GRADE 9; INTEGRATED SCIENCE NOTES

CBC RATIONALIZED WORK

Well-organized, simplified learning notes that provide clear, concise information in a logical sequence, making key concepts easily accessible and memorable, enhancing understanding and retention while fostering engagement and facilitating effective study.

By providing a clear focus on key ideas, these Mwalimu Consultancy Notes foster better retention and comprehension, making learning more accessible and enjoyable.

UPDATED VERSION

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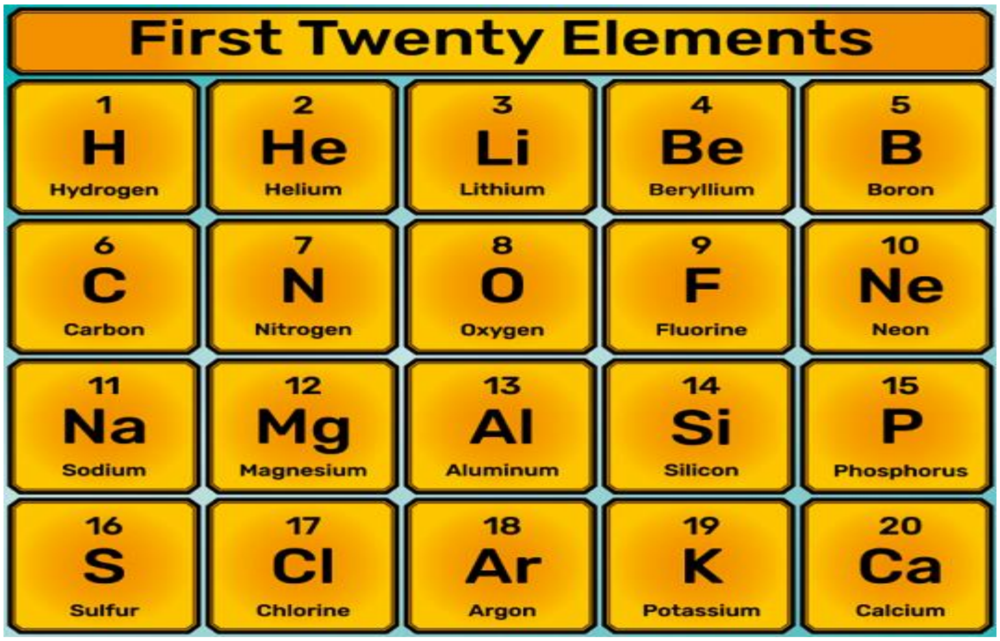
MWALIMU CONSULTANCY

STRAND 1: MIXTURES, ELEMENTS AND COMPOUNDS

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;

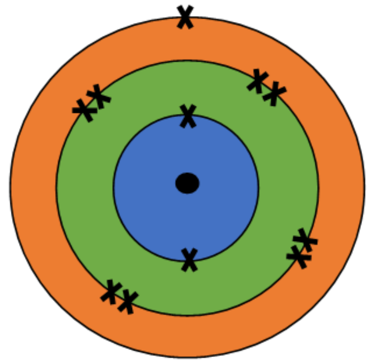
- **Protons -** found in the nucleus, they are positively charged (+ve)
- **Electrons -** found in the nucleus, they are negatively charged (– ve)
- **Neutrons -** they can be imagined as circulating the nucleus in energy levels, they have no charge
- In a neutral atom, *Number of protons = Number of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

Particles present in an atom are summarized below.

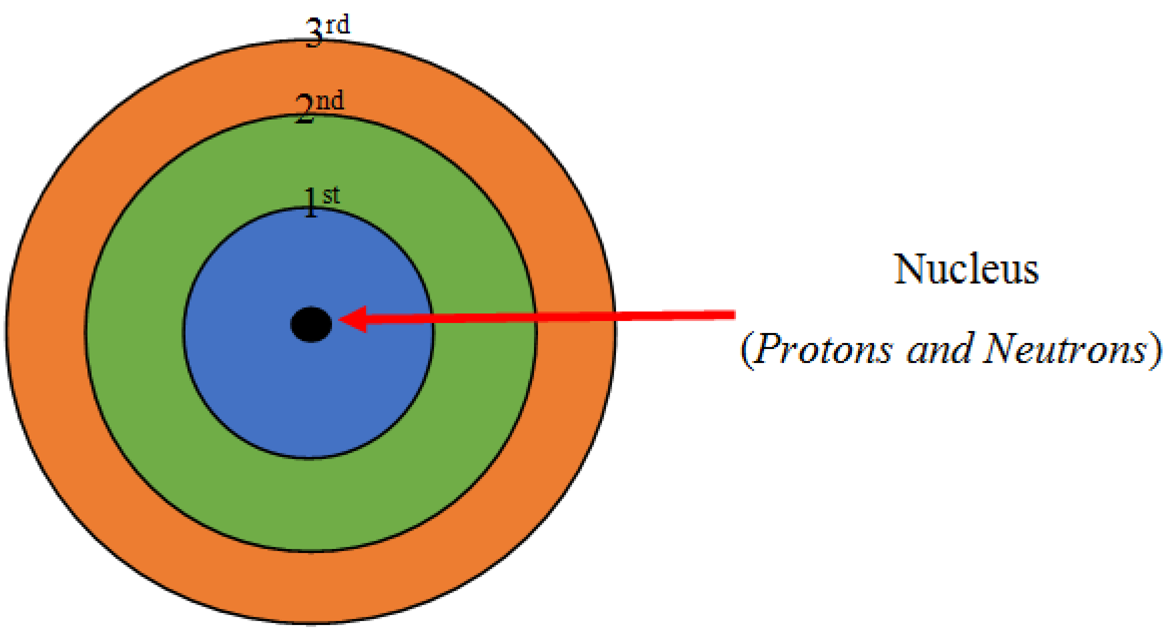
Sub-atomic Particle	Mass	Charge	Where found in atom
Proton	1	+ (Positive)	inside nucleus
Neutron	1	0 (Neutral)	inside nucleus
Electron	1/1840	- (Negative)	outside nucleus

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 1st, 2nd, 3rd, 4th 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

Element	Symbol	Electron Configuration
Helium	He	2
Lithium	Li	2.1
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
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

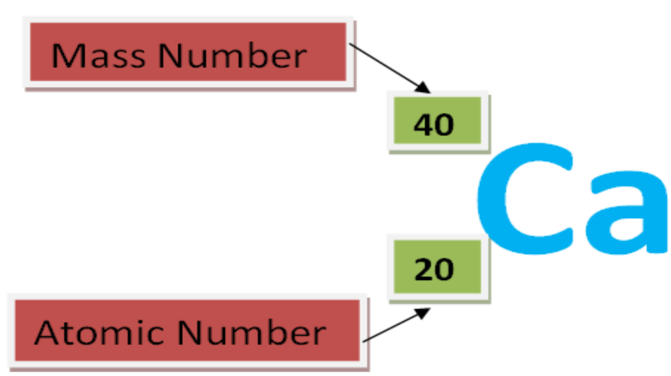
The number of neutrons

= 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

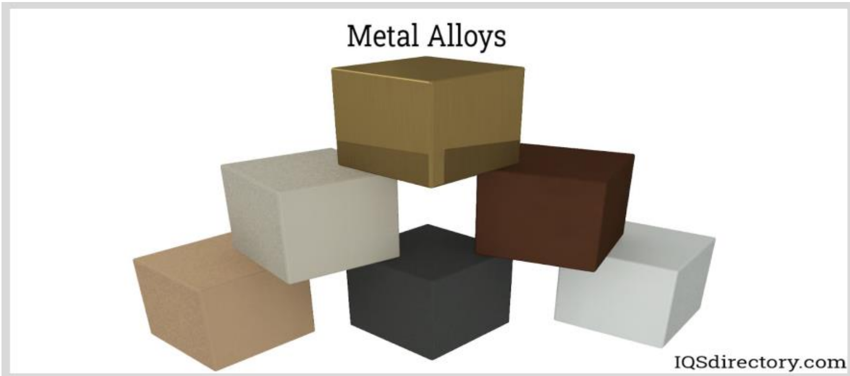


NOTE: The top number is referred to as the superscript and bottom number as the subscript

Metal and alloys

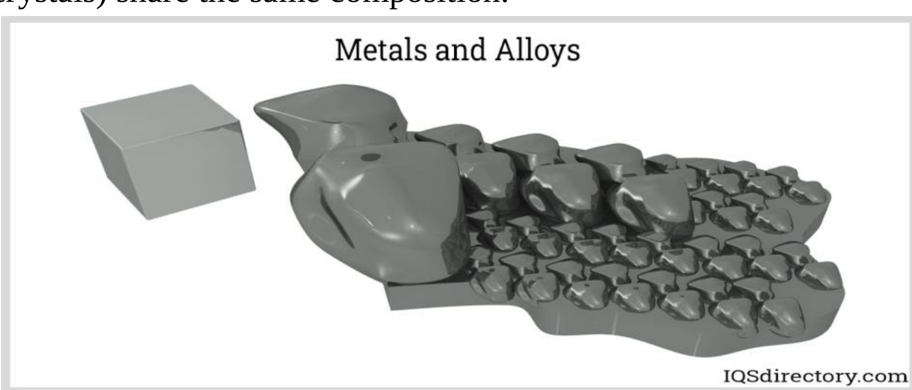
Alloys

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.

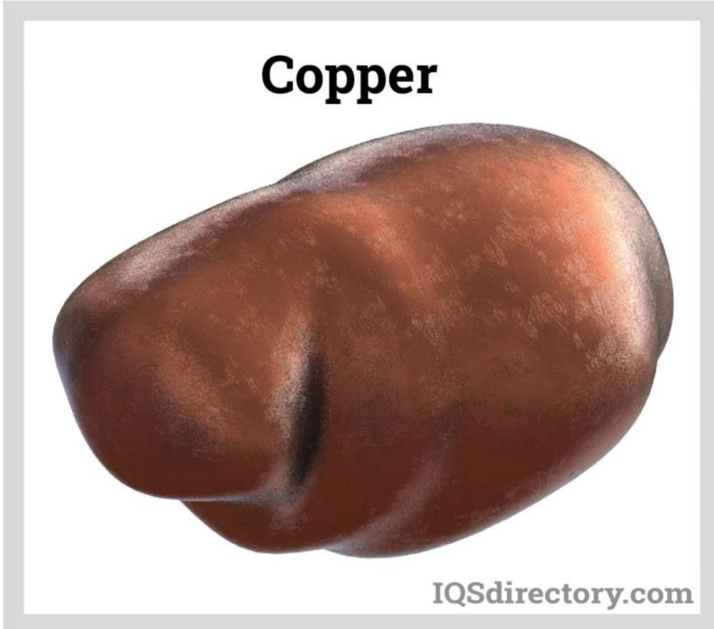
- ✓ The additional elements in an alloy, which may or may not be metals, are soluble in the molten base metal and integrate into the mixture.
- ✓ The mechanical characteristics of alloys are frequently very different from those of their base metal. Alloying a metal with another soft metal, such as copper, 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.

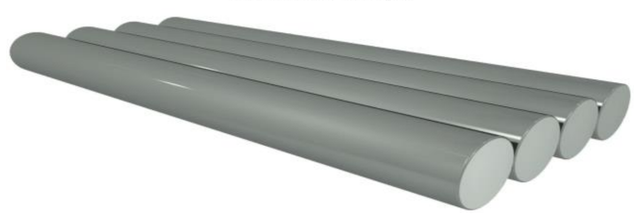
Properties of Steel

- **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.

Aluminum Alloys



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

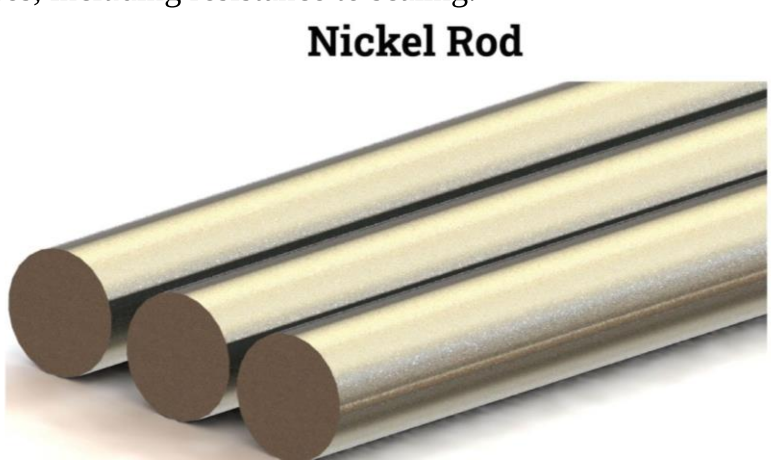
Nickel readily alloys with various metals like chromium, iron, molybdenum, and copper, allowing for the creation of diverse alloys with remarkable properties. These alloys often display exceptional high-temperature strength, excellent corrosion resistance, and resistance to high-temperature scaling. 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

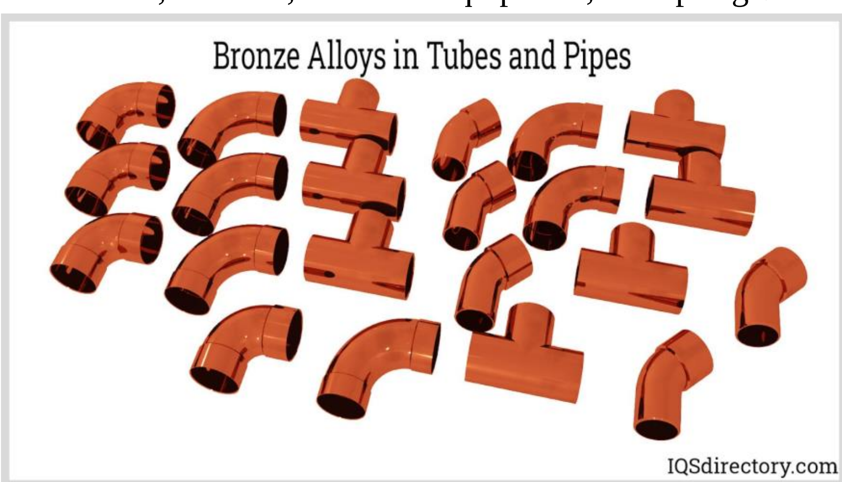
Cupronickel is a bronze alloy composed of copper and 2% to 30% nickel. It is renowned for its excellent thermal stability and corrosion resistance, particularly in steam or moist air environments. Cupronickel outperforms other bronze types in seawater, making it ideal for use in ship hulls, pumps, valves,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

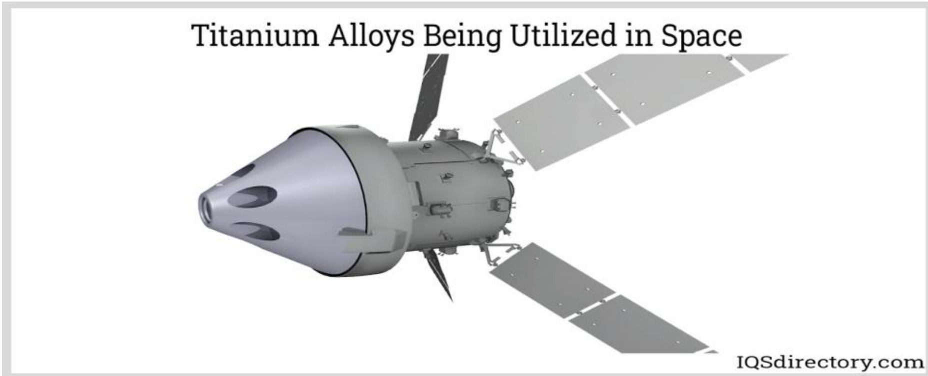
Tin Bronze

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.

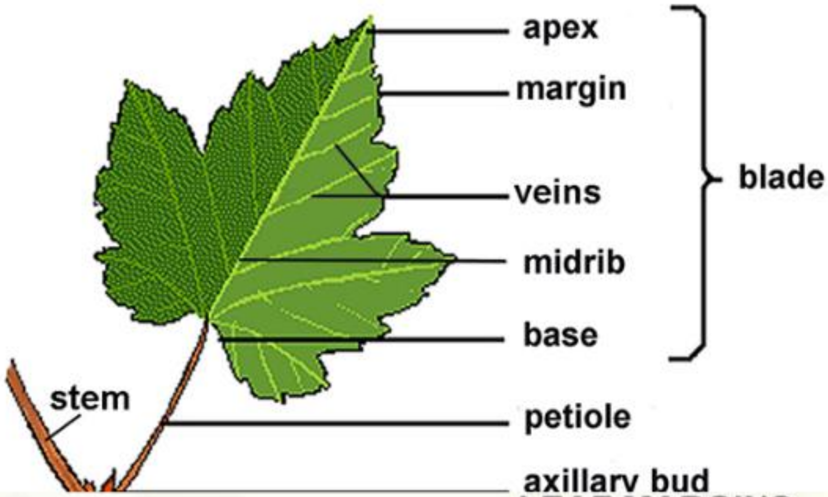
Photosynthesis largely occurs in the leaf.

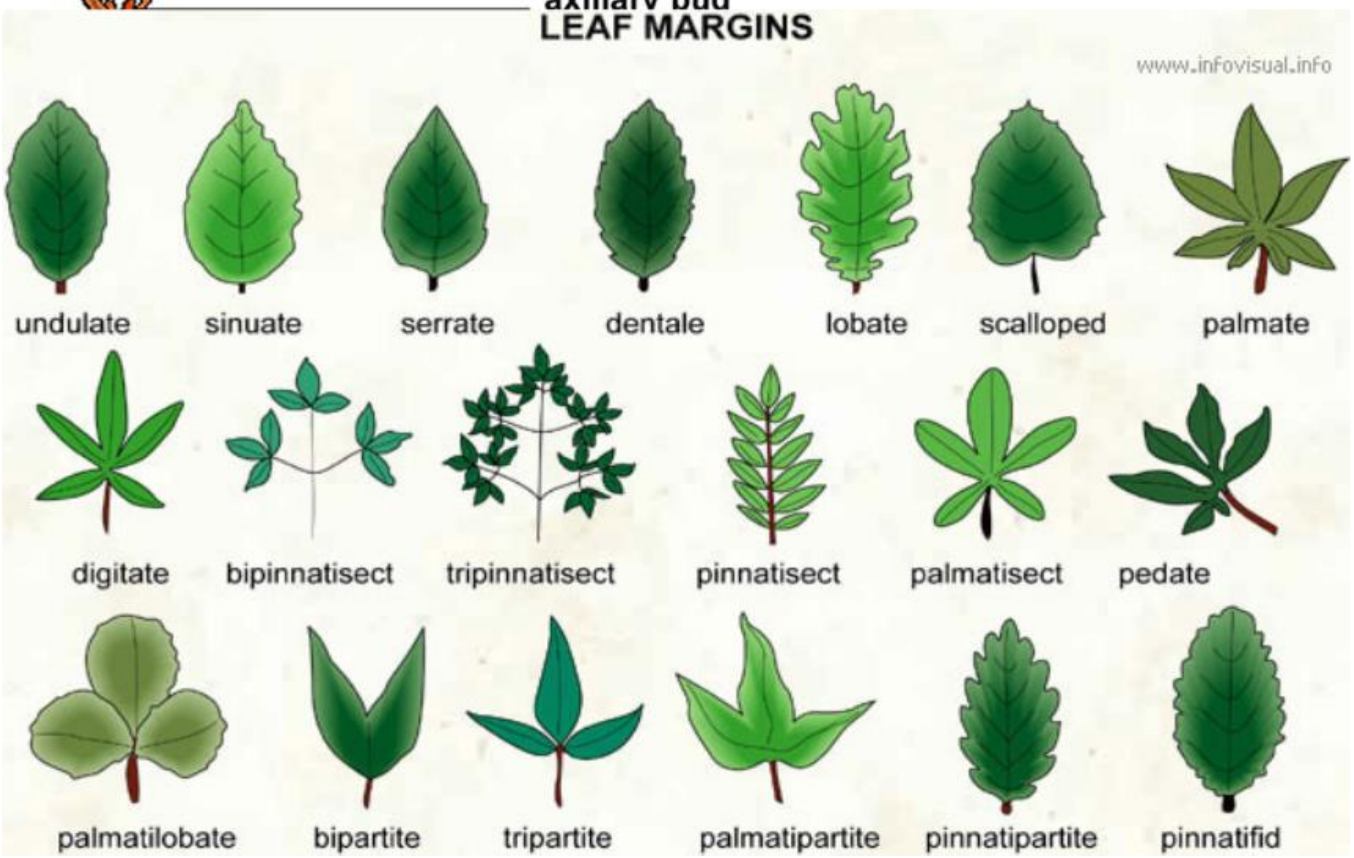
To understand the process of photosynthesis, it is important to understand the leaf structure.

External Leaf Structure

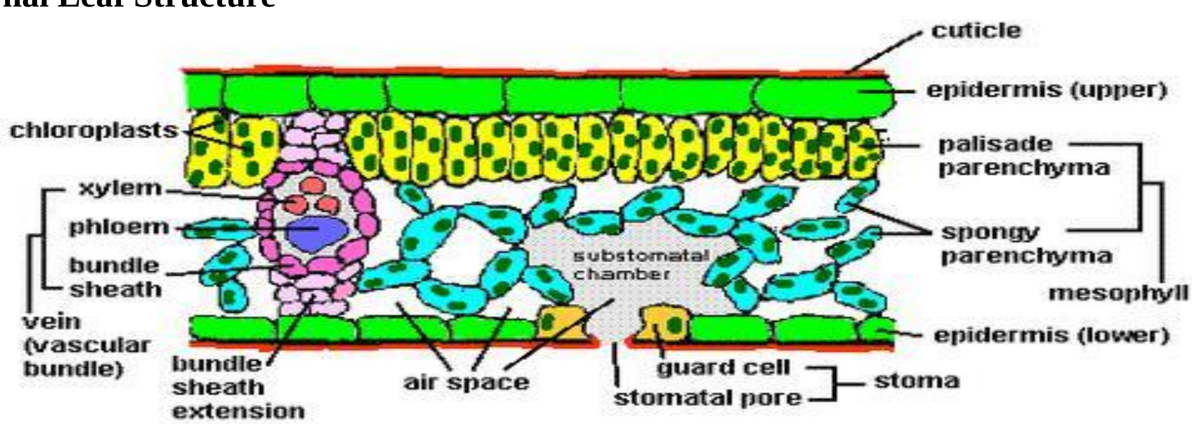
- Externally, the leaf has a petiole through which it attaches to the leaf branch or stem, lamina- the broad flat surface, margin- the outline and the leaf apex.
- The leaf margin can be smooth, dentate, serrated or entire.
- The size of a leaf depends on its environment. Plants in arid areas have small 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.

$ADP+P \rightarrow ATP$

- 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.

<u>3. Temperature</u>

- 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.

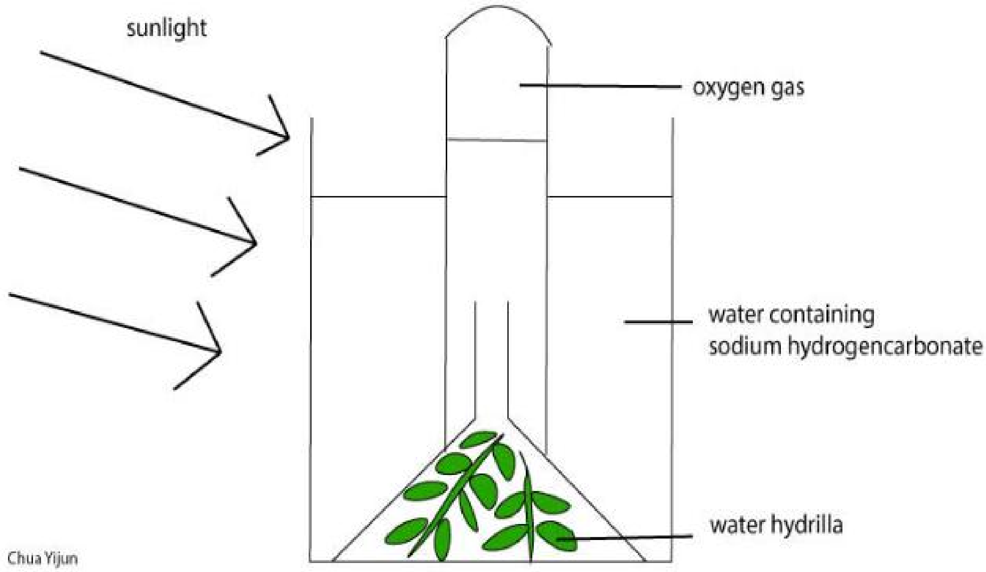
Experiment to Investigate the Gas Produced During Photosynthesis

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.

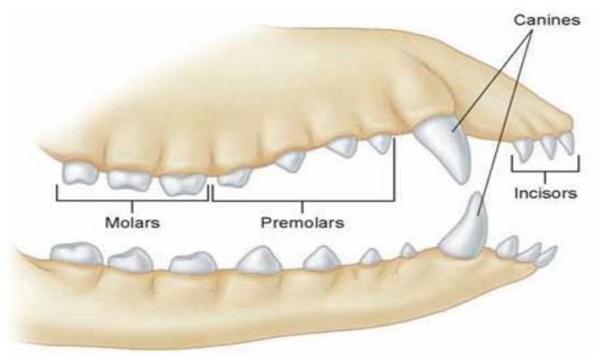
The breakdown is both physical and chemical.

- 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.

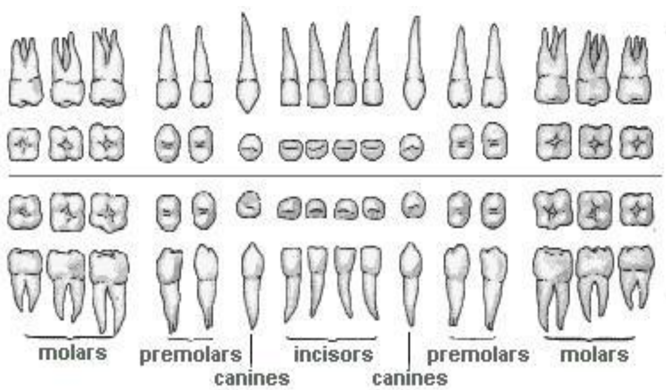
Types of Dentition

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



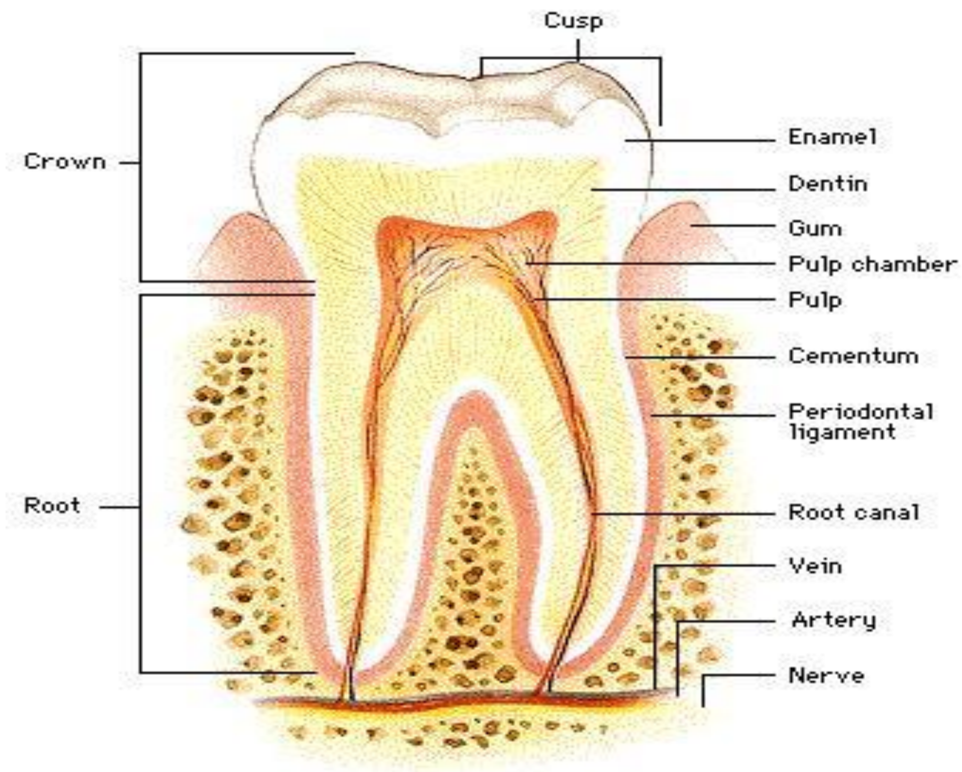
1. **Incisors**
- Are flat and chisel shaped with sharp ridged edges for cutting and biting food.
- They have one root.

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.



<u>POLITE NOTE!</u>

Take note that this is a Sample of the Well Organized Detailed Simplified Notes.

Call/Text/WhatsApp <u>0746 222 000</u> / <u>0742 999 000</u> for the Complete Notes.

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