# Topic: MINERALS

Minerals are nutrients required by the body in small amounts hence should be eaten daily.

Minerals can be classified into two groups;

I. The macro minerals.

The macro minerals can also be called major, big or essential minerals. These minerals are essential for the proper function of the body and they include calcium, phosphorus, magnesium, sodium, potassium, chloride and sulphur.

II. The micro minerals.

Micro minerals can also alternatively be called the trace or small minerals. They include iron, copper, zinc, iodine, fluoride, cobalt, manganese, nickel, and chromium.

**General functions of minerals.**

- Minerals are components of essential body compounds. Minerals play an important role in building up of our bodies. Without minerals, many of the most essential compounds of the body could not be formed. Bones and teeth contain large concentrations of calcium and phosphorus containing compounds playing largely structural roles. Chloride ions are required to form hydrochloric acid within the stomach, which assists in digestion.
- Minerals are also cofactors in biological reactions. Many mineral ions bind to specific enzymes and form may parts of the active sites of the enzymes, which are the regions of the enzymes at which the reactions they catalyse actually take place. The mineral ions required by the enzyme are known as cofactors for example zinc, iron and copper and the complexes that form with enzymes are known as metallo-enzymes.
- Minerals also facilitate absorption, digestion and transport. The absorption of some nutrients from the gastro intestinal tract and transport across the cell membranes within the body are dependent on a variety of minerals. Sodium and magnesium facilitate the

absorption of carbohydrates and their entry into the cells. Calcium facilities the absorption of Vitamin B12.

- Minerals are also essential for maintenance of an acid base balance. The normal on of blood is 7.35 to 7.45. A particular mixture of mineral ions in any region of the body has a stronger influence on the prevailing on level. Some acid forming minerals are chlorine, sulphur and phosphorous. The alkali forming minerals include sodium, potassium, magnesium and calcium. Buffers in the blood include carbonated and phosphates of sodium and potassium and protein molecules.

- Minerals are also essential in the maintenance of a water balance. Mineral ions like sodium and potassium have a great influence on the movement of water among the various components of the body because of their effect on the osmotic pressure of the solutions of which they are part.

- Minerals are also essential in the transmission of nerve impulses. A nerve impulse is essentially just a wave of mineral job movement across the nerve cell membrane. Sodium, potassium and calcium are important for the normal functioning of the nervous system.

- Some minerals are important in regulation of muscle contraction. Calcium encourages muscular contraction and minerals like potassium, sodium and magnesium encourage muscular relaxation.

**Digestion and absorption of minerals**

Minerals are already nutrients in the form in which they are taken into the body. That is to say they are simple enough substances to be absorbed I to the blood stream without being broken down. Soluble mineral elements that is to say potassium and sodium are absorbed in the stomach and the small intestines. Calcium and iron are absorbed in the small intestines.

## MAJOR MINERALS

**CALCIUM.**

Calcium is the most abundant cation in the human body with 99% of the calcium being stored in the bones and teeth and the remaining 1% is present in the blood and other tissue fluids.

**Physiological functions of calcium.**

- Calcium is very essential in the formation of bones. This is because the major site for calcium deposition after being absorbed is the bone. Bone constitutes the major reservoir of body calcium which is 99% of the total. In the process of bone mineralization, an inorganic containing complex hydroxyapetite is formed and consists of phosphorus and hydroxyl ions.

- Calcium is also important in tooth formation and this begins in childhood and requires calcium as well as phosphorus, magnesium and fluoride which liberalize an organic protein matrix to give teeth their rigidity.

- Calcium is also a major factor at three key points in the blood clotting process. This process begins with the exposure of collagen on the walls of broken blood vessels causing platelets to gather in the vicinity of the wound. In the presence of calcium ions, platelets release thromboplastins which in the presence of calcium activates pro-thrombin and causes it to change to thrombin which again in the presence of calcium converts soluble fibrinogen into insoluble fibrin thus forming the hardened protective blood clot which seals off the outside of the wound.

- Calcium is essential in the absorption of vitamin B12. This process requires the presence of an enzyme called intrinsic factor secreted by the mucosal cells of the stomach whose absence leads to vitamin B12 deficiency. The intrinsic factor complex passes from the stomach down to the ileum where it is complexed further with calcium and magnesium ions and is adsorbed to the surface of the mucosa. It is then dissociated from the calcium or magnesium and vitamin B12 is absorbed by pinocytosis.

- Calcium is required in the transmission of nerve impulses at synapses between nerves and between nerve and muscle tissue. When the nerve impulse reaches the end of the nerve cell, proteins in the membrane let the calcium ions enter the cell which induce the release of neurotransmitter molecules (acetylcholine), which can bind to the membrane of the next nerve cell in line and initiate it to transmit an impulse and so cause the whole process to be repeated in another nerve cell.
- Calcium is also required for activation of several important enzymes such as pancreatic lipase.
- Calcium also increases permeability of cell membranes. Apparently it functions in the transport of certain ions into and out of cell membranes.
- Calcium is needed for the regulation of muscle relaxation and contraction. The contraction of skeletal and cardiac muscle tissues is dependent upon a certain level of calcium ions.

**FACTORS THAT AFFECT THE ABSORPTION OF CALCIUM**

**a) Factors that increase the absorption of calcium.**

- ✓ The rate of absorption is increased with decreased dietary intake of calcium and with increased physiological need for calcium that occurs during growth, pregnancy, and lactation.
- ✓ The presence of an acidic environment. Foods that are acid forming for example cereals and protein foods increase the absorption of calcium.
- ✓ Amino acids appear to increase the solubility of calcium and therefore increase its absorption. The amino acids formed from protein as a result of digestion combine with calcium to form soluble calcium salts and these salts are readily absorbed.
- ✓ Absorption of calcium is increased when the diet contains calcium to phosphorus ratio of 1:1 or 2:1. Absorption of calcium is maximised when dietary calcium and phosphorus are present in equal amounts.

- ✓ Presence of parathyroid hormone increases absorption by increasing the conversion of vitamin D to its active form.
- ✓ Increased intake of vitamin D increases the absorption of calcium. Vitamin D promotes the production of the carrier protein needed for the absorption of calcium.
- ✓ Presence of lactose. Lactose increases the solubility of calcium upon hydrolysis of the milk sugar. Lactose increases the absorption of calcium as does vitamin D.

b) **Factors that decrease the absorption of calcium**.

- ✓ Deficiency of vitamin D
- ✓ Decreased intestinal acidity common in later age.
- ✓ Diarrhoea and any condition that generally results in malabsorption. Diarrhoea increase intestinal motility and this allows less time for calcium to be absorbed.
- ✓ Oxalic acid found in spinach, coloured greens and rhubarb combines with dietary calcium to form insoluble calcium oxalate thereby binding calcium and making it unavailable for absorption.
- ✓ Phytic acid found in outer layers of cereals and cereal products containing unrefined grains also binds dietary calcium to form insoluble complex calcium phytate. Phytic acid can however be broken down by phytase which is present in flour.
- ✓ Free fatty acids particularly unsaturated variety may also combine with calcium to form the type of insoluble complexes known as soaps.
- ✓ Dietary fibre binds calcium and decrease its absorption.
- ✓ A high ph also decreases the absorption of calcium. Alkalinity decreases the absorption of calcium.

**Control of calcium in blood.**

Calcium can be raised by the action of the parathyroid hormone which increases the activation rate of vitamin D thus increasing absorption of dietary calcium from the intestines. Both vitamin D and parathyroid hormone act to release calcium from storage sites in bone and to reduce its urinary excretion.

If blood calcium exceeds optimal levels, an antagonist of the hormone counteracts the effects of the hormone by increasing the conversion of vitamin D to its active form thus diminishing the absorption of calcium.

***Hypercalcemia***

This occurs as a result of excess calcium or vitamin D and this includes;

a) Calcium deposition in the heart and lungs and other soft tissues
b) Nausea
c) Loss of appetite
d) Reduced growth
e) Weight loss

NB: Excess calcium is normally excreted through urine sweat and faeces

***Hypocalcaemia***

This occurs as a result of low calcium in blood. If there is no enough calcium and vitamin D in the diet the blood takes what it needs from the bones and teeth, thus causing bad breath and disease of the body.

Little calcium in the body results into tetany which is characterised by stiff contracted muscle, twitching of the face, hands, and feet, muscles may become flaccid and increased nerve activation.

***Food sources of calcium***

- Milk and milk products
- Tinned fish
- Hard water
- Dark green vegetables
- Nuts
- Seeds and legumes
- Soya beans.

**PHOSPHORUS**.

Phosphorus is the second abundant mineral in the body and has a major role in energy metabolism.

**Functions of phosphorus.**

- ✓ Role of phosphorus in energy metabolism.
- ✓ Development of bones and teeth.
- ✓ Phosphorus is a component of phosphor lipids which are a major component of the cell membranes in which they regulate what enters and leaves the cells. The phospholipids also help to transport other lipids in the blood since they are normally soluble in water.
- ✓ One of the buffer systems in the blood that helps to maintain its acid-base balance, contains phosphorus and phosphate compounds are effective buffers.

**Food sources of phosphorus.**

- Milk and milk products
- Meat
- Poultry
- Nuts
- Carbonated beverages
- Egg yolk
- Food grains
- Legumes.

**POTASSIUM**

Potassium is the most abundant cation in the intracellular fluid of cells.

***Functions of potassium***.

- ✓ Transmission of nerve impulses. The reversal distribution of potassium ions and sodium ions is essential for the contraction of muscles and impulse conduction. Together with sodium, potassium enables movement of substances in and out of cells.

- ✓ Muscle contraction especially the skeletal and cardiac muscle tissue.
- ✓ Carbohydrate and protein metabolism. Potassium is important in glycogenesis and functions as a catalyst in the synthesis of proteins.
- ✓ Maintenance of a water balance. The osmotic pressure inside cells is due to the pressure primarily exerted by potassium.
- ✓ Maintenance of acid-base balance.
- ✓ Facilitates removal of excess sodium and this may help to prevent hypertension.

***Food source of potassium.***

- Meat
- Fish
- Dairy products
- Fruits and vegetables
- Whole grain cereals.

**Deficiency of potassium**.

Deficiency of potassium is called hypokalemia which is decreased blood potassium levels.

***Causes of hypokalemia.***

- Hypokalemia may result from chronic use of diuretics. Diuretics are agents that promote urine excretion and are used to alleviate oedema.
- Surgery
- Diarrhoea
- Vomiting

NB; low blood potassium produces tachycardia. Which is characterised by rapid and irregular heart beat.

- In severe depletion of potassium, heart failure may occur, hence death.

**SODIUM**

Sodium is the most abundant cation in the extracellular fluid of cells.

**Functions of sodium.**

- ✓ Role of sodium in conduction of nerve impulses.

  Transmission of nerve impulses through muscles and along nerves is strongly dependent of sodium ions and potassium ions. This accompanied by the reversal in the distribution of sodium and potassium ions indicating a fundamental involvement in cell fixing.

  When a nerve cell is induced to transmit an impulse, proteins in the membrane (sodium channels) change to the open configuration. This allows the sodium ions to flood into the cell from the extracellular fluid, where they are abundant.

  This entry of positive ions changes the electrical balance of the membrane in a way that causes the neighbouring sodium channels to open thus a wave of sodium ion entry moves down the cell, but the entry of the sodium ions is soon blocked by the closing of the sodium channels.

  Normality is then restored by the membrane proteins that pump sodium and other ions especially potassium ions across the nerve cell membrane.

- ✓ Maintenance of fluid balance by maintaining the osmotic pressure and the fluid level of blood. Whenever the level of sodium is low or high, the level of water will be affected greatly.
- ✓ Maintenance of an acid- base balance as a component of two buffer systems that help maintain a normal pH of blood which are sodium hydrogen phosphate and sodium di hydrogen phosphate.

***Food sources of sodium***.

- Table salt
- Cheese

- Milk
- Processed meats
- Shellfish
- Eggs
- Public water supply.

**Relationship between sodium and hypertension**.

Excessive sodium is not healthy for everyone especially for those with high blood pressure. When a person has hypertension and increased sodium level in blood, this results in a high osmotic pressure, pulling a large volume of water into the blood. This even causes the pressure to increase.

*Increased sodium in blood = increased osmotic pressure = increased movement of water into blood = increase blood pressure*.

If a hypertensive person decreases sodium intake, it will help to decrease the blood pressure. Hypertensive people are recommended to consume not more than 1.2g of sodium per day.

**CHLORIDE**.

Chloride is the form in which chlorine is present in the body. The anion is found in the extracellular fluid for example the gastric secretions.

**Functions of chloride.**

- ✓ <u>Role of chloride in digestion and absorption</u>.
  Chloride ions combine with hydrogen in the stomach to form hydrochloric acid which is essential for digestion of proteins and conversion of iron 111 (ferrous the absorbable form) and hydrolysis of some sucrose to fructose and glucose. Chloride in saliva functions to activate salivary amylase which is an enzyme that begins the breakdown of starch to maltose.

- ✓ Regulation of osmotic pressure where the chloride combine with sodium in the blood to help maintain the osmotic pressure thus helping maintain a normal blood volume.

***Food sources of chloride.***

- Table salt
- Meats
- Sea food
- Milk
- Eggs.

NB; foods rich in sodium are rich in chloride.

**MAGNESIUM.**

Magnesium is the second abundant cation in the intracellular fluids after potassium.

**Functions of magnesium**.

- ✓ Much of magnesium is located in the bone combined with Calcium and Phosphorus salts therefore plays structural roles.
- ✓ Synthesis of ATP. Magnesium activates the enzymes necessary to add the third phosphate group to ADP to form ATP.
- ✓ Transmission of impulses along nerves and muscles. Magnesium interacts with sodium and potassium ions to allow the transmission of impulses along nerves and muscles.
- ✓ Activator of enzymes necessary for metabolism of carbohydrate, fats and proteins. Magnesium helps in amino acid activation. It also activates many enzymes which are involved in the metabolic pathway that results in release of energy from carbohydrates, fats and proteins.
- ✓ Relaxation of skeletal muscles after contraction. Magnesium is essential in the proper working of the nervous system which is also essential for healthy nerves and muscles.

***Food sources of magnesium.***

- Milk and milk products
- Meat

- Poultry
- Organ meats
- Egg yolk
- Wholegrain cereals
- Bread
- Fruits
- Nuts
- Dried beans
- Peas
- Green leafy vegetables owing to their chlorophyll content

NB; magnesium is the core atom of chlorophyll hence mainly found in photosynthetic plants.

***Causes of magnesium deficiency.***

- Alcoholism
- Prolonged diarrhoea
- Vomiting
- Intestinal mal absorption

- Primarily deficiency can result in dietary deficiency. That is to say, when the diet lacks magnesium.
- Secondary deficiency can be caused by;
- Over consumption of alcohol
- Kidney diseases
- Liver cirrhosis due to smoking

NB: In alcoholics, magnesium deficiency is thought to be the cause of hallucinations.

***Symptoms of magnesium deficiency***.

- Tetany
- Continuous facial muscle contraction
- Confusion

- Increased response to sound and touch.

**SULPHUR**

***Role of sulphur in maintaining of protein structure.***

All body cells contain sulphur chiefly as a component of amino acids methionine, cysteine and cystine found in some proteins. The protein molecule structure is maintained by the disulphide linkages (-S-S-) that help to hold the amino acids together in a distinct shape.

Sulphur is seen in the rigid structure of keratin (protein) in hair, skin and nails. Disulphide links give great toughness and steady shape.

Gluten in flour also contains these links. When Vitamin C, an oxidising agent is added to dough it strengthens the links making the dough stronger and elastic. Malt is a reducing enzyme, softens the flour by breaking the links.

***Food sources of sulphur.***

- Cheese
- Eggs
- Poultry
- Fish
- Milk.

NB; Most protein foods contain sulphur.

**TRACE MINERALS.**

**IRON.**

The body of adult contains about 4g of iron.

**FACTORS THAT AFFECT IRON ABSORPTION**.

a) **Factors that increase iron absorption**.

- Nature of dietary iron. (haeme or nonhaeme iron).

Haeme iron is found in haemoglobin and myoglobin, thus is obtained exclusively from animal tissue (meat, poultry, and fish and organ meats like liver, heart and kidney). Non haeme iron is found in animal foods. (milk, cheese, eggs), grains and vegetable foods.
Absorption of iron from the haeme pool is distinctly better from the non haeme iron pool. Specifically, haeme iron absorption can be as high as 10-30% whereas absorption of iron from the nonhaeme sources is usually less than 5%.
The absorptive mechanisms differ for haeme and nonhaeme iron. Haeme iron is passed directly into mucosal cell, but the absorption of nonhaeme iron is controlled by receptors bordering the mucosal cells. This makes the absorption of non haeme more complex than the haeme iron.
By far the amount of iron in the diet is ironic or non haeme. This type of iron is readily precipitated by a number of substances present in food.
Non-haeme iron is present in food as ferric iron, which cannot be absorbed by the body. Before it can be absorbed, it has to be changed into a form of iron known as ferrous iron. Haeme iron in contrast is already in a soluble form when it enters the digestive tract.

- Chemical form of iron.

Inorganic iron occurs in foods primarily in oxidised form as the ferric ion and usually enters the body in this form, which cannot be readily absorbed. The reduced ferrous ion is more readily absorbed because it is more soluble in digestive juices. Thus factors that increase the reduction of iron increase its absorption for example acidity of the stomach.

- Increased acidity.

Increased acidity in food or gastric secretions (hydrochloric acid in the stomach) promotes iron absorption by maintaining nonhaeme iron in the more soluble ferrous form. The amount of iron absorbed from the stomach and duodenum where hydrochloric acid secretion results in low pH, is greater than from the ileum. Maximum absorption occurs at pH 2.0-3.5. Acid forming foods include high protein foods such as meat, poultry, fish, eggs and cereals.

- Ascorbic acid.

Presence of ascorbic acid increases the solubility and absorbability of iron by enhancing its conversion to the ferrous state or by forming soluble and readily absorbed complexes of iron and organic foods known as chelates, the effect of ascorbic acid is greatest in meals lacking in meat,

fish, or poultry. Other organic acids like lactic acid, pyruvic acid and citric acid and sugars such as fructose and sorbitol have a similar effect as they form soluble chelates with iron.

- Dietary intake.

Persons accustomed to diets low in iron certainly absorb higher proportions of their intake than those ingesting ample amounts. The absolute amount absorbed is increased as the oral dose increases.

- Physiological need for iron.

Absorption responds to increased demands of iron by the body such as when new red blood cells are being formed in the bone marrows of growing children and pregnant mothers.
When there is a greater need for iron in the body as during growth periods and pregnancy, lactation, haemorrhage, or after blood donation, more iron is absorbed.
What increases the iron absorption during these periods is the decreased ferritine levels. This relationship is important since it increases the absorption of iron when the body actually needs it but prevents excess storage in tissues to the point of causing iron toxicity. During other periods mucosal ferritine levels increase and less iron is absorbed and more is excreted.

- Presence of meat factor (animal tissue protein).

Non haeme iron is absorbed better if meat, fish or poultry MFP is present along with nonhaeme iron. The amino acid cysteine or cysteine containing peptides, released during digestion of animal protein may combine with iron to form soluble chelates which allow the iron to be more effectively absorbed. 1g of meat has the same enhancing effect as does 1mg of ascorbic acid. Products of protein digestion are also considered to favour absorption of iron due to the reducing properties of the sulphydryl groups present in the sulphur containing amino acid, cysteine, cystine and methionine.

- Amount of calcium.

Calcium binds to phosphate and phytate which prevents them from inhibiting the absorption of iron. Also the presence of xanthine oxidase in the intestinal mucosa promotes incorporation of iron into transferrine for transport in blood.

b) **Factors that decrease iron absorption.**

- Low gastric acidity. When the stomach or a portion of it is surgically removed, the amount of hydrochloric acid is decreased therefore ability to convert iron from the ferric to ferrous form is reduced. The secretion of hydrochloric acid into the stomach often decreases naturally with aging.
- Mal absorption problems like coeliac sprue, ulcerative colitis and diarrhoea affect the absorption of iron. Diarrhoea increases the transit time for food and hence iron may pass unabsorbed.
- High fibre diet. A diet high in fibre tends to move food through the intestine so quickly that it reduces iron absorption.
- Certain proteins that are not animal tissue proteins are found to inhibit iron absorption. Doubling the amount of dietary protein from non-tissue sources such as milk, cheese and eggs decrease iron absorption by 50%.
- Phytates and oxalates. Phytic acid is a phosphorus containing organic acid found in such foods as whole grains, bran, and soy products. Oxalic acid is an organic acid found in such foods as spinach, rhubarb, and chocolate. Phytates and oxalates formed by combination with iron ions can convert the iron into an insoluble form that is unavailable for absorption. Phosvitin in egg yolk also decreases the availability of non haeme iron. Excessive phosphorus in the diet has an inhibitory effect on the absorption of iron.
- Phenols are organic compounds for example tannins present in tea, coffee, cocoa and some vegetables that are able to reduce the absorption of iron from a meal by as much as 70%. This is because of their ability to form insoluble complexes with iron. (Iron tannate).
- A high manganese intake can depress iron absorption because manganese and non haeme iron appear to share the same absorption pathway and complete to follow the same entry route into the body.
- High dietary calcium and phosphorus intakes can reduce non haeme iron absorption especially in the form of either calcium carbonate or hydroxyapatite.

**Functions of iron in the body.**

- Oxygen transport.

Iron accomplishes this as an essential part of haemoglobin in the red blood cells and myoglobin in muscles. The function of the red blood cells is to carry oxygen from the lungs to the tissues where it is needed for releasing the energy from glucose. Haemoglobin combines with oxygen taken from the air by our lungs during breathing and carries it to every part of our bodies, giving up its oxygen to the cells requiring it. Each molecule of haemoglobin can combine with one molecule of oxygen, and when this happens, the haemoglobin becomes brighter red in colour. Every cell in the body must be supplied with oxygen and if the number of red blood cells in our blood were to fall below a certain level it would be difficult for the blood to supply the tissues with enough oxygen leading to anaemia. Haemoglobin also transports carbon dioxide, a by product of cellular metabolism back to the lungs for excretion.

- Cell respiration.

The cyto chrome enzyme system is an iron containing protein molecule that is important for the synthesis of ATP molecules from glucose in the electron transport system. It is also a component of enzyme catalase and xanthine oxidase.

**ANAEMIA**

High risk groups susceptible to iron deficiency anaemia include
Infants
Adolescents
Menstruating women
Pregnant mothers

**CAUSES OF IRON DEFICIENCY ANAEMIA.**

The life of each red blood cell is about four months and so the red bone marrow is constantly manufacturing new cells to allow for replacement. This process requires protein, minerals, vitamins A all of which must originate in food consumed. Anaemia can therefore result from the following.

- Lack of proteins needed for the framework of red blood cells and manufacture of haemoglobin to go with it. Haemoglobin is present in the red blood cells as a red pigment made of protein with iron linked to it.
- Lack of minerals such as copper and cobalt due to poor iron content of the diet, poor or defective absorption of iron present in the food, and un replaced loss from frequent or heavy bleeding.

- Lack of vitamins for example vitamin B12, folic acid and ascorbic acid which enhance the absorption of nonhaeme iron.
- In children anaemia can come from not eating foods rich in iron. It can also come from breast feeding or bottle feeding after six months without giving other foods too. The anaemia of pregnancy could result from haemo dilution due to increase in blood volume. Other causes include; diseases like malaria and HIV/AIDS
- Infestation with intestinal parasite like hook worms.
- Hemorriods cancers of the uterus that feed on red blood cells.
- Chronic infestions such as diarrhoea.
- Sickle cell disease.
- Severe bleeding from large wounds, bleeding ulcers, menstruation.

**SYMPTOMS OF ANAEMIA.**

- Iron deficiency anaemia can result in changes related to the fact that the anaemic person's tissues must function with less oxygen and have less energy due to the reduced blood haemoglobin levels, lack of red blood cells and or abnormal red blood cells. Iron is essential for the manufacture of haemoglobin and if insufficient, the red blood cells produced will be smaller in size than normal (microcytic) and each will have less haemoglobin than normal leading to pale colour (hypo chromic) or there is a reduction in the total number of red blood cells in the body. The condition is described as hypo chromic microcytic anaemia.
- In megaloblastic anaemia red blood cells production is impaired. The red blood cells become enlarged (megalo) and cannot give up their oxygen properly to the body cells.

- Pernicious anaemia refers to abnormalities in the size and shape of the red blood cells leading to changes in the nervous system.

**General symptoms of anaemia.**

- Weakness and tiredness or fatigue.
- Decreased work performance.
- Weight loss
- Dizziness
- Nausea
- Vomiting
- Loss of appetite
- Blurred vision
- Diarrhoea
- Increased risk of infection
- Impaired growth
- Loss of hair.

**IODINE**

***Role in maintaining health.***

- In basal metabolism its needed in the body by the thyroid gland for the production of thyroxine and tri iodothyronine which is essential for maintenance of metabolic rate, cellular metabolism and integrity of connective tissue.

The hormones are secreted by the thyroid gland to regulate basal metabolic rate in which the body uses energy for the maintenance of homeostasis.

- In the foetus, iodine is needed for the development of the nervous system during the first trimester.
- It accelerates the biochemical reactions in all cells of the body causing greater use of oxygen to release energy.

- Essential in the conversion of carotene to vitamin A
- Assists in the synthesis of cholesterol and protein synthesis.
- Iodine is found in the structure of insulin which helps control the sugar balance in the blood plasma.
- Iodine is part of the composition of platelets thus essential in forming blood clots.

***Food sources of iodine.***

- Iodized table salt
- Sea food
- Bread
- Diary products.

**Iodine deficiency disorders**

The thyroid is a butterfly shaped gland, which wraps around the front part of the wind pipe just below the Adam's apple. It produces hormones that regulate the body's mechanisms and organ function. The thyroid gland affects heart rate, cholesterol level, body weight, energy level, muscle strength, skin condition, vision, menstrual regularity, mental state and a host of other conditions. Two common thyroid disorders that result from disturbances in the regulating mechanisms are hyperthyroidism and hypothyroidism.

***Hyperthyroidism***

Here the thyroid gland produces more thyroxine hormone than needed. It occurs when the regulatory mechanisms that control thyroid hormone synthesis don't function. One type of hyperthyroidism is Grave's disease that manifests in;

- Nervousness
- Voracious appetite
- Weight loss
- Increased metabolic rate
- Vision problems

Treatment includes;

- The anti-thyroid drug therapy which blocks thyroid hormone production.

- Radioactive iodine treatment in which the overactive thyroid is disabled and reduced in size.
- Thyroid surgery to remove part or the entire gland which is usually used to treat very young patients.

***Hypothyroidism***

Refers to a condition where the thyroid gland fails to produce thyroxine hormones resulting in subnormal levels of thyroid hormones in the blood. This increases demand on the thyroid which may cause it to enlarge, resulting in what is commonly known as ***goiter.*** The victim has characteristic appearance called myxedema, which presents with;

- Dry coarse hair
- Yellowish skin
- Decreased tolerance to cold
- Overweight
- Other symptoms include
- Decreased metabolic rate
- Fatigue
- Hoarse voice
- Difficulty in swallowing
- Forgetfulness
- Mood swings
- Victims are slower, less energetic and they become fat more easily.

The goal of treating hypothyroidism is to restore normal blood levels of thyroid hormone. Treatment involves supporting the body's naturally produced hormone with a synthetic hormone tablet, which is generally taken for life.

**FLOURIDE**

Fluorine is an essential part of the dental enamel and can reduce decay of children's teeth. The major function of fluoride appears to be the protection of bone and especially dental tissue. Fluorine acts by enhancing the ability of teeth to withstand the effects of acid formed by cavity

causing bacteria. The acid is formed by micro organisms feeding fermentable carbohydrates adhering to the teeth after a meal.
Fluoride ions are said to reduce dental caries when they are present in drinking water, applied typically to teeth or included in tooth paste.

***Food sources of fluorine***

- Fluorinated water
- Tea
- See food
- Grains
- Vegetables
- Meat
- Fish
- Dairy products

NB: Excess fluorine causes mottling (browning)of the teeth.
Adequate intake of fluorine protects against osteoporosis in the elderly..
Fluorine also enhances wound healing and protects against anaemia by enhancing iron absorption.

**COPPPER**

**Functions of copper**

- Copper helps iron work as it appears in blood a ceruloplasmin, hence essential for the incorporation of iron in hemoglobin
- Copper also increases iron absorption and stimulates mobilization of iron from tissue stores.
- Along with iron, copper is involved in the synthesis of haemocyanin (oxygen carrier).

- Copper is involved with iron in enzymatic reactions that oxidize glucose and release energy.
- Copper containing enzymes play a part in various oxidized reactions in energy
- Metabolism of fatty acids.
- Copper aids in the synthesis of collagen (connective tissue)and the maintenance of the myelin sheath around the nerve fibers.

***Food sources of copper.***

- Meat
- Sea food
- Liver
- Legumes

***Causes of deficiency of copper***.

- Malnutrition
- Diarrhea
- Mal absorption
- Kidney diseases
- Symptoms
- Anaemia
- Cardiovascular lesions
- Degeneration of the nervous system
- Skeletal defects
- Hair abnormalities
- Loss of taste activity
- Subnormal body temperature.

**ZINC**

**Functions of zinc**

- Formation of collagen is dependent upon zinc and is important in the healing of wounds.

- As a component of insulin, it increases the duration of insulin action after injection
- Plays a role in the mobilization of vitamin A from the liver.
- Plays a role in the synthesis of nucleic acids DNA and RNA) and non enzyme proteins.
- Essential for the growth and reproduction.
- Essential in body use of carbohydrates, fats and protein.
- A component of many vital enzymes that are involved in metabolic activities for example release off carbon dioxide from tissues to lungs, protein digestion and synthesis and carbohydrate metabolism.

***Food sources of zinc***

- Milk
- Meat
- Egg yolk
- Sea food

***Symptoms of zinc deficiency***

The symptoms of zinc deficiency reflect its importance in nucleic acid and protein synthesis.

- Growth retardation
- Delayed sexual maturation
- Delayed wound healing
- Tissue repair
- Poor appetite
- Loss of sense of taste.

**ABSORPTION OF NUTRIENTS IN THE BODY**

**ABSORPTION OF NUTRIENTS.**

**Carbohydrates.**

Carbohydrates are absorbed from the small intestines through the villi and into the blood stream inform of glucose with some fructose and galactose. The villi increases the surface area for absorption.

Fructose and galactose are converted into glucose for the final absorption. These travel through the hepatic portal vein to the liver where they are either oxidized to produce energy and

heat,combined with phosphate and potassium to form glycogen and stored in the liver for future use.

The cells in the small intestine have membranes that contain many transport proteins in order to get the monosaccharides and other nutrients into the blood where they can be distributed to the rest of the body.

Fructose is absorbed by facilitated diffusion while glucose and galactose are actively transported.

The first organ to receive glucose ,fructose and galactose is the liver .the liver takes the up and converts galactose to glucose. breaks fructose into even smaller carbon containing units, and either stores glucose as glycogen or exports it back to the blood. How much glucose the liver exports to the blood is under hormonal control and you will soon discover that even the glucose itself regulates the concentration in the blood.

The excess is converted to fat and stored in the depose tissue.

The rest is eliminated as faces.

## Nutritional disorders related to minerals

### CRETINISM

- This is a congenital hypothyroidism where the new-borns severely lack the thyroid hormone, it may occur due to a problem with the child's thyroid gland (missing poorly formed or abnormally small thyroid gland) or iodine deficiency of the mother during pregnancy.
- cretinism is a condition of severe physical and mental retardation due to iodine deficiency, and specifically due to deficiency of thyroid hormones during early pregnancy. This condition is irreversible, even after treatment with thyroid hormones or iodine soon after birth, but can be corrected if treatment with iodine starts prior to or early in gestation.

- Neurological cretinism is characterised by mental retardation, deaf mutism, squint, spastic diplegia, and disorders of stance and gait. Myxoedematous or hypothyroid cretinism is less common and characterised by mental retardation (although less severe than in neurological cretinism), dwarfism, and hypothyroidism with associated physical symptoms (e.g., coarse and dry skin, husky voice, delayed sexual maturation)

**Cretinism Types**

Cretinism is classified into the following two types:

**Endemic cretinism**

It has the highest prevalence and arises due to insufficient dietary iodine intake. It is common in areas with iodine-deficient soils. This form is regarded as a major public health problem in many countries.

**Neurological Cretinism**

It is caused by thyroid deficiency in moths during the first and second trimesters of pregnancy. This leads to fetal iodine deficiency and consequent thyroid insufficiency, leading to neurological problems like inability to hear and perform motor functions and brain damage.

**Myxedamatous Cretinism**

Mental detainment is less severe in this form than in Neurological cretinism. It is marked by a number of abnormal effects, such as myxedematous (dry) skin, infrequent hair and a protruding abdomen.

Note : Cretinism is a condition arising from a deficiency of thyroid hormone, which is characterized by dwarfism and mental retardation while as Myxedema coma is a loss of brain function as a result of severe, longstanding low level of thyroid hormone in the blood.

It causes impaired nervous system function, stunted growth and physical deformities. Lack of weight gain, poor feeding. Fatigue, thickened facial features, mental retardation, excessive sleep, hoarse voice, constipation, jaundice, unusually large tongue, umbilical hernia, goitre

- The face of the newborn looks puffy, dull, and tends to have slow reaction
- The tongue appears large, thick and protruded
- There is low hair line and possibly dry brittle hair
- You may notice that the newborn has larger anterior frontier while the posterior fontanel is persistent
- Skin discoloration, usually appearing yellowish- a condition known as jaundice
- A belly button that is protruding
- Edema
- Decreased muscle tone, commonly known as hypotonia
- Low temperature or hypothermia
- A low, hoarse cry
- Inconsistent weight gain
- Poor growth or short stature
- Heart related problems such as slow pulse or abnormalities of the heart valve
- Difficult with breathing – also known as dyspnea
- Decreased activity of the newborn
- Excess sleeping
- Choking
- Infrequent bowel movement or constipation
- Undesirable feeding patterns.

**RICKETS**

Is a skeletal disorder that's caused by lack of vitamin D, calcium or phosphate. These nutrients are important for the development of strong, healthy bones.

Rickets is the softening and weakening of bones in children, usually because of an extreme and prolonged vitamin D deficiency.

Vitamin D promotes the absorption of calcium and phosphorus from the gastrointestinal tract. A deficiency of vitamin D makes it difficult to maintain proper calcium and phosphorus levels in bones, which can cause rickets.

Adding vitamin D or calcium to the diet generally corrects the bone problems associated with rickets. When rickets are due to another underlying medical problem, your child may need additional medications or other treatment. Some skeletal deformities caused by rickets may require corrective surgery.

Symptoms

- Weak and soft bones
- Stunted growth
- Skeletal deformities in severe cases
- Muscle weakness
- Leg pain
- Delayed dentition
- Anterior Bowing of the tibia and femur legs (bow legs)
- Convulsions

**ANAEMIA**

Condition of low energy of the body as a result of insufficient oxygen reaching the cells for respiration (energy production). There as many types of anaemia as there are the causes.

It is caused by lack of iron and its elements,blood loss, immaturity of red blood cell, low red blood cell production and destruction of red blood cells.

*Causes of anemia*

Different types of anemia and their causes include:

- **Iron deficiency anemia.** This is the most common type of anemia worldwide. Iron deficiency anemia is caused by a shortage of iron in your body. Your bone marrow needs iron to make hemoglobin. Without adequate iron, your body can't produce enough hemoglobin for red blood cells.

  Without iron supplementation, this type of anemia occurs in many pregnant women. It is also caused by blood loss, such as from heavy menstrual bleeding, an ulcer, cancer and regular use of some over-the-counter pain relievers, especially aspirin.

- **Vitamin deficiency anemia.** In addition to iron, your body needs folate and vitamin B-12 to produce enough healthy red blood cells. A diet lacking in these and other key nutrients can cause decreased red blood cell production.

  Additionally, some people may consume enough B-12, but their bodies aren't able to process the vitamin. This can lead to vitamin deficiency anemia, also known as pernicious anemia.

- **Anemia of chronic disease.** Certain diseases — such as cancer, HIV/AIDS, rheumatoid arthritis, kidney disease, Crohn's disease and other chronic inflammatory diseases — can interfere with the production of red blood cells.
- **Aplastic anemia.** This rare, life-threatening anemia occurs when your body doesn't produce enough red blood cells. Causes of aplastic anemia include infections, certain medicines, autoimmune diseases and exposure to toxic chemicals.
- **Anemias associated with bone marrow disease.** A variety of diseases, such as leukemia and myelofibrosis, can cause anemia by affecting blood production in your bone marrow. The effects of these types of cancer and cancer-like disorders vary from mild to life-threatening.

- **Hemolytic anemias.** This group of anemias develops when red blood cells are destroyed faster than bone marrow can replace them. Certain blood diseases increase red blood cell destruction. You can inherit a hemolytic anemia, or you can develop it later in life.
- **Sickle cell anemia.** This inherited and sometimes serious condition is an inherited hemolytic anemia. It's caused by a defective form of hemoglobin that forces red blood cells to assume an abnormal crescent (sickle) shape. These irregular blood cells die prematurely, resulting in a chronic shortage of red blood cells.

It is characterised by general body weakness, pale eyes

**Symptoms**

Anemia signs and symptoms vary depending on the cause of your anemia. They may include:

- Fatigue
- Weakness
- Pale or yellowish skin
- Irregular heartbeats
- Shortness of breath
- Dizziness or lightheadedness
- Chest pain
- Cold hands and feet
- Headache

**MOTTLING**

This is also known as fluorosis, a condition caused by deposition of fluorine and it is taken up by the enamel. It causes whitish or brownish decolouration of the teeth. This is not a disease and it has no physical damage on the teeth but usually has psychological effects as it spoils the smile.

1. a**) Giving examples discuss in detail the general functions of mineral elements**

- Bone and Tooth Health: Along with the minerals phosphorus and magnesium, calcium gives bones strength and density. This mineral also builds and maintains strong, healthy teeth. Calcium deficiency due to poor nutrition or illness can lead to osteoporosis, a condition in which the bones become brittle and less dense, increasing the risk of fractures
- Energy Production: the body requires oxygen to produce energy that is necessary for every bodily function and process. Red blood cells -- or erythrocytes -- carry oxygen to each of your infinite cells, where it is used to generate energy.
- Transportation of oxygen: Red blood cells contain a heme or iron component that binds to oxygen so that it can be transported. Without the iron molecules, oxygen could not be attached to the blood cells and the body would not be able to produce the energy necessary for life.
- Formation of blood: Iron is an essential mineral, and failing to get enough from your diet can lead to a condition called anemia, which causes weakness and fatigue. This mineral is primarily found in the blood, and it is also stored in your liver, spleen, bone marrow and muscles**.**
- Nerve and Muscle Function: Potassium is found in bananas, dates, tomatoes, green leafy vegetables, citrus fruits and legumes such as peas and lentils. This nutrient is important to keep muscles and the nervous system functioning normally.
- Water balance; Potassium, sodium and other molecule help to maintain the correct water balance in the cells of your nerves and muscles. Without this essential mineral, your nerves could not generate an impulse to signal your body to move, and the muscles in your heart, organs and body would not be able to contract and flex.
- Immune Health; Zinc is an essential mineral that is important for keeping your immune system strong and helps your body fight infections, heal wounds and repair cells. Kids Health notes that eating meat and legumes such as beans, peas and lentils will give you sufficient amounts of zinc. Selenium is also needed in small amounts for immune health. A deficiency of selenium has been linked to an increased risk of heart disease and even some types of cancers.
- **Eessential constituents of skeletal structures such as bones and teeth**
- **Structural constituents of soft tissues**
- **Essential for transmission of nerve impulses and muscle contraction**
- **Vital role in acid-base equilibrium of the body (pH)**
- **Minerals serve as essential components of many enzymes, catalysts and enzyme activators**

b**)What factors affect absorption and utilization of iron in the mineral elements?**

- Iron deficiency and the body's iron need

- the physical state of iron ($Fe^{2+}$is more rapidly oxidised to insoluble $Fe^{3+}$ )
- low pH due to gastric acid increases uptake of $F^{2+}$ascorbic acid and citrate increase iron absorption by binding with them increasing solubility of the metal
- phytates in wheat and tannins in tea inhibit absorption by binding with them to form insoluble substances
- lead is a competitive inhibitor as it is taken up by the iron absorption machinery
- immaturity of the gastrointestinal tract e.g. in children
- amino acids also increase iron absorption by increasing solubility
- oxalates also affect the absorption of iron by forming insoluble salts
- dietary fibres inhibit the absorption by binding iron
- presence of vitamin C
- presence of calcium charges in the body, the body can only absorb a particular amount of charged nutrients, so its presence affect the absorption of iron

**c) i) Explain why manganese and copper are referred to as trace elements.**

- These are present in minute amounts and are requires in small amounts by the body for normal metabolism, growth and development. They occur in less than 100micrograms per gram of food or tissue.
- If taken in excess they cause poisons and the body which may lead to the following symptoms
- Nausea, vomiting, diarrhoea, abdominal pain, headache, dizziness, and a metallic taste in the mouth.

  **Note:**

- ✓ What do you understand by the term wilson's disease
- ✓ What are the Functions of copper

**ii) Give the functions of calcium in the body**.

- o Essential component of bone and cartilage
- o Normal blood clotting by stimulating the release of thromboplastin from blood platelets
- o Activator for several key enzymes including pancreatic lipase, ATPases
- o Stimulates muscle contraction
- o Regulation of nerve impulse transmission from one cell to another through its control of acetylcholine production
- o It decreases colorectal cancer and lowers systolic blood pressurein individuals with high blood pressure
- o Calcium high diets also decrease the incidences of obesity and over weight

**iii) Explain how calcium can be metabolized in the body**

- This involves movement and regulation of calcium ions in and out of body compartments e.g. the GIT, blood plasma, extracellular and intercellular fluids and bone tissue.
- Bone tissue acts as a $Ca^{2+}$storage as the blood calcium levels are used to regulate calcium levels in the body.
- In the body calcium is readily bound to other substances to perform its functions e.g. hydroxyapatite or these calcium chelates broken down for it to function e.g. as an enzyme activator
- Bone mineralization and demineralization

**d) Discuss in detail the factors that determine the nutrient intake of an individual**

- o Age of an individual e.g. adults take in more protein than the elderly but less than teenager who are still growing.

- Sex; men generally require more energy than women because of a larger muscle mass
- Disease states
- Genetic makeup
- Socio-economic factors such as poverty
- Parasites like hookworms, malaria
- Socio-cultural factors like religion, socio-status, food taboo
- Environment's weather
- Physical activity
- Emotional factors