mineral	Major dietary sources	Some major functions	Mineral deficiency diseases and their symptoms.
Iron (Fe)	Meats, eggs, legumes, whole grains, green vegetables	Component of hemoglobin and of electron carriers in energy metabolism; enzyme cofactor	Iron-deficiency anemia, weakness, impaired immunity
Calcium (Ca)	Milk, soy milk, green leafy vegetables, sardines	Needed for nerve and muscle action; builds bone and teeth; helps blood clot	Retarded growth, possibly loss of bone mass and bone deformation called rickets.
Phosphorus (P)	Meat, poultry, pumpkin seeds, sunflower seeds, water melon, whole grains	Component of bones, teeth, lipids, cell membrane, and nucleotides.	Phosphorus deficiency results in a form of Bone malformation known as rickets

Sodium (Na)	Table salt, most processed foods	Needed for muscle and nerve function; helps maintain salt-water balance in body fluids, and assists active transport of certain material across the cell	cramps, reduced appetite
Potassium (K)	Meats, soy, beans, orange juice, tomato, potatoes, bananas	Assists active transport of certain material across the cell membrane Needed for muscle and nerve function; helps maintain salt-water balance in body fluids	Muscular weakness, paralysis, nausea, heart failure
Sulfur (S)	Whole grains, meats, seafood, eggs	Necessary component of amino acids many proteins and some coenzymes, e.g. acetyl coenzyme A	Symptoms of protein deficiency
Nitrogen (N)		Is a component of amino acids, proteins, coenzymes, vitamins	Digestion problem, skin disorders, defective bone growth.
Chlorine (Cl)	Table salt, most processed foods	Helps maintain water and pH balance; helps to form stomach acid (HCl)	Muscle cramps, reduced appetite
Fluorine (F)	Drinking water, tea, seafood	Component of certain digestive enzymes, component of teeth and bones	Tooth decay
Magnesium (Mg)	Whole grains, green leafy vegetables, nuts, seeds	Needed to form several enzymes	Nervous system disturbances

Copper (Cu)	Seafood, nuts, legumes, organ meats,	Enzyme cofactor in iron metabolism, melanin synthesis, electron transport, maintains the immune system stronger.	Growth failure, scaly skin inflammation, reproductive failure, impaired immunity.
Iodine	Seafood, dairy products, iodiz	Component of thyroid hormones	Cretinism, Goiter (enlarged thyroid)
Cobalt	Meats and dairy products	Component of vitamin B12	Deficiency of vitamin B12
Molybdenum	Beans, lentils, peas, grain products and nuts are the richest sources of molybdenum.	Promotes normal cell function, functions as a cofactor, used in production of red blood cells, enables the body to use nitrogen.	Tachycardia, tachypnea, headache, nausea, vomiting, and coma.
Manganese	Nuts, grains, vegetables, fruits, tea	Enzyme cofactor, growth factor in bone development.	bone and cartilage deformation
Zinc	oysters, beef, lamb, spinach, pumpkin seeds, squash seeds, nuts, dark, pork chocolate, beans, chicken and mushrooms.	It acts like a powerful antioxidant, is needed for proper cell division, to convert vitamin A into its active form in order to maintain proper vision, it is also needed for proper immune system functioning and wound healing.	Skin rashes and acne, thinning hair, nerve dysfunction, weak immunity, and nutrient malabsorption.

b. Vitamins

Like minerals, vitamins are also essential substances for the human body to function properly. They are required for metabolism, protecting health and for proper growth in children.

These are referred to as micro-nutrients. This is because our bodies require them in very small quantities but they are very important. Depending on the vitamin, the required amount ranges from about 0.01 to 100 mg per day.

Vitamins classification

There are thirteen vitamins required by human body. They are classified by their solubility, whether they dissolve in water or in fats.

Table 1.3 **Water-soluble and fat-soluble vitamins**

Water-soluble vitamins		Fat-soluble vitamins	
Vitamin	**Name**	**Vitamin**	**Name**
B1	Thiamine	A	Retinol
B2	Riboflavin	D	Calciferol
B3	Niacin (nicotinic acid)	E	Tocopherol
B5	Pantothenic acid	K	Phylloquinone
B6	Pyridoxine		
B7	Biotin		
B9	Folic acid (folacin)		
B12	Cyanocobalamine		
C	Ascorbic acid		

- **Water soluble**

These are vitamins **C** and **B**. They are called water soluble vitamins because they dissolve easily in water. They also dissolve when vegetables containing these vitamins are cooked for long time.

NB: We must never overcook vegetables.

- **Fat soluble.**

These consist of vitamins **A, D, E**, and **K**. They are called fat vitamins because they dissolve easily in oil and fat.

NB: We fry vegetables in some oil to be able to benefit from vitamin **A, D, E,** and **K** in them. If we only oil boil or steam them, our bodies will not be able to extract the vitamin in vegetables.

The vitamins are required for metabolism, protecting health and for proper growth in children. Vitamins also assist the formation of hormones, blood cells and genetic material.

Vitamins require no digestion and are absorbed directly from the small intestine into the blood stream. Features shared by all vitamins:

- They are not digested or broken down for energy
- They are not synthesized into the body structures (are essential)
- Most are rapidly destroyed by heat.
- They are essential for good human health (needed in a very small amount)
- They are required for chemical reactions in cells, working in association with enzymes.

Like minerals, vitamins are also essential substances for the human body to function properly. They are required for metabolism, protecting health and for proper growth in children.

Table: 1.4. **Major vitamins, sources, functions and deficiency**

Vitamins	Major dietary sources	Function in our lives	Possible symptoms of deficiency
Vitamin B_1 (thiamin)	Whole-grain products, eggs, peas, fish, yeast, beans, peanuts, meats	Helps break down macronutrients; essential for proper functioning of nerves	**Beriberi**: anemia, nerve disorders (such as confusion, paralysis, atrophy of limbs, hallucinations), and stunted growth in children.
Vitamin B_2 (riboflavin)	Milk, liver, green leafy vegetables, beef, eggs, Whole-grain products peanuts, yeast soybeans, lamb.	Helps the body process amino acids and fats; acts as antioxidants	Hair loss, insomnia, skin lesions such as cracks at corners of mouth, dermatitis and blurred vision. Also cataracts, lesion of intestinal mucosa, and one type of anemia.
vitamin B_9 Folic acid (folate or folacin)	Liver, green leafy vegetables, citrus fruits, legumes, and fortified bread.	Needed for normal production of red blood cells and white blood cells. Also is needed in DNA and RNA synthesis.	Anemia, gastrointestinal problems.
Vitamin B_3 Niacin or (nicotinic acid)	Meat, liver, fish, Whole-grain products, nuts, peas, beans.	Essential coenzyme in lipid metabolism.	Pellagra characterized by dermatitis, diarrhea and psychological disturbances.

Vitamin B_5 (Pantoth-enic acid)	Kidney, liver, sunflower seeds, broccoli, avocado, edible mushrooms, cereals.	A coenzyme in cellular respiration	Neuromotor disorders, fatigue and muscle cramps
Vitamin **B_6** (Pyridox-ine)	Liver, kidney, fish	Essential coenzyme for normal amino acids metabolism	Dermatitis of the eye, nose and mouth. Also retarded growth, kwashiorkor symptoms and nausea.
Vitamin B_7 (Biotin)	Yeast, liver, egg yolk, kidneys	Enables synthesis of fatty acids; helps store energy; keeps level of blood sugar stable	Mental depression, muscular pain, dermatitIs, fatigue, nausea.
B12 (Cyanoco-balamin)	Meat, liver, milk, shellfish, eggs, cheese. Is the only B vitamin not found in vegetables?	Needed for normal functioning of nervous system and formation of blood	Pernicious anemia, memory loss, weakness, personality and mood changes
C (Ascorbic acid)	Tomatoes, citrus fruits, green vegetables,	Needed to make many biological chemicals; acts as antioxidant, aids in detoxification; improves iron absorption	Scurvy (degeneration of skin, teeth, gum, blood vessels), weakness, delayed wound healing, impaired immunity.
Vitamin A (Retinol)	Carrots, spinach, milk, eggs, liver	Needed for good vision, reproduction, and fetal development	Night blindness, dry scaling skin, inability to gain weight. Increased incidence of ear, respiratory, urinary and digestive infections.
Vitamin D (Calciferol)	Liver, fish oils, dairy products, action of sunlight on the skin.	Essential in absorption as well as utilization of calcium and phosphorus, therefore important in formation of teeth and bones	Defective utilization of Calcium and phosphorus by bones leads to rickets in children and osteomalacia in adult.

Vitamin E (Tocoph-erol)	seed oils, nuts, green leafy vegetables, whole grains, fish	Acts as antioxidant to inactivate free radicals. Is involved in formation of DNA, RNA and red blood cells. It also promote wound healing	Hemolytic anemia,
Vitamin K (Phylloqui-none)	Cabbage, liver, green vegetables	Coenzyme essential for synthesis of clotting factors by liver including prothombin.	Delayed clotting time resulting in excessive bleeding.

c. Carbohydrates

They are macronutrients that provide our bodies with energy and warmth. The word carbohydrate suggests that these organic compounds are hydrates of carbon. Their general formula is $C_x (H_2O)_y$. The general function of carbohydrates is to provide energy that is used in cellular metabolism. Carbohydrates are divided into three groups including the monosaccharides (single sugars: glucose, fructose and galactose), disaccharides (double sugars: sucrose, maltose and lactose) and polysaccharides (many sugars: starch, glycogen and cellulose).

NB: We need carbohydrates to do work also to keep our bodies warm.

Table 1.5: **Types of disaccharides and their monomers**

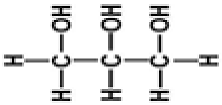
Disaccharides	Monomers
Maltose(malt sugar)	Glucose + glucose
Sucrose(cane sugar)	Glucose + Fructose
Lactose(milk sugar)	Glucose + galactose

The carbohydrates are energy giving nutrients. They are burned by Oxygen in a process of cell respiration to produce energy to be used in cell metabolism. The common know monosaccharides of carbohydrates is glucose with molecular formula $C_6H_{12}O_6$. If is burned by Oxygen, it produces energy as shown in equation of cell respiration below: **$C_6H_{12}O_6$ +6 $O_2$6 CO_2 +6 H_2O+ Energy (ATP + heat).**

All monosaccharides and disaccharides have the following characteristics: sweet taste, soluble in water and lower molecular mass. In the same way that two monosaccharides may combine in pairs to give a disaccharide, many monosaccharides may also combine by condensation reactions to form a **polysaccharide.** The polysaccharides like starch are not soluble in water, and do not have the sweet taste.

d. Lipids (Fats and oils)

Fat sometimes 'lipids' refers to both fats and oils. Where by fats and oils have the same basic chemical structure but their appearance differs at room temperature that is, fats are solids at room temperature while oils are liquids at room temperature. Fat is composed of three elements which are carbon, oxygen and hydrogen.



Sources and classification of lipids

Fats and oils are obtained from both the plants and animals. And fat is present in food either as visible fat or invisible fat.

Visible fat is the one that is easily seen or detected in food for example; fat in meat, butter, margarine, lard, suet and cooking fat and oil.

Cooking oil

Cheese

Margarine

Invisible fat is the part of food that is not easily seen for example fat with in lean meat, egg yolk, flesh of oily fish, groundnuts, soya beans, avocado and fat found in prepared foods, for example, pastry, cakes, biscuits, French fries, pancakes, croquettes.

Cake

Meat pie

Lipids are of different types as it is summarized in the following table

Table 1.6: **Lipids, structure, main role and features**

Lipid	Structure	Main role	Other features
Triglyceride	Glycerol plus fatty acids	Compact energy store, insoluble in water so doesn't affect water potential.	Stored as fat, which also has thermal insulation and protective properties.
Phospholipid	Glycerol plus two fatty acids and a phosphate group	Forms a molecule that is part hydrophobic, part hydrophilic ideal for basis of cell surface membranes	Phosphate groups may have carbohydrate parts attached: These Carbohydrates are involved in cell signaling.
Cholesterol	Four carbon-based ring structures joined together		Used to form steroid hormones

Functions of lipids

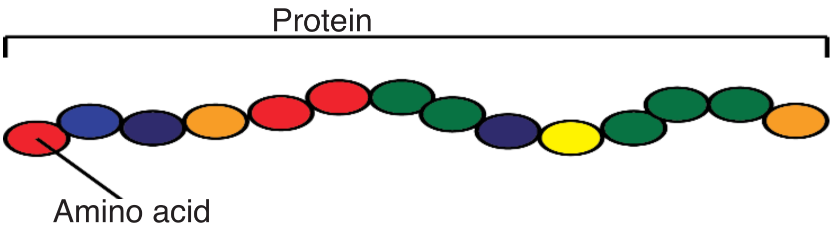
- Fats are a source of energy. They supply energy to the body more than carbohydrates and proteins.
- Fat surrounds and protects important organs of the body such as the kidney and the heart, however too much fat around the organs is dangerous as it slows down their functioning.
- Fat forms an insulating layer beneath the skin to help keep us warm by preserving body heat and it also protects the skeleton and organs.
- Fat provides a source of fat soluble vitamins A, D, E and K in the body.
- Fat is a reserve of energy for long term storage and can be used if energy intake is restricted.
- Fat in foods provides texture and flavour in foods and it helps to make it palatable.
- Food containing fat provides a feeling of satiety or fullness after a meal as fat is digested slowly.

e. Proteins

These are also referred to as macro-nutrients. The protein are also called **body- building food**.

Proteins are made of complex molecules which contain elements like oxygen, hydrogen, carbon, nitrogen and sometimes Sulphur and phosphorous. The protein molecules are made up of small units called

Amino acids joined together like links in a chain.



There are 21 different amino acids and each has its own chemical name. Different proteins are made when different numbers and types of amino acids combine through a covalent peptide bond. Proteins are therefore known as polypeptides.

Examples of proteins:

a) Collagen, myosin and elastin found in meat,

b) Caseinogen, lactalbumin, lacto globulin found in milk,

c) Avalbumin, mucin and liporitellin found in eggs,

d) Zein found in maize

The 21 different amino acids found in protein are:

-Arginine	-Glycine	-Aspartic acid
-Serine	-Methionine	-Glutamine
-Selenocysteine	-Lysine	-Alanine
-Leusine	-Asparagine	-Tyrosine
-Histidine	-Proline	-Glutamic acid
-Threonine	-Phenylalanine	-Cysteine
-Valine	-Tryptophan	-Isoleucine

They are used to repair, to build, to maintain our bodies; to make muscles and to make breast milk during lactation period. The proteins are classified into two categories: animal or complete proteins and plant proteins or incomplete proteins.

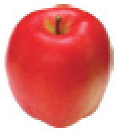
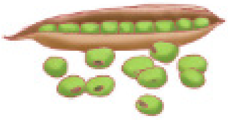
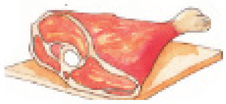
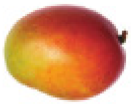
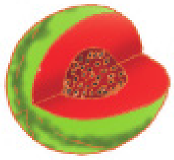
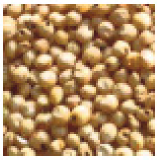
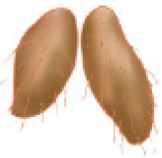
Functions of proteins

Proteins are large organic compounds formed by amino acids and they are not truly soluble in water. In addition to carbon, hydrogen and oxygen, proteins always contain nitrogen, usually Sulphur and sometimes phosphorus.

Function of proteins in the body
1. Help in growth of body cells such as fingernails, hair, skin
2. Help in maintaining and repairing body cells due to wear and tear or injury
3. They are a source of energy in circumstance when there is lack of carbohydrates and fats in the body, proteins will be converted to energy
4. Used in the formation of antibodies that guard against diseases, infections and illness
5. Build up body metabolism substances, for example hormones and enzymes which increase the rate of chemical reactions in the body
6. They form parts of the blood substance called hemoglobin which transfers oxygen in the blood from lungs to body tissues

Application activity 1.2 **Identification of food groups**

1. Analyze the following table of a variety of food
2. Put the food into a group of 3, energy giving food, body building food and protective food.

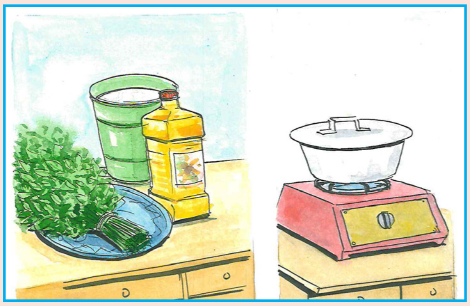
 Avocado	 Apple	 Peas	 Leafy vegetables
 Meat	 Paw paws	 Mango	 Green grams
 Water melon	 Sorghum	 Yam	 Strawberries.

Application activity 1.3

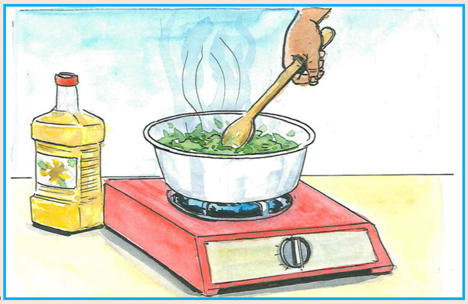
Observe the picture **A** and **B**

1. Analyse if vegetables are being cooked in oil?

A.



B.



2. Do you think that vegetables should be necessary cooked in water. Justify
3. a) Using library textbooks or search engine debate what happen when in body calcium or magnesium level is low. What are the symptoms?

   b) Observe the pictures below. These symptoms do they have dietary causes? Is it a micronutrient deficiency symptoms? Justify.

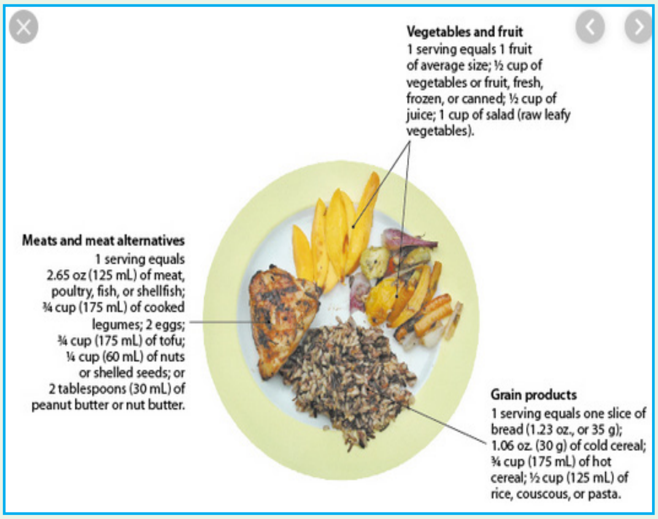
4. How can you avoid dietary deficiency consequences in a family?

1.2.2. Balanced diet and food service techniques

Activity 1.3

Selecting component of well-balanced diet

A



B

B is 2-3 pc chicken/Fish/1 egg + a Bowl chicken soup + 1 cup vegetable

1. Observe the recipes (A& B) above then respond to related questions
   a) what are main nutrients in A and B?
   b) Compare recipes A and B: Which one is not balanced? Why?
2. What are consequences when B is your diet all the time?
3. Propose a good healthy family eating plan

a. Balance diet

Eating a balanced diet means eat at least 5 portions of a variety of fruit and vegetables every day (see 5 A Day), base meals on higher fibre starchy foods like potatoes, bread, rice or pasta, have some dairy or dairy alternatives (such as soya drinks) eat some beans, pulses, fish, eggs, meat and other protein

Food variety means eating a wide variety of foods from each of the five food groups, in the amounts recommended. Eating many different foods helps maintain a healthy and interesting diet which provides a range of different nutrients to the body. Eating a variety of foods promotes good health and can help reduce the risk of disease. (https://www.google.balanced diet chart for family)

The **nutritional requirement** is influenced by **age, sex**, growth, pregnancy and breastfeeding, illness, psychological and emotional stress, activity level and other **factors** like smoking and drinking. Biological factors include age, gender, growth, disease states, and genetic makeup. Among the no biological factors, socio-economic status is the most important. Poverty is one of the major socio-economic causes of variation in nutrient intake, and it also impacts nutrient requirements. (https://www.google.balanced diet chart for family)

Example:

Aging is linked to a variety of changes in the body, including muscle loss, thinner skin and less stomach acid. ... Low stomach acid can affect the absorption of nutrients, such as vitamin B12, calcium, iron and magnesium. Although the recommended breakdown of carbohydrate, protein, and fat are the same for both genders, because men generally need more calories, they also require higher total intake of each of the macronutrients. Women need fewer calories than men, but in many cases, they have higher vitamin and mineral needs.

Reference Intakes

Nutritional needs vary depending on sex, size, age and activity levels so use this chart as a general guide only. The chart shows the Reference Intakes (RI) or daily amounts recommended for an average, moderately active adult to achieve a healthy, balanced diet for maintaining rather than losing or gaining weight. The RIs for fat, saturates, sugars and salt are all maximum amounts, while those for carbs and protein are figures you should aim to meet each day. There is no RI for fibre although health experts suggest we have 30g a day.

Reference intakes (RI)	Men	Women
Energy (kcal)	2500	2000
Protein (g)	55	50
Carbohydrates (g)	300	260
Sugar (g)	120	90
Fat (g)	95	70
Saturates (g)	30	20

https://www.google.balanced diet chart for family

Name of Food	Amount in gms.			
	per child 4-10 year	boy-girl 11-15 year	Per man	per woman
CEREALS	250-300	430,450	475	350
PULSES	50-70	50-70	70-80	VEGETARIAN 70 NON-VEGETARIAN 55
GREEN VEGETABLES	75-90	100-135	125	125
OTHER VEGETABLES	50-70	75-75	75	75
ROOTS & TUBERS	——	75-75	100	75
MILK	200-250	200-250	150-200	150-200
FRUITS	50	30-30	30	30
EGGS	15	30-30	30	30
MEAT	15	30-30	40	30
FATS & OILS	——	——	40-70	40-60
SUGAR JAGGER	30-50	30-30	40	30

https://www.google.balanced diet chart for family

A balanced diet is one that contains all nutrients required in health in appropriate proportion. A balanced diet must should contain all food groups such as: body building food, energy giving food and protective food in an appropriate amount. A balanced diet help a person to:

- Make you strong
- Provide better health
- Make you more productive
- Ensure strong immune system

It's not hard to include foods from the five food groups into appetizers and meals. Some suggestions include:

- **Vegetables and legumes** – raw or cooked vegetables can be used as a snack food or as a part of lunch and dinner. Salad vegetables can be used as a sandwich filling. Vegetable soup can make a healthy lunch. Stir-fries, vegetable patties and vegetable curries make nutritious evening meals. Try raw vegetables like carrot and celery sticks for a snack 'on the run'.
- **Fruit** – this is easy to carry as a snack and can be included in most meals. For example, try a banana with your breakfast cereal, an apple for morning tea and add some berries in your yoghurt for an afternoon snack. Fresh whole fruit is recommended over fruit juice and dried fruit. Fruit juice contains less fibre than fresh fruit and both fruit juice and dried fruit, and are more concentrated sources of sugar and energy. Dried fruit can also stick to teeth, which can increase the risk of dental caries.
- **Bread, cereals, rice, pasta and noodles** – add rice, pasta or noodles to serves of protein and vegetables for an all-round meal. There are many varieties of these to try. Where possible, try to use wholegrains in breads and cereals.
- **Lean meat, fish, poultry, eggs, nuts, legumes and tofu** – these can all provide protein. It's easy to include a mixture of protein into snacks and meals. Try adding lean meat to your sandwich or have a handful of nuts as a snack. You can also add legumes to soups or stews for an evening meal.
- **Milk, yoghurt and cheese** – try adding yogurt to breakfast cereal with milk, or using cottage cheese as a sandwich filling. Shavings of parmesan or cheddar can be used to top steamed vegetables or a salad. Use mostly reduced fat products.

Feeding on unbalanced diet for a longtime may lead to malnutritional diseases. Malnutrition means feeding on a meal lacking some food nutrients (deficient diseases), or on a meal with all food nutrients but in unappropriated amount (over eating).

Some deficient diseases include: kwashiorkor (caused by the meal lacking proteins), marasmus (caused by the meal lacking overall nutrients), and goitre (caused by the meal lacking iodine). The diseases caused by over eating include: obesity, a condition in which excessive fats are deposited in the body. More malnutritional diseases are described in the tables above describing functions of minerals and vitamins.

b. Basic food service technics

They are many different approaches of serving food. An operation should use a service style that is the best to satisfy its family members. The traditional table service provides service for family members who are seated at table. The English service comparable to Rwandan style is a type of service known as “family style service”. In this service the big dish is placed in front of the host along with serving plate and family members serve themselves.

- **Principles for meal service**

The family style meal service allows participants to eat together and to make food choices based on individual appetites and food preferences. It promotes mealtime as a learning experience to help participants develop positive attitudes toward nutritious foods, share in group eating situations, and develop good eating habits. Family style meal service can be conducted in a variety of ways. For example, participants may help in preparing for the meal by clearing the table and setting places, sharing conversation during the meal, and cleaning up after the meal.

Family style meal service operates as follows:

- All required meal components are placed on the table at the same time.
- Participants may serve themselves from serving dishes that are on the table
- Adults supervising the meal help those participants who are not able to serve themselves.
- Participants can make choices selecting foods and in the size of the serving.

- A supervising adult actively encourage family members to serve themselves and offers the food item again later in the meal if member (s) initially refuse the food or take a very small portion. Adult should model good eating habits while supervising participants at the dining table.

- **Standards of serving food temperatures**

The importance of temperature

The crucial important part of food safety in the home is to keep hot food hot and to keep cold food cold. For safety it is vitally important to keep food out of that danger zone.

The food being served should be kept at specified range and appropriate temperature (T):

Type of food	Hot food	Cold food
T	$63^oC < T < 75^oC$	$0^oC < T < 5^oC$

Note:

- The temperature danger zone for bacteria reproduction and growth: $5^oC < T < 63^oC$, food is not suitable for eating.
- Bacteria do not multiply and start to die at 63^oC above and do not grow and multiply at 5^oC below.

Application activity 1.4 *Basic table service methods*

1. Observe the picture below:

2. Describe the food setting order on pictures above?
3. Analyze the table setting on the picture above? Justify your answer.

End unit assessment

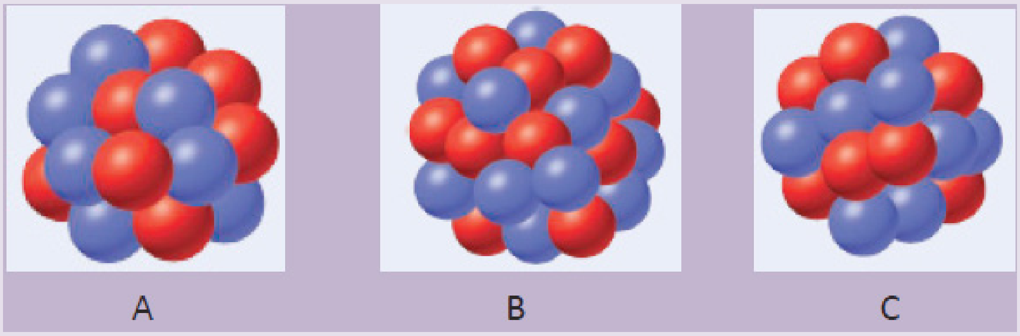
1. Analyze the importance of food nutrients.
2. Explain the importance of a balanced diet.
3. Explain how the condition factors (age, gender; activity; pregnant and breastfeeding mothers) affect the dietary needs of humans.
4. Justify the different functions of food nutrients in the body.
5. Classify vitamins and minerals as nutrients.
6. Organize the diet components in food groups.
7. Organize a list of foods that are good sources of specific food nutrients.
8. Prepare a balanced diet
9. Discuss services techniques of healthy diet.
10. Recognize the role of integrated science in everyday life experiences

UNIT 2: STRUCTURE OF AN ATOM AND ELECTRONIC CONFIGURATION

Key unit competence: **Describe the structure of an atom, calculate relative atomic mass and practice writing of electronic configuration using s, p, d orbitals**

Introductory Activity

Study the presentations carefully and answer the questions below.



1. How many blue and red spheres do you see in each of the diagrams above?
2. What do the three diagrams A, B, and C have in common?
3. Based on your knowledge concerning atomic structure, what do you think that
   a) the blue spheres represent?
   b) the red spheres represent? Provide explanations.
4. Are there some other particle(s) missing from the above diagrams? If yes name the particle(s).
5. What could you obtain if the atom is broken down?

2.1. SIMPLE OUTLINE OF SUB-ATOMIC PARTICLES DISCOVERY AND PROPERTIES

Activity 2.1

Using a search engine or library textbook, discuss the discovery of main atom particles.

The ancient Greek philosophers Leucippus and Democritus believed that atoms existed, but they had no idea as to their nature. Centuries later, in 1803, the English chemist John Dalton, guided by the experimental fact that chemical elements can't be decomposed chemically, was led to formulate his atomic theory.

Dalton's atomic theory was based on the assumption that atoms are tiny indivisible entities, with each chemical element consisting of its own characteristic atoms.

1) Dalton's Atomic Theory

a. Each element is made up of tiny particles called atoms.

b. The atoms of a given element are identical; the atoms of different elements are different in some fundamental way(s).

c. Chemical compounds are formed when atoms of different elements combine with each other. A given compound always has the same relative numbers and types of atoms.

d. Chemical reactions involve reorganization of the atoms—changes in the way they are bound together. The atoms themselves are not changed in a chemical reaction.

e. Dalton's atomic theory successfully explained the following laws – conservation of mass, constant composition and multiple proportions. However, it failed to explain certain other observations like the generation of electricity on rubbing glass or ebonite with silk or fur. These observations propelled the discovery of sub-atomic particles in the 20th *century. Let's learn about the discovery of the first sub-atomic particle – Electron.*

The atom is now known to consist of three primary particles: protons, neutrons, and electrons, which make up the atoms of all matter.

A series of experimental facts established the validity of the model. Radioactivity played an important part. Marie Curie suggested, in 1899, that when atoms disintegrate, they contradict Dalton's idea that atoms are indivisible. There must then be something smaller than the atom (subatomic particles) of which atoms were composed.

Long before that, Michael Faraday's electrolysis experiments and laws suggested that, just as an atom is the fundamental particle of an element, a fundamental particle for electricity must exist.

The "particle" of electricity was given the name *electron.*

a. Discovery of the electron

Experiments conducted by the British physicist **Joseph John Thomson**, in **1897** proved the existence of the electron and obtained the charge-to- mass ratio for it.

Conclusions from the Study of the Electron:

- All elements must contain identically charged **electrons**. Concluded that electron was part of an atom.
- Atoms are neutral, so there must be **positive particles** in the atom to balance the negative charge of the electrons
- **Electrons have so little mass** that atoms must contain other particles that account for most of the mass

Thomson believed that the electrons were like plums embedded in a positively charged "pudding," and thus his atomic model was called the "**plum pudding**" model.

Efforts were then turned to measuring the charge on the electron, and these were eventually successful and in 1916 – Robert Millikan determines the mass of the electron: 1/1840 the mass of a hydrogen atom. The electron has a mass of 9.11×10^{-28} g and has one unit of negative charge

b. Discovery of the nucleus, 1911

In 1911, **Ernest Rutherford** (1871-1937) and his co-workers discovered the nucleus and their main conclusions were the following.

- The nucleus is small
- The nucleus is dense
- The nucleus is positively charged and electrons are distributed around the nucleus and occupy the most of the volume.

The positively charged particles in the nucleus were called **protons**. The Rutherford Atomic Model was called a "**nuclear model**"

Neils Bohr worked under Rutherford but found problems with his theory. He ultimately determined that electrons are in circular orbits with increasing energy levels.

c. Discovery of the neutrons, 1932

In spite of the success of Rutherford and his co-workers in explaining atomic structure, one major problem remains unsolved.

If the hydrogen contains one proton and the helium atom contains two protons, the relative atomic mass of helium should be twice that of hydrogen. However, the relative atomic mass of helium is four and not two.

James Chadwick, English physicist (1891-1974), showed that the origin of the extra mass of helium was due to uncharged particles present in the nucleus that they call **neutrons.**

Bohr's theory said that the protons are in the middle and the electrons travel in specific energy levels and orbits around the nucleus

The modern model is basically the same except the nucleus contains protons and neutrons

2) Properties of sub-atomic particles

The following table summarizes the relative masses, the relative charges and the position within the atom of these sub-atomic particles.

Particle	**Symbol**	**Mass (g)**	**Mass (relative to that of a proton)**	**Charge (relative to that of a proton)**	**Position within the atom**
Proton	p^+	1.673×10^{-24}	1	+1	Nucleus
Neutron	n^0	1.675×10^{-24}	1	0	Nucleus
Electron	e^-	9.11×10^{-28}	$\frac{1}{1840}$	-1	Electron cloud

Application activity 2.1

1. Compare the Thomson's and Rutherford's models of the structure of an atom.
2. Answer the following questions without referring to any table.
   a) What are the main sub-atomic particles that make up the atom?
   b) What is the relative charge (in multiple of the electronic charge) of each of the particles
   c) Which of the sub-atomic particles is the most massive?
   d) Which of them is the least massive?
3. Why did it take a long time for the discovery of the neutrons?

2.2. ATOMIC MASS, MASS NUMBER AND ISOTOPES AND CALCULATION OF RELATIVE ATOMIC MASS

Activity 2.2

Atoms of the same element may exhibit some physical properties like mass, density, velocity. Is the statement true or false? Perform a research to figure out an appropriate explanation?

a. Atomic number

The **atomic number** (**Z**) or **proton number** is the number of protons in the nucleus of an atom. It corresponds to the order of the element in the periodic table.

The number of the protons in the nucleus of an atom determines the element to which the atom belongs. If an atom has an atomic number of 7, the atom must be a nitrogen atom. All nitrogen atoms have 7 protons in the nucleus.

Atoms carry no overall charge. The number of protons must therefore be the same as the number of electrons.

b. Mass number

The **mass number (A)** or **nucleon number** is the sum of the number of protons and the number of neutrons in the nucleus of an atom.

The number of neutrons can be obtained by subtracting the atomic number from the mass number.

Chemists use the following shorthand to represent an atom. The mass number is shown as a superscript (top number) and the atomic number is shown as a subscript (bottom number) beside the symbol of the element.

Example:

mass number → $^{19}_{9}F$ ← atomic number

Each fluorine atom contains: 9 protons, 9 electrons and 10 neutrons

The term **nuclide** is used to describe any atomic species of which the proton number and the nucleon number are specified. The species and are nuclides.

c. Isotopes

Isotopes are atoms of the same element with the same atomic number but different mass numbers. They have different numbers of neutrons. They are nuclides of the same element.

Example:

	Protons	Neutrons	mass number
carbon-12	6	6	12
carbon-13	6	7	13
carbon-14	6	8	14

Isotopes of an element have the **same chemical** properties because they have the same number of electrons.

When elements react, it is the **electrons** that are involved in the reactions.

This means that the isotopes of an element cannot be differentiated by chemical reactions.

Because isotopes of an element have different numbers of neutrons, they have different **masses,** and isotopes have slightly different **physical** properties.

Isotopes and their abundance are estimated using an apparatus called mass spectrometer (See figure 2.1)

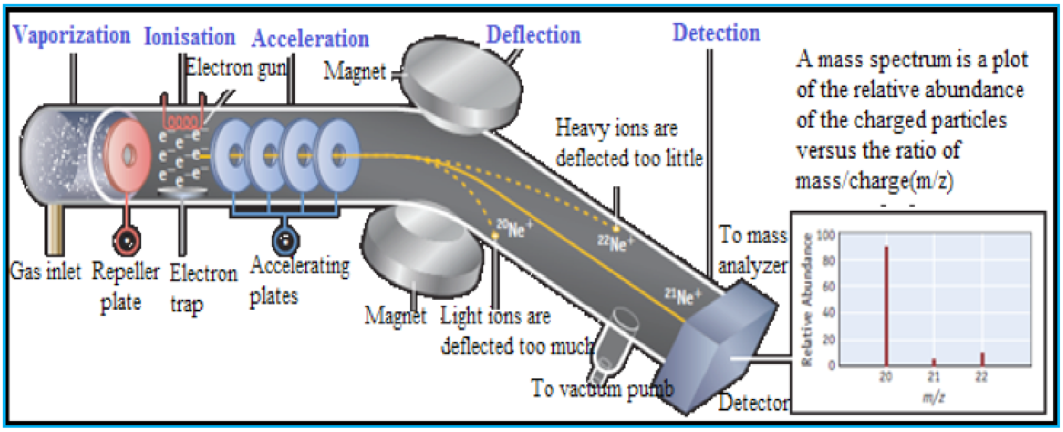


Figure 2.1: Diagram of Mass spectrometer

d. Relative isotopic and atomic masses

The mass of a single isotope is its **isotopic mass**. The **relative isotopic mass** of an isotope is the relative mass of that isotope compared with the isotope which is given a mass of 12.00 units (12.00 atomic mass units). That is, relative isotopic mass relates to the relative atomic mass scale on which one isotope of the carbon element, **carbon-12** is taken as the reference standard for atomic masses and is given a relative mass of 12 units, precisely 12 **atomic mass units (a.m.u)**.

$$\text{Relative isotopic mass} = \frac{\text{mass of 1 isotope of the element}}{\frac{1}{12}\text{ x mass of 1 atom of } {}^{12}_{6}C}$$

Atomic mass unit (a.m.u) is a unit of mass used to express "relative atomic masses". It is 1/12 of the mass of the isotope of carbon-12 and is equal to 1.66054×10^{-27}kg.

The relative isotopic masses of all others atoms are obtained by comparison with the mass of a carbon-12 atom.

On that scale, the relative atomic mass of a proton and that of a neutron are both very close to one unit (1.0074 and 1.0089 units respectively). Since the relative mass of an electron is negligible (0.0005units), it follows that all isotopic masses will be close to whole numbers.

However relative atomic masses of elements are not close to whole numbers because natural occurring elements are often mixtures of isotopes.

The **relative atomic mass (RAM)** of an element, $\mathbf{A_r}$, is the average of the relative isotopic masses of the different isotopes weighted in the proportions in which they occur.

Example: Natural occurring lead contains 1.55% lead-204, 23.6% lead-206, 22.6% lead-205 and 52.3% lead -208. Calculate the relative atomic mass of lead.

The relative atomic mass of lead

$$(A_r) = 204 \times \frac{1.55}{100} + 206 \times \frac{23.6}{100} + 207 \times \frac{22.6}{100} + 208 \times \frac{52.3}{100} = 207.2$$

Application activity 2.2

1. How do you call the members of each of the following pairs? Explain.

   (a) $^{35}_{17}Cl$ and $^{37}_{17}Cl$

   (b) $^{63}_{29}Cu$ and $^{65}_{29}Cu$

2. Write, using the periodic table, the correct symbols to identify an atom that contains

   a) 4 protons, 4 electrons, and 5 neutrons;

   b) 23 protons, 23 electrons, and 28 neutrons;

   c) 54 protons, 54 electrons, and 70 neutrons; and

   d) 31 protons, 31 electrons, and 38 neutrons.

3. Use the list of the words given below to fill in the blank spaces. Each word will be used once.

   Atomic number, Mass number, protons, Electrons, Isotopes, neutron

   a) The atomic number tells you how many ____________ and ______________are in an atom. ___________ is the number written as subscript on the left of the atomic symbol.

   b) The total number of protons and neutrons in an atom is called the ________________

   c) Atoms with the same number of protons but different number of neutrons are called _____________. The subatomic particle that has no charge is called a _________________.

The table below shows the mass number and the percentage abundances of the isotopes of an element X

Mass number	54	56	57	58
Percentage abundance	5.84	91.68	2.17	0.31

a) Calculate the relative atomic mass of X

b) Identify the element X.

2.3. RULES GOVERNING THE ELECTRONIC CONFIGURATIONS

Activity 2.3

1. In senior 1, you dealt with the electronic configuration of elements. Explain the concept of electronic configuration.
2. What rule(s) have you used to predict electrons configurations for the first twenty elements?
3. Bohr found that electrons are located in energy levels or shells called K, L, M, N, O, P, O numbered 1,2,3,4,5,6,7. What do these numbers represent?

The **Electron Configuration** is the way electrons are arranged around the nucleus. Electrons occupy shells starting with the one closer to the nucleus, i.e by increasing energy level. Energy levels are numbered 1, 2, 3, 4, 5, 6, 7 starting with K. Each of these numbers is called energy quantum number or **principal quantum numbers**.

a. Quantum numbers

Energy levels or shells are subdivided into sub-shells known a**s s, p, d, f**. Each sub-level is split into orbitals. Orbitals of a given sub-shell have the same name. Each electron is associated with a set of four quantum numbers **s**

The **principal quantum number, n**, can have positive integral values 1, 2, 3, 4,.... It governs the **energy of the electron** and also its probable distance from the nucleus. The most stable electronic state of an atom is called its **ground state**. Any higher energy state is called **excited state**.

The **angular momentum quantum number** or **(azimuthal quantum number), l,** can have an integral values from zero to (n-1) for each value of n. It determines the **shape** of the volume of space that an electron can occupy. It also indicates the number of sub-levels for each level.

The values of l is generally designated by the letters:

l = 0	1	2	3	4
S	p	d	f	g

If an electron has a principal quantum number n=2 and an angular momentum quantum number l=0 it is said to be a 2s electron.

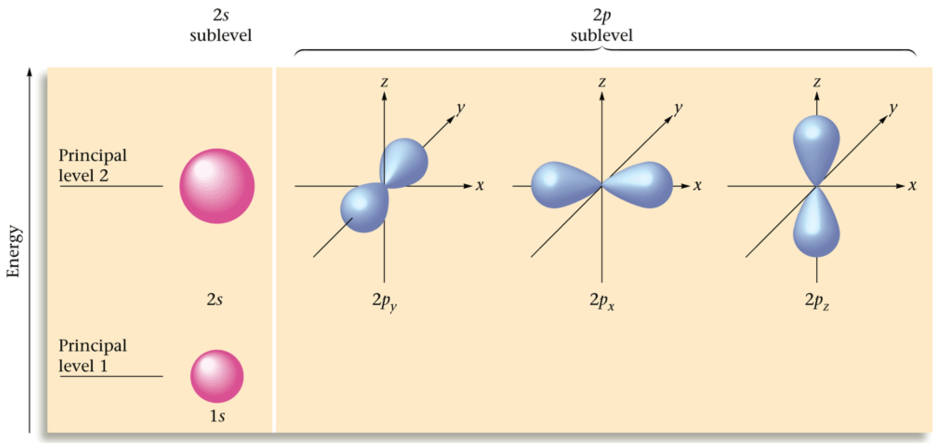
- The **magnetic quantum number, m_l**, has values ranging from –l to +l. Within a sub- shell, the value of m_l depends on the value of the angular momentum quantum number, l. For a certain value of l, there are (2l + 1) integral values of m_l as follows: -l, (-l +1), . . . 0, . . . (+l-1), +l. It determines the spatial orientation of an orbital.
- The (**Electron) Spin Quantum Number, m_s**, may have values of - ½ or + ½ only. The value of m_s does not depend on the value of any other quantum number. It represents the spin of an electron that occupies a given orbital. Electrons will spin opposite each other in the same orbital

Table 2.1: **Relationship among values of n, l, m_l through n=4**

No.	**Possible values of l**	**Subshell designation**	**Possible values of m_l**	**Orbital desig-nation**	**Number of orbitals in subshell**	**Total of orbitals in shell**
1	0	1s	0	1s	1	1
2	0 1	2s 2p	0 -1, 0, +1	2s 2p	1 3	4
3	0 1 2	3s 3p 3d	0 -1, 0, +1 -2, -1, 0, +1, +2	3s 3p 3d	1 3 5	9
4	0 1 2 3	4s 4p 4d 4f	0 -1, 0, +1 -2, -1, 0, +1, +2 -3, -2, -1, 0, +1, +2, +3	4s 4p 4d 4f	1 3 5 7	16

Shape of orbitals

The s, and p orbitals are pictured below while d and f orbitals have complex shapes.



b. Rules governing the electron configuration of element

- Atoms of the various elements differ from each other in their values of Z and electrons.
- Electrons in atoms are arranged in orbitals and shells.
- Orbitals are characterized by the quantum numbers n, l and m_l.
- Orbitals having the same value of n are said to be in the same shell. Orbitals having the same values of n and l are said to be in the same subshell.
- Electrons are distributed in orbitals following the rules below.

b. 1 Pauli Exclusion Principle

No two electrons in the same atom can have the same set of the four quantum numbers. If two electrons have the same values of n, l, m_l, they must have different values of m_s. Then, since only two values of m_s are allowed, *an orbital can hold only two electrons, and they must have opposite spins*.

b. 2 Hunds' rule

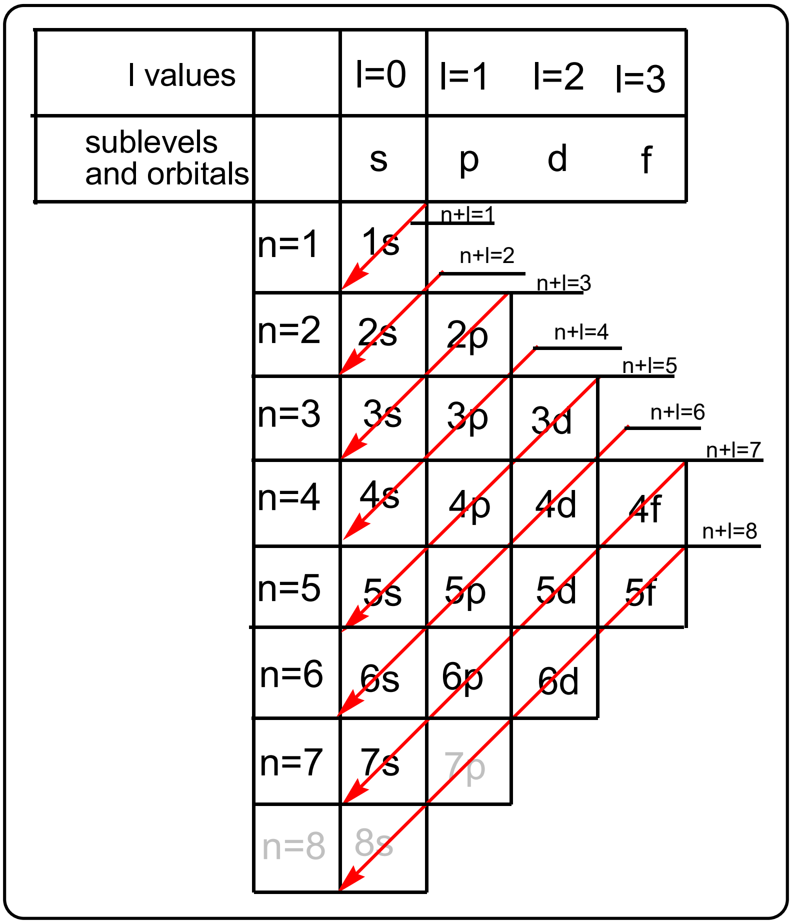
Electrons occupy all the orbitals of a given sublevel singly before pairing begins.

Spins of electrons in different incomplete orbitals are parallel in the ground state. The most stable arrangement of electrons in the subshells is the one with the greatest number of parallel spins.

b. 3 Aufbau principle or build up principle or construction principle

The Aufbau principle or build up principle or construction principle state that "Electrons fill lower energy orbitals (closer to the nucleus) before they fill higher energy ones".

Electron filling order



Application activity 2.3

1. What values of m_l are permitted for an electron with (a) l = 2 (b) l = 4?
2. How many different values of m_l are permitted for electron with (a) l = 2 (b) =4?
3. Discuss the rules used to establish electronic configurations

2.4. ELECTRONIC CONFIGURATIONS OF ELEMENTS USING S, P, D, F ORBITALS

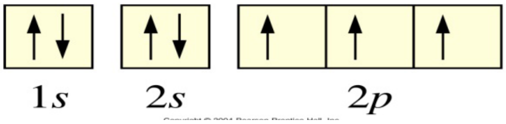
Activity 2.4

1. Using your knowledge in chemistry acquired so far, explain the concept of electronic configuration.
2. Use rules pointed out before and that may be followed to predict the distribution of electrons in sub-shells within a shell and write down electrons configurations of hydrogen (Z = 1), lithium (Z = 3), fluorine (Z = 9), magnesium (Z= 12), phosphorus (Z = 15), calcium (Z = 20), vanadium (Z = 23)?

The **Electron Configuration** is the way electrons are arranged around the nucleus. That is, the electron configuration describes the distribution of electrons among the various orbitals in the atom. The filling of orbitals follows the above rules.

The **s p d f** notation uses numbers to designate a **principal shell** and the letters to identify a subshell; a superscript number indicates the **number of electrons** in a designated subshell

An orbital diagram uses boxes to represent orbitals within subshells and arrows to represent electrons:



Each box has arrows representing electron spins; opposing spins are paired together.

Condensed electron configurations

The electron configurations of all elements except hydrogen and helium are represented by a ***noble gas core,*** which *shows in brackets the noble gas element that most nearly precedes the element being considered,* followed by the symbol for the highest filled subshells in the outermost shells.

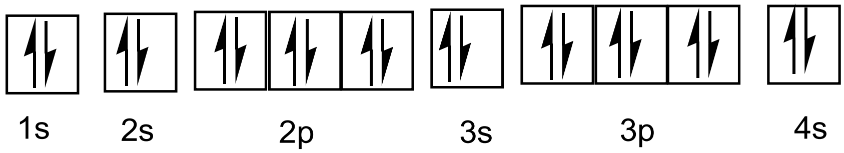
[*Noble Gas Core*] + higher energy electrons

Example: predict the electronic configuration of an element with atomic number, Z =20

Answer:

a. Full electronic configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

b. Using the orbital diagram, we get the following representation.



c. Condensed electron configurations [Ar]4s2

Others examples of full and condensed electronic configurations include the following.

- Aluminum: $1s^2 2s^2 2p^6 3s^2 3p^1$

  $[Ne]3s^2 3p^1$
- Nickel: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$

  $[Ar]4s^2 3d^8$ {or $[Ar]3d^8 4s^2$}
- Iodine: $[Kr]5s^2 4d^{10} 5p^5$ {or $[Kr]4d^{10} 5s^2 5p^5$}
- Astatine (At): $[Xe]6s^2 4f^{14} 5d^{10} 6p^5$

  {or $[Xe]4f^{14} 5d^{10} 6s^2 6p^5$}

Electron configuration of ions

When an atom gains or loses electrons to form an ion, the electron configuration change.

Examples:

Na atom	Na^+ ion
$1s^2 2s^2 2p^6 3s^1$	$1s^2 2s^2 2p^6$
O atom	O^{2-} ion
$1s^2 2s^2 2p^4$	$1s^2 2s^2 2p^6$

Notice that the Na^+ ion and the O^{2-} ion have the same electron configuration. Ions that have the same electron configuration are **isoelectronic**.

With the transition metals, it is the **ns** electrons that are first lost when they form ions.

Examples:

Ti atom	Ti^{2+} ion
$1s^22s^22p^63s^23p^63d^24s^2$	$1s^22s^22p^63s^23p^63d^2$
Cr atom	Cr^{3+} ion
$1s^22s^22p^63s^23p^63d^54s^1$	$1s^22s^22p^63s^23p^63d^3$

Application activity 2.4

1. Using, s, p , d, f notation, write the electronic configuration for elements of atomic numbers: 16, 23,37, 47,56. At which block belongs each of them?
2. Using boxes to represent orbitals, give the full electronic structure of the following atoms:

   a) Lithium b) fluorine c) potassium
3. Give the electronic configuration of the following ions.

   a) Mg^{2+} K^+ Al^{3+}

   a) Cl^- Br^- P^{3-}
4. Write the full electron configuration of the Fe^{2+} and Fe^{3+} ions. Which of these ions has the greater stability? Explain why.

Skill lab

Using adequate materials, construct any three models of atoms of your choice. These models show shells and all electrons. These atoms should be Cl, C, H, O, N, B, F.

End unit assessment

1. Given the following data concerning isotopes of nickel:

Isotope	Isotopic mass/amu	% abundance
^{58}Ni	57.9353	X
^{60}Ni	59.9332	26.23
^{61}Ni	60.9310	1.19
^{62}Ni	61.9283	3.66
^{64}Ni	63.9380	1.08

   How many protons, neutrons, and electrons are there in a nickel-58 atom?

   a) Calculate the value of X.

   b) Calculate the relative atomic mass of nickel

2. The ground-state electron configurations listed here are incorrect. Explain what mistakes have been made in each and write the correct electron configurations.

   Al: $1s^2 2s^2 2p^4 3s^2 3p^3$

   B: $1s^2 2s^2 2p^5$

   F: $1s^2 2s^2 2p^6$

3. Concerning the concept of energy levels and orbitals,

   a) How many subshells are found in $n = 3$?

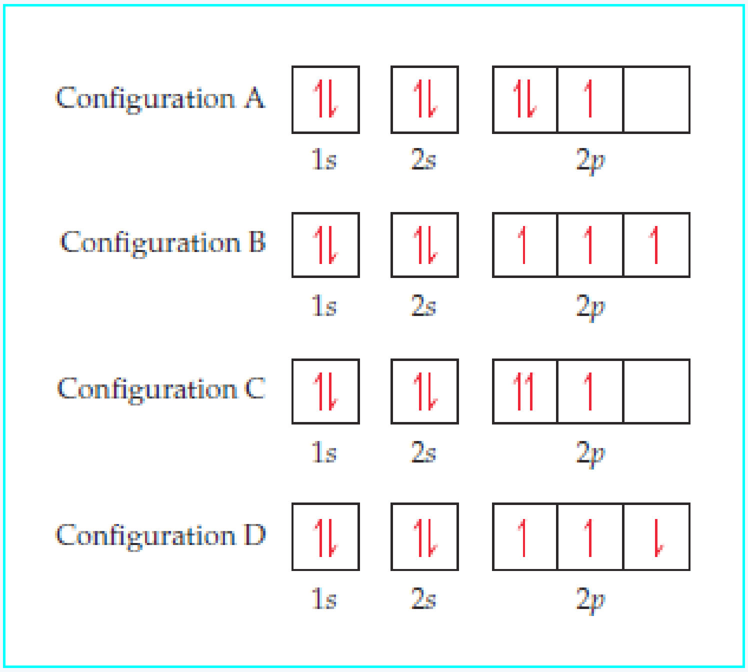
   b) What are the names of the orbitals in $n = 3$?

   c) How many orbitals have the values $n = 4$ and $l = 3$?

   d) How many orbitals have the values $n = 3$, $l = 2$ and $m_l = -2$?

   e) What is the total number of orbitals in the level $n = 4$?

4. Four possible electron configurations for a nitrogen atom are shown below, but only one represents the correct configuration for a nitrogen atom in its ground state. Which one is the correct electron configuration? Which configurations violate the Pauli Exclusion Principle? Which configurations violate Hund's rule?

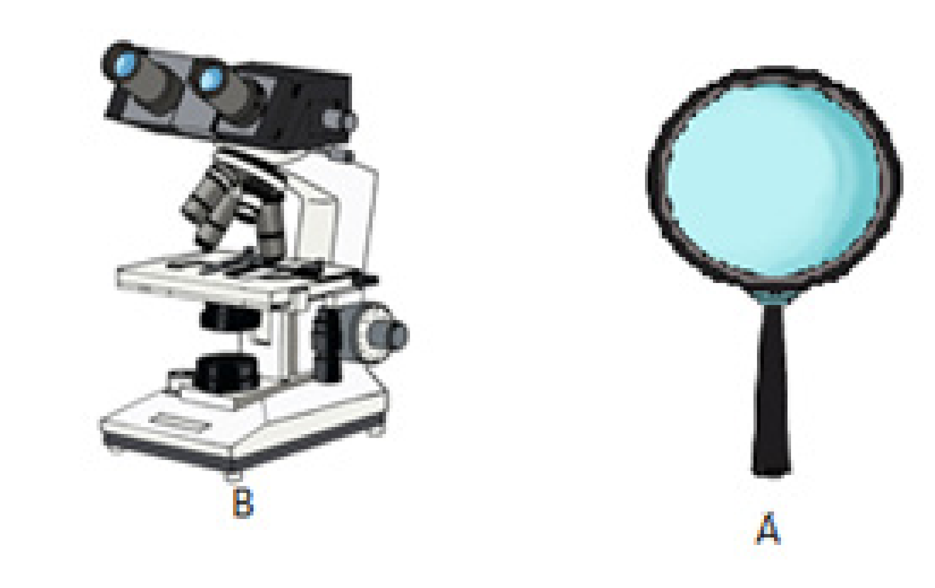

Configuration A
1s
2s
2p
Configuration B
1s
2s
2p
Configuration C
1s
2s
2p
Configuration D
1s
2s
2p

UNIT 3: CELL STRUCTURE

Key unit competence: **Distinguish between the structure of animal and plant cells**

Introductory Activity

a) Pictures of magnifying tools: microscope, magnifying lens, prism binocular ect



b) 2 Pictures, one on which students, another a doctor are using a microscope.

1. Name the illustrations in a) above
2. What about use of illustrated materials in a)? Where are they used?
3. Predict what you are going to learn in this unit

3.1. COMPOUND LIGHT MICROSCOPE

Activity 3.1

Observe the illustration **B** and respond related questions.

B

1. What are the basic, structural components of a compound microscope?
2. Using library textbook or internet identify main parts of light microscope

The three basic, structural parts of a compound microscope are:

- head/body houses the optical parts in the upper part of the microscope,
- base of the microscope supports the microscope and houses the illuminator;
- arm connects to the base and supports the microscope head

The different parts of light microscope are described below:

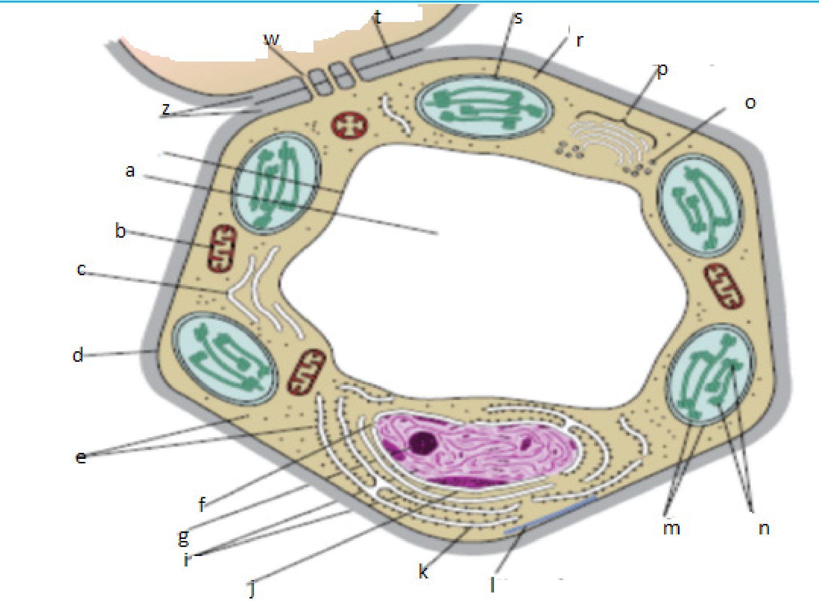
- **Base**: supports and stabilizes the microscope on the table or any other working place
- **Light source**: It is made by lamp or mirror which provides light for viewing the slide.
- **Stage**: is a platform used to hold the specimen in position during observation.
- **Stage clips**: are pliers used to fix and hold tightly the slide on stage.
- **Arm**: supports the body tube of microscope
- **Body tube**: maintains the proper distance between the objective and ocular lenses

- **Arm**: used for holding when carrying the microscope and it holds the body tube which bears the lenses.
- **Coarse focus adjustment** moves stage up and down a large amount for coarse focus
- **Fine focus adjustment** moves stage up and down a tiny amount for fine focus
- **Objective lenses**: focuses and magnifies light coming through the slide

3.2. ULTRA-STRUCTURE OF CELL

Activity 3.2

Observe the ultra-structure of a plant cell below



1. Using library textbooks or internet and identify parts of illustration above and those of the animal cell.
2. Identify parts that are easily recognizable when compared with a photomicrograph form of a light microscope.

Under electron microscope, it is possible to identify a range of organelles in plant and animal cells. **Ultrastructure** is the detailed of cell as revealed by the electron microscope.

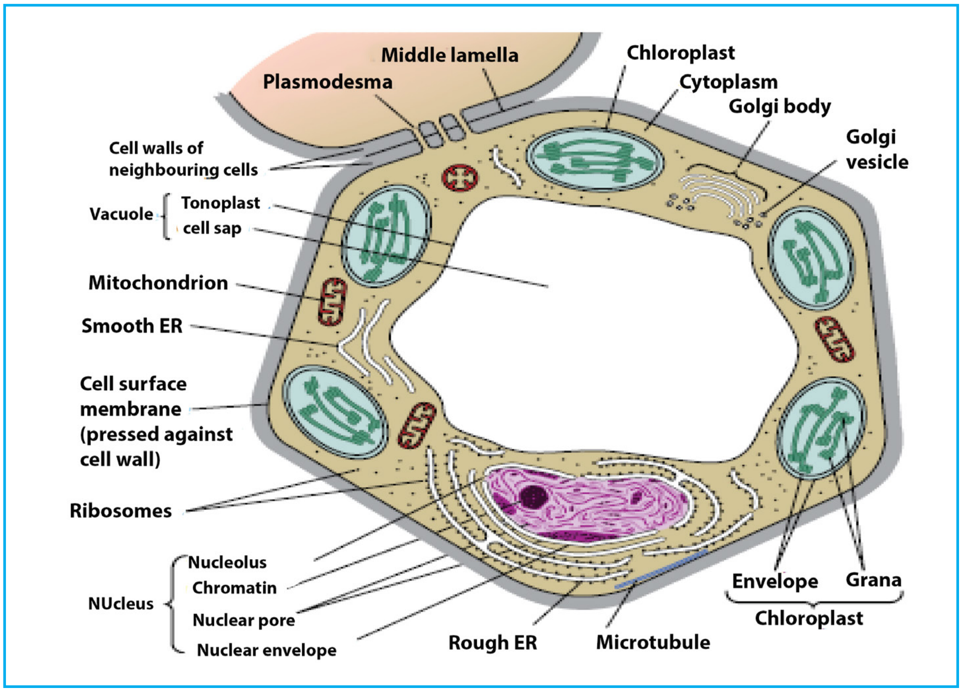


Fig. 3-1: Ultrastructure of a typical plant cell (Adapted from Cambridge International AS and A Level Biology Course Book Fourth Edition)

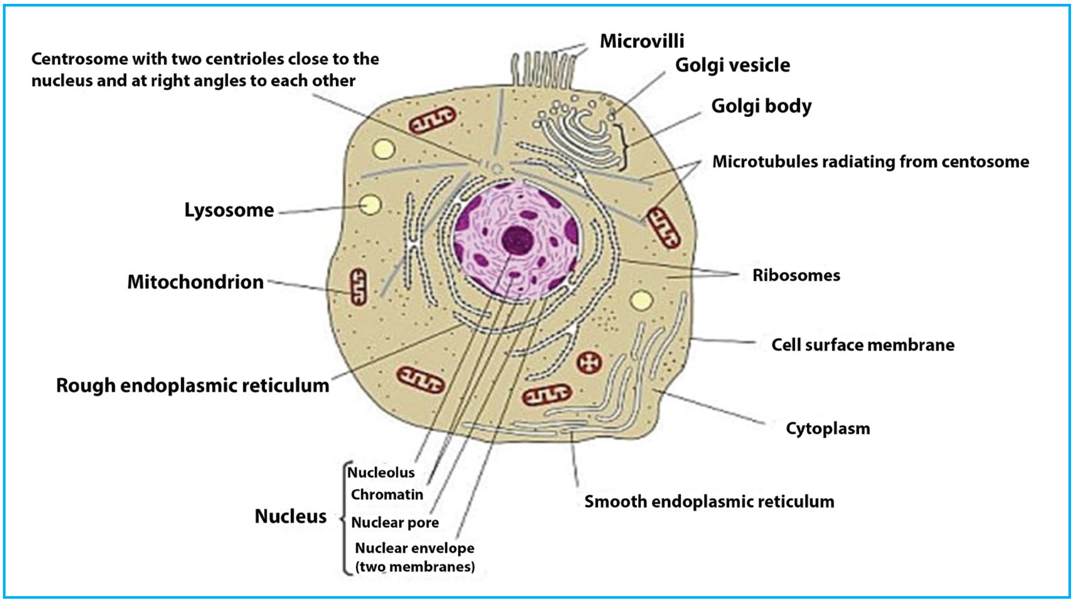


Fig.3.2 A generalized animal and cells showing structures visible under electron microscope (Adapted from Cambridge International AS and A Level Biology Course Book Fourth Edition)

3.2.1. Ultrastructure of cell membrane

a. The cell membranes ultrastructure is not easily visible under a light microscope but is studied by electron microscopes, freeze structuring and other modern techniques which reveal complex structures.

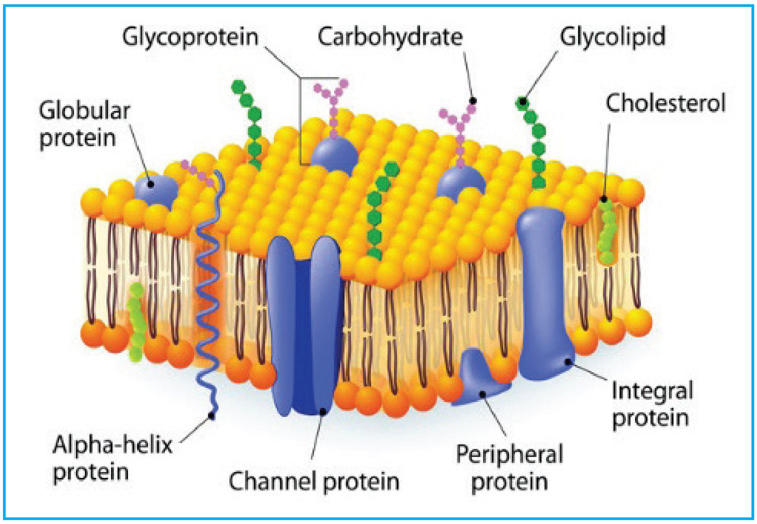


Fig.3.3. *Fluid mosaic model of the cell surface membrane*

b. Roles of different components of cell membrane

Cholesterol

- Gives the membranes of some eukaryotic cells the mechanical stability.
- It fits between fatty acid tails and helps make the barrier more complete, so substances like water molecules and ions cannot pass easily and directly through the membrane.

Channel proteins

- Allow the movement of some substances across the membrane.
- Large molecules like glucose enter and leave the cell using these protein channels.

Carrier proteins

- Actively move some substances across the cell membrane. For example, magnesium and other mineral ions are actively pumped into the root's hair cells from the surrounding soil.
- Nitrate ions are actively transported into xylem vessels of plants.

Receptor sites

- Allow hormones to bind with the cell so that a cell response can be carried out.
- Glycoproteins and glycolipids may be involved in cells signalling and they allow the immune system to recognize foreign objects to the cells.
- Some hormone receptors are glycoprotein, and some are glycolipid.

3.2.2. Cytoplasmic constituents and their functions

plant and animal cells contain a variety of cell organelles including nucleus, mitochondria, Golgi apparatus, endoplasmic reticulum, ribosomes, centrioles, vacuoles, chloroplasts, lysosomes and cytoskeleton.

a. Endoplasmic reticulum (ER)

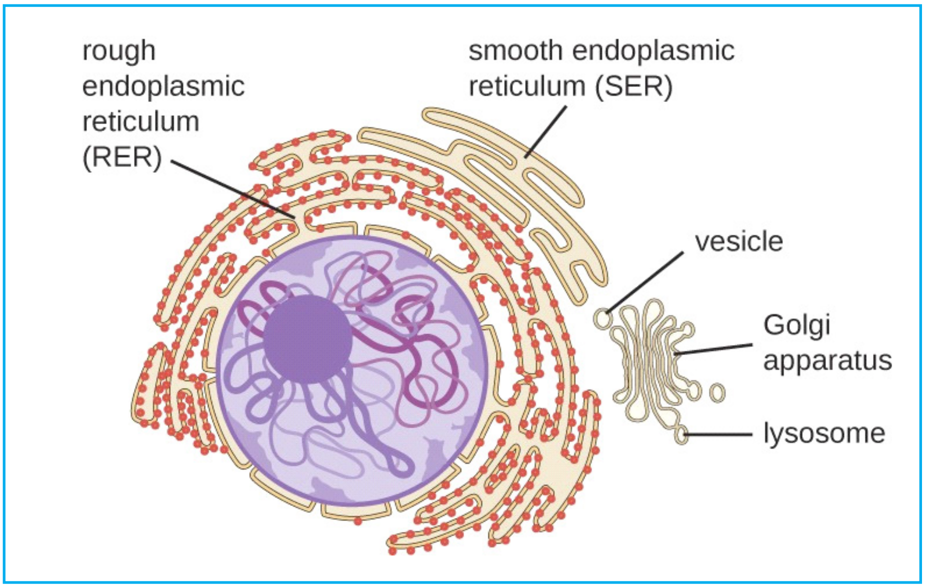


Fig. 3.5. Endoplasmic reticulum

The ER consists of a series of flattened membrane-bound sacs called **cisternae.** The rough ER is surrounded with ribosomes. The rough ER transports proteins made on attached ribosomes. The smooth ER is made of tubular cavities lacks ribosomes, and it involves in synthesis of lipids that the cell needs.

NB: Glandular cells are seen to have several RER for synthesis of hormones and enzymes. Examples include liver cells, plasma cells, and pancreatic cells.

b. Golgi apparatus

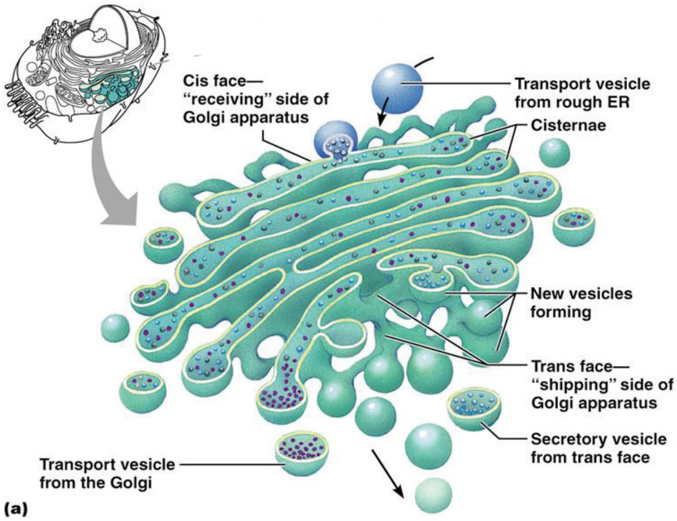


Fig. 3.6. Golgi apparatus

The Golgi apparatus is a stack of membrane-bound, flattened sacs, which receives proteins from the ER and modify them. It may add sugar molecules to them. The Golgi apparatus then packages the modified substances into vesicles that can be transported to their final destinations throughout the cell or outside of the cell.

c. Lysosome

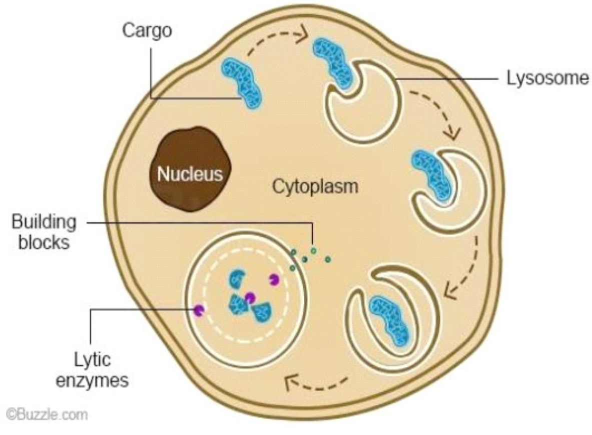


Fig. 3.7 Lysosome

These are spherical sacs surrounded by a single membrane. They contain powerful **digestive enzymes.** Their role is to break down materials such as white blood cells, and destroy invalid microorganisms. In acrosome, lysosomes help the sperm to penetrate the egg by breaking down the material surrounding the egg.

d. Ribosomes

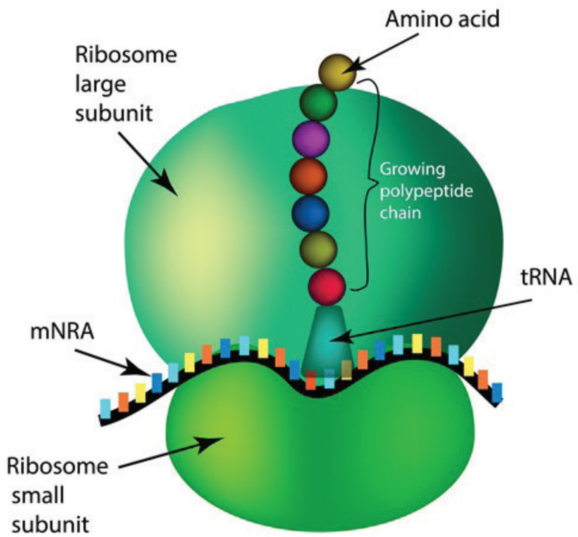


Fig. 3.8: Structure of a Ribosome © Timonina /shutterstock.com

Ribosomes are the site of protein synthesis in the cell. Some are in cytoplasm; others are bound to ER. **Ribosomes** consist of two major components (two subunits): the small **ribosomal subunit**, which reads the RNA, and the large **subunit**, which joins amino acids to form a polypeptide chain.

e. Centrioles

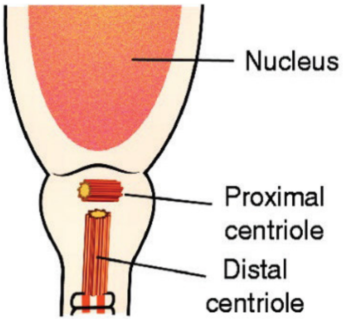


***Fig.3.9**: Centrioles. (Adapted from: Heide Schatten and Qing-Yuan Sun1)*

Centrioles are small tubes of protein fibres (microtubules), which are involved in animal cell division. They form fibres, known as **spindle,** which move chromosomes during nuclear division.

f. Vacuole

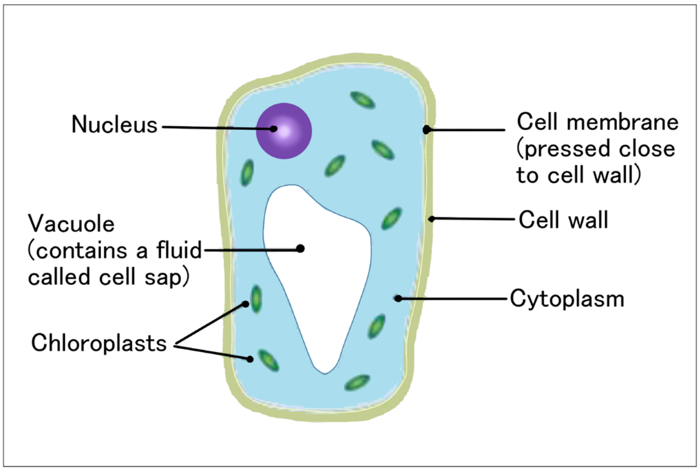


Fig.3.10: *Vacuole*

A vacuole is a saclike structure that is used to store materials such as water, salts, proteins, and carbohydrates. In many plant cells there is a single, and large central vacuole filled with liquid. The pressure of central vacuole in this cells makes it possible for plants to support heavy structures such as leaves and flowers. Some animals and some unicellular organisms contain **contractile vacuoles** which contract rhythmically to pump excess water out of the cell.

g. Cytoskeleton

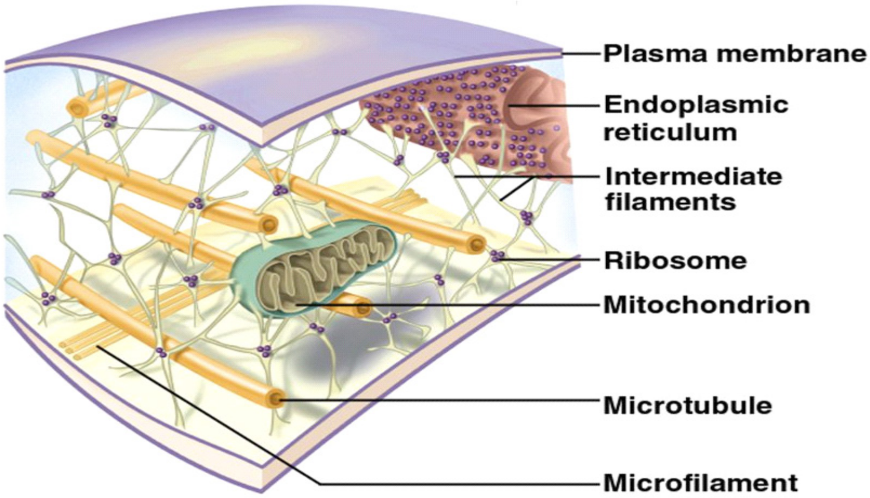


Fig.3.11: *cytoskeleton*

Cytoskeleton is a network of protein filaments that helps the cell to maintain its shape. It is also involved in in movement.

3.2.3. Nuclear constituents and their roles

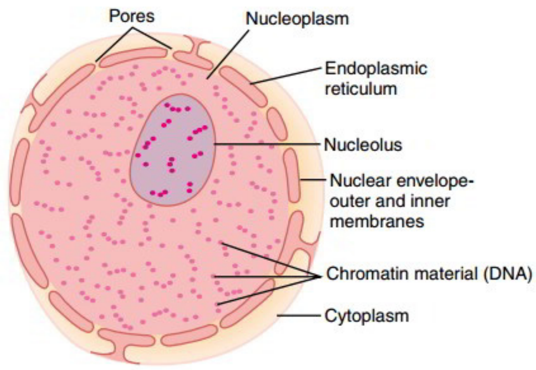


Fig.3.12: Ultra-structure of a nucleus (https://www.earthslab.com/physiology/nucleus/)

The cell nucleus contains nearly all the cell's DNA with the coded instructions for making proteins and other important molecules. The nucleus is surrounded by a double nuclear envelope, which allow materials to move into and out of the nucleus through nuclear pores. The granules found in the nucleus are called **chromatin** which consist of **DNA** bound to protein. When a cell divides, the chromatin condenses into **chromosomes** containing the genetic information. The nucleus contains a dense spherical structure called **nucleolus** in which assembly of ribosomes occurs.

3.2.4. Structure of chloroplast and mitochondria

a. The structure of the chloroplast

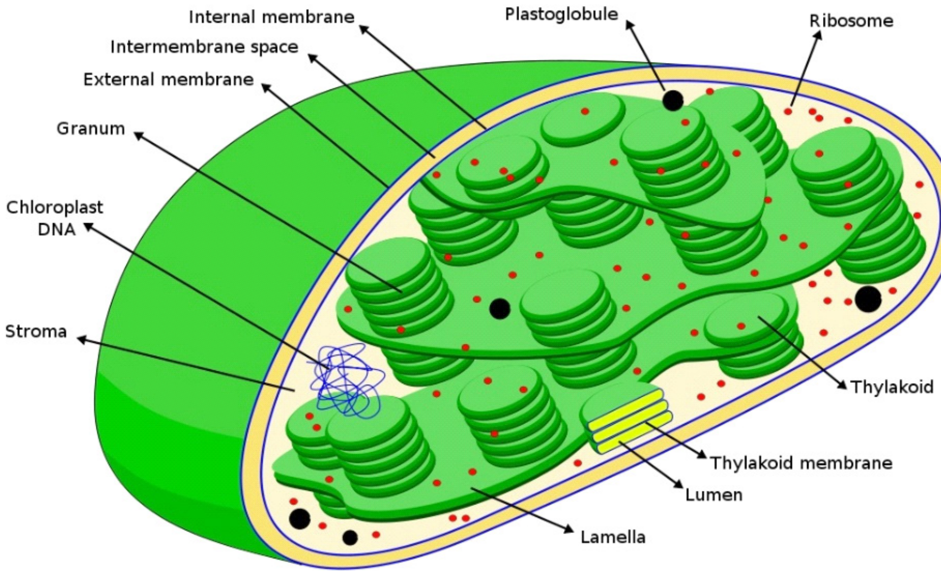


Fig. 3.13: Chloroplast

Chloroplasts are the site of **photosynthesis** in plant cells. These are found in plant cells and in cells of some protoctists. They also have two membranes separated by a fluid-filled space. The inner membrane is continuous, with **thylakoids.** A stalk of thylakoids is called a **granum (plural: grana)**. A chloroplast contains many sets of disc like sacs called thylakoids, which are arranged in stacks known as grana. Each granum looks like a stack of coins where each coin being a thylakoid. The thylakoid contains chlorophyll molecules which capture the light energy that is needed for in the process of light-dependent reactions of photosynthesis. A typical chloroplast contains approximatively 60 grana, each consisting of about 50 thylakoids. The space outside the thylakoid membranes are made by watery matrix called **stroma**. The stroma contains enzymes responsible for light-independent reactions of photosynthesis.

b. The structure of the mitochondrion

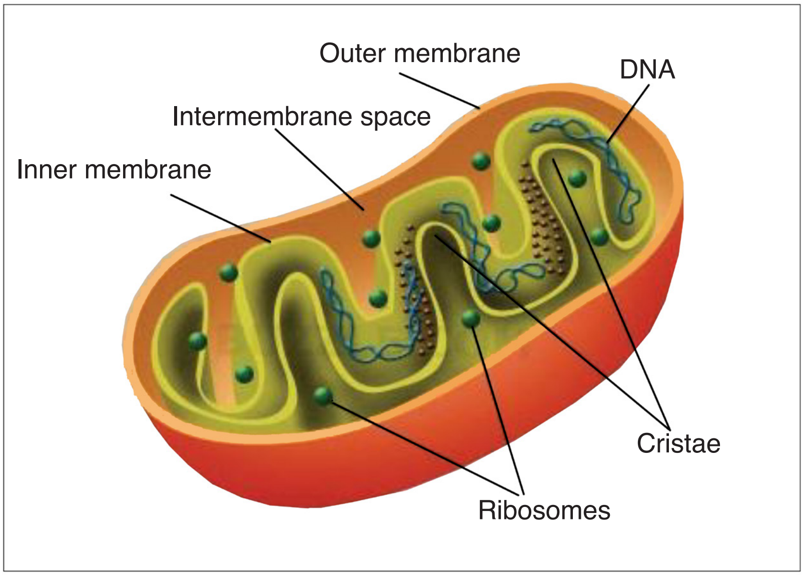


Fig. 3.14: structure of the chloroplast

Mitochondrion have two membranes separated by a fluid-filled intermembrane space. The inner membrane is highly folded to form **cristae** that plays a big role in aerobic respiration. The central part of the mitochondrion is called **matrix**. The mitochondria are the site where **Adenosine triphosphate (ATP= cellular energy)** is produced during aerobic respiration.

3.3. COMPARISON OF THE STRUCTURE OF AN ANIMAL AND A PLANT CELL

Activity 3.3 *Observation of permanent slides*

1. Two prepared slides, one with onion tissue another with tissue from a cheek. Observe them under the light microscope.
2. Draw the two structures you see through the microscope and compare them according to their components.

Ultrastructure is the detail of the inside of cell as revealed by the electron microscope.

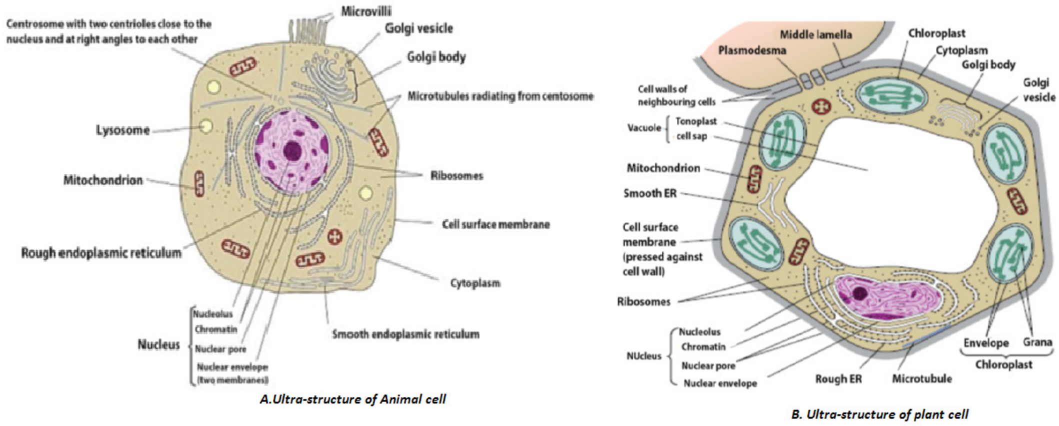


Fig.3.15: Animal and plant cell structures

3.3.1. Similarities between animal cell and plant cell

- Both animal and plant cells have a cell membrane, a cytoplasm and a nucleus.
- Both animal and plant cells have a true nucleus bounded by an envelope.
- Both animal and plant cells have mitochondria, Golgi apparatus, Reticulum endoplasmic, lysosome, big ribosomes (80S), peroxisome, microtubules.
- The protoplasm is enveloped by a bounding cell membrane called plasmalemma.
- The protoplasm is composed of a dense round structure called nucleus which is surrounded by a less dense jelly-like cytoplasm.

- Vacuoles contain secretions, food- particles, or decomposing organic substances.
- Chemically, both plant and animal cells are made up of water (80-90%), proteins (7-13%), lipids (1-2%), carbohydrates (1-1.5%) and inorganic salts.
- The cytoplasmic organelles are suspended in a semi-fluid jelly matrix called cytosol.

3.3.2. Difference between animal and plant cells

Criterion	Animal Cell	Plant Cell
Shape	irregular	Regular
Chloroplasts/ chlorophyll	Absent	Present
Centrioles	Present	Absent
Vacuole	Small or absent	Big with a tonoplast
Cell wall	Absent	Present
Microvilli	Present	Absent
Plasmodesmata	Absent	Present

Skill lab **Experiment**

Prepare a water wet mount of onion skin. Do this by using your fingernail to peel off the inside of a layer of onion bulb. The layer must be almost transparent.

Make sure that the onion layer is lying flat on the glass slide and is not folded.

Observe the onion cells under low-and high-power magnification. Identify as many organelles as possible.

Repeat step 1 through 3 only this time use an iodine stain instead of water.

1. What organelles were easily seen in the unstained onion cells? In cells stained with iodine?
2. How are stains useful for viewing cell?

End unit assessment

A. Multiple choice questions

1. Which organelle converts the chemical energy in food into a form that cells can use?

   a) Chromosome

   b) Chloroplast

   c) Nucleus

   d) Mitochondrion

2. The cell membranes are constructed mainly of:

   a) Carbohydrate gates

   b) Protein pumps

   c) Lipid bilayer

   d) Free-moving proteins

3. In many cells, the structure that controls the cell's activities is the:

   a) Nucleus

   b) Nucleolus

   c) Cell membrane

   d) Organelle

4. Despite differences in size and shape, all cells have cytoplasm and a

   a) Cell wall

   b) Cell membrane

   c) Mitochondria

   d) Nucleus

5. If a cell of an organism contains a nucleus, the organism is a (an)

   a) Plant

   b) Eukaryote

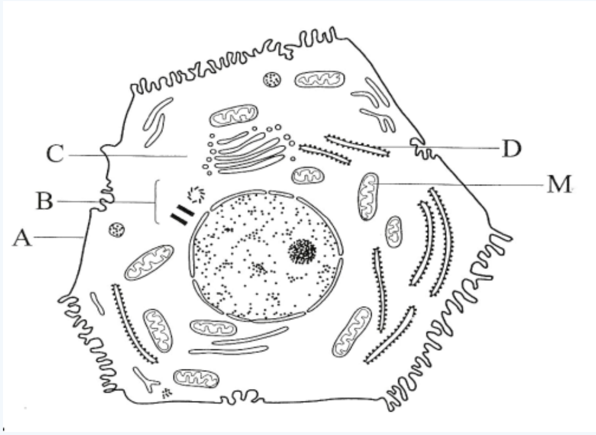
   c) Animal

   d) Prokaryote

6. Match each part of the cell (left column) to corresponding statement (right column):

Nucleus	controls movement of substances in and out of the cell
Mitochondrion	where photosynthesis takes place
Chloroplast	where aerobic respiration takes place
Smooth ER	controls the activity of the cell
Ribosomes	where lipids including steroids are made

7. How does a cell membrane differ from a cell wall?
8. Name the structures that animal and plant cells have in common, those found in only plant cells, and those found only in animal cells.
9. List:
   a) Three organelles each lacking a boundary membrane
   b) Three organelles each bounded by a single membrane
   c) Three organelles each bounded by two membranes (an envelope
10. The diagram below shows the structure of a liver cell as seen using an electron microscope.

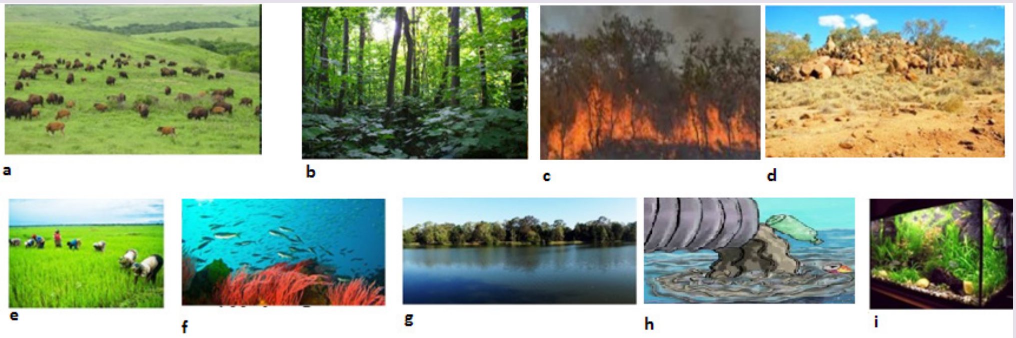


   a) Name the parts labelled A, B, C and D.
   b) The magnification of the diagram above is 12 000. Calculate the actual length of the mitochondrion labelled M, giving your answer in μm. Show your working.
   c) Explain the advantage to have a division of labor between different cells in the body.

UNIT 4: INTRODUCTION TO BIODIVERSITY

Key unit competence: **Explain how biodiversity on the earth is threatened by climatic change and human activities**

Introductory Activity



1. Observe illustrations above from **a** to **i**

   a) What are the threat to biodiversity?

   b) What are the threat to natural resources?

2. **a-**illustrations represent entire mirror of Rwanda's ecosystem. Justify the statement.

3. Predict what you are going to learn in this unit?

4.1. ECOLOGICAL TERMS

Activity 4.1

Use library text books or research engine to find the meaning of main ecological terms such as "Species, Ecosystem, Niche, population, community and biodiversity".

Species is a group of closely related organisms which are capable of interbreeding to produce fertile offspring. Occasionally two organisms which are genetically closely related but not of the same species can interbreed to produce infertile offspring. For example, a cross between a **donkey** and a **horse**, produces a **mule**, which is infertile. Hence, a donkey and a horse do not belong in the same species. Another example includes lions and tigers belonging in different species. However, when a male tiger mates with a female lion they can have fertile offspring called **tiglon**, although the offspring of female tigers and male lions called **ligers** are not fertile. Note that normally tigers are forest dwellers and lions are plains dwellers and they are ecologically isolated. Breeding has only been observed in captivity.

An ecological population is a group of individuals of the same species which live in a particular area at any given time.

An ecological community consists of populations of different species which live in the same place at the same time, and interact with each other.

A habitat is a specific area or place in which an individual organism lives. When a habitat is very small it is regarded as a **microhabitat.**

Within the habitat, **an ecological niche** is the status or the role of an organism in its habitat or the mode of life of an organism within its habitats. For example, insects are pollinating agents and preys of insectivores.

In an environment, communities are influenced either by **abiotic components**, also called **abiotic factors**. These are the non-living physical aspects of the environment such as the sunlight, soil, temperature, wind, water, and air. Communities are also influenced by **biotic components**, or **biotic factors**. These are the living organisms in the environment.

The **biosphere** is the whole of the earth's surface, the sea and the air that is inhabited by living organisms. The biosphere is made up of all ecosystems.

An ecosystem is a collection of all the organisms that live together in a particular place, together with their nonliving, or physical environment.

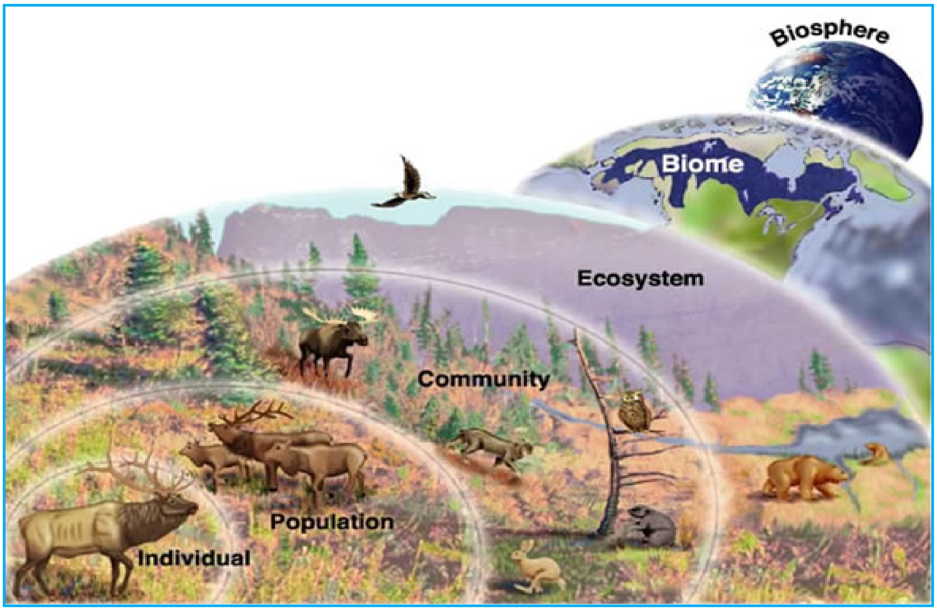


Fig.4.1: Ecological organizational levels

Biodiversity is defined as the full range of variety and variability within and among living organisms and the ecological complexes in which they occur. In other words, biodiversity is the variety of life. It refers to the totality of the species including the genetic variation represented in the species populations, across the full range of terrestrial organisms, including vertebrates and invertebrates, protista, bacteria and plants.

4.2. CATEGORIES OF BIODIVERSITY

Activity 4.2 *Distinguishing features of biodiversity types*

Observe the pictures above from a to c

a b c

1. According to illustrations, what is biodiversity and types?
2. Do they show different levels of biodiversity through **a** to **c** pictures? Justify

Biodiversity is can be categorized into three groups:

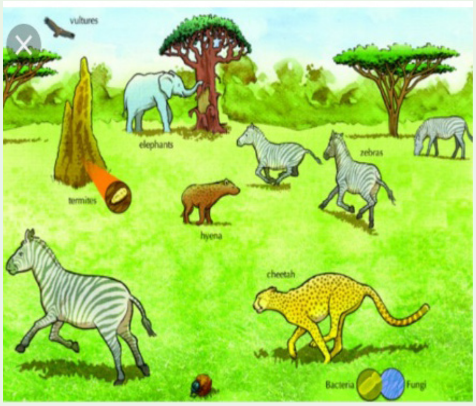
- **Genetic diversity (c):** The combination of different genes found within a population of a single species, and the patterns of variation found within different populations of the same species. These variations are caused by the gene mutations or chromosomal mutations which create differences in individuals of the same species.
- **Species diversity (b):** This is concerned with variation in number of species and their relative abundance in an area in which they inhabit. All species are different from each other. These could be structural differences, such as the difference between a mango tree and a cow. They could also be functional differences, such as the differences between bacteria that cause decay and those that help us to digest food. The variation in the relative abundance of species within a habitat may be caused by different factors, mainly environmental factors which can affect their rate of reproduction.
- **Ecosystem diversity (a) :** This is concerned with variations in ecosystems or habitats that occur within a region. Environmental factors like climate change may cause diversity of habitats or systems within a region.
- **Functional diversity**

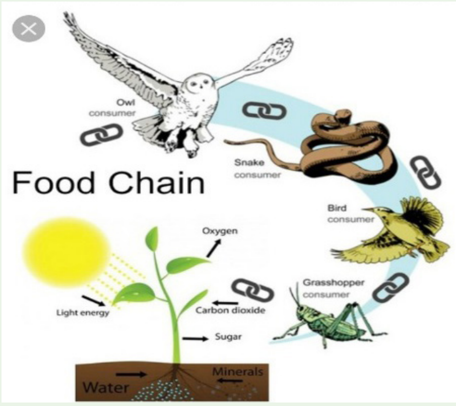
  Biodiversity / biological diversity means the variability among living organism from all sources and ecological complex of which they are part. In general a species rich ecosystem is presumed to have high functional diversity, because there are many species with many different behaviour.

4.3. IMPORTANCE OF BIODIVERSITY

Activity 4.3

Achieving sustainable food production in an ecosystem





1. Observe illustration and respond to the questions:
   a) What is a food chain in science?
   b) Does biodiversity affects food production?
   c) How can we protect biodiversity?
2. Why is it important to have an ecological balance in the ecosystem?

Looking anywhere around we can help us appreciate the beauty biodiversity gives our environment. Beyond beauty, why is biodiversity important? Biodiversity and its maintenance are very important for sustaining life on earth. The points below guide carrying out of importance of biodiversity:

1. Importance to the nature

Biodiversity maintains food chain in the nature, all living things in environment are interdependent. Animals could not exist without green plants. These plants could not exist without animals to pollinate them. These plant are dependent on decomposers. Whereas some living things can be niches for others living things. Thus, living things have many complex relationships among organisms.

They are adapted to live together in communities. If a species is lost from an ecosystem the lost may have consequences for others living things in the area**.** An organism suffers when a plant or animal it feed upon is removed permanently from a food web.

Genetic biodiversity, arboreal plants, such as trees, tend to have more genetic diversity, on the whole, than vascular plants, such as grasses. This holds true both within populations and within the different species.

Large populations are more likely to maintain genetic material and thus generally have higher genetic diversity. Hence, genetic diversity plays an important role in the survival and adaptability of a species.

Maintaining balance of the ecosystem, a population may soon exceed the area's carrying capacity if its predator is removed; if the symbiotic relationship among organisms are broken due to the loss of species, the remaining species will also be affected.

Biodiversity protects water resources, natural vegetation cover in water catchments help to maintain hydrological cycles, regulating and stabilising water runoff, and acting as a buffer against extreme events such as flood and drought.

Biodiversity increases ecosystem productivity where each species, no matter how small, all have an important role to play, a large number of plant species means a greater variety of crops. Greater species diversity ensures natural sustainability for all life forms.

Promote soils formation and protection, the well-being of all plants and land-based animals depends on the complex processes that take place in soil. Soil develop from parent material by various weathering processes. Organic matter accumulation, decomposition, and humification are as critically important to soil formation as weathering.

Provision of biological resources, biodiversity provides main ecosystem service such as nutrient cycling, carbon sequestration, pest regulation and pollination, sustain agriculture productivity. Promoting the healthy functioning of ecosystems ensures the resilience of agriculture as it intensifies to meet growing demands for food production.

2. Importance to people

By diverse species of plants and algae living in variety of ecosystem through photosynthesis process, regularly supply oxygen for breathing process to human being. Yet only a few species of plants and animals supply the major portion of food eaten by the human population.

Drugs companies manufacture synthetic drugs are first isolated from living things. Example, mold penicillium provides an antibiotic penicillium, cinchona tree release antimalarial drug etc Preserving biodiversity ensures there will be a supply of living things, some of which may provide future drugs.

Figure 4.1: Some of the common medicinal plants (A: Aloe vera, B: Spinacia oleracea, C: Datura stramonium, D: Camellia sinensis)

Biodiversity and food security, the provisioning of clean water and diverse food supply makes it vital for all living things, biodiversity helps regulate the nutrients cycle and water and mitigates impacts of climate change

3. Biodiversity stability

Biodiversity can bring stability to ecosystems. These are stable if their biodiversity is maintained. Instead of being clumped together, the plants are scattered in many parts of the rain forest, making it more difficult for the disease organism to spread.

4.4. THREATS AND CONSEQUENCES OF BIODIVERSITY LOSS

Activity 4.4

1. Observe the figure below, and relate the human activities illustrated in them with the biodiversity loss

2. Explain the impact on ecosystem when occur diverse activities as shown above?
3. What are advice to protect your school surroundings and various ecosystems in general?

4.4.1. Threats of biodiversity

the main causes of biodiversity loss can be attributed to the influence of human activities on ecosystems. Threats to biodiversity may include:

a. Habitat loss and the degradation of the environment

The habitat loss and the degradation of the environment occur in different ways.

The most occurring, are tree cutting, agriculture and fires. These human activities lead to the alteration and loss of suitable habitats for biodiversity. As a consequence, there is a loss of plant species as well as the decrease in the animal species associated to this plant diversity.

b. ntroduction of invasive species and genetically modified organisms

Species originating from a particular area are harmful to native species also called endemic species when they are introduced into new natural environments. They can lead to different forms of imbalance in the ecological equilibrium, so that endemic species may fail to compete with introduced species, and they may affect the abundance and distribution in natural habitat.

c. Pollution

Human activities such as excessive use of fertilizers, and increased pollutants from industries and domestic sewage affect biodiversity. They contribute to the alteration of the flow of energy, chemicals and physical constituents of the environment and hence species may die as a result of toxic accumulation.

d. Overexploitation of natural resources

Increased hunting, fishing, and farming in particular areas lead to the decrease and loss of biodiversity due to excessive and continuous harvesting without leaving enough time for the organisms to reproduce and stabilize in their natural habitat.

e. Climate change

This is a change in the pattern of weather, related changes in oceans, land surfaces and ice sheets due to global warming resulting from man's activities. Increasing global temperatures have resulted into melting of icebergs raising sea levels and so flooding coastal areas eventually affecting the niche, and these may take the lives on many living things.

4.4.2. Consequences of loss of biodiversity

They are various consequences of loss of biodiversity that include:

- Desertification, is thought by scientists to be a consequence of climate change, has been considered to be related to deforestation. Disrupting water cycles and soil structure results into less rainfall in an area.
- Floods as a result of rising sea levels.
- Habitat destruction for extensive farming, timber harvesting and infrastructure and settlement.
- Decrease in food production as result of change in pattern of weather that affects productivity
- Large scale deforestation has a negative effect on nutrient recycling and can accelerates soil erosion.
- Diseases that come as effects of floods and malnutrition due to famine

Skill lab 4

Calculating index of biodiversity of school garden

A diversity index is a quantitative measure that reflect how many different types there are in a dataset and that can simultaneously take into account the phylogenetic relations among the individuals distributed among those types, such as richness, etc.

NB: This biodiversity index is commonly used as a quick way to differentiate between different locations, ecosystems, or populations of organisms. It is a calculation of the total number of species in a particular place.

Activity:

1. Survey a school garden and in your data table, record the number of different species of plants.
2. Survey school garden again. This time, make a list of the plants by assigning each a number as you walk by it. Place X under plant 1 on your list. If plant 2 is the same species as plant 1, mark an X below it. Continue to mark an X under the plant as long as the species is the same as the previous one. When a different species is encountered, mark an O under that plant on your list. Continue to mark O if the next plant is the same species as the previous, if the next plants is different mark an X. Record in your data table:

   a) The number of "runs". Runs are represented by a group of similar symbols in a row.

Example:

XXXOOXO would be 4 runs (XXX= first run; OO = Second run; X= third run; O= fourth run).

b) The total number of plants counted.

Calculate the index of diversity (ID) using the formilar in the data table

Index of diverisity:

Number of spaces

Number of runs

Number of plants

$$\text{Index diverisity} = \frac{\text{Number of species X Number of runs}}{\text{Number of plants}}$$

End unit assessment

1. Explain what is meant by a habitat and make a list of all the habitats you can see in your school compound.
2. Pollution is one of the causes of aquatic biodiversity loss.
   a) What do you understand by water pollution?
   b) Outline human activities that contribute to water pollution
   c) Discuss how polluted water affects aquatic living organisms?
   d) Relate desertification with biodiversity loss.

UNIT 5: INTRODUCTION TO CLASSIFICATION

Key unit competence: Apply the basic knowledge of classification to group living organisms in three domains

Introductory Activity

1. Observe various illustrations below

2. Do they all illustrate living things?
3. From your observation of illustrations above, identify different groups according to the external features
4. Predict what you are going to learn in this unit

5.1. THE TAXONOMIC HIERARCHY

Activity 5.1

You are provided with cards written on a list of words such as continent, district, country, cell, province, sector, village and family.

1. Arrange the above words in increasing size
2. What is your opinion about the people of the same family and those in the whole country?
3. By search engine or library textbooks compare your arrangement above with groups of the biological taxonomic hierarchy.

Taxonomy is the study of classification of living organisms in taxonomic levels called taxa (singular: taxon). In biological classification, these taxa form a hierarchy. Each kind of organism is assigned to its own species, and similar species are grouped into a genus (plural: genera). Similar genera are grouped into a family, families into an order, orders into a class, classes into a phylum (plural: phyla) and phyla into a kingdom. The hierarchy classification starts from the largest group, the **domain.**

The eight levels of classification are known as **taxa** (taxon in singular), these include: **Domain, Kingdom, phylum, class, order, family, genus and species**. As one moves down the taxonomic hierarchy, it follows that the number of individuals decreases but the number of common features increases.

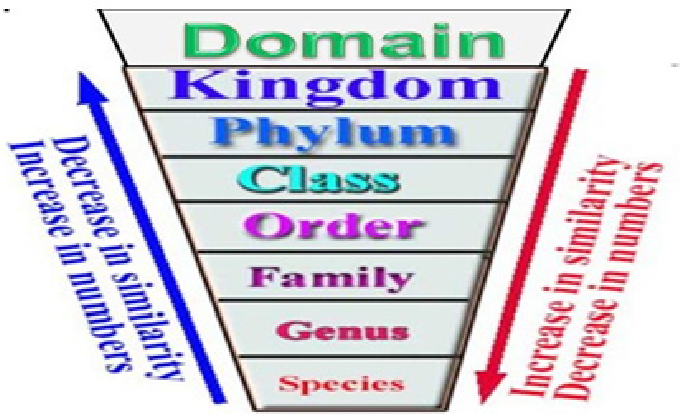


Fig.5.1. Levels of classification

Table 5.1 **below shows how human being, earthworm and hibiscus are classified.**

Taxa	Human	Earthworm	Hibiscus
Domain	Eukarya	Eukarya	Eukarya
Kingdom	Animalia	Animalia	Plantae
Phylum	Chordata	Annelida	Angiospermae
Class	Mammalia	Oligochaeta	Dicotyledonae
Order	Primata	Terricolae	Malvales
Family	Homonidae	Lumbricidae	Malvaceae
Genus	Homo	Lumbicus	Hibiscus
Species	H. sapiens	L. terrestris	H. rosa sinesis

5.2. DOMAIN SYSTEM OF CLASSIFICATION

Activity 5.2

Using library textbooks or search engine, identify the characteristics of each of the three biological domains (archaea, bacteria and eukarya).

Three domains are used by biologists to divide organisms into three large groups based on their cell structure. The domain is the highest taxon in the hierarchy. The prokaryotes are divided between the domains **Eubacteria/ Bacteria and Archaebacterial/ Archea**, while all the eukaryotes are placed into the domain **Eukarya.**

5.2.1. Domain eubacteria/ bacteria

domain bacteria include prokaryotic organisms as their cells do not have defined, membrane-limited nuclei.

They are all microscopic that vary in size between 0.2 to 10 micrometers. The characteristic features of bacteria are:

- Cells with no true nucleus
- DNA exists in circular chromosome and does not have histone proteins associated with it.
- No membrane-bound organelles (mitochondria, endoplasmic reticulum, *Golgi body, chloroplasts)*

- Contain mesosomes as infolding of membrane and acts as sites for respiration as they lack mitochondria.
- Ribosomes (70 S) are smaller than in eukaryotic cells
- Cell wall is always present and contains peptidoglycans in place of cellulose
- Cells divide by binary fission
- Usually exist as single cells or colonies.

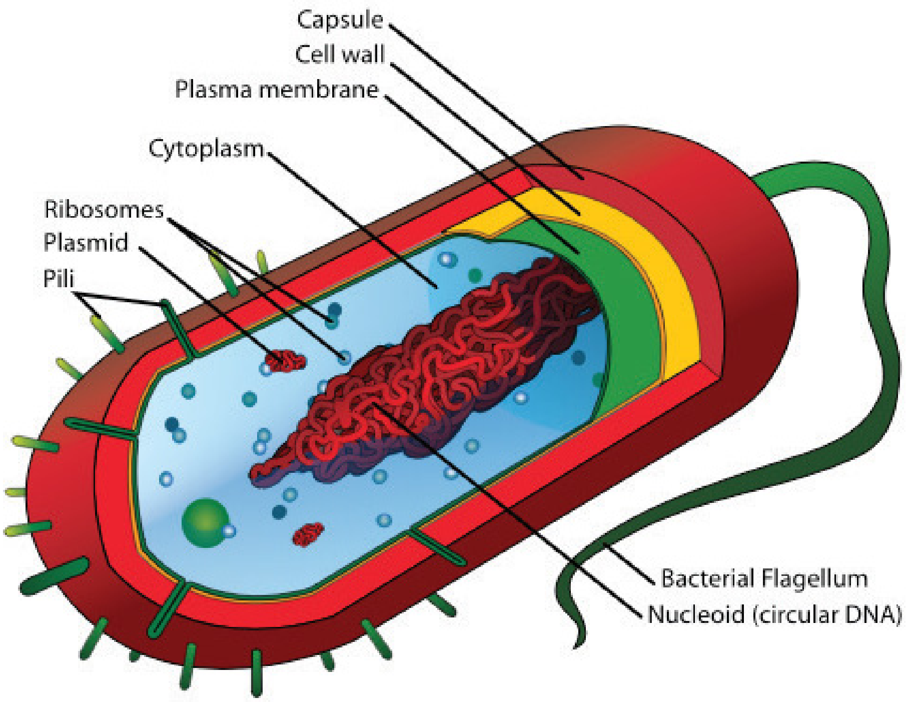


Fig.5.2: Structure of a typical bacterial

The bacteria are important when they help to fertilize fields, to recycle nutrients on earth, and to produce food and medicines. The bacteria that live in soil recycle the nitrogen and carbon contained in the complex organic molecules that remain in plants and animals after they have died. While most bacteria is found in many disease, bacteria is very useful to our lives because is found in the digestive system to help break down food.

a. Domain Archaea (Archaebacteria)

This contains bacteria that live in extreme environments where few other organisms can survive, like in volcanic hot springs and black organic mud totally devoid of Oxygen.

Types and economic importance

They are classified according to the environments they live in:

- Methanogenic bacteria that live in habitats deprived of oxygen and give off methane as a product of metabolism for example those that live in the guts of ruminant animals such as cows.
- Halophilic bacteria live only in water with high concentration of salt.
- Thermoacidophilic bacteria tolerate extreme acid and temperature that exceed boiling point of water and a pH below 2.They are autotrophic producer for a unique animal community's food chain.

b. Domain Eukarya

All the organisms classified into this domain have cells with true nuclei and membrane-bound organelles. It include the four remaining kingdoms: **protists, fungi, plantae and Animalia**. Their characteristic features are:

- Cells with a nucleus and membrane-bounded organelles
- linear DNA associated with histones arranged within a chromosome in the nucleus
- Ribosomes (80S) in the cytosol are larger than in prokaryotes, while chloroplasts and mitochondria have small ribosomes (70S ribosomes), like those in prokaryotes.
- Chloroplast and mitochondrial DNA is circular as in prokaryotes suggesting an evolutionary relationship between prokaryotes and eukaryotes
- A great diversity of forms: unicellular, colonial and multicellular organisms
- Cell division is by mitosis.
- Many different ways of reproduction including asexually and sexually.

5.3. CHARACTERISTIC FEATURES OF THE KINGDOMS IN LIFE SCIENCE

Activity 5.3

1. Collect different living things from your school surrounding.
2. Observe each of these above living things and group them based on their external features.
3. Based on groups made, how many groups are most closely related?
4. Analyze the characteristics comparative table of living things groups, and use engine research or library textbooks to find under which biological term are grouped.

5.3.1. Protoctista

This kingdom is made up of a very diverse range of eukaryotic organisms, which includes those that are often called protozoans and algae. Living things such as paramecium, amoeba, euglena, algae and plasmodia belong to the kingdom Protoctista.

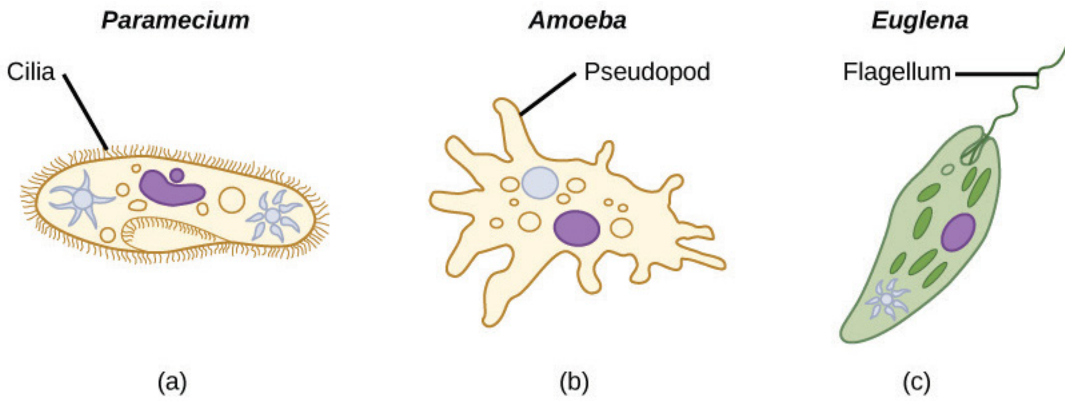


Figure 5.3: Paramecium, Amoeba and Euglena.

The characteristic features of protoctists are listed according to the different phyla due to their diverse range:

- **Rhizopus** that have pseudopodia for locomotion. Example, amoeba.
- **Flagellates** which are protoctista which move by using flagella. Example, Trypanosoma.
- **Sporozoans** which are mainly parasitic organisms that reproduces by multiple fission. Example plasmodium.
- **Ciliates** are protoctista which move with cilia. Example paramecium.
- **Euglenoid flagellates** which are organisms with flagella but with a biochemistry quite distinct from that of flagellates. Example Euglena.
- **Green algae** are photosynthetic protoctista with chlorophyll pigments. Example chlorella.
- **Red algae** are photosynthetic protoctista with red pigment as well as chlorophyll. Example, chondrus
- **Brown algae** which are photosynthetic protoctista with brown pigments as well as chlorophyll. Example Fucus and sea weed.

NB: Some protists are used in food industry. eg saccharomyces cerevisiae (yeast). The plants protists produce almost one half of the oxygen on the planet through photosynthesis. They participate in decomposition and recycling of nutrients that humans need to live.

5.3.2. Fungi

Fungi are all heterotrophic, obtaining energy and carbon from dead and decaying matter or by feeding as parasites on living organisms. There is a vast range in size from the microscopic yeasts to macroscopic fungi.

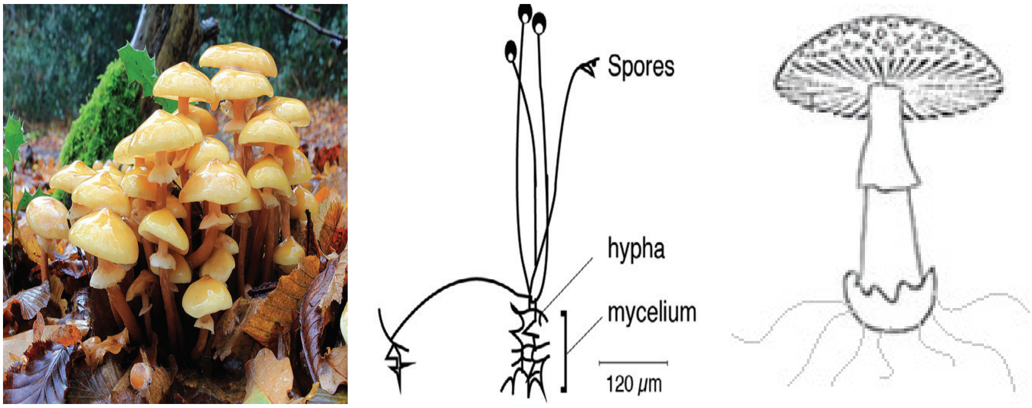


Fig.5.4 ***Forms of fungi***

Other characteristic features of fungi are:

- Heterotrophic nutrition.
- They use organic compounds made by other organisms as their source of energy and source of molecules for metabolism.
- Reproduce asexually by means of spores and sexually by conjugation.
- Simple body form, which may be unicellular or made up of long threads called hyphae (with or without cross walls).
- Large fungi such as mushrooms produce large compacted masses of hyphae known as fruiting bodies to release spores.
- Cells have cell walls made of chitin or other substances.

NB: As economic importance some mushrooms are used as food, saprophytic fungi such as mucor spp/Rhizopus spp are used in the curing of tea and tobacco; the fungi decompose organic matter helping to clean the environment and recycle materials.

5.3.3. Plantae

Plants are all multicellular photosynthetic organisms. They have complex bodies that are often highly branched both above and below the ground. Characteristic features of plants are:

- Multicellular eukaryotes with cells that are differentiated to form tissues and organs.

- Few specialized cells.
- Cells have large and often permanent vacuoles for support with cell walls made of cellulose.
- Autotrophic living organisms (most plants contain chlorophyll and store carbohydrates as starch or sucrose).
- Usually plants are green
- Roots ,stems and leaves
- Sexual and asexual reproduction

NB: People depend upon plants to satisfy such basic human need as food, clothing, shelter and health care.

5.3.4. Animalia

Animals are multicellular organisms that are all heterotrophic with different methods of obtaining their food.

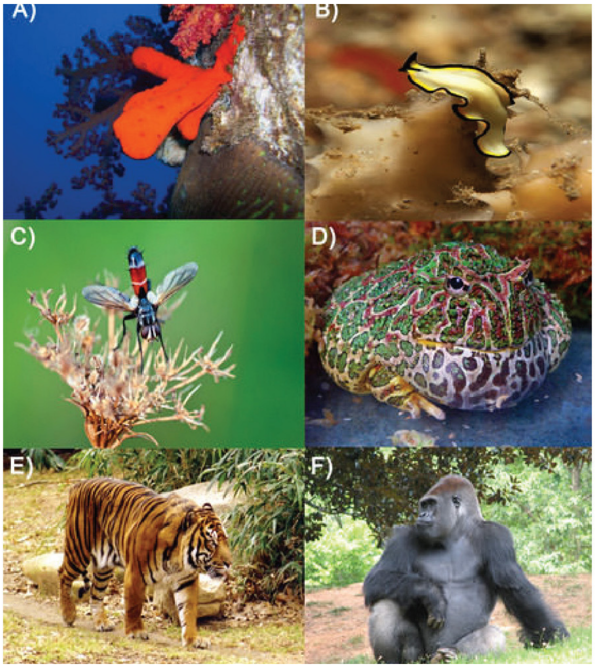


Fig. 5.5 **(A)** *Sponge,* **(B)** *Flatworm* **(C)** *Housefly* **(D)** *Frog* **(E)** *Tiger* **(F)** *Gorilla*

Organisms in Animalia kingdom share the following features:

- Multicellular (different types of specialized cells).
- Eukaryotic
- Heterotrophic (cells do not have chloroplasts and cannot photosynthesize, although some, such as coral polyps have photosynthetic protoctists living within their tissues).

- Cell vacuoles are small and temporary (for example lysosomes and food vacuoles).
- Cells do not have cell walls.
- Sense organs (communication is by the nervous system)
- Motile, at least for part of their life

NB: Many animals are helpful to humans; many varieties of livestock are kept because they add protein to our diets in the form of meat, milk products, and egg. Fiber bearing animals such as sheep provide material for making clothing

5.3.5. Monera

Organisms in this kingdom are unicellular, that do not have a nucleus. They are prokaryotic. They are the smallest and simplest organisms. Some of them stick together to form chains or clusters while others are single cells. The figure below shows a typical structure of a bacterial cell which contains all the main features of prokaryotes.

Although some of them are harmful in causing human diseases, others are beneficial species that are essential to good health, as they are involved in food industry, medicine and in pharmacy.

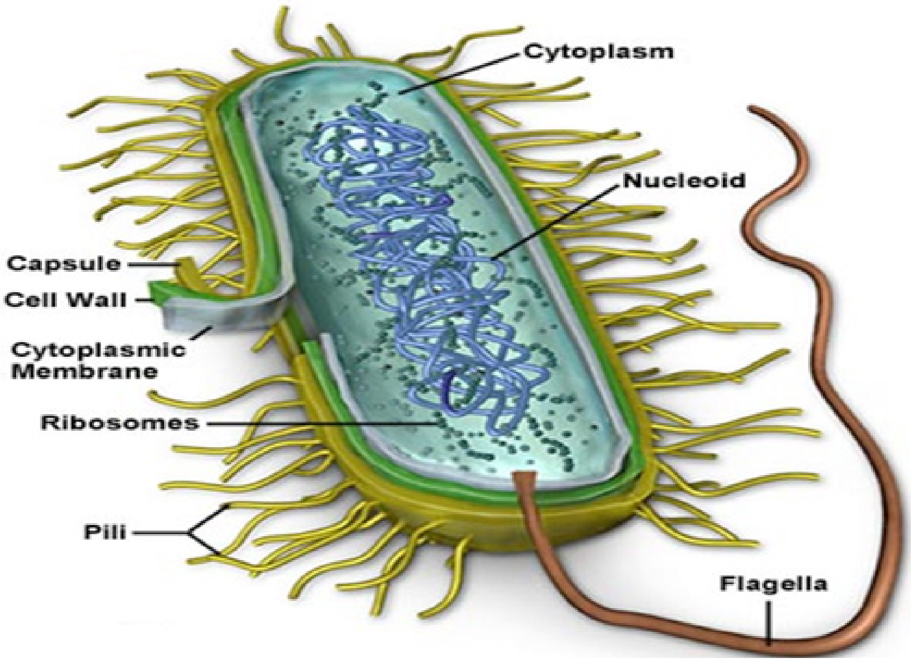


Fig.5.6 *Procaryotic cell structure*

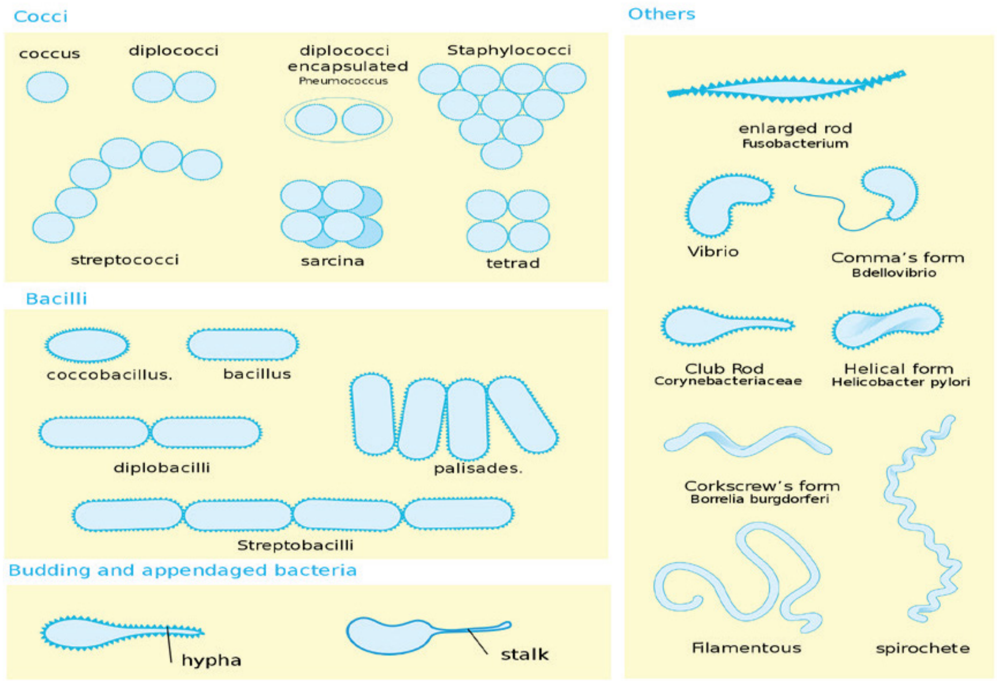


Fig. 5.7 *Structure of a typical bacterial and bacterial features*

NB: About economic importance of monera kingdom, many of Nostoc species fix atmospheric nitrogen and thus increase soil fertility. They are also important in the manufacturing and services industries (eg production of many dietary supplements and pharmaceuticals)

5.4. CLASSIFICATION OF VIRUSES AND THEIR ECONOMIC IMPORTANCE

Activity 5.4

By using the library textbooks or search engine classify and explain the economic importance of viruses.

5.4.1. Classification of viruses

Viruses can be classified into four groups based on shape: filamentous, isometric/icosahedral, enveloped, and head and tail.

- **Type of nucleic acid molecules** they have. Most animal viruses contain **RNA** while plant viruses contain **DNA**.
- **Type of host cell**: plant or animal viruses as they are specific to their hosts.

– **Presence or absence of the envelope**: Plant viruses' bacteriophage are no enveloped while animal viruses like HIV and influenza virus are enveloped.

5.4.2. Characteristics of viruses

Viruses are microorganisms whose structure is only visible with electron microscopes. A typical virus consists of DNA or RNA within a protective protein coat called capsid which provides protection. Viruses become active in metabolism only once inside the host cell. When they infect cells, they use biochemical machinery and proteins of the host cell to copy their nucleic acids and to make proteins coats often leading to destruction of the host cells. The energy for these processes is provided by the ATP from the host cell. Because viruses do not consist of cells, they also lack cell membranes, cytoplasm, ribosomes, and other cell organelles. Without these structures, they are unable to make proteins or even reproduce on their own. Instead, they must depend on a host cell to synthesize their proteins and to make copies of themselves. Viruses infect and live inside the cells of living organisms. They are also regarded as parasites since they depend entirely on living cells for their survival. Although viruses are not classified as living things, they share two important traits with living things: They have genetic material, and they can evolve.

End unit assessment

1. Which one of the following living organisms belongs to domain bacteria?

   a) Euglena

   b) Vibrio cholerae

   c) Paramecium

   d) moulds

2. The group of classification where organisms resemble one another and are capable of interbreeding together to produce viable offspring is known as:

   a) Species

   b) kingdom

   c) Genus

   d) Phylum

3. Which one of the following is not a kingdom of living organisms?
   a) Monera
   b) Animalia
   c) Annelida
   d) Protoctista
4. Which one of the following is a characteristic feature common to fish, reptiles and birds but absent in mammals?
   a) Possession of scales
   b) Has no limbs
   c) Possession of feathers
   d) Undergo internal fertilization
5. Which one of the following statements about fish is not correct?
   a) Fish live both in water and on land and undergo external fertilization.
   b) Most fish have bones while others are cartilaginous
   c) Most fish have streamlined body, lateral line and swim bladder.
   d) Gills are organs for gaseous exchange in fish
6. Which one of the following is not a characteristic of all insects?
   a) They have three body parts namely head, thorax and abdomen.
   b) They have three pairs of jointed legs attached on segment of the thorax.
   c) They have four pairs of jointed legs
   d) They have a pair of antennae attached on the head.
7. The following are characteristics of all mammals except;
   a) They have mammary glands to secrete milk feed their young ones.
   b) Their skin is covered with hair.
   c) Undergo internal fertilization and internal development of the embryo.
   d) They have a pair of wings made up feathers.

8. The point where the leaf joins the stem is called;

a) Apex

b) Margin

c) Leaf base

d) Lamina

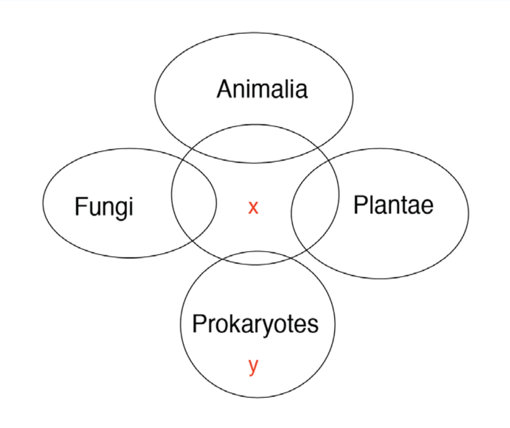
e) Length of petiole.

9. Match the structures with the organisms which possess them.

Structures Organisms

- Antennae
- Flagella
- Spores
- Coiled shell
- Pseudopodia
- Cilia
- Fungus
- Snail
- Housefly
- Euglena
- Amoeba
- Paramecium

10. A group of S4 students drew a Venn diagram below to summarize the five kingdoms into which organisms are classified. Study the diagram and answer the questions that follow:



a) Which kingdoms are represented by the letters x and y?

b) State one characteristic that organisms of x may share with:

i. Prokaryotes

ii. Fungi

iii. Plantae

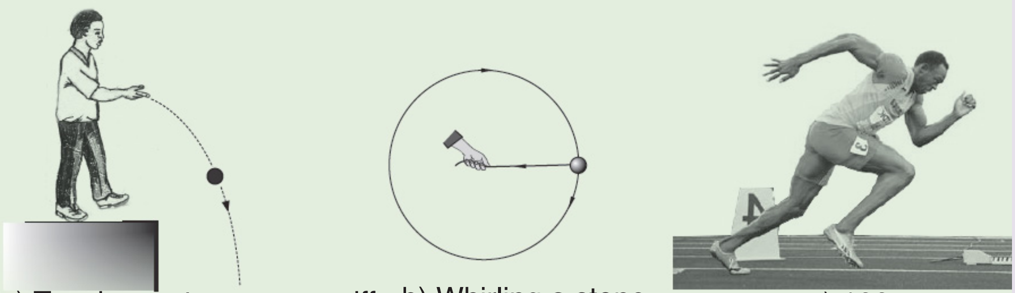
11. What is the significance of classification of living organisms?

UNIT 6: MOTION ON A STRAIGHT LINE

Key unit competence: **Apply equations of motion on a straight line to solve real life problems**

Introductory Activity

Here below there are three photos, carefully observe them and answer to the next questions:



a) Trowing a stone over a ciff b) Whirling a stone c) 100 m race

Fig.6.1. Different types of motion

1. Refer to your observation and our daily life situations give at least three activities that involves the concepts shown by the above illustration.
2. Is there any moving body on this illustration? List them.
3. From your observation of figures above what do you predict to learn in this unit?

6.1. UNIFORM MOTION IN A STRAIGHT LINE

Activity 6.1: *How fast and how far?*

1. Using a stopwatch, find out how long it takes you to walk 5 meters at a normal pace. Record your time.
2. Now find out how far you can walk in 5 seconds if you walk at normal pace
3. Repeat step 1 and 2, walking slower than your normal pace. Then repeat steps 1 and 2 walking faster than your normal pace.

What is the relationship between the distance you walk, the time it takes you to walk and your walking speed?

In our daily lives, we come across various objects moving from one point to the other. The objects are said to be in motion. People, animals and machines are from time to time involved in motion in different directions. Motion in a straight line is called **linear motion**.

In this unit, we are going to study linear motion. We shall pay attention to the time taken, distance covered, speed, velocity and acceleration of the motion and their relationships.

There are two types of linear motion namely: uniform motion and non-uniform motion.

Uniform motion

In this motion, the speed of the moving remains the same or constant.

Non-uniform or uniform accelerated motion

In this motion the speed of an object changes at a constant rate, a good example is the free fall.

6.1.1. Distance and displacement

Distance

Distance is the total length of the path followed by an object, regardless of the direction of motion. It is a scalar quantity and measured in units of length. The SI unit of distance is the metre (m). Long distances may be measured in kilometers (km) while short distances may be measured in centimeters (cm) or millimeters (mm).

It should be noted that in determining the distance between two points, the direction at any point along the path is not considered. The direction along the path may keep on changing or remain constant.

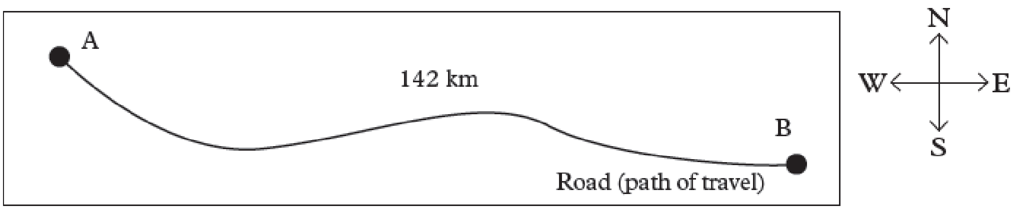


Fig. 6.2: *Distance*

Displacement

Displacement is the object's overall change in position from the starting to the end point. It is the shortest distance along a straight line between two points in the direction of motion. The *SI unit* of displacement is the *metre* (m).

To fully describe displacement, you need to specify how far you have travelled from where you started and in what direction you have travelled. For example, point A is 100 kilometres Northwest of point B. In diagrams, an arrowhead indicates the direction of motion (. Displacement is a vector quantity.

displacement = distance in a stated direction from a reference point

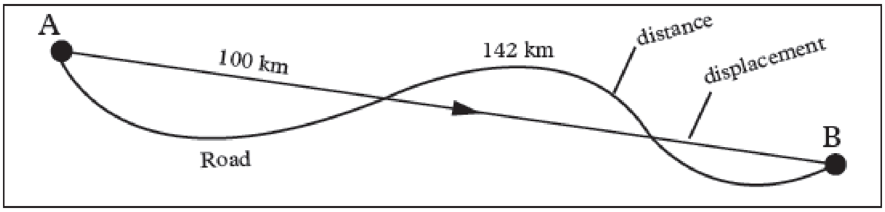


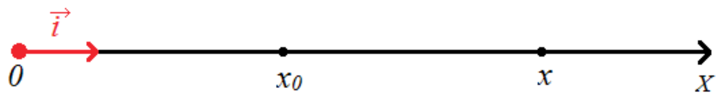
Fig. 6.3: *Distance and displacement*

6.1.2. Average velocity and instantaneous velocity

velocity or speed may be defined as the rate at which something happens, moves or functions within a time interval, that is, how fast is a progress, movement or an operation. In general, the average speed of an object is defined as the covered distance divided by the time it takes to travel this distance.

$$\text{Average speed} = \frac{\text{distance}}{\text{time}}$$

Suppose that an object is moving on *X*-axis so that at an instant t_0, the object is at point (coordinate) x_0, and at another later instant t the object is at point x.



If during the time interval $\Delta t = t - t_0$, the displacement of an object is $\Delta x = x - x_0$, then the **average speed** is

$$v = \frac{\Delta x}{\Delta t} = \frac{x - x_0}{t - t_0}$$

The **instantaneous speed** at any moment is

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

In physics we make a distinction between speed and velocity. **Speed** is simply a positive number, with units. **Velocity**, on the other hand, is used to define both the magnitude of how fast an object is moving and the direction in which it is moving. Namely, the average velocity is defined in terms of displacement, rather than total distance.

If $\vec{r}_0 = x_0 \vec{i}$ and $\vec{r} = x \vec{i}$ are **position vectors** of an object moving along *X*-axis, respectively at the instants t_0 and t, the **average velocity** is

$$\vec{v} = \frac{\Delta \vec{r}}{\Delta t} = \frac{x - x_0}{t - t_0} \vec{i}$$

Thus the **instantaneous velocity** is

$$\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d\vec{r}}{dt} = \frac{dx}{dt} \vec{i}$$

6.1.3. Average acceleration and instantaneous acceleration

Acceleration is the rate at which something increases in velocity within a time interval. The **average acceleration** between the instants t_0 and t is given by

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v} - \vec{v}_0}{t - t_0} = \frac{v - v_0}{t - t_0}\vec{i}$$

The **instantaneous acceleration** for a particle moving along the *OX* axis is

$$\vec{a} = \lim_{\Delta t \to 0} \frac{\Delta\vec{v}}{\Delta t} = \frac{d\vec{v}}{dt} = \frac{dv}{dt}\vec{i}$$

6.1.4. Velocity - time and distance - time graphs

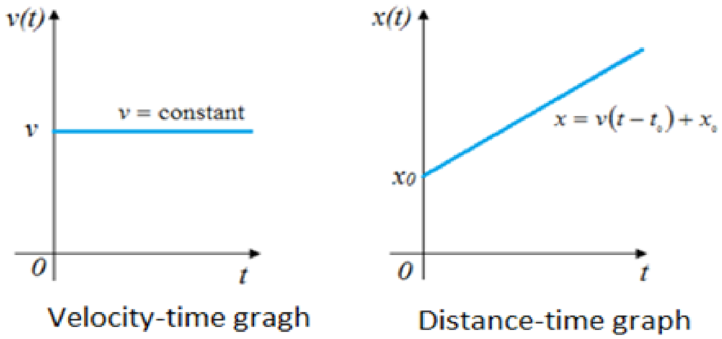
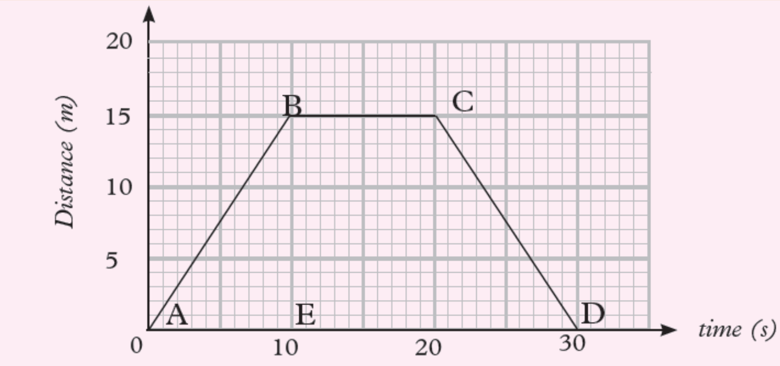


Fig. 6.4*: Velocity-time graph and distance-time graph*

Application activity 6.1

1. What is the speed of a racing car in metres per second if the car covers 360 km in 2 hours?
2. A car accelerates from rest to a velocity of 20 m/s in 5 s. Thereafter, it decelerates to a rest in 8 s. Calculate the acceleration of the car (a) in the first 5 s, (b) in the next 8 s.
3. Figure below shows a distance-time graph for a motorist. Study it and answer the questions that follow.



a) How far was the motorist from the starting point after 10 seconds?

b) Calculate the average speed of the motorist for the first 10 seconds.

c) Describe the motion of the motorist in regions (i) BC (ii) CD

6.2. UNIFORMLY ACCELERATED AND DECELERATED RECTILINEAR MOTION

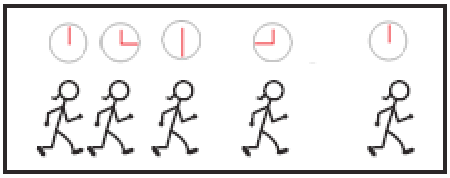
Activity 6.2: *Wiil you hurry up?*

1. Measure 10 meters in an open area. Mark the distance with masking tape.
2. Walk the 10 meters in such way that keep moving faster throughout the entire distance. Have a partner time you.
3. Repeat step 2, walking the 10 meters in less time than you did before. Then try it again, this time walking the distance in twice the time as the first.

N.B: Remember to keep speeding up throughout the entire 10 meters

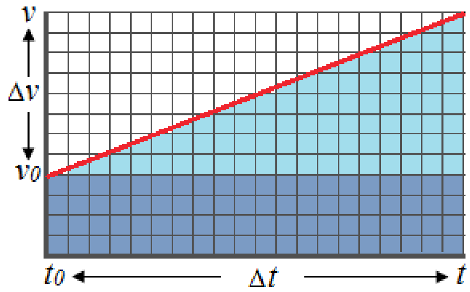
How is the change in your speed related to the time in which you walk the 10 meters course?

6.2.1. Uniformly accelerated rectilinear motion (uarm)



Many practical situations occur in which the acceleration is constant or close enough that we can assume it is constant. We defined acceleration as the rate at which something increases in velocity. In this case, both the acceleration and velocity of the particle are either negative or positive in a same time, meaning that their vectors are always parallel.

Consider a particle moving from x_0 to x with a positive constant acceleration a starting with speed v_0. Assuming the acceleration positive and constant, the velocity keeps changing monotonously as shown by the *v*-*t* graph below



The area under the *v*-*t* graph is equal to the object's displacement. The area under the graph can be calculated by dividing it into a rectangle and a triangle.

The area of the rectangle is

$$\Delta x_{\text{Rectangle}} = v_0 \Delta t$$

The area of the triangle is

$$\Delta x_{\text{Triangle}} = \frac{1}{2} \Delta v \Delta t$$

As the average velocity is $\Delta v = a\Delta t,$ the area of the triangle can also be

$$\Delta x_{\text{Triangle}} = \frac{1}{2} a \Delta t^2$$

The total area Δx is given by

$$\Delta x = \Delta x_{\text{Triangle}} + \Delta x_{\text{Rectangle}}$$

$$\Delta x = \frac{1}{2} a \Delta t^2 + v_0 \Delta t$$

$$x - x_0 = \frac{1}{2} a (t - t_0)^2 + v_0 (t - t_0)$$

The position x of an accelerated object at any other time t relatively to x_0 is given by

$$x - x_0 = \frac{1}{2} a (t - t_0)^2 + v_0 (t - t_0)$$

Solving the equation of average acceleration for $t - t_0$, we get

$$t - t_0 = \frac{v - v_0}{a}$$

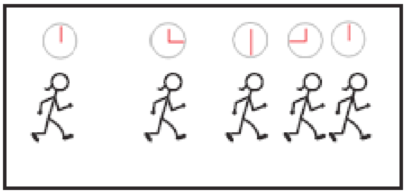
Substituting equation it is into the equation above we get

$$v^2 - v_0^2 = 2a(x - x_0)$$

To find the average speed, we divide the equation of position by $t - t_0$ and we get

$$\bar{v} = \frac{v + v_0}{2}$$

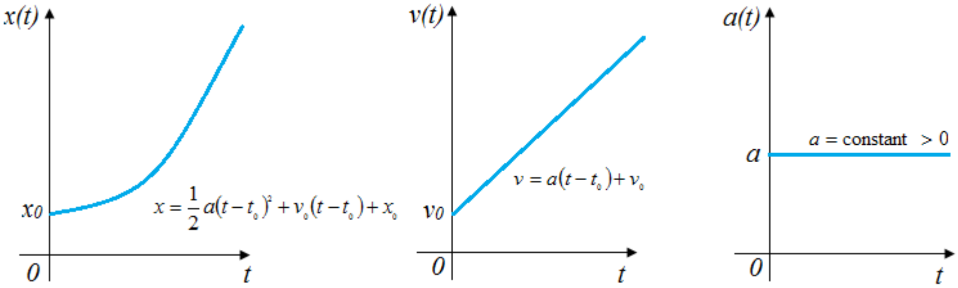
6.2.2. Uniformly decelerated rectilinear motion (udrm)



For this case, one of the acceleration or velocity of the particle is considered as negative and takes a negative value in equations. Acceleration and velocity have antiparallel (parallel but opposite) vectors

6.2.3. Distance - time, velocity - time and acceleration - time graphs

a. Uniformily Accelerated - Rectilinear Motion (UARM)



b. Uniformily Decelerated Rectilinear Motion (UDRM)

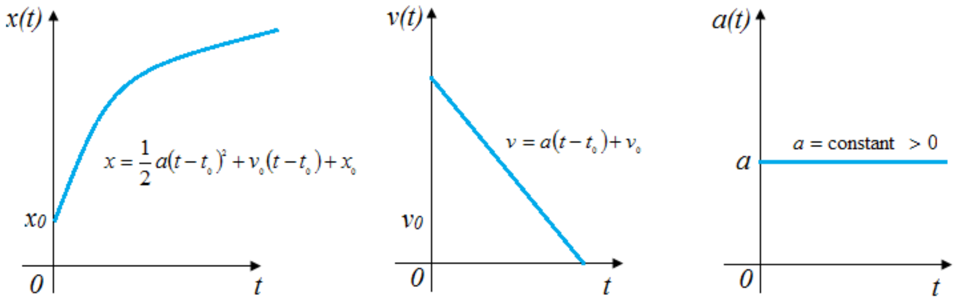


Fig.6.5: *x (t)-t graph, v(t)-t graph and a(t)-t graph for UARM and UDRM*

Example 6.1

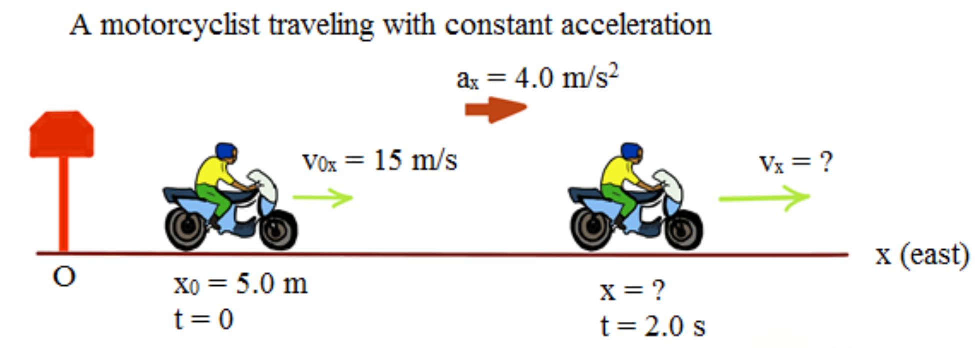
Constant –acceleration calculations

A motorcyclist heading east through a small Iowa city accelerates after he passes the signpost marking the city limits (fig). His acceleration is a constant. At time he is 5.0 m east of the signpost, moving east at 15 m/s.

a) Find his position and velocity at time

b) Where is the motorcyclist when his velocity is 25 m/s?

c) Where is the motorcyclist when his velocity is 25 m/s?



Solution

a) Position and velocity at time are:

$$\boldsymbol{x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2}$$

$$= 5.0\,m + (15.0\,m/s)(2.0\,s) + \frac{1}{2}(4.0\,m/s^2)(2.0\,s)^2$$

$$= 43\,m$$

The x- velocity at this time is:

$$\boldsymbol{v_x = v_{0x} + a_x t}$$

$$= (15.0\,m/s) + (4.0\,m/s^2)(2.0\,s)$$

$$= 23\,m/s$$

b) We want to find the value of x when v_x=25m/s , but we don't know the time when the motorcyclist has this x-velocity. So we use this equation:

$$v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$$

Solving for x and substituting the known values we get:

$$x = x_0 + \frac{v_x^2 - v_{0x}^2}{2a_x} = 5.0\,m + \frac{(25\;m/s)^2 - \left((15.0\,m/s)\right)^2}{2(4.0\,m/s^2)} = 55\,m$$

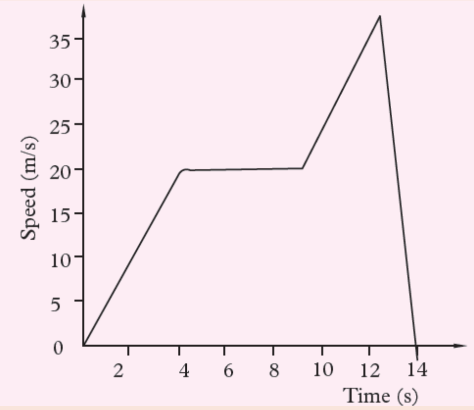
Application activity 6.2

1. A car moving at 30 m/s slows uniformly to a speed of 10 m/s in a time of 5.0 s. determine (a) the acceleration of the car and (b) the distance it moves in the third second.
2. Figure below shows a graph of speed against time for the motion of a car travelling from Musanze to Muhanga.

Determine:

a) The acceleration of a car in the first 4 s.

b) The distance travelled in the first 4 s.



6.3. FREE FALL (Downward and Upward)

Activity 6.3 *Effect of earth's gravitational force*

Materials: A tennis ball

1. Throw a tennis ball vertically upwards and catch it when it comes down.
2. Describe the motion of the ball in terms of variation of velocity with time.
3. Suggest a reason why the ball falls back to you.
4. Repeat the activity using other objects such as polystyrene balls or paper balls. Consult your teacher if you have to use an object such as a stone. Take care that you are not hit by the falling objects.
5. Compare and discuss your findings with other members in your class

One of the most common examples of uniformly accelerated rectilinear motion is that of an object allowed to fall freely near the Earth's surface. For free fall, Galileo postulated that: "at a given location of the Earth and in the absence of air or other resistance all objects fall with the same constant acceleration". In the free-fall motion air resistance is negligible and the action can be considered due to gravity alone.

We call this acceleration the **acceleration due to gravity** on the Earth, and we give it the symbol g. Its magnitude is approximately $g = -9.8\ m/s^2$. g varies slightly according to latitude and elevation. The effects of air resistance are often small, and we will neglect them for the most part. We will also suppose that an object moves along *Y*-axis.

6.3.1. Object thrown downward

a. General condition

Suppose an object released to fall from a height y_0. The vectors of g and v_0 are parallel. The following figure shows how the ball accelerates within equivalent time intervals.

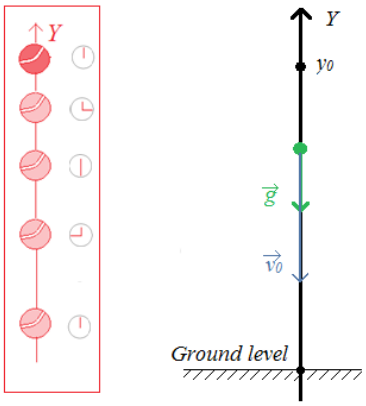


Fig.6.6: *Object thrown downward*

The position, the speed and the acceleration of the object after a time $\Delta t = t - t_0$ are respectively:

$$y = \frac{1}{2}g(t-t_0)^2 + v_0(t-t_0) + y_0$$

$$v = g(t-t_0) + v_0$$

$$a = g$$

The relation between y, v and g is given similarly to the equation of accelerated motion:

$$v^2 - v_0^2 = 2g(y - y_0)$$

b. Initial condition

Suppose an object released to fall from rest $(v_0 = 0, t_0 = 0)$.

From the above equations, the position, the speed and the acceleration of the object after a time $\Delta t = t$ are respectively:

$$y = \frac{1}{2}gt^2 + y_0$$

$$v = gt$$

$$a = g$$

c. Duration of the motion

When the object reaches the ground $y = 0$ and it follows that

$$0 = \frac{1}{2}gt^2 + y_0$$

The duration or final time t_f of the motion is given by

$$t_f = t = \sqrt{-\frac{2y_0}{g}}$$

When the object reaches the ground, the position is $y = 0$. The relation between y, v and g becomes:

$$v^2 = 2gy_0$$

The final speed v_f of the motion is given by

$$v_f = v = \sqrt{2gy_0}$$

Example 6.2 Free-falling coin

A one-euro coin is dropped from the Leaning Tower of Pisa. It starts from rest and falls freely. Computer its position and velocity after 1.0 s, 2.0 s, and 3.0s.

Solution

We take the origin O at the starting point and the upward direction as positive.

The initial coordinate y_0 and the initial y-velocity v_{0y} are both zero. The y-acceleration is downward, in the negative y-direction, so $a_y = -g = -9.8\, m/s^2$ (remember that, by definition g is always positive)

At time t after the coin is dropped, its position and y-velocity are:

$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2 = 0 + 0 + \frac{1}{2}(-g)t^2 = (-4.9\, m/s^2)t^2$$

$$v_y = v_{0y} + a_y t = 0 + (-g)t = (-9.8\ m/s^2)t$$

When: $t=1.0S$:

$$y = (-4.9\, m/s^2)(1.0\ s)^2 = 4.9\, m$$

$$(v_y = -9.8\ m/s^2)(1.0\ s) = -9.8\ m/s$$

The position and y-velocity at 2.0 s and 3.0 s are found in the same way. Can you show that

y=-19.6 m and v_y=-19.6 m/s at t=2.0 s and that y=-44.1 m and v_y=-29.4 m/s at t=3.0 s?

After 1 s, the coin is 4.9 m below the origin (y is negative) and has a downward velocity (v_y is negative) with magnitude 9.8 m/s.

6.3.2. Object thrown upward

an object shot through the air is called a projectile. Consider an object thrown upward from a tower of height y_0 into the air with an initial speed v_0.

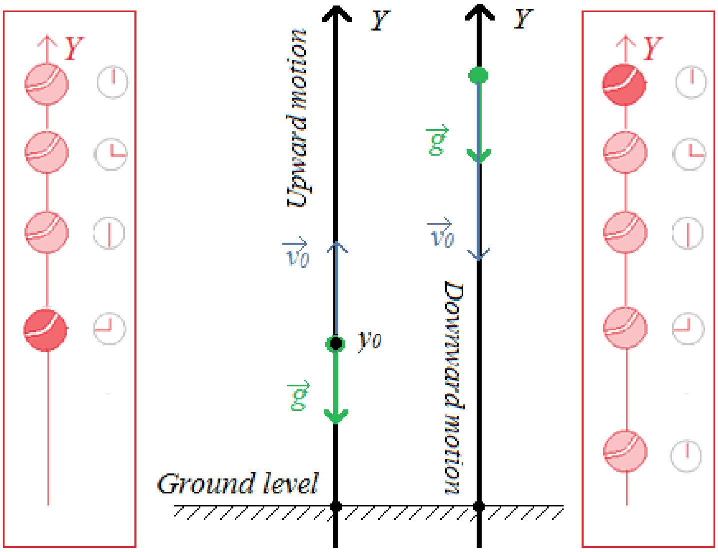


Fig. 6.7: *Object thrown upward*

a. General condition

The object is in the UDRM when it is moving upward. The position and the speed of the object after a time $\Delta t = t - t_0$ are respectively:

$$y = \frac{1}{2}g(t-t_0)^2 + v_0(t-t_0) + y_0$$

$$v = g(t-t_0) + v_0$$

The relation between y, v and g is:

$$v^2 - v_0^2 = 2g(y-y_0)$$

b. Initial condition

Suppose an object at rest thrown vertically upward from a height y_0 $(t_0 = 0)$ The position and the speed of the object after a time t are respectively:

$$y = \frac{1}{2}gt^2 + v_0 t + y_0$$

$$v = gt + v_0$$

Maximum height

When the object reaches its maximum height

$$v = 0 \Rightarrow gt + v_0 = 0$$

The time t_m it takes the object to reach the maximum height:

$$t_m = t = -\frac{v_0}{g}$$

The maximum height y_m can be found affirming that $y_m = y(t_m)$.

$$y_m = \frac{1}{2}g(t_m)^2 + v_0(t_m) + y_0$$

$$\Leftrightarrow y_m = \frac{1}{2}g\left(-\frac{v_0}{g}\right)^2 + v_0\left(-\frac{v_0}{g}\right) + y_0$$

$$\Leftrightarrow y_m = \frac{1}{2}\frac{v_0^2}{g} - \frac{v_0^2}{g} + y_0$$

$$\Leftrightarrow y_m = -\frac{1}{2}\frac{v_0^2}{g} + y_0$$

When the object falls back down it moves as in the free fall motion. Note also that the speed of the object at any height is the same when going up as coming down (but the directions are opposite). In addition t_m is supposedly the time to reach the initial position. If the object is launched on the ground level the height $y_0 = 0.$ the duration of the motion

$$t_f = 2t_m = -\frac{2v_0}{g}$$

Example 6.3

You throw a ball vertically upward from the roof of a tall building. The ball leaves your hand at a point even with the roof railing with an upward speed of 15.0 m/s; the ball is then in free fall. On its way back down, it just misses the railing. At the location of the building, g=9.8 (m)/s² . Find

a) The position and velocity of the ball 1.00 s and 4.00 s after leaving your hand;

b) The velocity when the ball is 5.00 m above the railing;

c) The maximum height reached and the time at which it is released;

d) The acceleration of the ball when it is at its maximum height.

Solution

a) The position y and y-velocity v_y at time t after the ball leaves your hand are:

$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2 = y_0 + v_{0y}t + \frac{1}{2}(-g)t^2$$

$$= 0 + (15\,m/s)t + \frac{1}{2}(-9.8\ m/s^2)t^2$$

$$v_y = v_{0y} + a_y t = v_{0y} + (-g)t = (15\,m/s) + (-9.8\ m/s^2)t$$

When *t=1.00s*, these equations gives:

$$y = +10.1\,m \text{ and } v_y = +5.2\,m/s$$

The ball is 10.1 m above the origin (y is positive) and moving upward (v_y is positive) with a speed of 5.2 m/s. This is less than the initial speed because the ball slows as it ascends.

When t=4.00 s, the equations for y and v_y as functions of time t give

$$y = -18.4\,m \qquad v_y = -24.2\,m/s$$

The ball has passed its highest point and is 18.4 m below the origin. It has a downward velocity with magnitude 24.2 m/s. the ball loses speed as it ascends, then gains speed as it descends; it is moving at the initial 15.0 m/s speed as it moves downward past the ball's launching point (the origin), and continues to gain speed as it descends below this point.

b) The y-velocity at any position is given as:

$$v_y^2 = v_{0y}^2 + 2a_y(y - y_0) = v_{0y}^2 + 2(-g)(y - 0) = (15.0\,m/s)^2 + 2(-9.8\ m/s^2)y$$

When the ball is 5.00 m above the origin, y=+5.00 m, so

$$v_y^2 = (15.0\,m/s)^2 + 2(-9.8\ m/s^2)(5.00\,m) = 127\ m^2/s^2$$

$$v_y = \pm 11.3\,m/s$$

We get two values of v_y because the ball passes through the point y=+5.00 m twice, once on the way up so v_y is positive and once on the way down so v_y is negative.

c) Just at the instant when the ball reaches the highest point, it is momentarily at rest and v_y=0. The maximum height y^1 can then be found in two ways. The first way is :

Substitute $v_y = 0, y_0 = 0$ *and* $a_y = -g$ *we get:*

$$0 = v_{0y}^2 + 2(-g)(y_1 - 0)$$

$$y_1 = \frac{v_{0y}^2}{2g} = \frac{(15.0m/s)^2}{2((9.8\,m/s^2))} = +11.5\,m$$

The second way is find time at which v_y=0 and substitute this time to find the position at this time. The time t_1 when the ball reaches the highest point is given by

$$v_y = 0 = v_{0y} + (-g)t_1 \ = (15\,m/s) + (-9.8\ m/s^2)t_1$$

$$t_1 = \frac{v_{0y}}{g} = \frac{(15m/s)}{9.8\,m/s^2} = 1.53\,s$$

So, the position at this time is:

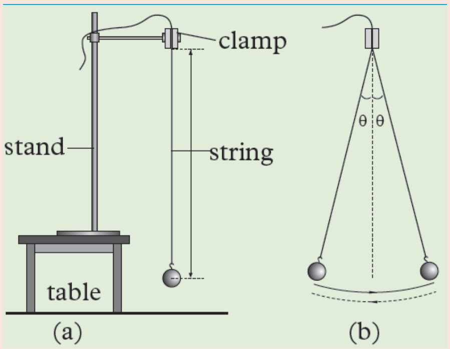
$$y = y_0 + v_{0y}t + \frac{1}{2}a_yt^2 = 0 + (15\,m/s)(1.53\,s) + \frac{1}{2}(-9.8\ m/s^2)(1.53\,s)^2$$

$$= +11.5\,m$$

At the highest point, the acceleration is still a_y=-g=-9.8(m)/s^2 , the same value as when the ball is moving up and when it's moving down. That because the ball's velocity is continuously changing, from positive values through zero to negative values.

Application activity 6.3 *Acceleration due to gravity*

Materials: A string, pendulum bob, stand, stop watch, metre rule.



1. Assemble the apparatus as shown in Fig. (a).
2. Displace the pendulum through a small angle θ (i.e $\theta < 10°$) and release it (Fig (b)).
3. Use a stop- watch to time 20 oscillations (complete cycles) of the pendulum.
4. Repeat the activity a second time and calculate the average time for 20 oscillations.
5. Repeat the process for at least six different lengths.
6. Record your results in a table (see Table below).
7. Draw a graph of T^2 against l.

Length, l (m)	Time for 20 oscillations (s)		Average time t for 20 oscillations (s) $t = \frac{t_1+t_2}{2}$	Periodic time T(s) $T = \frac{t}{20}$	$T^2(s^2)$
	Trial 1:t_1	Trial 2: t_2			
0.60					
0.70					
0.80					
0.90					
1.00					
1.10					

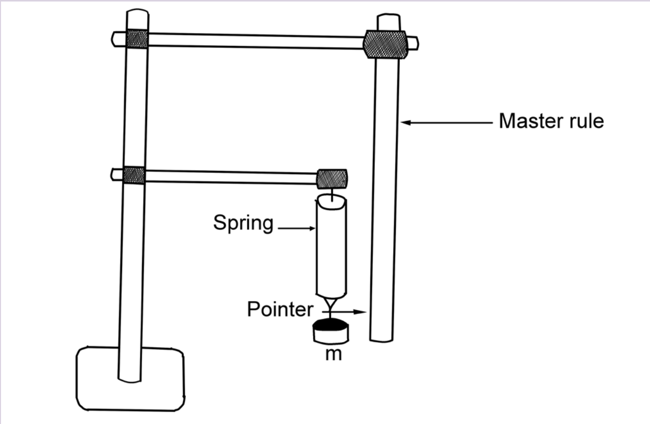
8. Draw the line of best fit through the points. Determine the gradient, m of the line.

Skill lab

In this experiment you will determine the acceleration due to gravity.

Apparatus:

1 retort stand, 1 meter rule, the helical spring with a pointer, 1 stop watch, 1 mass of 50 g, and 3 mass of 100 g each



Procedure

a) Suspend the spring provided from a retort stand as shown in the figure.

b) Hang a 0.050 kg mass carrier from the lower end of the pointer. Note and record the reading on the meter rule.

c) Add a mass m = 0.05 kg on the mass carrier and note the new position of the pointer. Hence calculate the extension x, in meters, of the spring.

d) Repeat procedure (c) for m = 0.100, 0.150, 0.200, 0.250, and 0.300 kg.

e) Tabulate your results

f) Plot a graph of x against m and determine the slope S_1, of the graph at the point for which m = 0.200 kg

g) Unload the mass carrier. Place a mass of 0.050 kg on the carrier so that the total mass of the carrier and added mass m= 0.100 kg.

h) Give the carrier a small vertical pull and allow the system to oscillate. Measure the time for 10 oscillations. Hence find the period T.

i) Repeat the procedures (g) and (h) for m = 0.150, 0.200, 0.250, 0.300, and 0.350 kg.

j) Tabulate your results including values of T^2.

k) Plot a graph of T^2 against m and determine the slope S_2 of the graph.

l) Find the intercept, C on the m-axis.

m) Calculate the acceleration, due to gravity from the equation: $g = \frac{4\pi^2 S_1}{S_2}$

End unit assessment

1. Define the following terms:

   a) Distance

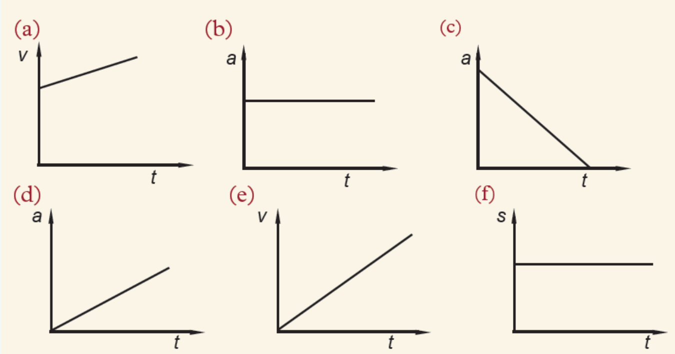
   b) Velocity

   c) Displacement

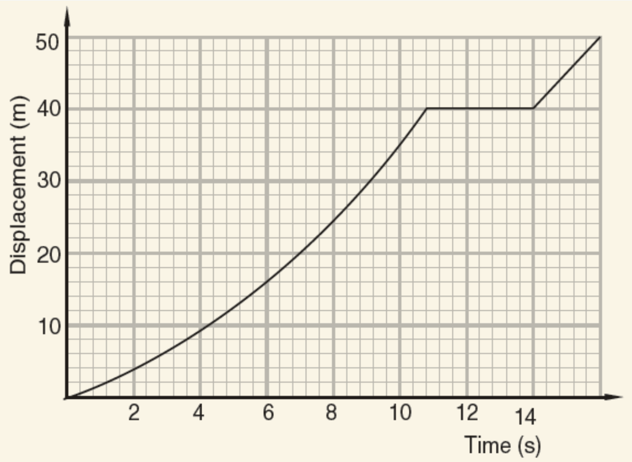
   d) acceleration

   e) Speed

2. Which one of the following motion-time graphs and acceleration-time graphs represents a body moving with uniform acceleration from rest?.



3. Fig. below shows a displacement-time graph of the motion of a body over a period of 14 s. Use the graph to determine:

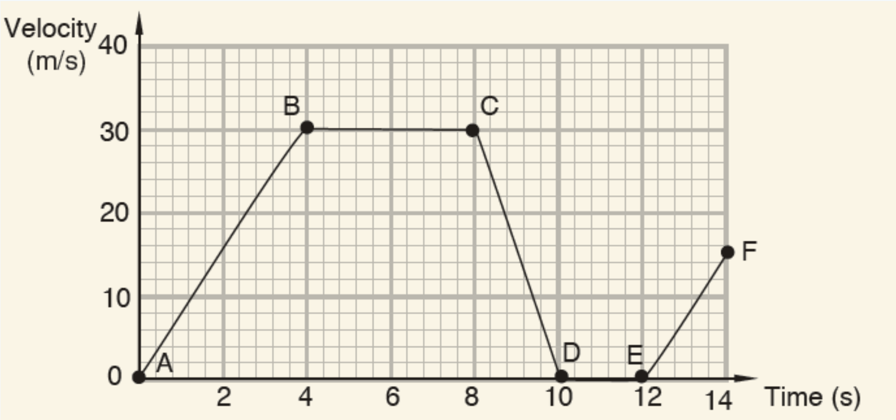


   a) The velocity when t = 3 s and t = 7 s.

   b) The acceleration of the body between 3 s and 7 s.

   c) The time, in seconds, the body was stationary.

4. Figure below shows the motion of a motorcyclist on a straight road. Use the information on the graph to answer the following questions.



a) In which section of the graph was the cyclist accelerating most rapidly? Explain how you would determine this acceleration.

b) Calculate the retardation of the motorcyclist from the graph.

c) Which part of the graph shows that the motorcyclist was stationary and for how long?

UNIT 7: BONDS AND MOLECULAR STRUCTURE

Key Unit competence: Explain how the nature of the bonding is related to the properties of compounds and molecular structures

Introductory Activity

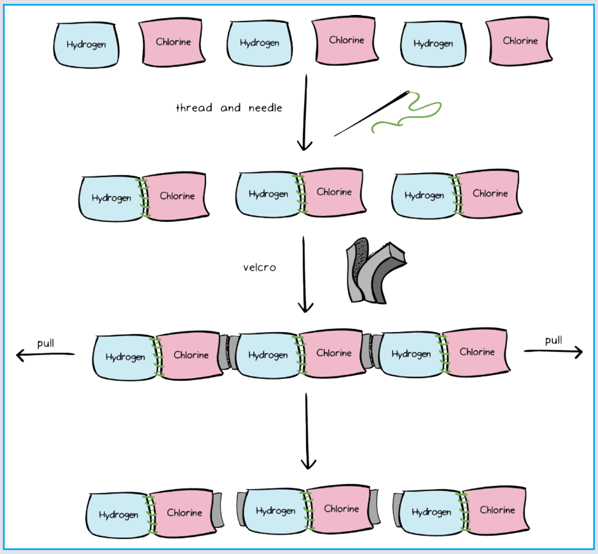


Figure of towels sewn and Velcroed representing bonds between hydrogen and chlorine atoms

We have six towels: three are blue in color, labeled hydrogen and three are pink in color, labeled chlorine. We are given a sewing needle and black thread to sew one hydrogen towel to one chlorine towel. After sewing, we now have three pairs of towels: hydrogen sewed to chlorine. The next step is to attach these three pairs of towels to each other. For this we use Velcro as shown above. So, the result of this exercise is that we have six towels attached to each other through thread and Velcro.

1. What do you think will happen if we pull this assembly from both ends?
2. Which of these attachments will be weaker?
3. Suppose that a slight force applied to either end of the towels. Will the sewed junctions be torn apart?

Exactly the same situation exists in molecules. Just imagine the towels to be real atoms, such as hydrogen and chlorine. These two atoms are bound to each other through a *polar covalent bond* analogous to the thread. Each hydrogen chloride molecule in turn is bonded to the neighboring hydrogen chloride molecule through a *dipole-dipole attraction* analogous to Velcro. We will talk about dipole-dipole interactions in detail a bit later.

The polar covalent bond is much stronger in strength than the dipole-dipole interaction. The former is termed an ***intramolecular attraction*** while the latter is termed an ***intermolecular attraction***. So now we can define the two forces:

- *Intramolecular* forces are the forces that hold atoms together *within a molecule*.
- *Intermolecular* forces are forces that *exist between molecules.*

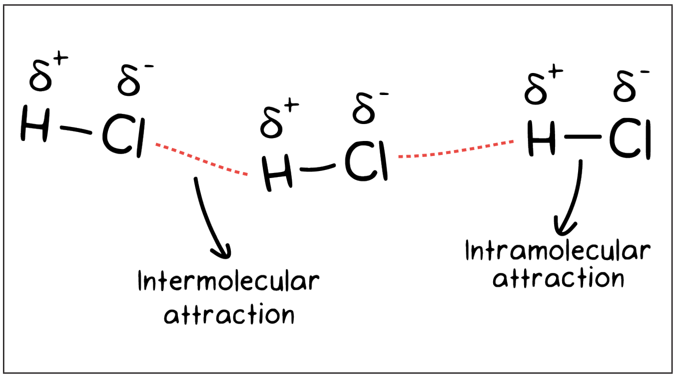


Figure 7.1.: Intermolecular and intramolecular attractions in HCl molecules

7.1. TYPES OF INTRAMOLECULAR BONDS

Activity 7.1

Consider the pairs of atoms given: Chlorine (Cl, Z = 17) and Sodium (Na, Z = 11), Fluorine (F, Z = 19) and Hydrogen (H, Z = 1).

a) Write the electron configuration of each of the atoms.

b) Suggest the possible reasons why

i. Chlorine needs to form bond with sodium to form NaCl.

ii. Fluorine will not let the present hydrogen be alone without making the bond with it to form HF.

Intramolecular bonds are the chemical bonds that hold the atoms of a molecule or compound together. These can be *covalent*, *ionic* or *metallic bonds*.

7.1.1. Covalent bond

this bond is formed between atoms that have similar electronegativities i.e. the affinity or desire for electrons. Because both atoms have similar affinity for electrons and neither has a tendency to donate them, they share electrons in order to achieve octet configuration and become more stable. A covalent bond involves electrons being shared between atoms.

Some covalently bounded compounds have a small difference in charge along one direction of the molecule. This difference in charge is called a dipole, and when the covalent bond results in this difference in charge, the bond is called a *polar covalent bond*.

- A **non-polar covalent bond** is formed between same atoms or atoms with very similar electro negativities where the difference in electronegativity between bonded atoms is less than 0.5.

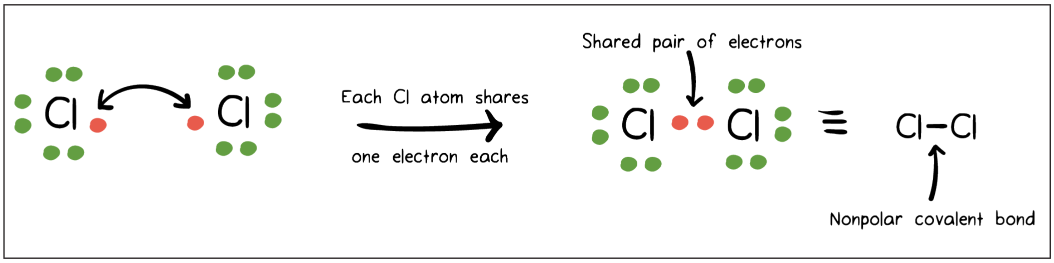


Figure 7.2.: Covalent bond forming between two Cl molecules

- A **polar covalent bond** is formed when atoms of slightly different electronegativities share electrons. The difference in electronegativity between bonded atoms is between 0.5 and 1.9. Hydrogen chloride, HCl; the O-H bonds in water and hydrogen fluoride, HF, are all examples of polar covalent bonds.

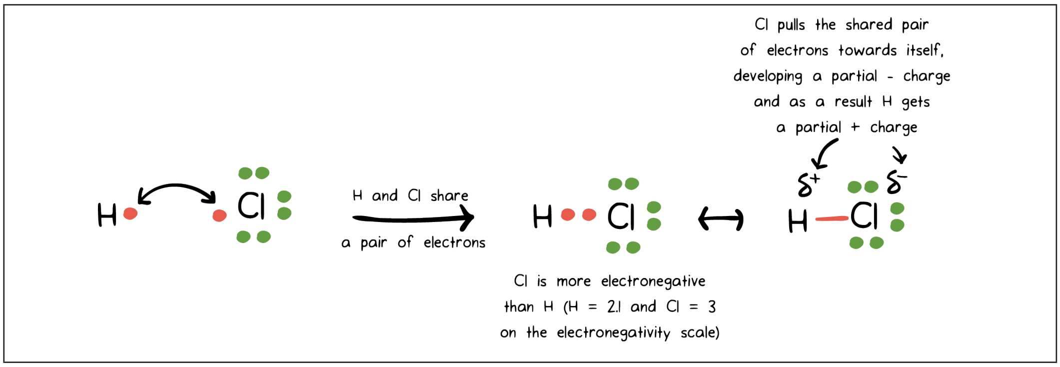


Figure 7.3.: Polar covalent bond forming between H and Cl

7.1.2. Ionic bond

this bond is formed by the complete transfer of valence electron(s) between atoms. It is a type of chemical bond that generates two oppositely charged ions. In ionic bonds, the metal loses electrons to become a positively charged cation, whereas the non-metal accepts those electrons to become a negatively charged anion.

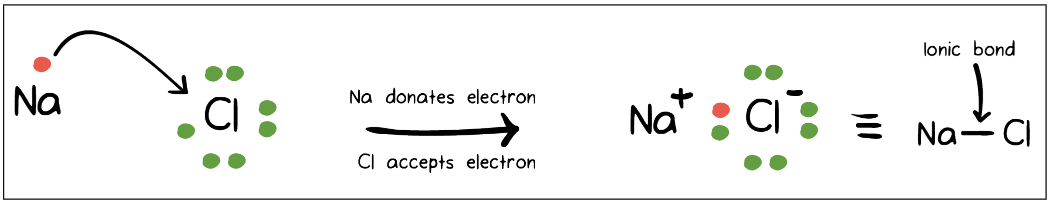


Figure 7.4.: Ionic bond forming between Na and Cl

Pure ionic bonding cannot exist: all ionic compounds have some degree of covalent bonding. Thus, an ionic bond is considered a bond where the ionic character is greater than the covalent character. The larger the difference in electronegativity between the two atoms involved in the bond, the more ionic (polar) the bond is. Bonds with partially ionic and partially covalent character are called polar covalent bonds.

7.1.3. Metallic bonding

this type of covalent bonding specifically occurs between atoms of metals, in which the *valence electrons are free to move through the lattice*. This bond is formed via the attraction of the mobile electrons, referred to as sea of electrons; and the fixed positively charged metal ions. Metallic bonds are present in samples of pure elemental metals, such as gold or aluminum, or alloys, like brass or bronze.

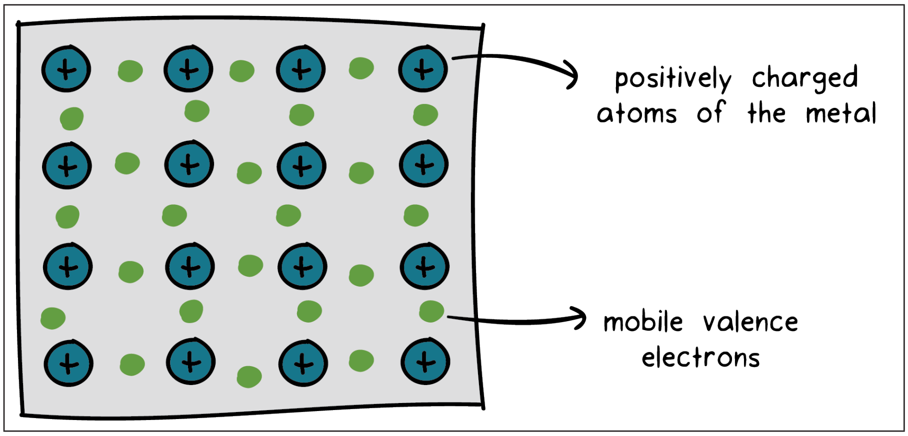


Figure 7.5.: Metal with positively charged atoms and mobile valence electrons

The freely moving electrons in metals are responsible for their reflecting property (freely moving electrons oscillate and give off photons of light) and their ability to effectively conduct heat and electricity.

Relative strength of the intramolecular forces

Intramolecular force	Basis of formation	Relative strength
Metallic bond	Metal cations to delocalized electrons	1 (strongest)
Ionic bond	Cations to anions	2
Polar covalent bond	Partially charged cation to partially charged anion	3
Non-polar covalent bond	Nuclei to shared electrons	4 (weakest)

Application activity 7.1

1. State two points of differences between covalent, ionic and metallic bonding.
2. Give the meaning of a polar covalent bond. State two examples of compounds with polar covalent bonds.
3. Use the knowledge acquired about the types of intra-molecular bonding to illustrate the formation of: Sodium chloride, magnesium oxide and magnesium chloride.
4. Aluminium is a metal which has many industrial applications.

   a) Describe the structure and bonding in aluminium metal.

   b) Explain two properties of aluminium as a metal which make it to be widely used.
5. The following compounds are examples of Period 3 chlorides: NaCl (Group 1), $MgCl_2$ (Group 2), $AlCl_3$ (Group 3) and $SiCl_4$ (Group 4). From the chlorides given, choose with explanations, one which is mostly:

   a) Covalent

   b) Ionic
6. Using a table salt as a typical example of ionic compounds, carry out experiments to show properties of ionic compounds (solubility in water, electrical conductivity of their aqueous solution and their brittleness).

7. Copy and complete the table below of the differences between ionic and covalent bonds, their properties, and how to recognize them:

	Ionic Bonds	Covalent Bonds
Description		
Polarity (High or Low)		
Melting Point (High or Low)		
Boiling Point (High or Low)		
State at Room Temperature		
Example		
Chemical Species		

7.2. PHYSICAL PROPERTIES OF METALS

Activity 7.2

With your colleagues, make a list of five metallic objects that are available at your proximity.

Discuss and find different physical properties they have in common and for each of the properties, suggest the cause of that property.

Because electrons are delocalized around positively-charged nuclei, metallic bonding explains many properties of metals.

1. **Electrical Conductivity**

Most metals are **excellent electrical conductors** because the **electrons in the electron sea are free to move and carry charge.** For example, electric wires in our homes are made of aluminium and copper. They are good conductor of electricity. Electricity flows most easily through gold, silver, copper and aluminium. Gold and silver are used for fine electrical contacts in computers.

2. **Thermal conductivity**

Metals conduct heat because the **free electrons are able to transfer energy away from the heat source** and also because **vibrations of atoms (phonons) move through a solid metal as a wave.** Cooking utensils and water boilers are also made of iron, copper and aluminium, because they are good conductors of heat.

3. Ductility

Metals **tend to be ductile or able to be drawn into thin wires** because **local bonds between atoms can be easily broken and also reformed.** Single atoms or entire sheets of them can slide past each other and reform bonds. Wires are mainly made from copper, aluminium, iron and magnesium.

4. Malleability

Metals **are often malleable or capable of being molded or pounded into a shape,** again because ***b*onds between atoms readily break and reform.** This ability to bend or be shaped without breaking occurs because **the electrons simply slide over each other instead of separating.** *The* binding force between metals is non-directional, so drawing or shaping a metal is less likely to fracture it. **Electrons in a crystal may be replaced by others.** Gold and Silver metals are the most malleable metals. They can be hammered into very fine sheets. Thin aluminium foils are widely used for safe wrapping of medicines, chocolates and food material.

5. Metallic Luster

Metals **tend to be shiny or display metallic luster.** They are opaque once a certain minimum thickness is achieved. The **electron sea reflects photons off the smooth surface** therefore there is an upper frequency limit to the light that can be reflected. Silver is a very good reflector. It reflects about 90% of the light falling on it. All modern mirrors contain a thin coating of metals. Due to their shiny appearance they can be used in jewellery and decorations.

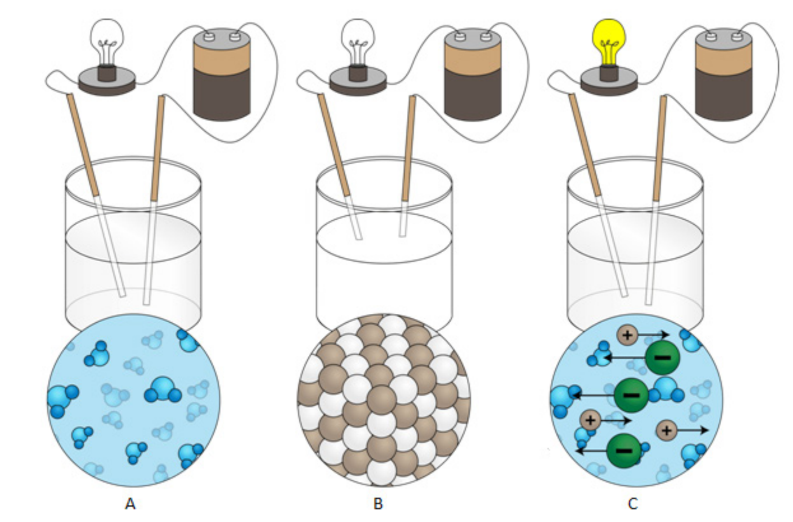
Application activity 7.2

1. Describe the formation of metallic bond and the physical properties of metals.
2. Give the difference between two properties: Malleability and Ductility

7.3. PROPERTIES OF COVALENT AND IONIC COMPOUNDS

Activity 7.3

The figure below shows the electric conductivity of distilled water, solid table salt and a solution of a table salt respectively.



a) State the types of bonding in water and in table salt.

b) Use the diagrams **A**, **B** and **C** to explain the observations from the set up.

i. No light is given out by bulb in **A**

ii. No light is given out by bulb in **B**

iii. Light is given out in **C**

c) Suppose that you have a 30 cm bar made of table salt. Suggest the change, if there is any, that can occur and deduce the property related, when this salt bar is:

i. Dropped from a table of 1 m high to the floor

ii. Immersed in water found in a water bath.

iii. Dry heated to 100 oC

d) In the experiments shown above, the electrodes used are made in copper metal. Deduce the electrical conductivity behaviour of covalent, ionic and metallic compounds

Almost all the compounds in Chemistry can be broadly categorized into ionic and covalent Compounds. They differ from each other due to the bonding type between the atoms that take part in making a molecule/ compound. As their names suggest, ionic compounds are made of ionic bonds, and covalent compounds are made of covalent bonds.

7.3.1. Properties of ionic compounds

here are the properties shared by the ionic compounds. Notice that the properties of ionic compounds relate to how strongly the positive and negative ions attract each other in an ionic bond.

1. **They have high melting points and high boiling points**

In an ionic lattice, there are ***many strong electrostatic attractions between oppositely charged ions.*** We therefore expect that ionic solids will have high melting points. On melting although the regular lattice is broken down, there will still be significant attractions between the ions in the liquid. This should result in high boiling points also.

The factors which affect the melting point of an ionic compound are:

- The **charge on the ions:** «*The greater the charge, the greater the electrostatic attraction, the stronger the ionic bond, the higher the melting point*»**.** For example, Melting Point of **NaCl** is **801 °C** and that of **MgO** is **2,800 °C**.
- The **size of the ions:** «*Smaller ions can pack closer together than larger ions so the electrostatic attraction is greater, the ionic bond is stronger, the melting point is higher* ». For example, Melting Point of **NaF** is **992 °C** and that of **CsF** is **2,800 °C**.

2. **Most ionic compounds are soluble in water**

This is because the electrostatic forces of the polar water molecules are stronger than the electrostatic forces keeping the ions together. When an ionic compound like NaCl is added to water, water molecules attract the positive and negative salt ions. Water molecules surround each ion and move the ions apart from each other. The separated ions dissolve in water. There are several exceptions, however, where the electrostatic forces between the ions in an ionic compound are strong enough that the water molecules cannot separate them. Despite these few limitations, water's ability to dissolve ionic compounds is one of the major reasons it is so vital to life on Earth. Ionic compounds are generally insoluble in non-polar solvents like kerosene.

3. **They are hard and brittle**

Ionic crystals are hard because the positive and negative ions are strongly attracted to each other and difficult to separate, however, ionic solids ***are brittle***. When a stress is applied to the ionic lattice, the layers shift slightly. The layers are arranged so that each cation is surrounded by anions in the lattice. If the layers shift then ions of the same charge will be brought closer together. Ions of the same charge will repel each other, so the lattice structure breaks down into smaller pieces.

4. **They conduct electricity when molten or dissolved in water**

In order for a substance to conduct electricity, it must contain mobile particles capable of carrying charge.

- **Solid** ionic compounds ***do not conduct electricity*** because the ions (charged particles) are locked into a rigid lattice or array. The ions cannot move out of the lattice, so the solid cannot conduct electricity.
- When is **molten**, the ions *are free to move* out of the lattice structure.
- Cations (positive ions) *move towards the negative electrode* (cathode): $M^+ + e^- \rightarrow M$
- Anions (negative ions) *move towards the positive electrode* (anode): $X^- \rightarrow X + e^-$
- When is **dissolved in water** to form an aqueous solution, the ions are released from the lattice structure and ***are free to move*** so the solution conducts electricity just like the molten (liquid) ionic compound.

5. **They form crystals**

Ionic compounds form *crystal lattices* rather than *amorphous solids*. Although molecular compounds form crystals, they frequently take other forms but molecular crystals typically are softer than ionic crystals. At an atomic level, an ionic crystal is a regular structure, with the cation and anion alternating with each other and forming a three-dimensional structure based largely on the smaller ion evenly filling in the gaps between the larger ions.

7.3.2. Properties of covalent compounds

1. **Most covalent compounds have relatively low melting points and boiling points.**

While the ions in an ionic compound are strongly attracted to each other, covalent bonds create molecules that can separate from each other when a lower amount of energy is added to them. Therefore, molecular compounds usually have low melting and boiling points.

2. **Covalent compounds tend to be soft and relatively flexible.**

This is largely because covalent bonds are relatively flexible and easy to break. The covalent bonds in molecular compounds cause these compounds to take form as gasses, liquids, and soft solids. As with many properties, there are exceptions, primarily when molecular compounds assume crystalline forms.

3. **Covalent compounds tend to be more flammable than ionic compounds.**

Many flammable substances contain hydrogen and carbon atoms which can undergo combustion, a reaction that releases energy when the compound reacts with oxygen to produce carbon dioxide and water. Carbon and hydrogen have comparable electronegativies so they are found together in many molecular compounds.

4. **When dissolved in water, covalent compounds do not conduct electricity.**

Ions are needed to conduct electricity in an aqueous solution. Molecular compounds dissolve into molecules rather than dissociate into ions, so they typically do not conduct electricity very well when dissolved in water.

5. **Many covalent compounds do not dissolve well in water.**

There are many exceptions to this rule, just as there are many salts (ionic compounds) that do not dissolve well in water. However, many covalent compounds are polar molecules that do dissolve well in a polar solvent, such as water. Examples of molecular compounds that dissolve well in water are sugar and ethanol. Examples of molecular compounds that do not dissolve well in water are oil and polymerized plastic.

Note that **network solids** are compounds containing covalent bonds that violate some of these «rules». Diamond, for example, consists of carbon atoms held together by covalent bonds in a crystalline structure. Network solids typically are transparent, hard, good insulators and have high melting points.

In summary:

1. Ionic compounds are formed by the transfer of electrons that are positively and negatively charged, whereas, covalent compounds are formed by sharing the electrons.
2. The melting and boiling points of ionic compounds are *much higher* compared to those of the covalent compounds.
3. Ionic compounds are *hard and crystal-like*, while covalent compounds are *softer and more flexible*.

4. Covalent compounds are more flammable when compared to ionic compounds.
5. Ionic compounds are *more soluble in water* than covalent compounds.

Application activity 7.3

1. Use a table to compare the properties of ionic and covalent compounds.
2. For each of the following statements about the properties ionic and covalent compounds, give a reason.
   a) The melting and boiling points of ionic compounds are much higher compared to those of the covalent compounds.
   b) Covalent compounds are more flammable when compared to ionic compounds.
   c) Ionic compounds are more soluble in water than covalent compounds.
   d) Ionic compounds are hard and crystal-like, while covalent compounds are softer and more flexible.

7.4. INTERMOLECULAR FORCES

Activity 7.4

Investigate different types of intermolecular forces: Dispersion forces, induced dipole-dipole forces, dipole-dipole forces, and hydrogen bonding.

Use your textbook and/or the Internet to learn about each type.

– Make a table that explains each intermolecular force.
– What holds the molecules together
– The relative strength of the intermolecular force
– A drawing (diagram/ model) of the force

7.4.1. Definition, types and origin of intermolecular forces

Intermolecular forces are the forces between molecules forces between molecules that bind them together. Intermolecular forces are like the glue that holds molecules together. There are strong and weak forces; the stronger the force, the more energy is required to break those molecules apart from each other.

Intermolecular forces are ***much weaker*** than the intramolecular forces of attraction but are important because they determine the physical properties of molecules like their boiling point, melting point, density, and enthalpies of fusion and vaporization.

Intermolecular forces include (listed from weakest to strongest):

- Van der Waals dispersion forces
- Van der Waals dipole-dipole interactions
- Hydrogen bonding

So, if two molecules are only connected using van der Waals dispersion forces, then it would require very little energy to break those molecules apart from each other. On the other hand, if two molecules are connected using ionic bonds, it takes a whole lot more energy to break those two apart.

1. Van der Waals Dispersion Forces

Van der Waals dispersion forces, also called London forces, occur due to instantaneous dipoles. At any given moment the electrons in a molecule or atom may not be evenly distributed around the molecule. If more electrons are on the left side of the molecule than on the right side, then there will be a slight (partial) negative charge on the left side of the molecule. The side with fewer electrons will have a slight (partial) positive charge.

These momentary, partial, positive and negative charges are attracted to each other (like the positive and negative ends on a magnet). This causes momentary bonds between molecules.

Van der Waals dispersion forces increase as the atomic size increases. This means that larger molecules will feel more force, thus increasing the intermolecular forces. So if we have two molecules that are exactly the same except that one is bigger than the other (such as methane and ethane), then the intermolecular forces of the bigger one will be stronger than for the smaller one.

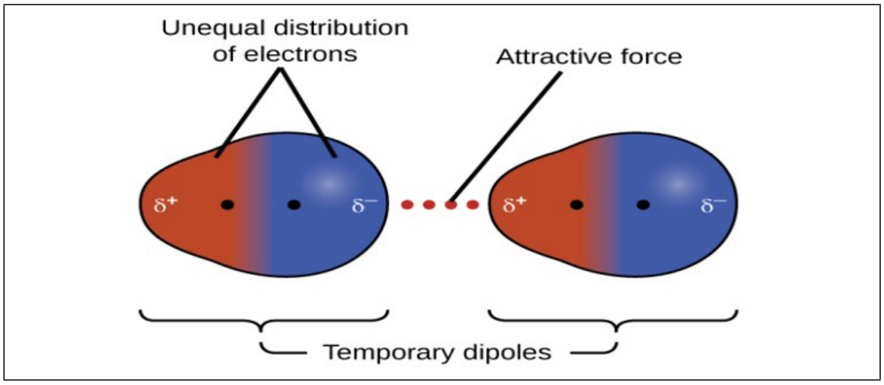


Figure 7.6.: Dispersion forces result from the temporary dipoles for two non-polar diatomic molecules.

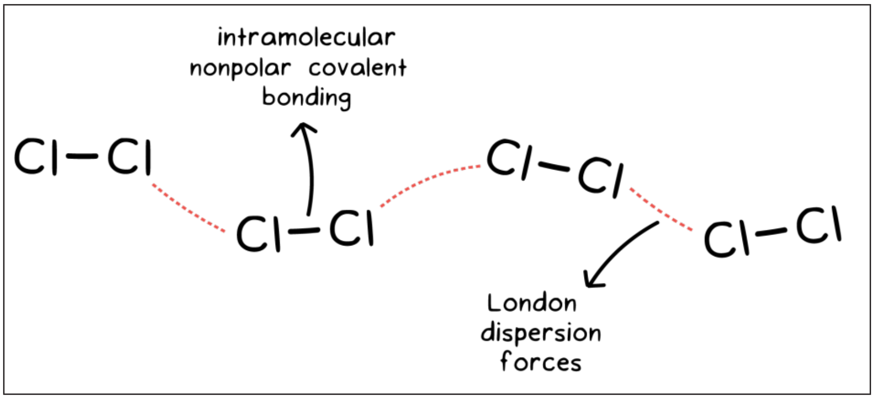


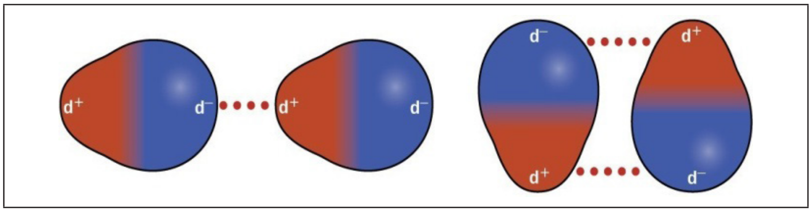
Figure 7.7.: Intramolecular non-polar covalent bonding between Cl-atoms and London dispersion forces between Cl-Cl molecules

2. Van der Waals Dipole-Dipole Interactions

A partial positive charge and a partial negative charge can be created between two atoms when there is a difference in electronegativity. These interactions are called van der Waals dipole-dipole interactions.

For example, carbon is less electronegative than oxygen, creating a partial positive on carbon and a partial negative on oxygen. The dipole interactions are stronger than the dispersion forces because the oxygen will almost always have slightly more electrons than the carbon, instead of constantly changing. There still is not a full negative charge on the oxygen, or a full positive charge on the carbon. But the partial positive and negative charges are still enough to attract opposite charges together.

The *higher the difference in electronegativity, the strong the dipole-dipole interactions will be.* So compounds with a higher electronegativity difference will have strong intermolecular forces.



This image shows two arrangements of polar molecules, such as HCl, that allow an attraction between the partial negative end of one molecule and the partial positive end of another.

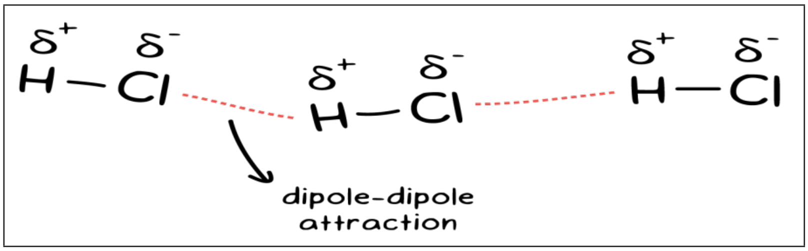


Figure 7.8.: H-Cl to H-Cl dipole-dipole attraction

3. Hydrogen bonding

This is *a special kind of dipole-dipole interaction that occurs between a hydrogen atom bonded to a high electronegative atom,* specifically either an oxygen, nitrogen, or fluorine atom. The partially positive end of hydrogen is attracted to the partially negative end of the ***oxygen, nitrogen,*** or ***fluorine*** of another molecule. A hydrogen bond is usually represented as a dotted line between the hydrogen and the unshared electron pair of the other electronegative atom.

Hydrogen bonding is a relatively strong force of attraction between molecules, and considerable energy is required to break hydrogen bonds. This explains the exceptionally high boiling points and melting points of compounds like water and hydrogen fluoride.

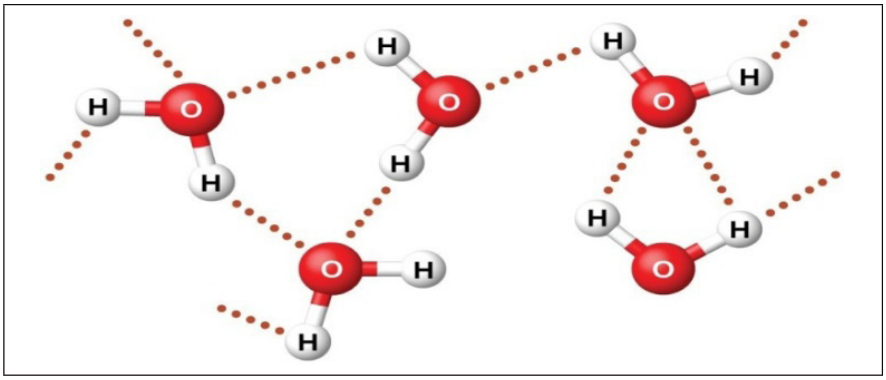


Fig. 7.8.: Water molecules participate in multiple hydrogen-bonding interactions with near-by water molecules.

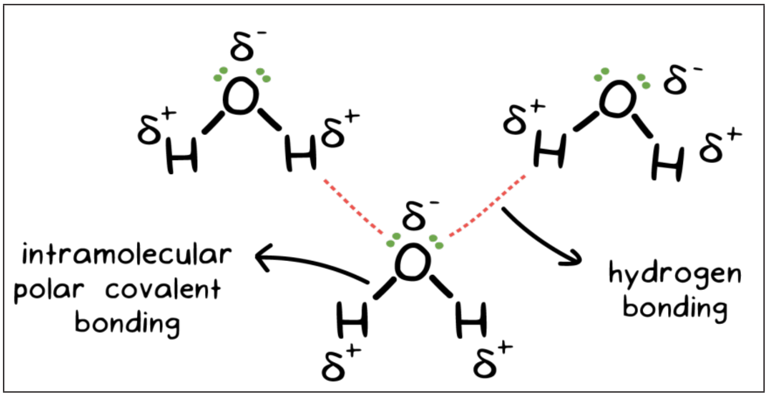


Fig. 7.9.: Intramolecular polar covalent bonding within H2O molecules and hydrogen bonding between O and H atoms

7.4.2. Effect of intramolecular forces on physical properties of certain molecules

Intermolecular forces control how well molecules stick together. This affects many of the measurable physical properties of substances:

- **Melting and Boiling Points**

If molecules stick together more, they will be tougher to break apart
Stronger intermolecular forces → higher melting and boiling points

- **Viscosity**

Viscosity is a measure of how well substances flow.
Stronger intermolecular forces → higher viscosity.

- **Surface Tension**

Surface tension is a measure of the toughness of the surface of a liquid
Stronger intermolecular forces → higher surface tension.

- **Vapour Pressure**

This is a small amount of gas that is found above all liquids.
Stronger intermolecular forces → Lower vapour pressure.

Note: If you are asked to rank molecules in order of melting point, boiling point, viscosity, surface tension or vapour pressure, what they are actually asking is for you to rank them by strength of intermolecular forces (either increasing or decreasing).
Here is the strategy for this:

- Look for molecules with *hydrogen bonding*. They will have the strongest intermolecular forces.

- Look for molecules with *dipoles*. These will have the next strongest intermolecular forces.
- Larger molecules will *have stronger London dispersion forces*. These are the weakest intermolecular forces but will often be the deciding factor in multiple choice questions.

If we use this trend to predict the boiling points for the ***lightest hydride for each group***, we would expect NH_3 to boil at about **–120 °C**, H_2O to boil at about **–80 °C**, and HF to boil at about **–110 °C**. However, when we measure the boiling points for these compounds, we find that they are dramatically higher than the trends would predict, as shown in the figure below. The stark contrast between our naïve predictions and reality provides compelling evidence for the strength of hydrogen bonding

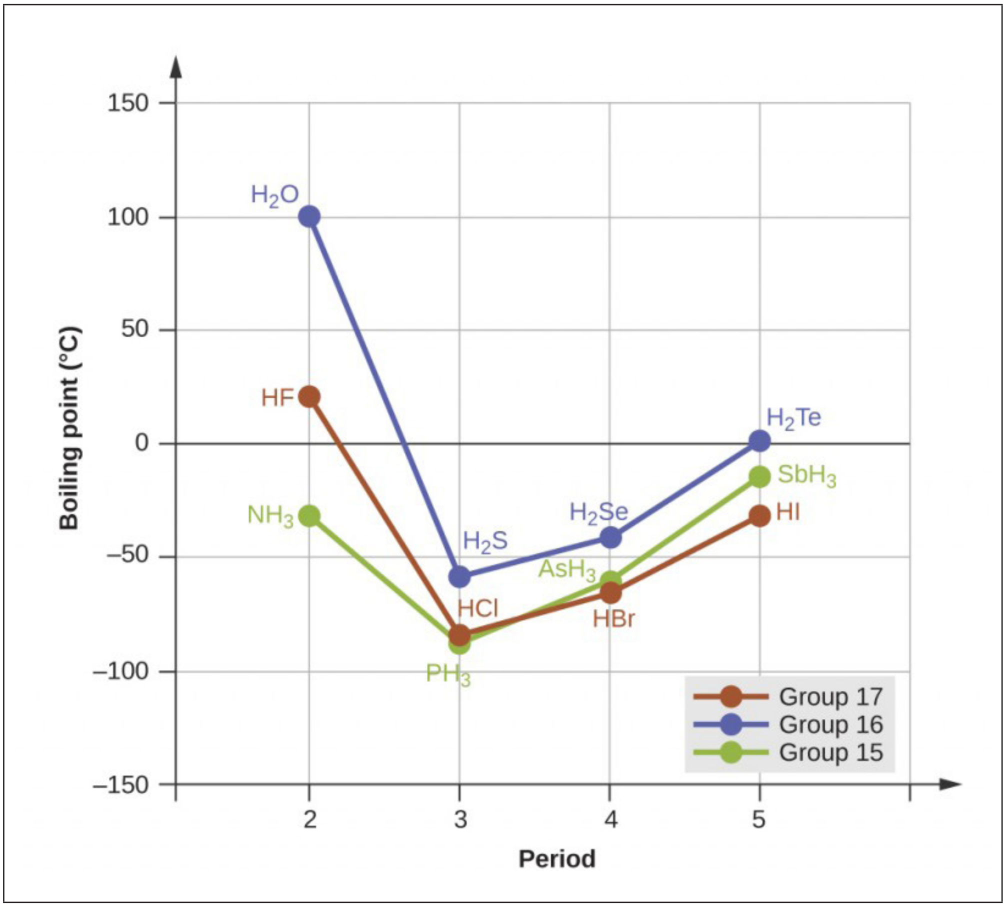


Fig. 7.10.: Comparison of the melting points of some hydrides of groups 17, 16 and 15

These exhibit anomalously high boiling points due to **hydrogen bonding**. Hydrogen bonding is important in many chemical and biological processes. It is responsible for water's unique solvent capabilities.

Hydrogen bonds hold complementary strands of DNA together, and they are responsible for determining the three-dimensional structure of folded proteins including enzymes and antibodies.

1. Water

Since oxygen is more electronegative than hydrogen, oxygen pulls the shared electrons more closely to itself. This gives the oxygen atom a slightly more negative charge than either of the hydrogen atoms. This imbalance is called a dipole, causing the water molecule to have a positive and negative side, almost like a tiny magnet. Water molecules align so the hydrogen on one molecule will face the oxygen on another molecule. This gives water a greater viscosity and also allows water to dissolve other molecules that have either a slightly positive or negative charge.

2. Protein Folding

Protein structure is partially determined by hydrogen bonding. Hydrogen bonds can occur between a hydrogen on an amine and an electronegative element, such as oxygen on another residue. As a protein folds into place, a series of hydrogen bond "zips" the molecule together, holding it in a specific three-dimensional form that gives the protein its particular function.

3. DNA

Hydrogen bonds hold complementary strands of DNA together. Nucleotides pair precisely based on the position of available hydrogen bond donors (available, slightly positive hydrogens) and hydrogen bond acceptors (electronegative oxygens). The nucleotide thymine has one donor and one acceptor site that pairs perfectly with the nucleotide adenine's complementary acceptor and donor site. Cytosine pairs perfectly with guanine through three hydrogen bonds.

4. Antibodies

Antibodies are folded protein structures that precisely target and fit a specific antigen. Once the antibody is produced and attains its three-dimensional shape (aided by hydrogen bonding), the antibody will conform like a key in a lock to its specific antigen. The antibody will lock onto the antigen through a series of interactions including hydrogen bonds. The human body has the capacity to produce over ten billion different types of antibodies in an immunity reaction.

Application activity 7.4

1. Base on several physical properties of three liquids: Water, ethanol, and cyclohexane. How do intermolecular forces relate to the physical properties of substances?
2. Describe the role played by hydrogen bonding in biological molecules like proteins and DNA.
3. Suppose that the boiling points of ethanol (CH_3CH_2OH) and methanol (CH_3OH) are all above 50^oC. Given that the boiling point of ethanol is 78.3^oC; predict with reasons, the boiling point of methanol.

End unit assessment

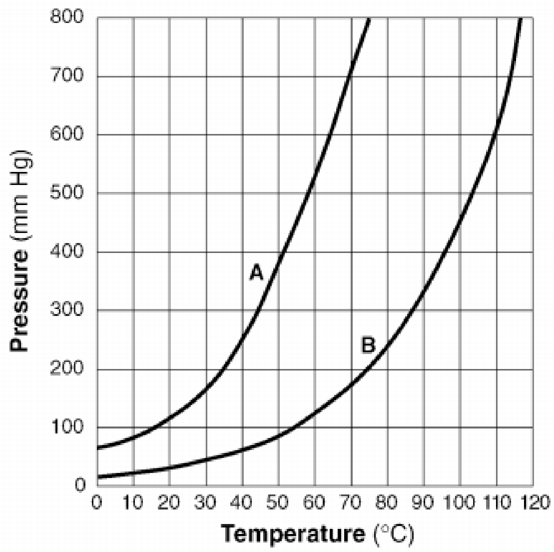
1. Base your answer to the following question on the information below.
   - Carbon forms molecular compounds with some elements from Group 16. Two of these compounds are carbon dioxide, CO_2, and carbon disulfide, CS_2.
   - Carbon dioxide is a colorless, odorless gas at room temperature. At standard temperature and pressure, $CO_2(s)$ changes directly to $CO_2(g)$.
   - Carbon disulfide is formed by a direct reaction of carbon and sulfur. At room temperature, CS_2 is a colorless liquid with an offensive odor. Carbon disulfide vapors are flammable.

Compare the intermolecular forces in CO_2 and CS_2 at room temperature.

2. Base your answer to the following question on the information below.

Naphthalene, a nonpolar substance that sublimes at room temperature, can be used to protect wool clothing from being eaten by moths. Explain, in terms of intermolecular forces, why naphthalene sublimes.

3. Base your answer to the following question on the graph below, which shows the vapor pressure curves for liquids A and B.



Which liquid will evaporate more rapidly? Explain your answer in terms of intermolecular forces.

4. Base your answer to the following question on the information below and on your knowledge of chemistry.

   Rubbing alcohol is a product available at most pharmacies and supermarkets. One rubbing alcohol solution contains 2-propanol and water. The boiling point of 2-propanol is 82.3°C at standard pressure. Explain in terms of electronegativity differences, why a C–O bond is more polar than a C–H bond.

5. Base your answer to the following question on the information below.

Physical Properties of CF_4 and NH_3 at Standard Pressure

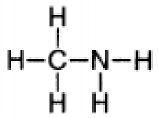
Compound	Melting Point (°C)	Boiling Point (°C)	Solubility in Water at 20.0°C
CF_4	–183.6	–127.8	insoluble
NH_3	–77.7	–33.3	soluble

a) State evidence that indicates NH_3 has stronger intermolecular forces than CF_4.

b) Base your answer to the following question on the information below.

6. Bond energy is the amount of energy required to break a chemical bond. The table below gives a formula and the carbon-nitrogen bond energy for selected nitrogen compounds.

Selected Nitrogen Compounds

Compound	Formula	Carbon-Nitrogen Bond Energy (kJ/mol)
hydrogen cyanide	H−C≡N	890.
isocyanic acid	H−N=C=O	615
methanamine		293

Explain, in terms of charge distribution, why a molecule of hydrogen cyanide is polar

7. Base your answers to the following questions on the table below.

Physical Properties of Four Gasses

Name of Gas	hydrogen	hydrogen chloride	hydrogen bromide	hydrogen iodide
Molecular Structure	H-H	H-Cl	H-Br	H-I
Boiling Point (K) at 1 Atm	20.	188	207	237
Density (g/L) at STP	0.0899	1.64	?	5.66

a) Explain, in terms of molecular polarity, why hydrogen chloride is more soluble than hydrogen in water under the same conditions of temperature and pressure.

b) Explain, in terms of intermolecular forces, why hydrogen has a lower boiling point than hydrogen bromide.

c) Explain, in terms of electronegativity difference, why the bond in H bonding is stronger.

8. Base your answers to the following questions on the information below.

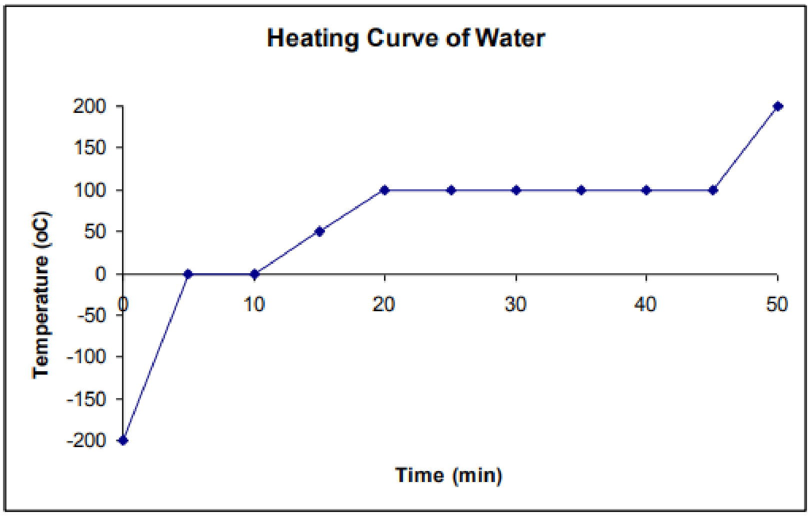
Each molecule listed below is formed by sharing electrons between atoms when the atoms within the molecule are bonded together.

Molecule A: Cl_2 Molecule B: CCl_4 Molecule C: $[NH_3–Cl]^+$ is more polar than the bond in H–I.

a) Explain why NH_3 has stronger intermolecular forces of attraction than Cl_2.

b) Explain why CCl_4 is classified as a non-polar molecule.

9. Examine the heating curve of water below



a) Indicate the key temperatures on the graph. Indicate the state(s) of matter present along each major section of the graph (HINT: look at the temperature scale and remember when water freezes and boils).

b) Draw a picture of what the water molecules look like in each section of your graph. Be as specific as possible.

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