CBC

INTEGRATED SCIENCE

GRADE 9

FIRST EDITION

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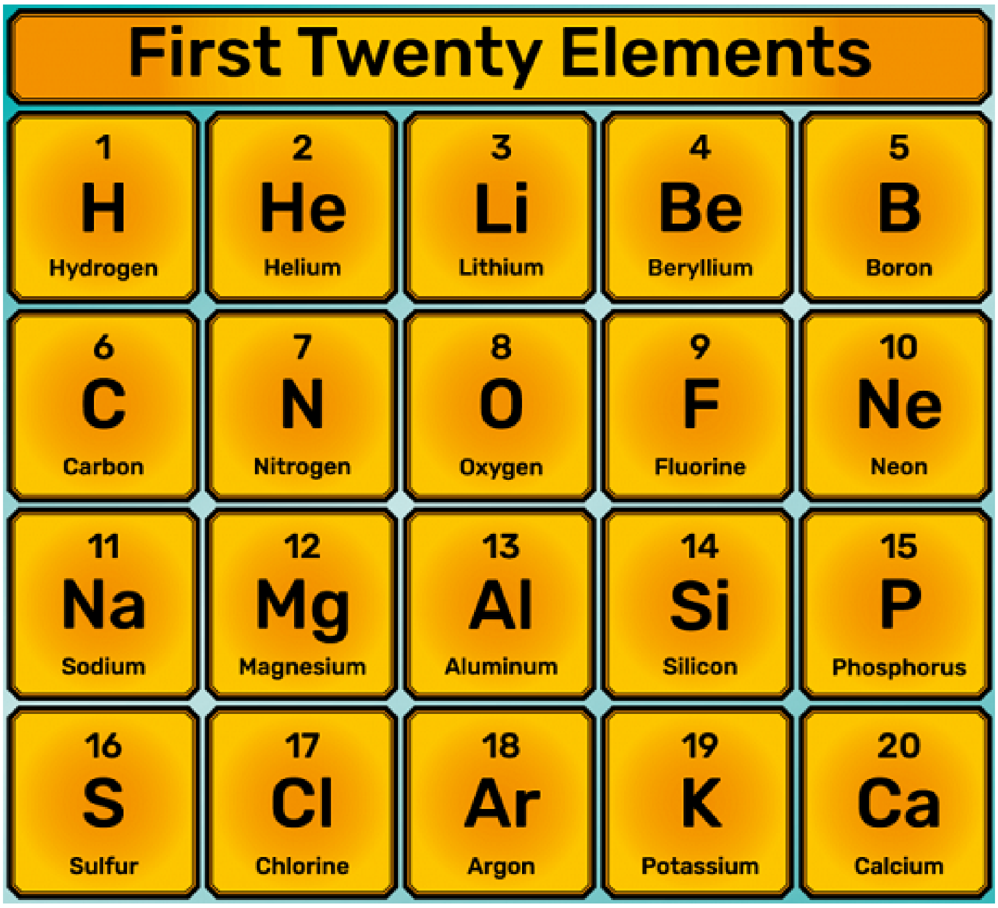
Simple Structure of the Atom

The are there are about 119 known elements

The following illustration shows the names and symbols of first 20 elements of the periodic table.



Atoms are very small particles of an element, but they contain even smaller particles called sub-atomic particles as follows;

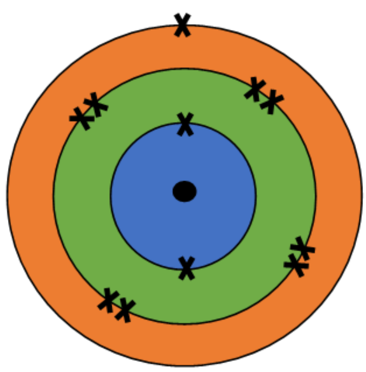
- **Protons -** found in the nucleus, they are positively charged (+ve)
- **Electrons -** found in the nucleus, they are negatively charged (□ve)
- **Neutrons -** they can be imagined as circulating the nucleus in energy levels, they have no charge
- In a neutral atom, *Number of protons = Number of electrons*

Particles present in an atom are summarized below.

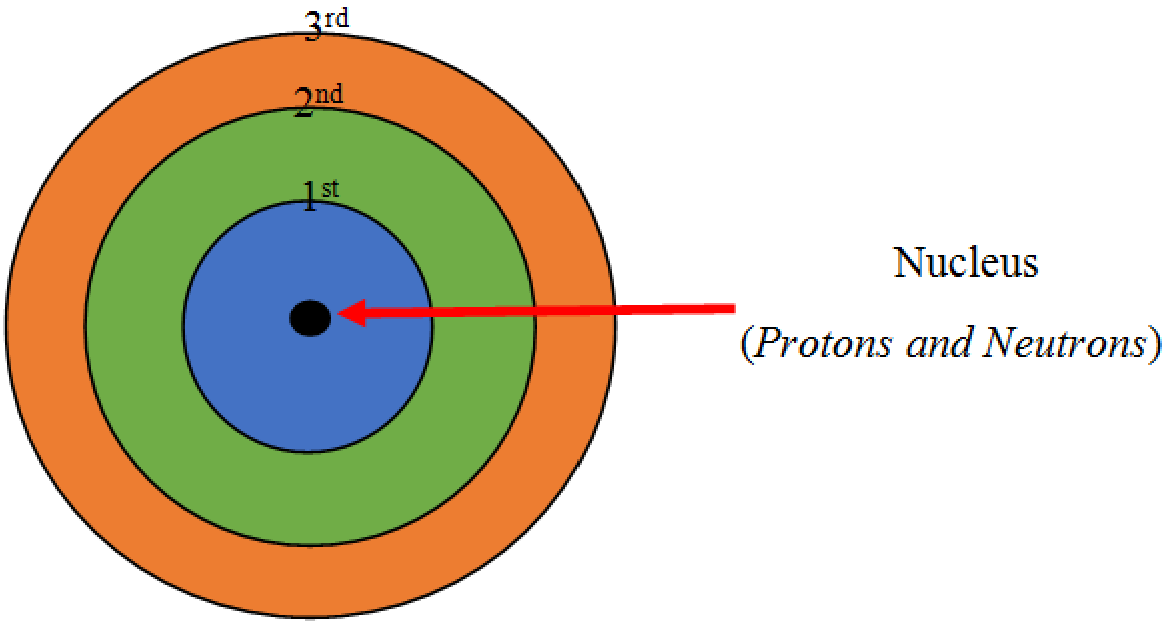
Sub-atomic Particle	Mass	Charge	Where found in atom
Proton	1	+ (Positive)	inside nucleus
Neutron	1	0 (Neutral)	inside nucleus
Electron	1/1840	- (Negative)	outside nucleus

Structure of the Atom

The various energy levels in an atom are represented by a series of circles sharing the same centre (nucleus), separated from each other by roughly equal distances



The nucleus of the atom is at the centre of the circles. The electrons in the energy levels are represented by dots (.) or crosses (x). The energy levels are labelled 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and so on starting from the one nearest to the nucleus as shown below;



The electrons that occupy the 1st energy level have lower energy than those in the 2nd energy level. Subsequently those in the 2nd energy level have lower energy than those in the 3rd energy level and so on. The 1st energy level usually has a maximum of two electrons while the 2nd energy level has a maximum of eight (8) electrons.

We can summarise the electrons, and their arrangement in each energy level as shown in the table below.

Element	Symbol	Electron Configuration
Hydrogen	H	1
Helium	He	2
Lithium	Li	2.1

Element	Symbol	Electron Configuration
Beryllium	Be	2.2
Boron	B	2.3
Carbon	C	2.4
Nitrogen	N	2.5
Oxygen	O	2.6
Fluorine	F	2.7
Neon	Ne	2.8
Sodium	Na	2.8.1
Magnesium	Mg	2.8.2
Aluminium	Al	2.8.3

Element	Symbol	Electron Configuration
Silicon	Si	2.8.4
Phosphorous	P	2.8.5
Sulphur	S	2.8.6
Chlorine	Cl	2.8.7
Argon	Ar	2.8.8
Potassium	K	2.8.8.1
Calcium	Ca	2.8.8.2

Atomic Characteristics

Atomic Number and Mass Number

The atomic number tells us *how many protons* are there in a nucleus. It is denoted by letter Z.

It also tells us the number of electrons in an atom

Atomic Number = Number of Protons = Number of Electrons

The mass number is the sum of protons and neutrons, therefore it is always bigger than the atomic number. It is denoted by letter A.

Roughly the mass number is double the atomic number.

To get the number of neutrons, we just subtract the atomic number from the mass number, that is A Z.

Atom	Symbol	Number of Protons: Atomic number, Z	Neutrons	Mass Number, A
Hydrogen	H	1	0	1
Carbon	C	6	6	12
Nitrogen	N	7	7	14
Sodium	Na	11	12	23
Chlorine	Cl	17	18	35

Example

Calculate the number of neutrons in a chlorine atom given that the atomic number, Z = 17 and mass number, A = 35

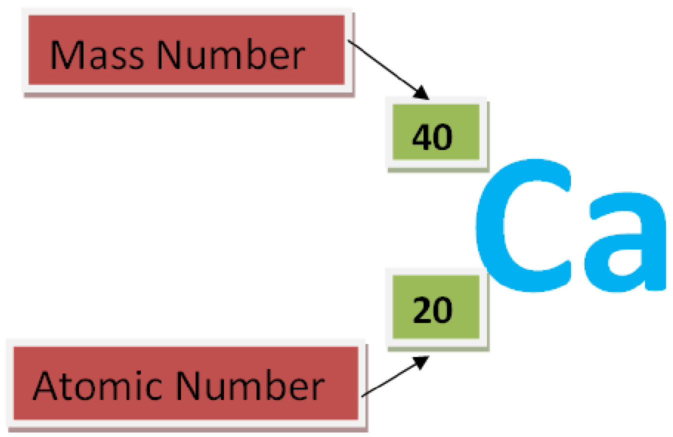
The number of neutrons

= A − Z

= 35 − 17

= 18

Usually, the atomic number, Z, and mass number A, of an atom of an element X can be written alongside the symbol of that element, one as a superscript and the other a subscript as shown below

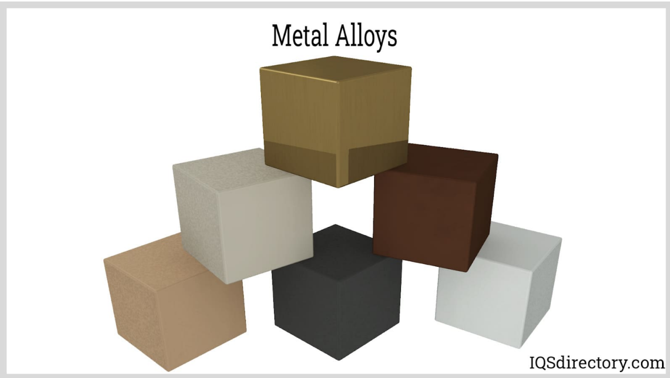


NOTE: The top number is referred to as the superscript and bottom number as the subscript

Metal and alloys

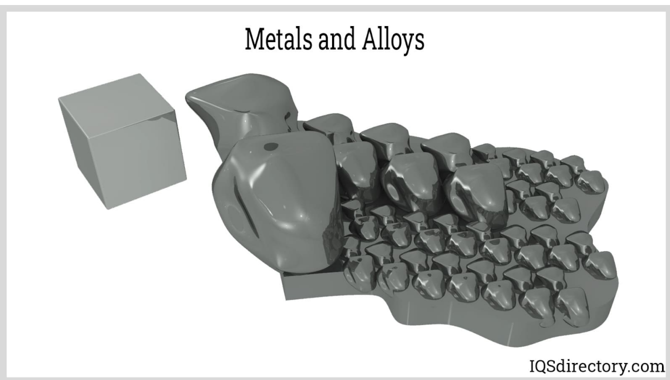
Alloys

Metal alloys are created by combining two or more elements to form a new material. These alloys can be composed entirely of metals or a mix of metals and non-metals. While the combination results in a new alloy, it retains the properties of the original metals, such as electrical conductivity, opacity, ductility, and luster.



However, they may exhibit traits distinct from pure metals, such as increased hardness or strength. In some cases, an alloy can retain the essential properties of a metal while reducing overall material costs. Additionally, the chemical combination in alloys can impart synergistic qualities to the component metals, such as enhanced corrosion resistance or improved mechanical strength.

For practical applications, alloy components are usually measured by mass percentage, while atomic fraction is used in fundamental scientific research. Alloys are categorized based on their atomic arrangement: substitutional alloys, where some atoms of the base metal are replaced by another element; interstitial alloys, where smaller atoms fit into the gaps between metal atoms; and heterogeneous alloys, which consist of two or more distinct phases. Additionally, alloys can be classified as intermetallic compounds or homogeneous alloys, which have a single phase. An alloy may either be a blend of different metallic phases or a solid solution, where all metal grains (crystals) share the same composition.



Characteristics of Alloys

- ✓ An alloy is a mixture of chemical elements that creates a material with metal-like properties, combining at least one metal with other elements. Unlike impure metals, such as wrought iron, which are less controlled but still useful, alloys are carefully engineered to achieve specific characteristics. The main metal in the alloy is often called the base metal or primary metal, and the alloy may be named after it.

- ✓ The additional elements in an alloy, which may or may not be metals, are soluble in the molten base metal and integrate into the mixture.

- ✓ The mechanical characteristics of alloys are frequently very different from those of their base metal. Alloying a metal with another soft metal, such as copper, can change a metal that is typically highly soft (malleable), such as aluminum.
- ✓ Despite the fact that both metals are relatively ductile and soft, the final alloy of aluminum will be stronger.
- ✓ By adding a small amount of non-metallic carbon to iron, its excellent ductility is exchanged for the increased strength of an alloy known as steel. Steel is a highly practical and widely-used alloy due to its remarkable strength, substantial toughness, and the ability to undergo significant modification through heat treatment.

- ✓ Additionally, steel can be enhanced for specific purposes: chromium can be added to improve corrosion resistance (resulting in stainless steel), or silicon can be incorporated to enhance electrical conductivity (producing silicon steel).

Metals

- ➢ Pure metals consist of a single type of atom and exhibit a uniform structure, making them single-phase metals. In contrast, alloyed metals are combinations of pure metals mixed in specific percentages to create a composite with distinct properties.

- ➢ Pure metals have defined mass, melting point, and physical characteristics. However, pure metals, with some exceptions, generally lack the strength, toughness, and durability of alloyed metals, which is why they are often used as components in alloys.

- ➢ All metal products incorporate a form of pure metal that has been alloyed. While the periodic table lists numerous pure metals, only a few are widely used in commercial products and are present in various metal items.

- ➢ Metals such as iron, aluminum, copper, zinc, titanium, chromium, and nickel are commonly used to manufacture both commercial and industrial products.

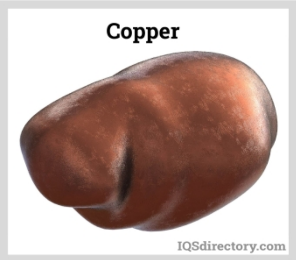
- ➢ Alloys derived from pure metals play a crucial role in modern society. Metallurgists and engineers continually explore innovative methods to blend pure metals, creating alloys that are both strong and durable. During the Bronze Age, early metallurgists developed techniques to mix pure metals, resulting in stronger and more resilient products. To qualify as "pure," a metal must consist of 99% or more of that metal without any alloying.

Copper

- Copper was among the first metals discovered by humans. Known for its remarkable malleability, it also boasts excellent thermal and electrical conductivity.

- Copper's resistance to corrosion and its durability make it a valuable material. Unlike many pure metals, copper is frequently utilized in its pure form, especially in electronic products, due to its superior conductivity.

- Additionally, its resilience in high-moisture environments contributes to its long-lasting nature.



Aluminum

- Similar to copper, aluminum is utilized in its pure form because of its excellent thermal and electrical conductivity, ease of workability, and resistance to corrosion.

- Pure aluminum, which is soft and has a silvery-white appearance, belongs to the boron group of metals and has an atomic number of 13.

- In addition to its various alloys, pure aluminum is commonly used in power lines, beer kegs, window frames, automobiles, and kitchen utensils.

- When exposed to oxygen, aluminum develops a protective oxide layer that safeguards its surface from environmental damage.

Iron

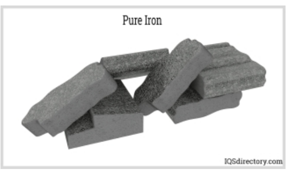
- Iron is a hard, brittle metal that corrodes when exposed to moisture and high temperatures.

- Most of the iron mined is used to produce steel by alloying it with carbon. Its widespread use is due to its affordability and strength.

- Iron is a gray, silvery metal with magnetic properties and reacts readily with acids.

- It rusts easily in the presence of air and water, which is why it is typically alloyed to maintain its strength.

- Pure iron is 99.8% iron, with small amounts of carbon, manganese, and other elements.



Nickel

- Nickel, similar to aluminum, develops a passivation layer when exposed to oxygen, which safeguards it against corrosion.
- While both nickel and aluminum are silver-white metals, nickel has a distinct golden hue.
- Nickel is a hard, ductile metal with chemical reactivity and is magnetic at room temperature.
- Its corrosion resistance makes it a popular choice for alloys and coatings. Nickel is commonly used in products such as wiring, batteries, and electrodes.
- Additionally, like copper and aluminum, nickel exhibits excellent thermal conductivity, which is why it is also utilized in heat exchangers.

Chromium

- Chromium is a pure metal known for its ability to form a protective oxide layer. It is a lustrous, brittle, and hard metal primarily used in producing stainless steel and for plating, thanks to its bright, polished finish.
- Chromium can exist in various oxidation states ranging from -2 to +6, with the +0, +3, and +6 states being the most stable.
- Its widespread use stems from its shiny appearance, which enhances the aesthetic appeal of products like cars and household appliances.

Zinc

- Pure zinc is utilized as a protective coating because of its excellent corrosion resistance. This bluish-white metal is commonly used in alloys.
- In the galvanization process, a layer of zinc is applied to iron and steel, significantly enhancing their resistance to corrosion.
- Zinc is also alloyed with aluminum and copper to boost their strength, durability, and other properties.
- As the zinc content increases, copper and aluminum alloys become stronger, more durable, and highly resilient, though they also become more challenging to work with.

Titanium

- Titanium boasts a high strength-to-weight ratio, is highly resistant to rust, and can withstand a wide range of chemicals.
- The pure titanium grades are 1, 2, 3, and 4. Grade 1 is the softest and most formable, while Grade 2 offers increased strength. Grade 3 provides even more strength, is weldable, and highly resistant to corrosion.

- Grade 4 is the strongest of the pure titanium grades, though it is the least malleable. It is durable, strong, and weldable, and can be cold worked. Among pure metals, titanium is particularly versatile, as it can be used in its pure form or alloyed with other metals to create exceptionally durable materials.

Different types of metal alloys

The different types of metal alloys are:

Steel

- Steel is an alloy primarily composed of iron with a small amount of carbon, which enhances its strength and resistance to fractures.

- The temperature of steel affects its crystalline structure, which can be either body-centered cubic or face-centered cubic.

- The way iron's allotropes interact with other elements in the steel imparts its distinctive and unique properties.

Properties of Steel

- **Hardness:** Hardness is the ability of a metal to withstand friction and abrasion, which is one of the most important properties of steel.
- **Toughness:** Toughness is the ability of a metal to absorb impact without cracking, fracturing, or rupturing and is measured in foot lbs per square inch. Material that can deform with breaking is extremely tough.
- **Yield:** Yield is a measurement of the amount of force necessary to deform a metal such as bending or warping.
- **Tensile Strength:** Tensile strength is a calculation of the amount of force necessary to break a metal.
- **Ductility:** Ductility refers to how much a metal can be stretched, bent, compressed or endure plastic deformation.

Aluminum Alloys

Alloys made of aluminum are very robust, reliable, and adaptable. They are one of the most popular metal materials, along with steel, and are highly sought-after in engineering, construction, and automotive applications. Iron, copper, magnesium, silicon, and zinc are elements commonly used in aluminum alloys. When aluminum is molten (liquid), the alloy components are combined, and when it cools, a homogeneous solid solution is created. These other elements could account for up to 15% of the alloy's bulk.

Alloys containing aluminum are often valued for their lightweight nature and corrosion resistance. While pure aluminum has notable properties, it lacks the strength needed for many high-durability applications. To address this, aluminum is alloyed with other elements to enhance its robustness and suitability for industrial uses. Aluminum alloys are particularly advantageous when engineers need to reduce the weight of a product, such as an airplane, without compromising its strength.

With the right combination of components, aluminum can become significantly stronger and, in some cases, even surpass steel. Many aluminum alloys offer the benefits of pure aluminum while being more cost-effective, thanks to their lower melting points.

Nickel Alloys

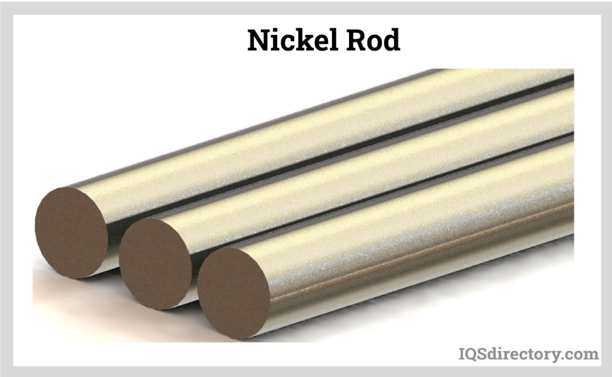
Nickel readily alloys with various metals like chromium, iron, molybdenum, and copper, allowing for the creation of diverse alloys with remarkable properties. These alloys often display exceptional high-temperature strength, excellent corrosion resistance, and resistance to high-temperature scaling. Additionally, they may feature unique properties such as shape memory, where the metal returns to its original shape upon heating, and a low coefficient of expansion, which measures how much the material expands when heated.

The chemical industry relies on pure nickel for its excellent corrosion resistance, particularly against alkalis. Additionally, its ability to shield against electromagnetic interference makes it valuable for use in transducers.

Nickel-iron alloys are chosen for glass-to-metal seals and soft magnetic materials due to their thermal expansion properties. Invar (UNS K93600), with 36% nickel and the remainder iron, is particularly notable for its minimal thermal expansion at room temperature. This characteristic makes Invar ideal for applications requiring high dimensional stability, such as precision measuring instruments and thermostat rods.

Due to its exceptionally low thermal expansion rates, this material is also suitable for cryogenic temperatures. Alloys containing 72□83 percent nickel exhibit the best soft magnetic properties and are commonly used in transformers, inductors, magnetic amplifiers, magnetic shields, and memory storage devices. Nickel-copper alloys, such as the widely used Alloy 400, are highly resistant to corrosion from seawater, non-oxidizing salts, and alkaline solutions.

Without the presence of oxidizing ions such as cupric (copper-based) and ferric (iron-based), or dissolved oxygen, nickel-molybdenum alloys exhibit significant resistance to reducing acids. On the other hand, nickel-chromium alloys are noted for their exceptional electrical resistance, robust high-temperature strength, and impressive corrosion resistance at both standard and elevated temperatures, including resistance to scaling.



Bronze Alloys

Historically significant, bronze remains widely used due to its unique properties. Compared to pure copper, bronze is more durable because it is alloyed with tin or other metals. It also melts more easily, facilitating casting. Moreover, bronze is more corrosion-resistant and tougher than pure iron. Although iron eventually replaced bronze in tools and weapons due to its greater availability, rather than superior strength, bronze continues to be valued for its durability and historical significance.

Aluminum Bronze

Aluminum bronze contains between 6% and 12% aluminum, iron, and nickel. This robust alloy is known for its excellent wear and corrosion resistance, making it an ideal choice for applications such as pumps, valves, and other hardware subjected to corrosive fluids.

Cupronickel

Cupronickel is a bronze alloy composed of copper and 2% to 30% nickel. It is renowned for its excellent thermal stability and corrosion resistance, particularly in steam or moist air environments. Cupronickel outperforms other bronze types in seawater, making it ideal for use in ship hulls, pumps, valves, electronics, and marine equipment.

Silicon Bronze

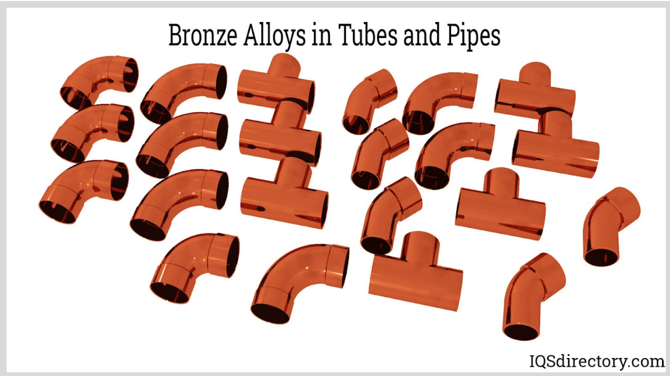
Cupronickel is a bronze alloy composed of copper and 2% to 30% nickel. It is renowned for its excellent thermal stability and corrosion resistance, particularly in steam or moist air environments. Cupronickel outperforms other bronze types in seawater, making it ideal for use in ship hulls, pumps, valves, electronics, and marine equipment.

Nickel Silver

Despite its name, nickel silver contains no actual silver. The name comes from its silvery appearance. Nickel silver is composed of zinc, nickel, and copper. It offers moderate strength and fair corrosion resistance. This versatile material is commonly used in dinnerware, decorative items, optical devices, and musical instruments.

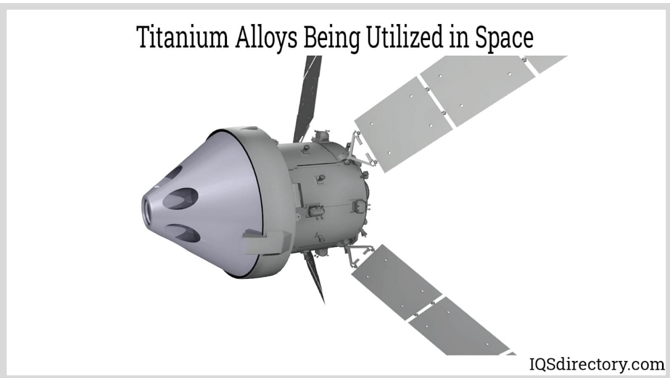
Tin Bronze

Tin bronze, also referred to as phosphor bronze, contains 0.01% to 0.035% phosphorus and 0.5% to 1.0% tin. This alloy is known for its fine grain, low friction coefficient, and excellent fatigue resistance, making it both durable and strong. Phosphor bronze is commonly used in applications such as bellows, washers, electrical equipment, and springs.



Titanium Alloys

Titanium alloys come in various types, each consisting of pure titanium combined with other metals or elements. For example, alpha titanium alloys incorporate alpha stabilizers such as oxygen or aluminum, which impart their unique properties.



Advantages of Alloy Metals

❖ Strong Mixtures of Positive Qualities

Metal alloys are blends of different metals designed to enhance desirable properties while minimizing drawbacks. These mixtures often result in materials that are more durable than their pure metal counterparts. Pure metals can be brittle, so alloys are created to combine strength with improved workability. Unlike pure metals, where all atoms are identical, metal alloys contain a variety of atoms. This variation makes it more difficult for atoms to move, resulting in alloys that are generally stronger and harder than pure metals. Utilizing alloys allows for the construction of more robust structures and the creation of more resilient products. For example, stainless steel is a particularly strong alloy.

❖ Built to Withstand Corrosion

Metal alloys are combinations of various metals and non-metals. Unlike pure metals, which are prone to chemical reactivity and corrosion, alloys can be engineered to resist these effects. Corrosion can rapidly degrade pure metals, leading to costly repairs. Metal alloys, with their enhanced resistance to corrosion, help mitigate and delay this persistent issue, making them more durable and cost-effective over time.

❖ Workable and Easily Adaptable

Metal alloys offer greater adaptability compared to pure metals. They can be tailored to enhance specific properties suited for various applications, whereas pure metals only exhibit their inherent qualities, for better or worse. By combining the best characteristics of different materials, metal alloys provide a broader range of possibilities for diverse projects.

Applications of Alloy Metals

- Stainless steel is utilized in its wire and ribbon forms for screening, staples, belts, cables, weldments, catheters, and suture wires.
- Gold and silver alloys are used to create jewelry. White gold, an alloy of gold, silver, palladium, and nickel, is often utilized as a less expensive alternative to platinum.
- Numerous industries employ a variety of alloys in welding applications.
- Alloys are useful in situations where there is a lot of moisture because they are corrosion-resistant materials.
- Many petrochemical and aeronautical industries require high-temperature alloys. Additionally, these alloys have been applied to the welding of wire in difficult conditions at high temperatures.
- Alloys have been utilized in situations where maintaining high strength and corrosion resistance is necessary.
- Magnetic alloys are utilized in dry reed switches and magnetic cores in order to continually maintain high standards of homogeneity and performance; magnetic alloys are useful for quality control techniques like magnetic testing.
- Nickel-chromium, nickel-chromium-iron, and iron-chromium-aluminum alloys have been employed as high-temperature heating elements.
- Several alloys are utilized as resistance elements to regulate or measure electric current. Wire-wound resistors, rheostats, potentiometers, and shunts are among the many items relying on these qualities for their applications.
- Thermocouple alloys are used in a variety of temperature-sensing and temperature-control applications.
- Alloys are also employed to create automotive components, radio and electrical equipment, precision tools for flight controls, and telecommunications devices.

STRAND 2: LIVING THINGS AND THEIR ENVIRONMENT

NUTRITION IN PLANTS

Introduction

- Nutrition refers to the process by which living organisms obtain and assimilate (utilize) nutrients.
- It is one of the fundamental characteristics of living things.
- The nutrients obtained are useful to the living organisms in many ways:

- The nutrients are required for growth and development of the living organisms.
- The nutrients are required for energy provision as they are broken down to release energy.
- The nutrients are also required for repair of worn out tissues
- Nutrients are required for synthesis of very vital macromolecules in the body such as hormones and enzymes.

Modes of Nutrition

- There are two main nutrition modes:

1. **Autotrophism:** mode of nutrition through which living organisms manufacture their own food from simple inorganic substances in the environment such as carbon (IV) oxide, water and mineral ions. Organisms that make their own food through this mode are autotrophs.
2. **Heterotrophism:** mode of nutrition in which living organisms depend on already manufactured food materials from other living organisms. Heterotrophs are the organisms that feed on already manufactured food materials.

Autotrophism

- In this mode of nutrition, organisms manufacture their own food from readily available materials in the environment. These organisms use energy to combine carbon (IV) oxide, water and mineral salts in complex reactions to manufacture food substances.
- Depending on the source of energy used to manufacture the food . There are two types of autotrophism:

1. Chemosynthesis

This is the process whereby some organisms utilize energy derived from chemical reactions in their bodies to manufacture food from simple substances in the environment.

This nutrition mode is common in non green plants and some bacteria which lack the sun trapping chlorophyll molecule.

2. Photosynthesis

This is the process by which organisms make their own food from simple substances in the environment such as carbon (IV) oxide and water using sunlight energy.

Such organisms often have chlorophyll which traps the required sunlight energy.

This mode of nutrition is common in members of the kingdom Plantae. Some protoctists and bacteria are also photosynthetic.

Importance of Photosynthesis

1. Photosynthesis helps in regulation of carbon (IV) oxide and oxygen gases in the environment.

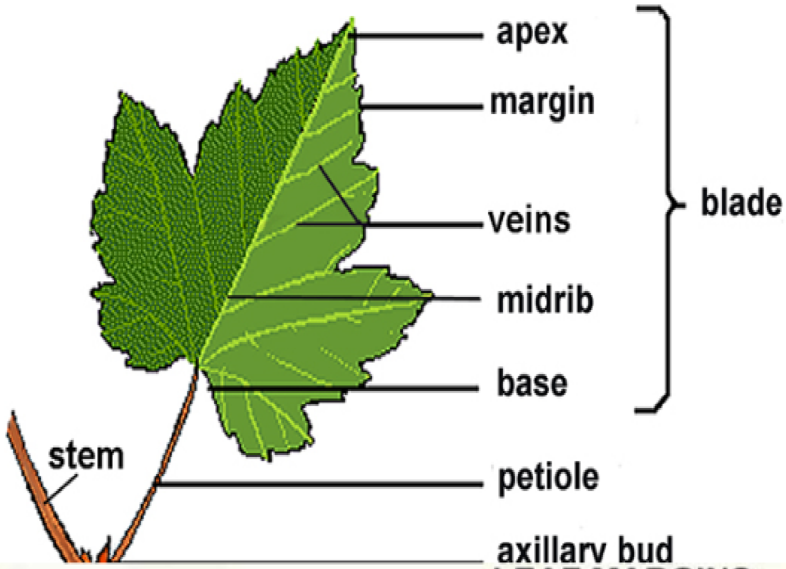
2. Photosynthesis enables autotrophs make their own food, thus, meet their nutritional requirements.
3. Photosynthesis converts sunlight energy into a form (chemical energy) that can be utilized by other organisms that are unable to manufacture their own food.

Photosynthesis largely occurs in the leaf.

To understand the process of photosynthesis, it is important to understand the leaf structure.

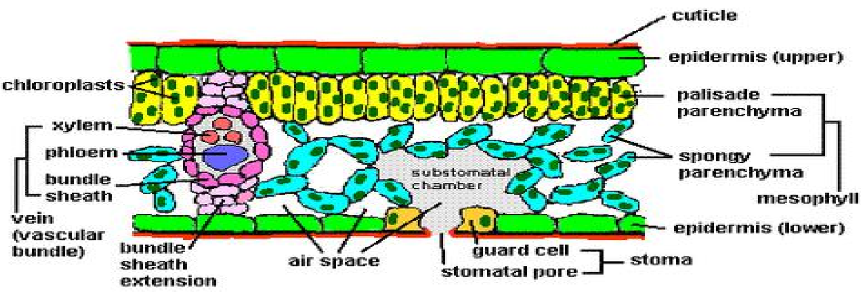
External Leaf Structure

- Externally, the leaf has a petiole through which it attaches to the leaf branch or stem, lamina- the broad flat surface, margin- the outline and the leaf apex.
- The leaf margin can be smooth, dentate, serrated or entire.
- The size of a leaf depends on its environment. Plants in arid areas have small sized leaves with some leaves reduced to needle like shape. This helps reduce the rate of water loss in such plants. However, the plants in areas of water abundance have broad leaves to enable them lose the excess water.



The image below shows types of leaves margins.

Internal Leaf Structure



1. **Cuticle**

- This is the outermost layer of the leaf.
- It is a thin non-cellular, waxy, transparent and waterproof layers that coats the upper and lower leaf surfaces.
- **Functions of the cuticle**

1. Being waterproof, it minimizes water loss from the leaf cells to the environment through transpiration and evaporation.
2. It protects the inner leaf tissues from mechanical damage.
3. It prevents entry of pathogenic microorganisms into the leaf.

2. Epidermis

- This is the outermost one cell thick layer covering upper and lower leaf surfaces. Its cells are flattened and lack chloroplasts.

Functions of the epidermis:

- It protects the leaf from mechanical damage.
- It also protects the leaf from entry of disease-causing microorganisms.
- It secretes the cuticle.

- There are many small pores on the epidermis known as stomata (singular-stoma) through which exchange of materials occur. The opening and closing of the stomata is controlled by the guard cells. Each stoma is controlled by two guard cells.
- The guard cells have chloroplasts and are bean shaped. They have thicker inner cell wall and thinner outer cell wall.

Adaptations of the guard cells

- They have differentially thicker walls to enable them bulge as they draw water through osmosis from the neighboring cells making them to open the stomata.
- They contain chloroplasts that manufacture sugars which increase osmotic pressure of the guard cells.

As they draw water through osmosis, they bulge making the stomata to open.

3. Palisade mesophyll

- This is the chief photosynthetic tissue in plants. Its cells are regular in shape.
- Its cells contain numerous chloroplasts for photosynthesis.

- Their close packing and location just below the epidermis enables them to trap maximum sunlight for photosynthesis.
- Location of palisade layer on the upper surface explains why upper leaf surfaces are greener than the lower surfaces.

4. Spongy mesophyll layer
   - This layer contains loosely arranged irregular cells. This leaves large airspaces between the cells which permits free circulation of gases carbon (IV) oxide and oxygen into the photosynthetic cells. Spongy mesophyll cells contain fewer chloroplasts compared to palisade cells.
5. Vascular bundle/tissue
   - This is found in the midrib and leaf veins. Vascular bundle is made of phloem and xylem tissues. Xylem tissues conduct water and some dissolved mineral salts from the roots to other plant parts while phloem translocates manufactured food materials from photosynthetic areas to other plant parts.
6. Chloroplast
   - This is the organelle in which photosynthesis takes place. It is an oval shaped double membrane bound organelle.
   - Internally, it is made up of membranes called lamellae suspended in a fluid filled matrix called stroma.
   - Lamellae forms stacks at intervals called grana (singular-granum). Chlorophyll molecules are contained in the grana.
   - Within the stroma, fat droplets, lipid droplets and starch grains are found.
   - The stroma contains enzymes and forms the site where light independent reactions take place.

Adaptations of the Leaf to Photosynthesis

- The leaf has a flat and broad lamina to increase surface area for trapping sunlight energy and for gaseous exchange.
- The leaf has numerous stomata through which photosynthetic gases diffuse.
- The leaf is thin to reduce the distance through which carbon (IV) oxide has to diffuse to the photosynthetic cells.
- The palisade mesophyll cells contain numerous chloroplasts which contain chlorophyll molecules which trap sunlight energy for photosynthesis.
- The photosynthetic mesophyll is located towards the upper surface for maximum absorption of sunlight energy.
- The leaf has an extensive network of veins composed of xylem which conducts water to the photosynthetic cells and phloem to translocate manufactured food materials to other plant parts.
- The epidermis and cuticle are transparent to allow light to penetrate to the photosynthetic cells.

Raw Materials for Photosynthesis

- Water
- Carbon (IV) oxide

Conditions for Photosynthesis

- Light energy
- Chlorophyll

Photosynthesis Process

Photosynthesis is a complex process that involves a series of reactions. It can be summarized into two main reactions.

- Light reaction/Light stage

- This is the first stage of photosynthesis. It occurs in the presence of light. Without light it cannot take place.
- Light stage occurs in the grana of the chloroplasts.
- During light stage, two fundamental processes occur:
  i. Photolysis of water
    - This refers to the splitting of water molecules using sunlight energy to give hydrogen ions and oxygen gas.
    - This is aided by the fact that the grana contain chlorophyll molecules that trap sunlight energy for photolysis.
    - The oxygen gas produced can either be released into the atmosphere or be utilized by the plant for respiration.
      Water → Hydrogen atoms + Oxygen gas

  ii. Formation of adenosine triphosphate (ATP)

- Some of the sun light energy is used to combine Adenosine Diphospate molecule in the plant tissues with a phosphate molecule to form Adenosine Triphosphate (ATP). ATP is an energy rich molecule that stores energy for use in the dark stage when sunlight energy could be unavailable.
  ADP+P→ATP
- The hydrogen ions and ATP formed during light stage are later used in dark stage.

- **Dark reaction/Dark stage**
  - These reactions are light independent. The energy that propels these reactions are derived from the ATP formed during light stage.
  - Also known as carbon (IV) oxide fixation, dark stage involves combination of carbon (IV) oxide molecule with hydrogen ions to form a simple carbohydrate and a water molecule.
  - Dark reactions take place in the stroma.
    $CO_2 + 4H^+ \rightarrow (CH_2O)n + H2O$
  - Other food materials are then synthesized from the simple sugars through complex synthesis reactions.
  - The simple sugar formed in dark stage is quickly converted to starch which is osmotically inactive. When a lot of simple sugars accumulate in the chloroplasts, osmotic pressure of the guard cells would increase causing the guard cells to draw a lot of water through osmosis. This makes the guard cells to bulge and open the stomata. This can result into excessive water loss. ▪ To prevent, this, the simple sugars are quickly converted to starch. To test whether photosynthesis has taken place in a leaf, therefore, a test for presence of starch and not simple sugars is carried out.

Factors Affecting the Rate of Photosynthesis

- **Carbon (IV) oxide concentration**

  - While the concentration of carbon (IV) oxide in the atmosphere is fairly constant at 0.03%, an increase in carbon (IV) oxide concentration translates into an increase in the rate of photosynthesis upto a certain point when the rate of photosynthesis becomes constant.
  - At this point, other factors such as light intensity, water and temperature

become limiting factors. 2. Light intensity

  - The rate at of photosynthesis increases with an increase in light intensity up to a certain level. ○ Beyond the optimum light intensity the rate of photosynthesis becomes constant. To this effect, plants photosynthesize faster on bright and sunny days than on dull cloudy days.

  - Light quality/wavelength also affects the rate of photosynthesis. Most plants require red and blue wavelengths of light for photosynthesis.
  - Light duration also affects photosynthesis rate.

3. Temperature
  - Photosynthesis is an enzyme controlled process.
  - At very low temperatures the rate of photosynthesis is slow because the enzymes are inactive.
  - As temperature increases, the rate of photosynthesis increases because the enzymes become more active. Rate of photosynthesis is optimum at (35-40) °C.
  - Beyond 40°C the rate of photosynthesis decreases and eventually stops since the enzymes become denatured.
4. Water
  - Water is a raw material for photosynthesis. At extreme level of water shortage, rate of photosynthesis will be severely affected.

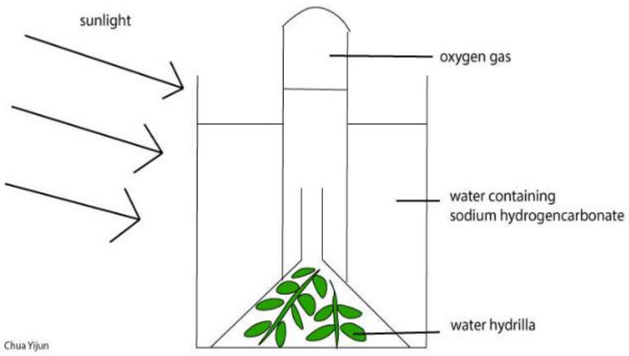
Experiment to Investigate the Gas Produced During Photosynthesis

Requirements

- Water plant e.g. elodea, spirogyra, Nymphea (water lily),
- glass funnels,
- beakers,
- small wooden blocks,
- test tubes,
- wooden splints and
- sodium hydrogen carbonate.

Procedure

1. Set up the apparatus as shown in the figure below



- Place the set up in the sunlight to allow photosynthesis to take place.
- Leave the set up in the sun until sufficient gas has collected in the test tube.
- Test the gas collected with a glowing splint.
- Record your observations.

Note:

- In this experiment, sodium hydrogen carbonate is added to the water to boost the amount of carbon (IV) oxide in the water since water has a low concentration of carbon (IV) oxide.
- A water plant is also selected because water plants are adapted to photosynthesis under the low light intensity in water where terrestrial plants cannot easily photosynthesize.
- This experiment can also be used to investigate the factors affecting the rate of photosynthesis:
    - Carbon (IV) oxide concentration
        - Carry out the experiment using different amounts of dissolved sodium hydrogen carbonate e.g 5g, 10g, 15g, 20g and examine the rate at which the gas collects.
    - Light intensity:
        - An artificial light source can be used. Illuminate the plant and vary the distance between the set up and the light source while recording the time it takes for the gas jar to fill or counting the number of bubbles per unit time.
    - Temperature:
        - carry out the experiment at varying temperatures and record the rate at which the gas collects.

Experiments on Factors Necessary for Photosynthesis

Light

- **Requirements**
  - Methylated spirit, iodine solution, water, white tile, droppers, beaker, source of heat, boiling tube, light proof material e.g. aluminium foil, potted plant and clips.
- **Procedure**
  - Cover two or more leaves of a potted plant with a light proof material.
  - Place the plant in a dark place for 48 hours (keeping the plant in the dark for 48 hours is to ensure that all the starch in it is used up. This makes the leaves ideal for investigating whether starch would form in the experimental period. This is called destarching).
  - Transfer the potted plant to light for 5 hours.
  - Detach and uncover the leaves and immediately test for starch in one of the covered leaves and one that was not covered.

Carbon (IV) oxide

- Requirement
  - Sodium hydroxide pellets, flask, jelly
- Procedure
  - Destarch the plant for 48 hours
  - Place a few pellets of sodium hydroxide in the flask
  - Bore a hole in the cork of the same size as the petiole of the leaf being used
  - Cut the cork lengthwise.

Chlorophyll

- For this experiment, a variegated leaf is required. This is a leaf in which some patches lack chlorophyll.
- These patches could be yellow. They lack chlorophyll hence photosynthesis does not take place in them.

Procedure

- Detarch or remove variegated leaf that has been exposed to light for at least three hours.
- Draw a large diagram of the leaf to show the distribution of the chlorophyll
- Test the leaf for starch and record observations.

NUTRITION IN ANIMALS

Heterotrophism

- This is a mode of nutrition in which organisms take in already manufactured complex food substances such as carbohydrates, proteins and lipids.
- Heterotrophs are organisms that feed on already manufactured food substances.
- These substances are broken down in the bodies of the Heterotrophs into simple soluble food substances that can be absorbed and be utilized by the cells.

Modes of Heterotrophism

There are four main heterotrophic modes on nutrition:

1. Holozoic - Where organisms ingest, digest and assimilate solid complex food substances.
2. Saprophytism Where organisms feed on dead decaying matter causing decomposition.
3. Parasitism - a feeding association in which one organism (parasite) feeds on or obtain nutrients on another organism, the host.
4. Symbiosis/Mutualism - An association where two organisms live together and mutually benefit from each other.

Parasitism

- There are two main types of parasites:
    - Endo parasites - Live inside the host
    - Ecto-parasites - Found on the external surface of the host.
- The parasite benefits but the host does not. Some of the parasites cause diseases to the hosts and damage their tissues thereby weakening them.

Symbiosis

- In symbiotic relationships, both organisms benefit:
- Symbiotic r/ships include
    - Rhizobium and leguminous plants: rhizobium fixes nitrogen for the legume while the bacteria obtains manufactured food from the legumes.
    - Lichen: association of fungi (absorbing water and nutrients) and algae (manufacturing food for the association.
    - Catalase digesting bacteria and ruminants.

Dentition

- Large animals depend on complex manufactured food substances.

- These food substances once ingested must be broken down to simpler forms that can be utilized by the cells.

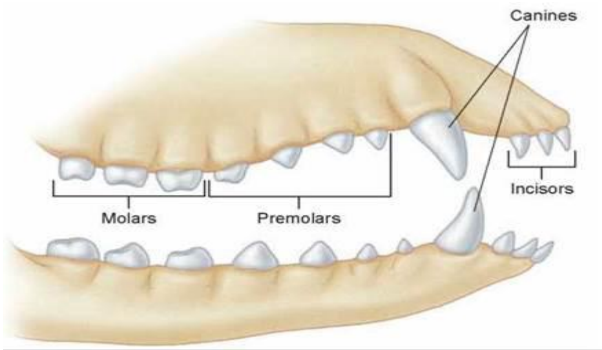
  The breakdown is both physical and chemical.

- Most of the large animals have teeth to enhance physical breakdown of the complex food substances.
- Dentition refers to the description of types of teeth, their arrangement and specialization.

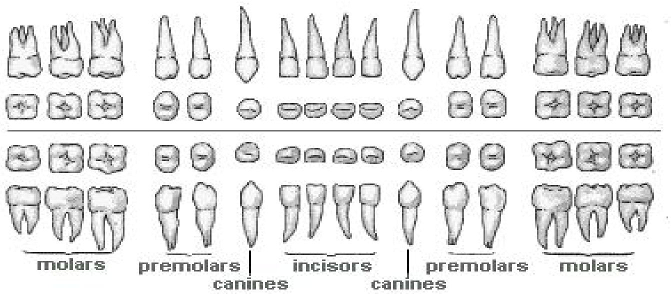
Types of Dentition

1. Homodont dentition: Teeth arrangement and description where an organism has teeth of the same size and shape. Fishes and birds have homodont dentition.

2. Heterodont dentition: where an organism has teeth of different sizes and shapes that is incisors, canines, premolars and molars. Heterodont dentition is common with mammals and reptiles.



Types of Teeth



1. **Incisors**
   - Are flat and chisel shaped with sharp ridged edges for cutting and biting food.

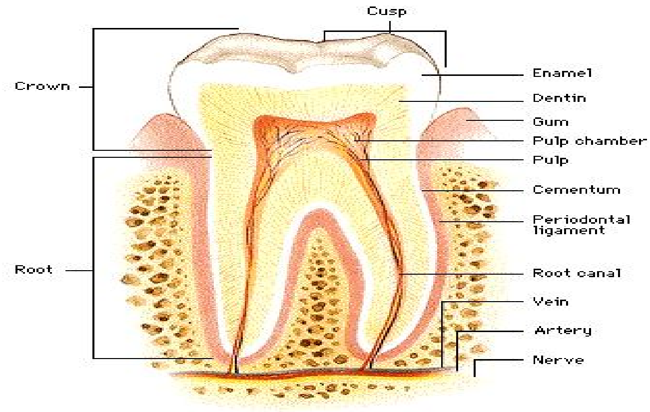
- They have one root.

2. **Canines**

  - Are conical teeth with sharp pointed edges modified for seizing and tearing prey among carnivores.
  - They have one root

3. **Premolar and molar**

  - They have cusps on their surface to suit their grinding action.
  - Premolars have two roots.
  - Molars have either two or three roots.



Classes of Holozoic Heterotrophs

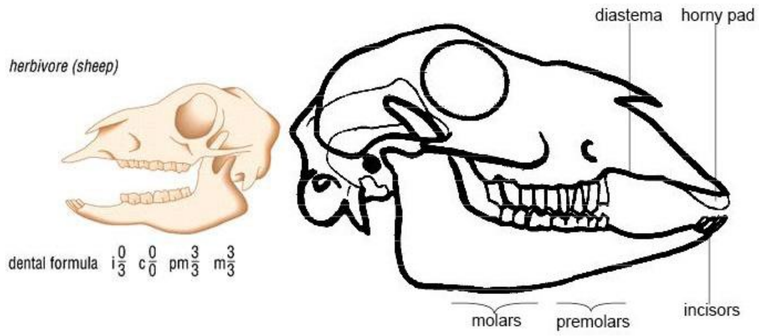
- Holozoic heterotrophs are classified according to the type of food they consume.
- These are:
  - Herbivores: heterotrophs that exclusively feed on vegetation.
  - Carnivores: heterotrophs that exclusively feed on flesh.
  - Omnivores: heterotrophs that feed on both flesh and vegetation.
- Dentition of heterotrophs is based on the kind of food they consume.

Dental Formula

- This is the description of the number, type and position of teeth in the jaws of animals.
- Number of teeth recorded represents half the total teeth in the upper and lower jaws.
- The teeth names are abbreviated as
  1. **i**-incisors.
  2. **c**-canines.
  3. **pm**-premolars.
  4. **m**-molars.

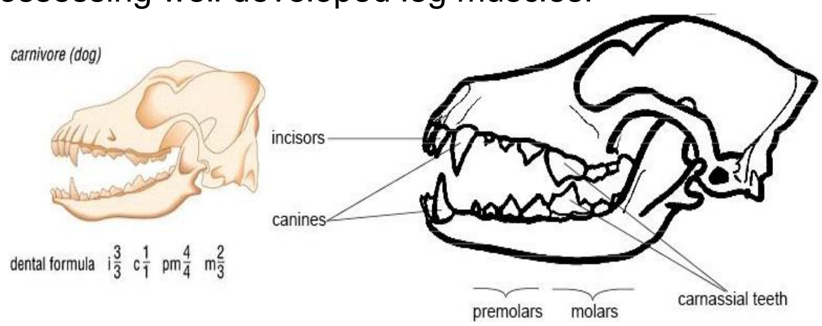
Herbivores

- Most do not have upper incisors. Instead they have a horny pad against which grass is pressed and cut by the lower incisors.
- They have a long tongue that assists in the cutting and moving food.
- They have a gap in the lower jaw separating canines from premolars known as diastema which allows the tongue to manipulate food.
- Herbivore teeth have open enamel which allows for continuous growth to replace worn out surfaces due to grinding.
- Their incisors are wedge shaped to cut grass and vegetation together with the horny pad
- The jaws have movable joints to allow the sideways movement of lower jaw to facilitate grinding of grass.



Carnivores

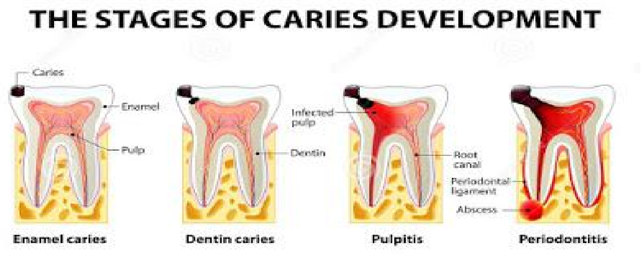
- Their incisors are chisel shaped and closely fitting to seize the prey.
- Their canines are long, conical and curved to hold, kill and tear the prey.
- Some of their premolars in the lower and upper jaw are modified into specialized carnassial teeth which have smooth sides and sharp edges to slice through flesh and crush bones
- Premolars and molars are broad with cusps for crushing bones.
- Their jaws are attached to powerful muscles that move the jaws up and down
- Carnivores are adapted to fast running by possessing well developed leg muscles.



Dental Diseases

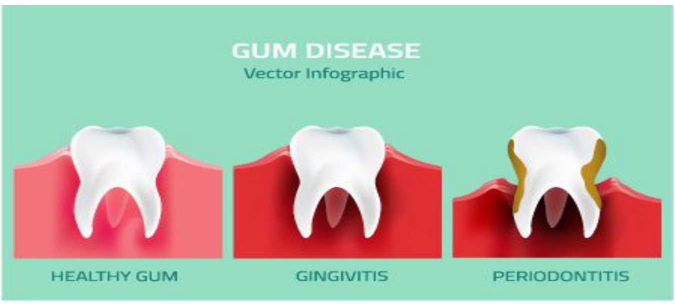
a) Dental Carries

- Caused by lack of hard food, too much sweet or sugary food, lack of calcium in diet, lack of vitamin D, lack of cleaning teeth and general ill-health. The bacteria in the mouth break down the sugars to form energy and organic acids. The acids corrode the enamel.



b) Periodontal Diseases

- Caused by lack of vitamins A and C, lack of massage of the gums and imperfect cleaning of gums.
- The gums become flabby and soft so they do not support the teeth. Common in adults than children.
- Are of two types:
  1. Gingivitis - Characterized by reddening of gums, bleeding and pus in the gums.
  2. Pyorrhea - The teeth become loose due to infection of the fibres holding the teeth in the sockets.

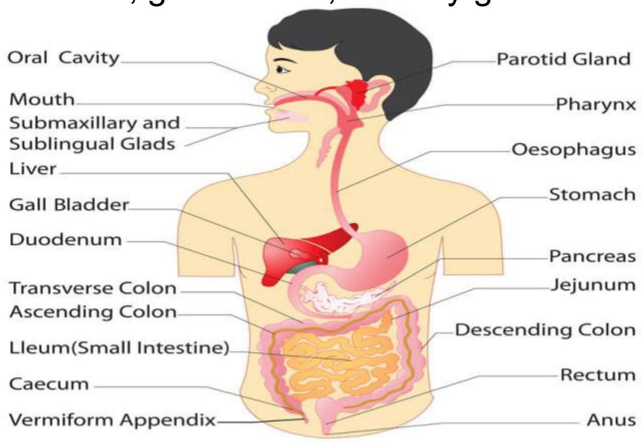


Dental Hygiene

- Proper teeth care requires:
  - Regular cleaning or brushing teeth after every meal
  - Avoid eating too much sugary foods.
  - Eating hard foods e.g. raw carrots, cassava, yams, sugar cane.
  - Eating diet rich in calcium, phosphate and vitamins A, C and D.
  - Teeth should be used for their correct purpose.
  - Regularly visit the dentist if necessary.

Digestion

- The process through which complex food substances is broken down physically and chemically into simpler food substances that can be absorbed by body cells
- However, small molecules like those of vitamins, mineral salts and water are directly absorbed into the bloodstream without undergoing digestion.
- Digestion occurs in the mouth, stomach, duodenum and ileum.
- There are glands also associated to the digestive system. These include the pancreas, gall bladder, salivary glands.



Digestion in the Mouth

- At the mouth both physical and chemical digestion takes place.
- The food is mechanically broken down by the teeth through grinding and chewing. This process is called mastication.
- Mastication reduces the food into small size to increase the surface area for enzymatic action.
- The tongue helps in manipulation of the food as it mixes the food with the saliva secreted from the salivary glands. The salivary glands are:
  - Sublingual salivary gland; beneath the tongue
  - Sub mandibular gland: under the jaw
  - Parotid gland: Found in the cheeks in front of the ears.
- All the glands have ducts through which saliva is directed to the mouth.
- The tongue also rolls the food into small round masses called boluses.
- The boluses are then pushed to the back of the mouth to initiate the swallowing process.
- The boluses are then moved to the stomach via oesophagus.
- Movement is facilitated by a wave of muscular contractions of longitudinal and circular muscles of the oesophagus known as peristalsis.
- There is a flap of cartilage, epiglottis which closes the wind pipe (trachea) during swallowing.

Digestion in the Stomach

- Upon swallowing, the boluses move down the gullet to the stomach. The boluses enter the stomach via the cardiac sphincter (a muscular valve).

- The stomach has thick circular and longitudinal muscle layers which contract and relax to produce movements that mix the contents of the stomach. The mixing process is known as churning and results in formation of a fluid called chyme
- Arrival of food in the stomach stimulates secretion of the hormone gastrin which stimulates the gastric glands in the stomach walls to secrete gastric juice which contains:
    1. Pepsinogen-This is activated to pepsin which breaks down proteins to peptides.
    2. Rennin- Digests caseinogens protein in milk to casein (curd).
    3. Hydrochloric acid- This:
        -
    4. Mucus- Forms a protective barrier to the stomach wall against corrosion by the HCl. Mucus is secreted by goblet cells in the epithelial membrane of the alimentary canal.

Duodenum

- The chyme then passes down to the duodenum through the pyloric sphincter. Duodenum is the first section of the small intestine. In humans it measures about 25-38 cm. The chyme is let down into the duodenum in small quantities.
- Secretions that contribute to digestion at the duodenum are received from:
    1. Gall bladder in the liver - Secretes bile.
    2. Pancreas - Secrete hormones and

digestive enzymes. • Arrival of food in the duodenum stimulates secretion of

1. Secretin hormone from the pancreas: Secretin stimulates secretion of pancreatic juice into the duodenum
2. Cholecystokinin from the duodenal wall: This stimulates secretion of bile

from the gall bladder. • Pancreatic juice contains:

1. Pancreatic amylase - This facilitates breakdown of the remaining starch into maltose
2. Trypsin- Digests proteins into peptides.
3. Pancreatic juice-Digests lipids into fatty acids and glycerol
4. Sodium hydrogen carbonate- This:
    - Provides alkaline medium for activity of the duodenum enzymes.
    - It also neutralizes the acidic chyme.

- The bile juice contains bile salts that include sodium glycocholate and sodium taurocholate. These salts:
    1. Aid in emulsification (breakdown of fat molecules into tiny fat droplets to increase surface area for digestion).
    2. The salts also provide a suitable alkaline medium for action of the duodenal enzymes.

3. In addition they neutralize the acidic chyme.

Digestion in the Ileum

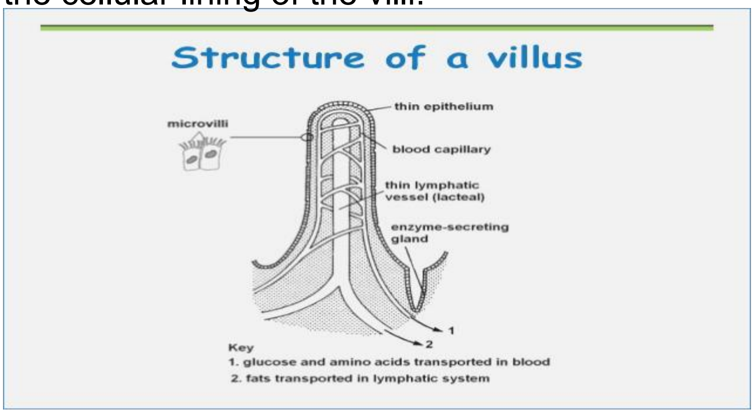
- Ileum is the final part of the small intestine.
- The inner cells contain secretory cells some of which secrete mucus while some secrete an alkaline fluid known as succus entericus (intestinal juice). The arrival of chyme in ileum stimulates secretion of intestinal juice which contains:
  - Maltase: speeds up breakdown of maltose to glucose
  - Sucrase: speeds breakdown of sucrose to glucose and fructose
  - Peptidase: speeds breakdown of peptides to amino acids
  - Lipase: speeds breakdown of lipids to fatty acids and glycerol.
  - Lactase: speeds breakdown of lactose to glucose and galactose.
  - Polypeptidase: speeds breakdown of plypeptides into amino acids

Note:

- The mucus secreted by the goblet cells lubricates food along the alimentary canal and also protect the canal from being digested by enzymes.
- At the end of digestion in the ileum, the resulting watery emulsion is called chyle; it contains soluble end products of digestion ready to be absorbed.

Absorption

- This is the process through which the soluble end products of digestion diffuse into the cellular lining of the villi.



- Absorption of micronutrients such as water soluble vitamins, mineral salts and alcohol are absorbed at the stomach. Alcohol is equally absorbed here without undergoing digestion.
- Most absorption of end products of digestion occurs in the ileum.
- Molecules of amino acids and glucose pass through the epithelial lining and capillary walls into the blood system by active transport.
- The capillaries drain into the hepatic portal vein where the absorbed products are transported to the liver before they are circulated to other body parts.
- The fatty acids are absorbed into the lacteals of the villi which drain into the lymphatic vessels. The lymphatic vessels later join the blood circulatory system which transports them to other body parts.
- The ileum is adapted to absorption in many ways

- It is long to provide a large surface area for absorption
- It has a narrow lumen so as to bring the digested food into close contact with the walls of the ileum for easier absorption
- It is highly coiled to slow down movement of food thus allowing more time for digestion and absorption of food.
- The inner surfaces have numerous villi and microvilli to increase surface area for absorption of end products of digestion.
- The epithelial lining is one cell thick to reduce the distance through which digested food diffuses.
- Has a dense network of blood capillaries into which digested food materials diffuse to increase transport and thus maintain a steep concentration gradient.
- Have lacteal vessels in the villi for absorption of fatty acids and glycerol.

Egestion

- This is the process through which the undigested and indigestible food substances are eliminated from the body.

Caecum and Appendix

- While these have no roles in man, they play vital roles in the ruminant animals and other herbivores. They contain some bacteria which secrete cellulose enzyme. These enzymes digest cellulose since most digestive systems cannot secrete cellulose digesting enzyme.

- The bacteria and the herbivores are in a symbiotic relationship.

Assimilation

- This is process of incorporation of the end products of digestion into the cell metabolism. It involves utilization of the end products of digestion into various uses.

Importance of Vitamins, Mineral Salts, Roughage and Water in Human Nutrition

1. Glucose
   - Oxidized to release energy
   - Excess glucose is stored under the skin to provide heat insulation
   - Glucose is used to synthesize complex polysaccharide such as cellulose that is an important structural compound in plants.
2. Fatty acids and glycerol
   - Oxidized to release energy
   - Combine to form neutral fats stored under the skin to provide heat insulation
   - Used to build structures
3. Amino acids
   - Used to synthesize proteins for general body growth
   - Oxidized during starvation to release energy.
4. Vitamins
   - These are organic chemical compounds that are essential for a healthy body.
   - Some are synthesized in the body through the action of some microorganisms while some are also obtained in fresh fruits and vegetables.
   - Vitamins are destroyed when foods are excessively cooked. They are required in small quantities.
   - They play vital roles in metabolic reactions. Some act as co-enzymes while some influence the intake of certain substances. In particular, vitamin C influences uptake of iron while vitamin D influences absorption of calcium ions in the gut.
   - Lack of vitamins in the body results into abnormities that manifest through various deficiency diseases. These deficiency diseases can be corrected by inclusion of the deficient vitamins in the diet or taking the vitamin supplements.
   - There are two classes of vitamins owing to their solubility:

- Fat soluble vitamins- They dissolve in fats and are often stored in the liver. Include Vitamins A, D, E, K.
- Water soluble vitamins- Dissolve in water. Include vitamins B_1, B_2, B_5, B_{12} and C. 5. Mineral salts

- These are important inorganic compounds containing elements required for essential
- body functioning. Depending on body requirements, mineral salts are of two classes:

1. Macro-nutrients: Nutrients required in large quantities. These include nitrogen, sulphur, phosphorous, calcium, sodium, iron and magnesium.
2. Micro-nutrients: Nutrients required in small quantities. Include copper, manganese, boron, iodine and cobalt.

6. Roughages

- This is the indigestible material in food. Mainly composed of cellulose from plant cell walls.
- They are found in full cereals, fresh fruit fibres like lemons, oranges, mangoes and vegetables.

Importance of roughage

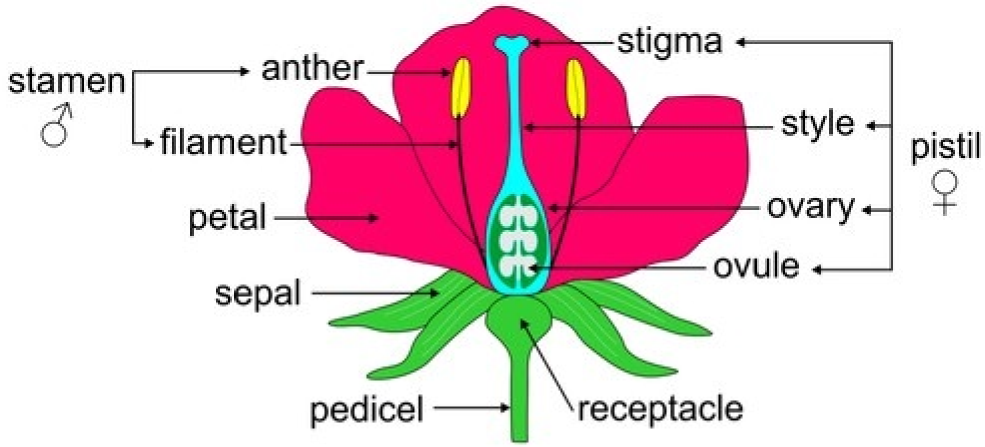
1. It rubs against the walls of the alimentary canal stimulating secretion of digestive enzymes and mucus to lubricate the epithelial lining.
2. Roughage enhance peristalsis since as they rub against the walls of the alimentary canal, they stimulate contraction and relaxation of the muscles.
3. Roughage is an absorbent; it extracts water from the alimentary canal making the fecal matter bulky and moist hence can be easily propelled by peristaltic movements. This prevents constipation.

REPRODUCTION IN PLANTS

- In flowering plants, the flower is the reproductive organ which is a specialised shoot consisting of a modified stem and leaves.
- The stem-like part is the pedicel and receptacle, while modified leaves form corolla and calyx.

Structure of a Flower

Parts of a Flower



(*Image Courtesy of shutterstock*)

- A typical flower consists of the following parts:

a) Calyx

- Made up of sepals.
- They enclose and protect the flower when it is in a bud. Some flowers have an outer whorl made of sepal-like structures called epicalyx.

b) Corolla

- Consists of petals.
- The petals are brightly coloured in insect-pollinated flowers.

c) Androecium

- Is the male part of the flower. It consists of stamens.
- Each stamen consists of a filament whose end has an anther.
- Inside the anther are pollen sacs which contain pollen grains.

d) Gynoecium (pistil)

- Is the female part of the flower.
- It consists of one or more carpels.
- Each carpel consists of an ovary, a sty le and a stigma.
- The ovary contains ovules which become seeds after fertilisation.
- A ***monocarpous pistil*** has one carpel e.g. beans.
- A ***polycarpous pistil*** has many carpels.
- If the carpes are free, it is called ***apocarpous*** as in rose and Bryophyllum.
- In carpels that are fused it is called ***syncarpous*** as in Hibiscus.
- A **complete flower** has all the four floral parts.
- A regular flower can be divided into two halves by any vertical section passing through the centre. e.g. morning glory.
- Irregular flower can be divided into two halves in only one plane e.g. crotalaria.

Pollination

Definition of Pollination

- This is the transfer of pollen grains from the anther to the stigma.

Types of Pollination

- Self pollination is the transfer of pollen grains from the anther of one flower to the stigma of the same flower.
- Cross-pollination is the transfer of pollen grains from the anther of one flower to the stigma of a different flower, of the same species.

Agents of Pollination

- Agents of pollination include wind, insects, birds and mammals.
- Insect pollinators include bees, butterflies and mosquitoes.

Fertilization in Plants

- The pollen grain contains the generative nucleus and a tube nucleus.
- When the pollen grain lands on the stigma, it absorbs nutrient and germinates forming a pollen tube.

- This pollen tube grows through the style pushing its way between the cells.
- It gets nourishment from these cells.
- The tube nucleus occupies the position at the tip of the growing pollen tube.
- The generative nucleus follows behind the tube nucleus, and divides to form two male gamete nuclei.
- The pollen tube enters the ovule through the micropyle.
- When the pollen tube penetrates, the ovule disintegrates and the pollen tube bursts open leaving a clear way for the male nuclei.
- One male nucleus fuses with the egg cell nucleus to form a diploid zygote which develops into an embryo.
- The other male gamete nucleus fuses with the polar nucleus to form a triploid nucleus which forms the primary endosperm.
- This is called double fertilisation.

Changes in a Flower After Fertilisation

- The integuments develops into seed coat (testa).
- The zygote develops into an embryo.
- The triploid nucleus develops into an endosperm.
- The ovules become seeds.
- The ovary develops into a fruit.
- The ovary wall develops into pericarp.
- The style, dries up and falls off leaving a scar.
- The corolla, calyx and stamens dry up and fall off.
- In some the calyx persists.

Fruit formation

- Fruit development without fertilisation is called ***parthenocarpy***
- e.g. as in pineapples and bananas.
- Such fruits do not have seeds.

Classification of Fruits

- False fruits develops from other parts such as calyx, corolla and receptacle,
- e.g. apple and pineapple which develops from an inflorescence.
- True fruits develop from the ovary, e.g. bean fruit (pod).
- True fruits can be divided into fleshy or succulent fruits e.g. berries and drupes and dry fruits.
- The dry ones can be divided into Dehiscent which split open to release seeds and indehiscent which do not open.

Methods of Fruit and Seed Dispersal

1. Animal Dispersal of Seeds

- Fleshy fruits are eaten by animals.
- Animals are attracted to the fruits by the bright colour, scent or the fact that it is edible.
- The seeds pass through the digestive tract undamaged and are passed out with faeces. E.g. tomatoes and guavas.
- Such seeds have hard, resistant seed coats.
- Others have fruits with hooks or spines that stick on animal fur or on clothes.
- Later the seeds are brushed of or fall off on their own e.g. ***Bidens pilosa*** (Black jack).

2. Wind Dispersal of Seeds

- Fruits and seeds are small and light in order to be carried by air currents.
- A fruit that is a capsule e.g. tobacco split or has pores at the top e.g. Mexican poppy.
- The capsule is attached to along stalk when swayed by wind the seeds are released and scattered.
- Some seeds have hairy or feather-like structures which increase their surface area so that they can be blown off by the wind e.g. Sonchus.
- Others have wing-like structures e.g. Jacaranda and Nandi Flame.
- These extensions increase the surface area of fruits and seeds such that they are carried by the wind.

3. Water Dispersal of Seeds

- Fruits like coconut have fibrous mesocarp which is spongy to trap air, the trapped air make the fruit light and buoyant to float on water.
- Plants like water lily produce seeds whose seed coats trap air bubbles.
- The air bubbles make the seeds float on water and are carried away.
- The pericarp and seed coat are waterproof.

4. Self Dispersal (Explosive) Mechanism

- This is seen in pods like bean and pea.
- Pressure inside the pod forces it to open along lines of weakness throwing seeds away from parent plant.

INTERDEPENDENCE OF LIFE

Abiotic factors (environmental factors)

1. Temperature
- Is the hotness or coldness of an area or habitat.
- It directly affects the distribution and productivity (yield) of populations and communities.
- Most organisms are found in areas where temperature is moderate.
- However, certain plants and animals have adaptations that enable them to live in areas where temperatures are in the extremes such as the hot deserts and the cold polar regions.
- Temperatures not only influence distribution of organisms but also determine the activities of animals.
- High temperature usually accelerates the rates of photosynthesis, transpiration, evaporation and the decomposition and recycling of organic matter in the ecosystem.

2. Light
- Light is required by green plants for photosynthesis.
- Light intensity, duration and quality affect organisms in one way or another.

3. Atmospheric Pressure
- The force per unit area of atmospheric air that is exerted on organisms at different altitudes.
- Growth of plants and activity of animals is affected by atmospheric pressure.
- e.g., rate of transpiration in plants and breathing in animals.

4. Salinity
- This is the salt content of soil or water.
- Animals and plants living in saline conditions have special adaptations.

5. Humidity
- This describes the amount of moisture (water vapour) in the air.
- Humidity affects the rate of transpiration in plants and evaporation in animals.

6. pH
- Is the measure of acidity or alkalinity of soil solution or water.
- pH is very important to organisms living in water and soil.
- Most prefer a neutral pH.

7. Wind:
- Is moving air currents and it influences the dispersion of certain plants by effecting the dispersal of spores, seeds and fruits.
- Air currents also modify the temperature and humidity of the surroundings.

8. Topography:
- These are surface features of a place.
- The topographical factors considered include altitudes, gradient (slope), depressions and hills.
- All these characteristics affect the distribution of organisms in an area.
- e.g., the leeward and windward sides of a hill.

Biotic factors:

- These are the living components in an ecosystem,

- competition
- predation
- symbiosis
- parasitism
- human activities

Inter-relationships Between Organisms

- The relationships between organisms in a given ecosystem is primarily a feeding one.
- Organisms in a particular habitat have different feeding levels referred to as trophic levels.
- There are two main trophic levels:

1. Producers:

- These organisms that occupy the first trophic level.
- They manufacture their own food hence are autotrophic.

2. Consumers:

- These are the organisms that feed on organic substances manufactured by green plants.

They occupy different trophic levels as follows:

Primary consumers:

- These are herbivores and feed on green plants.

Secondary consumers:

- These are carnivores and feed on flesh.
- First order carnivores feed on herbivores while second order carnivores feed on other carnivores, i.e., tertiary consumers.

Omnivores:

- These are animals that feed on both plant and animal material.
- They can be primary, secondary or tertiary consumers.

Competition:

- This describes the situation where two or more organisms in the same habitat require or depend on the same resources.
- Organisms in an ecosystem compete for resources like food, space, light, water and mineral nutrients.
- Competition takes place when the environmental resource is not adequate for all.

Intraspecific competition. - This is competition between organisms of the same species.

- For example, maize plants in a field compete for water and nutrients among themselves.

Interspecific competition.- This refers to competition between organisms of different species, e.g., different species of predators can compete for water and prey among themselves.

3. Predation

- It is a relationship whereby one animal (the predator) feeds on another (the prey).

Saprophytism

- Saprophytism is the mode of nutrition common in certain species of fungi and bacteria.
- Such organisms feed on dead organic material and release nutrients through the process of decomposition or decay.
- Saprophytes produce enzymes, which digest the substrates externally.
- The simpler substances are then absorbed.
- Saprophytes help in reducing the accumulation of dead bodies of plants and animals.
- Harmful saprophytes cause rapid decay of foods such as fruits, vegetables, milk and meat.
- Others damage buildings by causing wood rot.
- Some fungi produce poisonous substances called aflatoxins.
- These substances are associated with cereal crops which are stored under warm, moist conditions.
- If the infected grain is eaten, it may cause serious illness, and death.

Parasitism

- This is an association between members of different species.
- The parasite lives on or in the body of another organism, the host.
- The parasite derives benefits such as food and shelter from the host but the heist suffers harm as a result.

Symbiosis

- This is an association in which organisms of different species derive mutual benefit from one another.
- Some symbiotic associations are loose and the two partners gain very little from each other.
- Other symbiotic associations are more intimate and the organisms show a high degree of interdependence.

Nitrogen cycle

- Is the interdependence of organisms on one another and the physical environment as nitrogen is traced from and back into the atmosphere.
- Although nitrogen is abundant in the atmosphere, most organisms are not able to utilise it directly.
- Some bacteria are capable of converting atmospheric nitrogen into forms which can be used by other living organisms.
- These bacteria are referred to as nitrogen flxing bacteria.
- Symbiotic nitrogen fixing bacteria live in the root nodules of leguminous plants such as beans and peas.
- Non-symbiotic nitrogen fixing bacteria live in the soil.
- Nitrifying' bacteria convert ammonia into nitrites and nitrates.
- Denitrifying bacteria convert nitrates into atmospheric nitrogen.

Energy Flow in an Ecosystem

- Most of the energy used in an ecosystem is derived from the sun.
- Solar energy is trapped by photosynthetic plants.
- It flows through different trophic levels.
- At each level energy is lost as heat to space and also through respiration.

- Besides animals lose energy through excretion and defecation.
- The amount of energy passed on as food from one trophic level to another decreases progressively.
- The energy in the organisms is recycled back to plants through the various nutrient or material cycles.

Food Chains

- A food chain is a linear relationship between producers and consumers.
- It represents the transfer of food energy from green plants through repeated stages of eating and being eaten.

Types of Food Chain
- Grazing food chain - starts with green plants.
- Detritus food chain - starts with dead organic material ***(debris or detritus).***

Detritivores:
- Detritivores feed on organic wastes and dead matter derived from the grazing food chain.
- Many different types of organisms feed on detritus.
- They include fungi, protozoa, insects, mites annelids and nematodes.

Examples of Food Chains

- Green plants → aphids → lady-bird beetle
- Grass → antelope → lion
- Algae → Tilapia → kingfisher
- Plant debris → bacteria → eprotozoa → mosquito larva
- Phytoplankron → eZooplankton → Tilapia → Nile perch → Human

Food Web
- In a natural community, several food chains are interlinked to form a food web.
- Several herbivores may feed on one plant.
- Similarly, a given herbivore may feed on different plants and may in turn be eaten by different carnivores.

Decomposers
- These are mainly bacteria and fungi.
- These organisms feed on dead organic matter thereby causing decomposition and decay and releasing nutrients for plants.
- They form a link between the biotic and the abiotic components.

Ways Human Activities Impact the Environment Negatively

Pollution Air, CO2, Water, Light

Pollution remains one of the most concerning and pressing environmental concerns. Air pollution, largely driven by industrial emissions and vehicle exhaust, leads to smog, respiratory problems, serious weather events, and climate change. (CO2) emissions further influence global warming and feed the core problem. Water pollution, resulting from the discharge of pollutants into rivers and oceans, threatens aquatic ecosystems and human health. Even light pollution disrupts natural ecosystems and disrupts the behavior of nocturnal creatures. But we are past the point of minor influence and it is time to take charge in making a change for a better world.

Habitat Destruction

Human activities often involve the destruction of natural habitats to make way for urban development, agriculture, and infrastructure projects. This habitat loss threatens the survival of countless species and disrupts the delicate balance of ecosystems. Companies involved in land-intensive industries must consider the consequences of their actions on local wildlife and plant life. We have failed to see how we are all connected and need to put ethical practices above monetary gain.

Deforestation and Desertification

Deforestation, driven by logging and land conversion for agriculture, significantly contributes to habitat loss and carbon emissions. Similarly, desertification, often linked to unsustainable agricultural practices, transforms fertile lands into arid deserts. Both deforestation and **desertification** have severe consequences for biodiversity, climate, and local communities.

Fossil Fuel Consumption and Greenhouse Gas Emissions

The reliance on fossil fuels for energy production is a major contributor to environmental problems. The burning of fossil fuels releases greenhouse gases, including carbon dioxide, methane, and **nitrous oxide**, into the atmosphere. These gasses trap heat, leading to rising global temperatures and climate-related disasters. Companies, especially those in the energy sector, play a significant role in contributing to these emissions.

Residential and Industrial Waste Generation and Management

The waste generated by human activities and industries poses a significant challenge to the environment. Improper waste disposal, including plastic pollution in oceans and landfills, harms wildlife and ecosystems. Companies must adopt responsible waste management practices and invest in sustainable packaging to reduce their negative impact on the environment.

Industrialization, Mining, and Agriculture

Industrialization, mining, and agriculture are essential for economic development but can have detrimental environmental consequences. These activities often result in soil degradation, water pollution, and the release of hazardous chemicals into the environment. Sustainable practices and responsible resource management are crucial for mitigating these impacts.

Gene Modification

While genetic modification has the potential to improve crop yields and address food security, it also raises concerns about unintended consequences (GMOs) can potentially disrupt local ecosystems and harm non-target species. Companies involved in biotechnology and agriculture must adhere to strict regulations to minimize negative environmental impacts.

Tourism and Migration

The tourism industry, while contributing to economic growth, can also strain local environments and infrastructure. Overcrowding, resource consumption, and the development of tourist destinations often have negative environmental consequences. Similarly, large-scale human migration driven by social, economic, or environmental factors can place immense pressure on host environments. Being mindful of our choices should be the way we think and make choices for our own well-being. Otherwise, we all pay a dear price

Overpopulation

Overpopulation is a root cause of many environmental challenges. As the global population continues to grow, demands for resources and space increase, leading to deforestation, habitat loss, and resource depletion

Consumerism and Resource Depletion

Consumerism drives high levels of resource consumption and waste generation. The demand for different products often results in the extraction of finite resources, such as minerals and fossil fuels, at unsustainable rates.

Ways of mitigating human-environment degradation

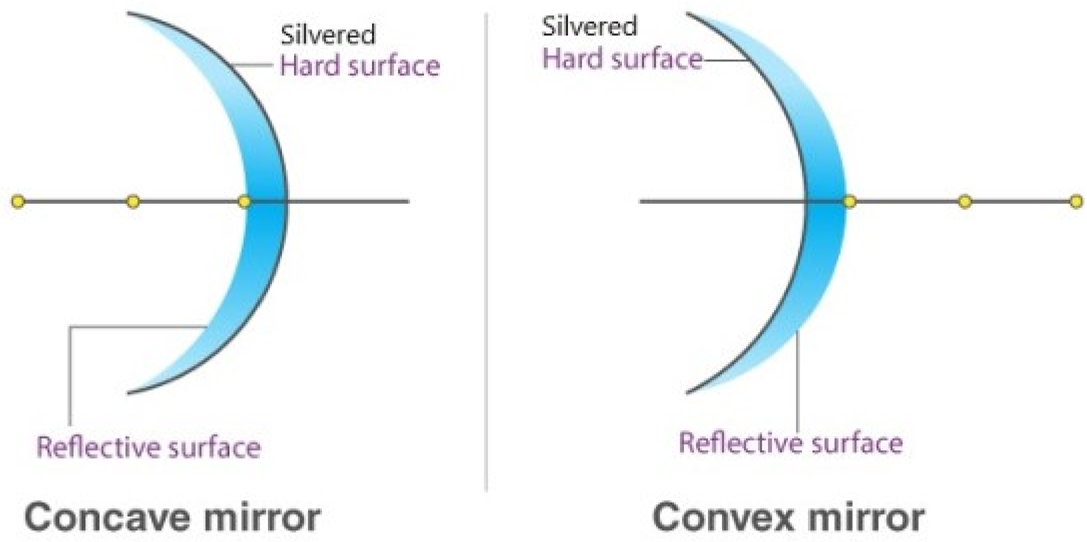
- ✓ Improve their environmental practices, including reducing plastic waste and carbon emissions.
- ✓ Raising awareness, adopting sustainable practices, and supporting policies and initiatives that prioritize environmental conservation.
- ✓ It is up to people and companies to embrace sustainability, adopt eco-friendly practices, and make responsible choices that protect our planet.

STRAND 3: FORCE AND ENERGY

Concave and Convex Mirrors

-They are also known as spherical mirrors and are formed when a spherical glass is silvered.

-If the inside is silvered a **convex** or **diverging** is formed while a **concave** or **converging** mirror is formed when the outside is silvered.

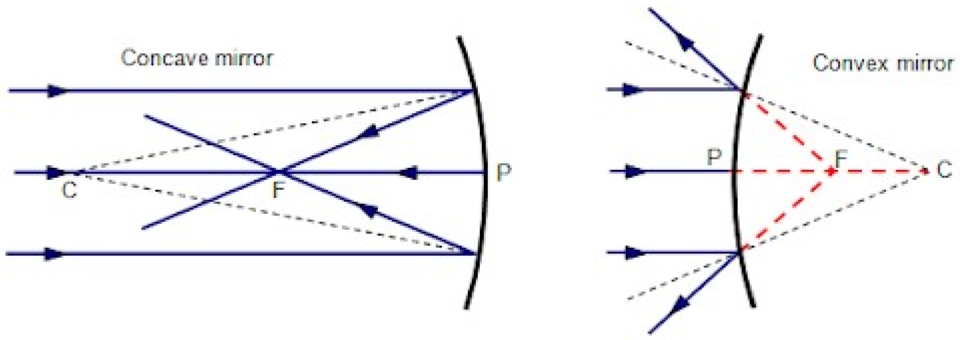


Parts of a Spherical Mirror

1. ***Centre of curvature* (C)** this is the centre of the sphere of which the mirror is part of. The centre itself is called the pole **(P).**
2. ***Principal axis*** this is the line joining the centre of curvature **(C)** to the pole **(P).**
3. ***Principal focus* (F)** is a point on the principal axis through which a ray is reflected when it hits a concave mirror. In a convex mirror the ray is

reflected and appears to originate from the point. **F** is virtual for a convex mirror while it is real for a concave mirror.

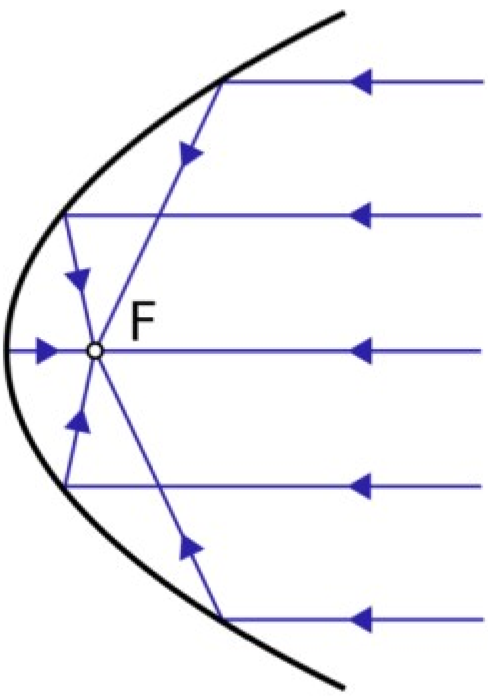
4. ***Radius of curvature*** **(r)** - this is the distance from the pole to the centre of curvature. The distance from the pole to the principal focus is called the focal length **(f).**



Parabolic Mirrors

- They produce a wide parallel beam or converge a large beam of light to a point.

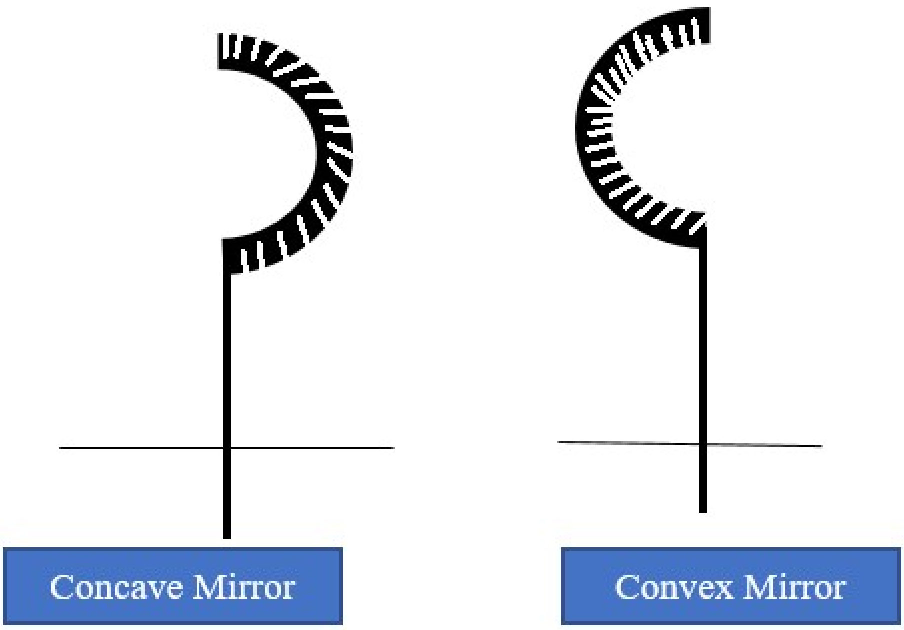
- They are widely used in making **car headlights** or in **spotlights.**



Images Formed by Spherical Mirrors

Location of images using ray diagrams

- When drawing ray diagrams the following symbols are used to represent the mirrors.



The image is located by drawing any two of the following rays:

A ray parallel to the principal axis which is reflected through the principal focus.

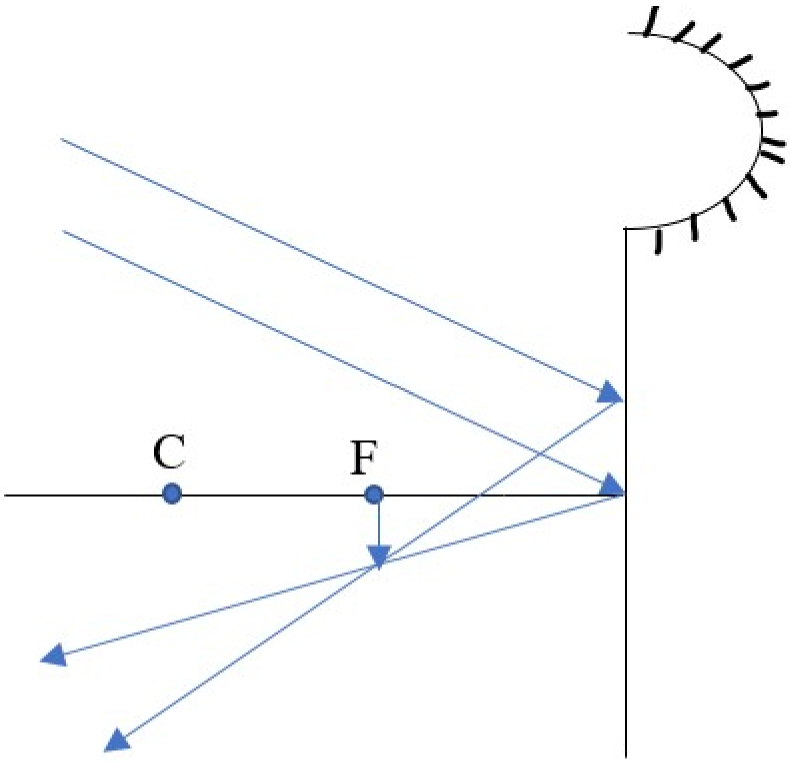
1. A ray through the centre of curvature which is reflected along its own path since it hits the mirror normally.
2. A ray through the principal focus which is reflected parallel to the principal axis.

- Virtual images are formed when rays diverge and as such the rays are extended backwards using dotted line till they meet.

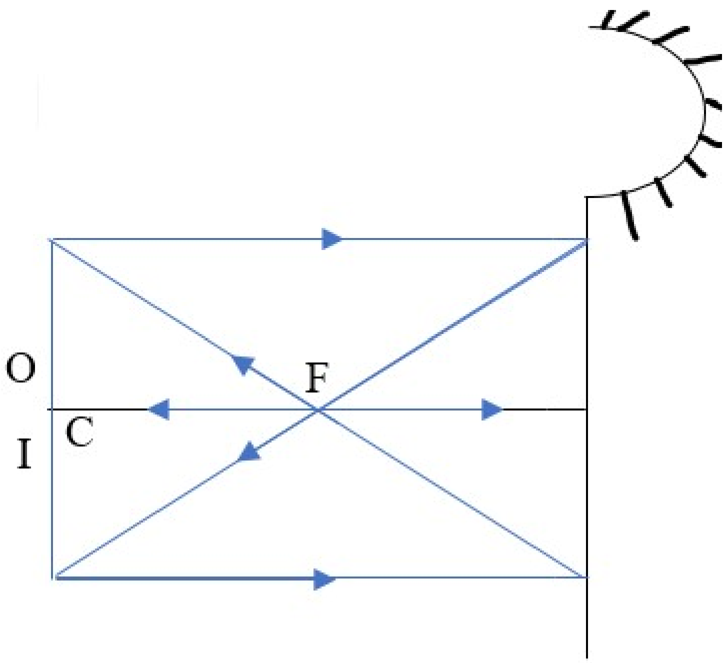
- A real image is formed by intersection of real rays.

a) Concave mirror

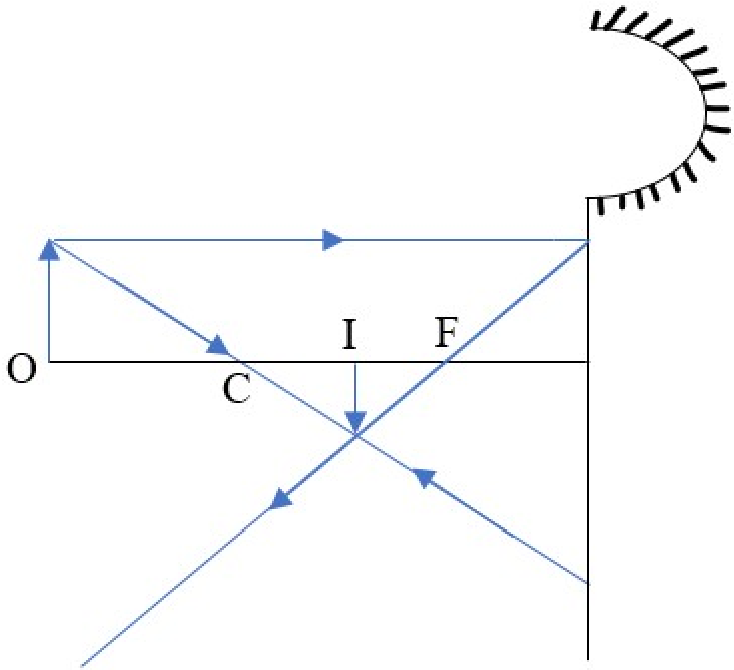
a) Object at infinity: image is formed at F. It is real, inverted and diminished.



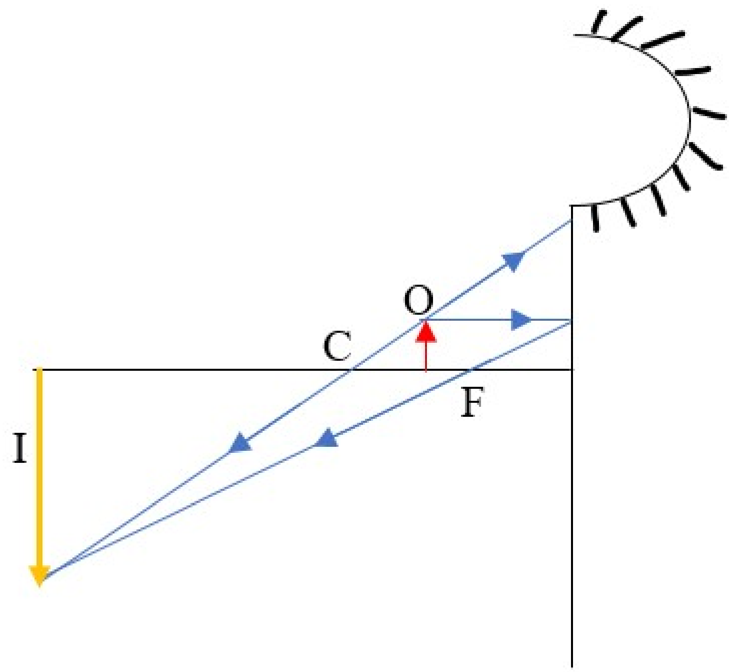
b) Object at C: image formed at C. It is real, inverted and the same size as the object.



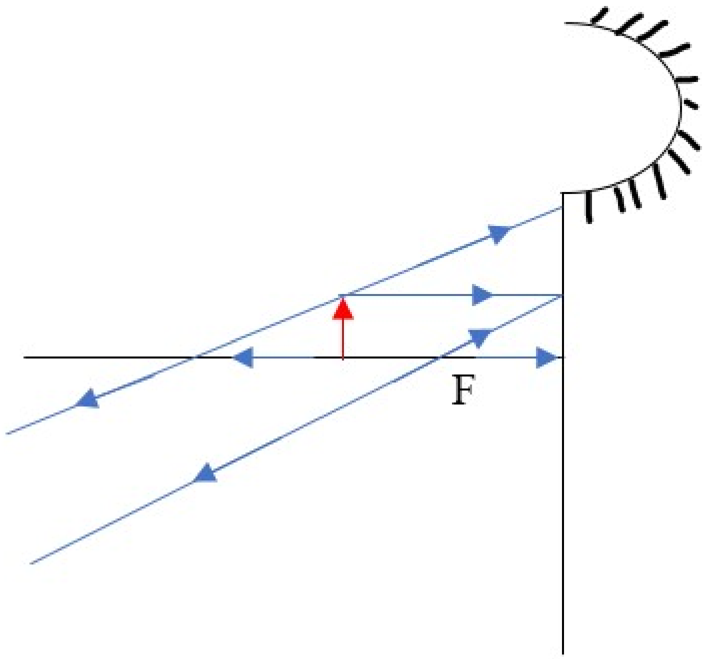
c) Object behind C: image is formed between C and F. It is real, inverted and diminished.



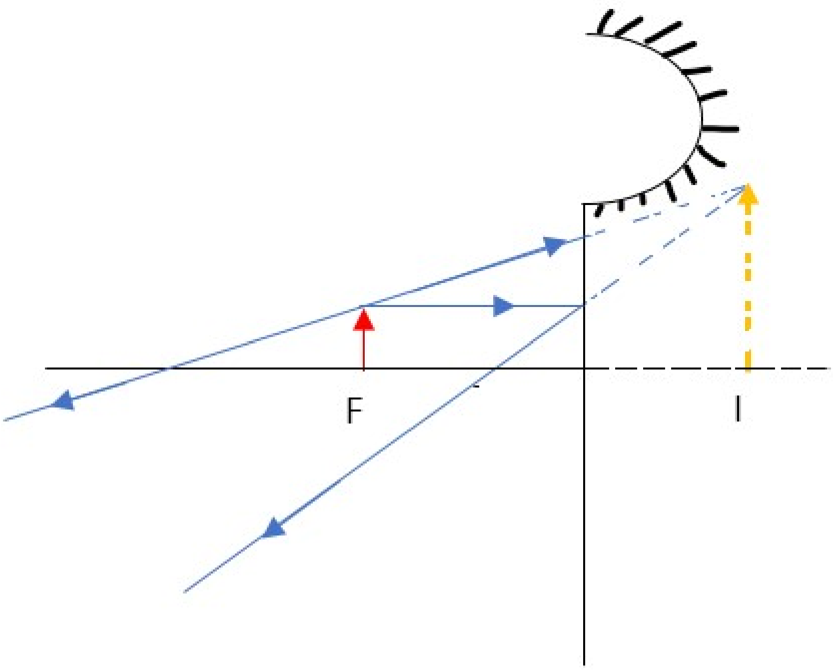
d) Object between F and C: Image is formed behind C. It is real, inverted and magnified.



e) Object at F: Image formed is at infinity.



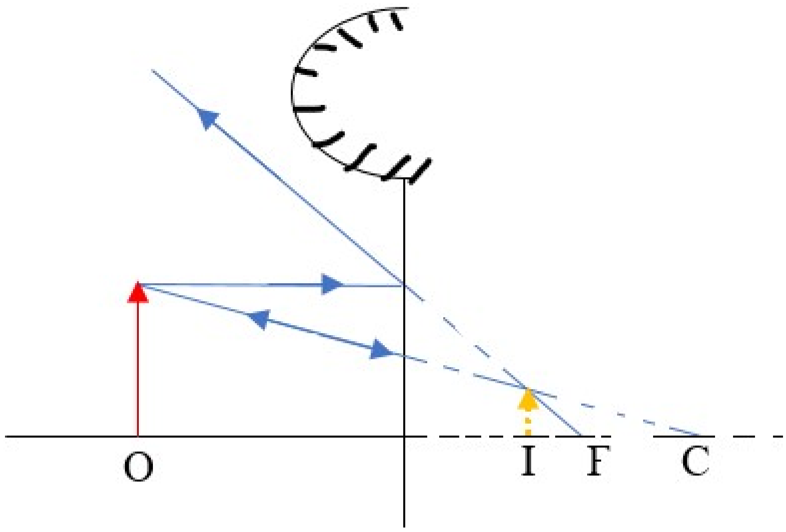
f) Object between F and P: Image is formed behind the mirror. It is virtual, erect and magnified.



b) Convex mirror

a) Image is always formed ***behind the mirror.*** It is virtual, erect

and **always** diminished.



Applications of curved reflectors

a) They are used in satellite dishes.

b) They are used in making shaving mirrors.

c) They are used in telescopes.

d) They are used in driving mirrors.

Magnification

- Magnification is the ratio of the image size to the object size.

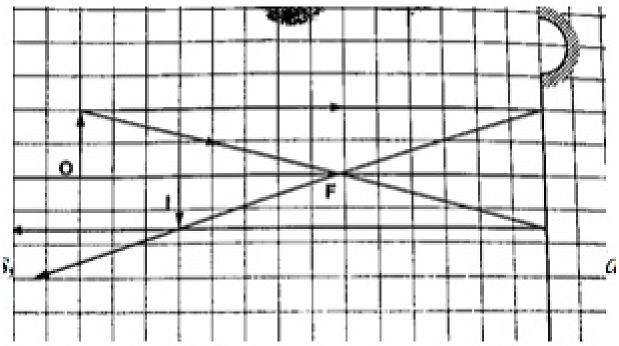
- ***Magnification (M) = height of the image / height of the object.***

- When the ratio is greater than one we say the image is magnified and when less than one we say it is diminished.

- ***Also magnification = image distance from the mirror / object distance from the mirror.***

Practice Example 1

1. Determine the size, position and nature of the image of an object 5.0 cm tall, placed on the principal axis of a concave mirror of focal length 15 cm, at a distance 35 cm from the mirror.



Solution

Let 1 cm represent 5 cm. Then the focal length is 3 cm.

Object distance = 7 cm, object height = 1 cm.

From the scale drawing,

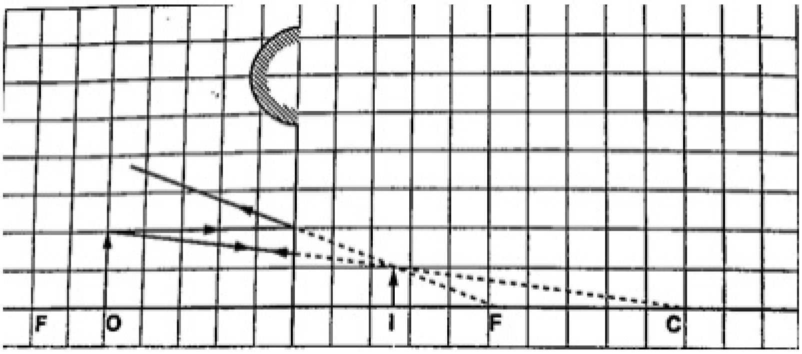
Image position = 5.4 cm × 5 = 27 cm in front of the mirror.

Image size = 0.75 cm × 5 = 3.75 cm.

Image is real and inverted.

Practice Example 2

2. A vertical object 5 cm high is placed 10 cm in front of a convex mirror of focal length 15 cm. find the position, size and nature of image formed. Determine the magnification of the image.



Solution

Let 1 cm represent 5 cm, then the focal length = 3 cm, object size = 1 cm

Object distance = 2 cm.

From the scale drawing,

Image position = 1.2 cm × 5 = 6.0 cm behind the mirror.

Image size = 0.6 cm × 5 = 3.0 cm.

The image is virtual and erect.

Magnification = image distance / object distance. Hence 6 /10 = 0.6 (diminished).

Waves

Introduction

- A wave is simply a disturbance that moves through a medium. Other waves do not require a medium to travel i.e. they can travel in a vacuum, are known as **electromagnetic waves** e.g. radio, X-rays, gamma rays UV rays etc.

- Other waves require a material medium to be transferred and are called **mechanical waves** i.e. water, sound waves etc.

Transverse and Longitudinal Pulses and Waves

1. Transverse waves

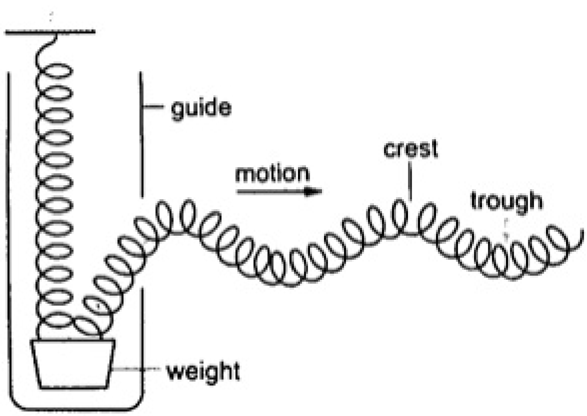
 They consist of a crest and a trough.

- In this case the displacement of the medium caused by these pulses are perpendicular to the direction in which the wave (disturbance) travels.

- A pulse is a single non-repeated disturbance.

- If the pulses are repeated periodically (regularly) they produce a series of waves called periodic transverse wave train.

- They can be produced as shown below.



2. Longitudinal waves

- These are waves whereby the particles of the medium vibrate parallel to the direction of movement of the disturbance.

- When several turns of a spring are pulled together (**compression**) and then released they tend to spread out to their original position.

- When pulled apart (**rarefaction**) they also turn to their original position.

- In this case the displacement of the spring is parallel to the motion of the wave and this is known as longitudinal.

Characteristics of waves

1. All waves have **speed** which depends on the nature of disturbance.
2. All waves have **wavelength** (distance between two successive points in a wave). Represented by the symbol **λ** and is measured in ***metres.***
3. All waves have **frequency - ' f '** which is the number of waves passing a point in one second. It is measured in cycles per second or **hertz (Hz).** The period of a wave is the time required for a complete wave to pass a given point.

   Therefore **$T = 1 / f$ or $f = 1 / T$** (period is measured in ***seconds***).

   The speed **'v'** is given as: **$v = \lambda / T$, since $f = 1 / T$** then **$v = (1 / T) \times \lambda = f\lambda$ or $v = f\lambda$.** This is the wave equation.
4. All waves have **amplitude** which is the maximum displacement of the particles of the medium as the wave passes.

Practice Example 1

1. A rope is displaced at a frequency of 3 Hz. If the distance between two successive crests of the wave train is 0.8 m, calculate the speed of the waves

along the rope.

Solution

v = f λ = 3 x 0.8 = 2.4 m

Hz = 2.4 m/s.

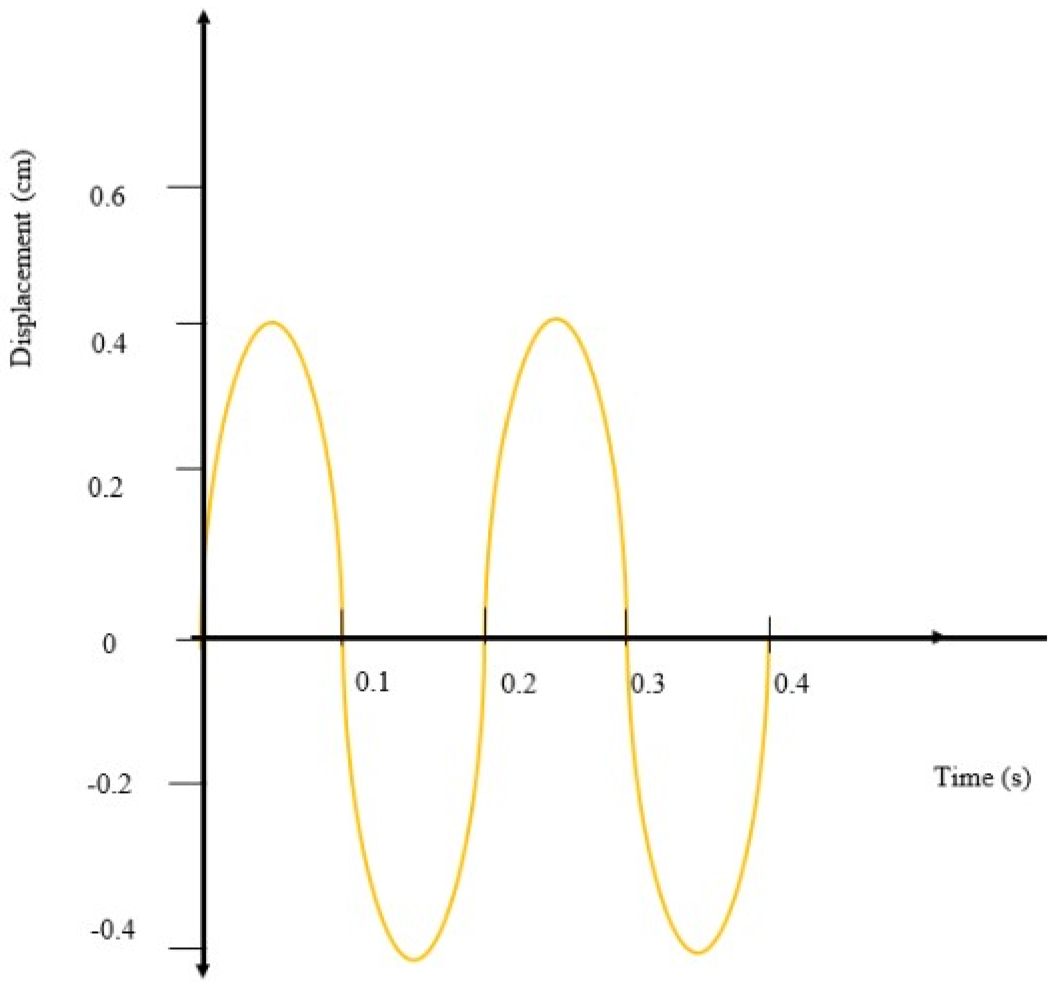
Practice Example 2

2. The figure below illustrates part of the displacement-time graph of a wave travelling across water at a particular place with a velocity of 2 ms^{-1} Calculate the wave's:

a) Amplitude

b) Frequency (f)

c) Wavelength (λ)



Solution

a) From the graph, maximum displacement

(a) = 0.4 cm.

b) From the graph, period T = time for one cycle = 0.20 seconds.

So $f = 1 / T = 1 / 0.20 = 5$ Hz.

c) Velocity = $f \lambda$ hence $\lambda = 2 / 5 = 0.4$ m.