

ENVIRONMENTAL POLLUTION AND NUTRITIONAL DISEASES

CHAPTER

7

LEARNING OBJECTIVES

After the completion of this chapter, you should be able to,

- ◆ *Define pollution and explain the causes, effects and control of air pollution*
- ◆ *Describe the ill effects of tobacco smoking*
- ◆ *Outline the properties, biological effects and uses of various air pollutants*
- ◆ *Summarize the classification and role of carbohydrates, proteins and lipids*
- ◆ *Provide a brief note on fat soluble and water soluble vitamins*
- ◆ *Discuss the different nutritional disorders*
- ◆ *Explain the pathophysiology of starvation.*

1. ENVIRONMENTAL POLLUTION

1.1 INTRODUCTION

Pollution is defined as intentional or unintentional introduction of harmful substances or different forms of energy (like radiation, heat and sound) by humans into the environment. Pollution has a threshold limit below which it is harmless to the environment but if the pollution exceeds this threshold limit, it is difficult to control and it may lead to short-term and long-term problems like chemical, biological and radiation effects or an increase in heat, light, dust, noise or bad odour causing inconvenience and deleterious effects on human health. Sometimes, it may also result in the accumulation of pollutants in tissues of living organisms resulting in major health issues. For example, accumulation of DDT and other pesticides/fertilizers in fat, accumulation of radioiodine in thyroid, accumulation of radioisotopes in bone, etc. From the perspective of pharmaceutical industries, environmental pollution is caused by chemical reactions, manufacturing processes etc. Hence, it is necessary that these industries are located at far off places away from usual habitat to avoid health hazards and environmental pollution. Pharmaceutical industries are also required to keep a check on the effluent produced by them.

Pollution is classified into different types as air pollution, water pollution, soil pollution, noise pollution, thermal pollution, solid pollution, marine pollution and nuclear hazards.

Pollutants

Pollutants or effluents refer to the waste products or by-products which are produced from various sources and are released into the environment causing harmful effects on naturally occurring components.

Examples: Sewage released from residential and commercial areas, chemicals released from factories, radioactive substances released from nuclear plants, smoke released from industries and automobiles etc., are some of the common pollutants.

Prevention of Pollution

Prevention of pollution can be defined as reducing the production of harmful substances at all the source levels and preventing their subsequent release into the environment.

The efforts made to protect the environment from pollution have always paid more attention towards controlling the pollution after its generation so as to protect human health from its adverse effects. However, this is not the desired solution as it does not completely eliminate the pollution but shifts it from one medium to another.

Moreover, high amounts of investment and expenditure are required for sourcing equipments and materials that are used in the control of pollution and waste management techniques. Hence, governmental organizations recognized that prevention of pollution i.e., reduction of pollution at source level is more advantageous, economical and time-saving method than pollution control and waste management. Thus, Pollution Prevention Act was established in 1990 by U.S Environmental Protection Agency (EPA) which adopted pollution prevention hierarchy as its national objective. This Act states that the generation of pollution should be avoided at the initial stages itself in all possible manners and when this is not possible, then pollution that has been generated should be effectively and safely recycled. When both pollution prevention and recycling of the pollutants cannot be possibly achieved, then proper treatment of the waste generated and its safe disposal into the environment should be adopted as the last resort to control pollution.

1.2 AIR POLLUTION

Air pollution is generally referred as the occurrence or release of harmful pollutants such as foreign particles, gases, dust, smoke etc., in excessive quantities in air which adversely affects human health, environmental life and property.

According to World Health Organization, air pollution is defined as, "*substances put into air by the activity of mankind into concentration sufficient to cause harmful effect to his health, vegetables, property or to interfere with the enjoyment of his property*".

Air pollution is growing at an alarming rate inspite of numerous measures that have been taken to control it.

Air pollutants are the substances which contaminate or pollute the air. They can either be solids, gases or liquid materials. When excessive concentration of air pollutants such as dust, gases, smoke, mist, odour, vapour, soot or fumes, etc., are released into the atmosphere, they cause damage to the health and property of individuals, as well as environment.

Sources of Air Pollution

The sources of air pollution can be classified in the following ways.

1. *Based on Source of Emission*

(a) *Natural Sources*

Natural sources of air pollutants include volcanoes, forest fires, sulphur springs, natural geysers, natural organic and inorganic decays, marsh gases, extraterrestrial bodies, cosmic dust, pollen grains of flowers, soil debris, fungal spores and photochemical reactions.

(b) *Anthropogenic (Man-Made) Sources*

Air pollutants produced by humans or controlled processes include domestic burning of wood, burning of fossil fuels, industrialization and agricultural activities, vehicular emissions, aircrafts, wars, nuclear tests, deforestation, incineration, power generation, mining, metallurgy, waste treatment plants and refrigeration industries.

2. *Based on Origin or Formation of Pollutants*

(a) *Primary Pollutants*

The harmful substances that are directly released into the atmosphere from an identifiable source are known as primary pollutants.

Examples include ash from volcanic eruption, carbon monoxide gas from a motor vehicle exhaust, sulfur dioxide released from factories, etc.

(b) *Secondary Pollutants*

Harmful substances that are formed in the air by chemical reaction between the primary pollutants of environment, are known as secondary pollutants.

Examples of secondary pollutants include the ground level ozone that is responsible for the formation of photochemical smog, sulphuric acid that forms acid rain, etc.

3. *Based on the Type of Sources of Pollutants*

Air pollutants in the atmosphere can also be classified into following types.

(a) *Point Sources*

This category includes stationary sources from an equipment or processes that release pollutants directly into the atmosphere. Examples include the following,

Power plants

Smelters

Industrial boilers

Commercial boilers

Wood and pulp processors

Paper mills

Refinery

Petroleum storage tanks

Incinerators

Chemical production

- Burning of coal and oil produces sulfur dioxide.
- Metals are separated from ores by smelting (heating to a high temperature to melt the metal). The process produces contaminant laden air emissions. E.g. Sulfur dioxide.
- Toxic air pollutants released are lead, arsenic, and acid gases.
- Produce pollutants such as mercury, dioxin, particulate matter, hydrogen chloride, carbon monoxide.
- Produce chlorine, persistent organic pollutants, chelating agents.
- Carbon dioxide, nitrous oxide, sulfur dioxide.
- Volatile organic compounds, sulfur dioxide and nitrogen oxides.
- Leakages in petroleum storage tanks can create fire and explosion hazards.
- Toxic gases, ash and other harmful chemicals.
- Organic compounds and metal compounds.

(b) *Non-point Sources*

This category includes non-point sources such as mobile sources and area sources that release pollutants into the atmosphere. Mobile sources include road traffic, aircraft emissions, whereas area sources include petrol refueling stations, fire extinguishers, aerosol spray cans etc.

Causes of Air Pollution

The various causes of atmospheric pollution are mentioned as follows,

1. Increase in the levels of atmospheric carbon dioxide beyond its normal levels causes air pollution.
2. Use of harmful chemicals like pesticides, insecticides, herbicides etc., in agriculture.
3. When domestic sewage is discharged into water bodies like rivers and oceans, which releases foul odour.
4. The discharge of radioactive substances into the rivers and seas, leads to emission of harmful radiations and gases.
5. Usage of aerosol spray propellants containing chlorofluorocarbons (CFCs) depletes the ozone layer, hence the harmful rays of the sun (ultraviolet rays) strike the earth and may lead to skin cancer in humans.
6. Air pollution also occurs naturally within the tolerance limits in the atmosphere due to the following reasons,
 - (a) Gases that are released into atmosphere due to volcanic eruptions
 - (b) Smoke arising from forest fires
 - (c) Dust arising due to storm and strong winds
 - (d) Evolution of methane gas from bogs, marshes and from the decomposing bodies of plants and animal residues
 - (e) Pollen grains are also a cause of natural air pollution.
7. Industries also contribute to air pollution when they manufacture aluminium, cement, fibre glass, paints, varnishes, phosphatic fertilizers etc.
8. Smoke arising from the kitchen chimneys, factories, automobiles, aeroplanes and railway engines pollute the atmosphere with soot and gases like carbon monoxide and carbon dioxide.
9. Exhaust gases emanating from the automobiles and factories pollute the air, thus causing serious health problems to humans. Vehicles which run on the internal combustion engines and factories release large amounts of sulphurous compounds into the atmosphere.
10. Various pharmaceutical processes such as tablet coating, spray drying, fluidized bed drying, milling, etc., release exhaust air which consists of particulate matter and gaseous pollutants thereby causing air pollution. The pollution of exhaust air may be due to the following causes,
 - (a) Pharmaceutical processes are not entirely efficient as some of the materials may be lost due to abrasion which are removed through exhaust air.
 - (b) Dust released from de-dusting of tablets during tablet manufacturing process is also removed through exhaust air.
 - (c) The loss of particulate matter generated during tablet coating process due to excessive friction between tablets and surface of coating pan when the tablets are left uncoated for longer time periods.
 - (d) The vapours of organic solvents that are used in coating solutions are also removed through exhaust air.

Effects of Air Pollution

Air pollution is a serious threat in Indian cities because of rapid industrialization and heavy traffic rush due to automobiles and vehicles. The damage caused is enormous. Air pollutants have a negative impact on humans, plants, animals, climate and on the environment as a whole.

Effects on Human Health

1. Respiratory disorders like bronchitis, asthma, emphysema and lung cancer are caused due to the presence of dust, soot and smog in polluted air.
2. Presence of cotton dust and other pollutants causes various types of lung fibrosis.
3. Presence of fly ash and metal dust is responsible for causing headache, loss of appetite, dizziness, weakness, insomnia and miscarriage of pregnant women.
4. When sulphur dioxide enters into the tissues it readily forms sulphuric acid which is responsible for causing dry mouth, sore throat and irritation of eyes.
5. Haemoglobin has more affinity towards some gases like carbon monoxide, sulphur trioxide and nitrogen oxide and hence it binds to these gases instead of oxygen thereby reducing the supply of oxygenated blood to the tissues which ultimately causes giddiness, exhaustion, blurred vision, CVS and CNS disorders and death.
6. Depletion of ozone layer due to air pollution is responsible for causing skin cancers and mutations in living organisms.
7. Smoke emitted from tobacco and cigarette smoking can lead to pulmonary cancer as it contains a carcinogenic hydrocarbon known as benzopyrene.

Effects on Plants

Plants are also highly affected by air pollution.

1. The pollutants such as dust, smoke and other particulate matter settle on the leaves and reduce the amount of sunlight thereby interfering with photosynthesis.
2. Presence of sulphur dioxide and other oxides of sulphur affects the leaves of fruit trees and cereal crops by causing chlorosis (bleaching), plasmolysis, necrosis, membrane damage and metabolic inhibition in leaves.
3. Presence of hydrocarbons like for example, ethylene affects the flower and fruit growth by inducing premature falling of leaves, dropping of fruits, shedding of floral beds, discolouration of sepals and curling of petals.

4. Air pollution causes death of lichens in a particular area and hence it can be considered as an indicator of air pollution.
5. Acid rains lower the pH of soil and water causing death of plants and microbes present in the soil as well as in the water bodies.

Effects on Animals

Animal life is also widely affected due to air pollution in a similar way to human life,

1. Presence of fluorine compounds in polluted air causes deposition of fluorine onto the fodder substances (animal feed). When animals consume this polluted fodder, they exhibit excessive calcification in bones and teeth which is known as fluorosis. Weakness, loss of weight and frequent diarrhoea are some other conditions seen in animals.
2. Several diseases are caused in animals due to microbial infections as a result of air pollution.

Effects on Environment

1. Acid Deposition

During the combustion of fossil fuels, gases such as sulfur dioxide and nitrogen oxides are released which react with water to form sulfuric acid and nitric acid. High acidity causes metals to dissolve in water, thus polluting the surface water. This has serious health effects on aquatic plants and animals. For example, high aluminium concentration hampers the nutrient uptake by plants leading to decay of plants in the long run.

2. Eutrophication

The main contributors to this phenomenon are nitrogen pollutants such as nitrogen oxides and ammonia. The increased plant nutrients in water cause some water plants such as algae and duckweed, to grow extensively. This extensive growth blocks the supply of sunlight to water. The oxygen supplies are exhausted by these plants which are not renewed because the heterotrophic plants and bacteria need light to carry out the process of photosynthesis, thus leading to the disruption of the ecosystem.

3. Smog

The word smog is a combination of the words smoke and fog. It causes a smoky dark atmosphere over the cities causing poor visibility and creating a haze throughout the area. Smog in the atmosphere comprises of over 100 chemicals from different sources like automobiles, fires, waste treatment, oil production, industrial solvents, paints and coatings, car engines. The particulates that are present in smog are carbon monoxide, dirt, soot, dust and ozone.

Loss of Ozone Layer

The increased UV radiation penetrating the earth's surface due to depletion of ozone layer has undesirable effects on the growth and photosynthetic activity in a number of plants including rice, corn and sunflower. These radiations can penetrate about twenty metres under the surface of water causing damage to species such as plankton, fish larvae, shrimps, crabs and sea weeds, thus leading to the disruption of the entire ecosystem.

Greenhouse Effect

As a result of human activities, a number of gases are being put into the atmosphere which trap energy that comes to earth as sunlight. The combustion of fossil fuels produce carbon dioxide, which contributes to the "greenhouse effect". Global warming leads to the melting of polar ice caps which rises global sea levels. In such a case, most of the islands would disappear and flooding would occur along coastlines all over the world. This would lead to destruction of cropland and relocation of millions of inhabitants to safer places.

Control of Air Pollution

The varied contaminants of air like carbon monoxide, nitrogen dioxide, sulphur dioxide, lead, particulate matter, methane, ozone and other toxic air pollutants cause serious damage to human health and property. Hence, adequate measures need to be taken to mitigate or reduce air pollution to the maximum possible extent. Some of them are indicated below.

1. One of the most effective methods to control air pollution in atmosphere is to provide a greater height to the smoke stacks of the industries. This facilitates the release of pollutants far away from the ground.
2. Use of proper filters or collectors or electrostatic precipitators to control particulate matter.
3. Air pollution can be controlled by increasing the energy efficiency of the vehicles. This would lead to minimal consumption of fuel and therefore reduced emissions to air.
4. Industries should be located far from the residential areas.
5. Usage of raw materials in industries which cause less pollution should be made mandatory.

Examples

- (a) Using non-reactive aqueous solvent as organic solvents pollute the atmosphere to a greater extent.
- (b) Washing of coal, grading of coal and its partial desulfurization helps to remove pyrites from it, thus causing less emission of SO_2 during combustion.

6. Substitution of fossil fuels by renewable sources of energy like solar energy, thermal energy, nuclear energy etc., minimizes the pollution in atmosphere.
7. Modifying the industrial equipments also helps to minimize air pollution.
Example: Usage of electric or oxygen furnaces in steel industry rather than open hearth furnaces.
8. Control of emission of carbon monoxide, hydrogen sulphide from petroleum refineries by converting them into CO_2 and H_2O helps to minimize air pollution.
9. Pollutants that are emitted from different sources can be removed by using various air pollution control devices. Examples
 - (a) Low energy devices like settling chambers, cyclone separators, spray chambers, wet scrubbers and impingement separators are used to remove both coarse and fine particles from the polluted air.
 - (b) Submicron particles are removed by using high energy consuming devices like bag filters, electrostatic precipitators and venturi scrubbers.
 - (c) Gaseous air pollutants can be removed by adsorption, absorption, condensation and incineration mechanisms. The devices used are filters, adsorbers, absorbers, incinerators, etc.

1.3 TOBACCO SMOKING

Smoking is considered as the most prevalent and preventable cause of diseases and death. Besides being harmful to health of the active smoker, it also greatly influences the surrounding environment.

Exhaled smoke contains large proportions of harmful chemicals like nicotine, phenol, carbon monoxide, nitrogen oxide, formaldehyde, tar etc., which when released in the atmosphere pollutes air, soil and even water bodies. Nicotine and phenol are well known tumour promoters whereas carbon monoxide reduces oxygen transport in the body. Nitrogen oxide and formaldehyde causes irritation and toxicity to respiratory mucosa while tar, nitrosamine etc., causes carcinogenesis. Besides active smokers, bystanders or the passive smokers, especially infants and children are also greatly affected by the exhaled smoke.

Tobacco plants are highly susceptible to pests and diseases. Hence require frequent spraying of chemicals and pesticides, thereby indirectly polluting environment. Also, manufacturing of only about 300 cigarettes requires about 4 miles of paper for rolling and packaging i.e., require wood of about one large tree. Chemical wastes from manufacturing units are frequently dumped in the soil or water bodies resulting in soil and water pollution. Millions of cigarette butts are thrown on the ground which finally end up in lakes and rivers. The remains of these butts on the ground require about 20-25 years for decomposition.

Out of the total Indian population about 25-30% are smokers. This indicates that an enormous quantity of pollution is released in the atmosphere everyday. The different forms of tobacco used by Indians with their ill effects on health include, paan (tobacco mixed with slaked lime and chewed for long durations) resulting in cancer of oral cavity and aerodigestive tract) and chutta (a kind of cigar of which the lightened end is placed in the mouth. It is associated with higher incidence of squamous cell carcinoma of hard palate). Besides these, tobacco is also used in the forms of bidis, zarda, gutka, paan masala, hookah etc., which also cause serious health hazards.

When the smoke of nicotine is inhaled, about 90% of it gets absorbed. After absorption, it gets concentrated in liver and brain. It is mainly metabolized in the liver through glucuronide conjugation. The glucuronide conjugates of nicotine gets excreted through kidneys. Elimination half-life of nicotine is about 2 hours.

Tobacco Related Diseases

Smoking of tobacco causes serious diseases like coronary heart disease, chronic obstructive pulmonary disease (COPD), cancer of lungs, larynx, mouth, oesophagus, bladder, cervix, pancreas etc. Besides smoke of tobacco, usage of smokeless tobacco and cigars have also shown to cause cancer of mouth, larynx and oesophagus. Various effects of tobacco smoking have been listed below.

1. On Heart

- (a) Cigarette smoking causes atherosclerosis of coronary arteries and aorta. This in turn increases platelet aggregation and also impairs lung function ultimately decreasing myocardial oxygen supply and hence causes myocardial infarction.
- (b) It also causes peripheral vasoconstriction leading to increase in blood pressure and tachycardia.
- (c) It may also lead to cardiac arrhythmias, coronary artery disease, thromboangitis obliterans (inflammation of arteries) and hypercholesterolaemia.

2. On Lungs

(a) Lung Cancer

Lungs cancer is the most common cancer in men throughout the world. A large number of cases of lung cancer are also being reported in women. Smoking is the direct cause of almost 90 percent of all lung cancer cases.

- (b) Smoking also causes chronic bronchitis (inflammation of airways leading to over productive cough) and emphysema (enlargement of air sacs resulting in shortness of breath).

3. On Nervous System

Nicotine causes stroke, tremors and irritability. It may also lead to euphoria, central respiratory paralysis, confusion, vomiting, coma and death at higher doses.

4. On GIT

Smoking causes intestinal cramps and diarrhoea or constipation. It is also associated with higher risk of development of cancer of lips, oral cavity, larynx and oesophagus.

5. Others

- (a) Smokers also have higher risk of development of diabetes mellitus and cancer of bladder, pancreas and kidneys.
- (b) Smoking causes drug abuse and dependence which is characterised by craving for the cigarettes. Depression, nervousness, restlessness, irritability, anxiety, impaired concentration, increased appetite and weight gain occurs on withdrawal.

1.4 AIR POLLUTANTS

Sulphur Dioxide (SO₂)

Properties

Colour	: Colourless
Odour	: Strong suffocating odour
State	: Gas
Solubility	: Highly soluble in water and forms sulfurous acid
Flammability	: Non-flammable

Pharmacokinetics

1. Highly water soluble, hence efficient by get absorbed in the nasopharynx when inhaled.
2. Instantly form sulfurous acid in eye and irritates.
3. A large portion of the inhaled gas (about 90%) gets absorbed in nasopharynx.

Biological Effects

1. Inhalation of sulphur dioxide causes coughing, choking, sneezing, running nose, laryngeal/glottal oedema, bronchitis, bronchoconstriction, upper airway oedema etc.
2. Dermal exposure to SO₂ causes itching, rashes or burning sensation at the area exposed.
3. Ocular exposure of gas and liquid SO₂ causes extreme irritation with lacrimation and severe corneal damage respectively.

Uses

1. Used as a preservative for fruits and vegetables
2. Used as a disinfectant in breweries, granaries and food factories
3. Used in wood pulp industries.

Nitric Oxide (NO)**Properties**

Colour	: Colourless
Odour	: Sweet odour
State	: Gas
Solubility	: Slightly soluble in water
Flammability	: Non-flammable

Source

Released from fossil fuel power stations, motor vehicles and domestic combustion appliances.

Pharmacokinetics

1. Insoluble in water, hence very little absorbed in the mucous membrane of eyes, nose and throat.
2. Distributes well in pulmonary parenchyma and causes injury to terminal bronchioles and the layers of alveoli.
3. Reacts with water in the respiratory tract and forms nitric acid.
4. In the deeper parts of lungs, nitric acid reacts with haemoglobin to form nitrite and nitrate which blocks gas exchange and cause local and systemic tissue damage.
5. Nitrates get excreted through urine.

Biological Effects

1. Inhalation of nitric oxide is very hazardous to lungs. It causes severe cough with shortness of breath. Burning sensation in chest and throat, nausea and fatigue are also experienced. Pulmonary oedema (a delayed reaction) may also be seen. In the deeper parts of lungs, nitric oxide reacts with haemoglobin to form nitrosylhaemoglobin which immediately converts to nitrite and nitrate.
2. Exposure of nitric oxide to skin, eye and mucous membrane causes severe irritation.

Uses

1. Used to bleach rayon.
2. Used in the production of nitric acid.
3. Used in the treatment of patients with pulmonary hypertension to produce selective pulmonary vasodilation as well as to improve oxygen transportation.

Nitrogen Dioxide**Properties**

Colour	: Reddish-brown
Odour	: Irritating odour
State	: Gas
Solubility	: Insoluble in water
Flammability	: Non-flammable

Source

Released during combustion of fuels, welding operations, usage and/or production of nitrate explosives and handling of rocket fuel oxidizers

Pharmacokinetics

It shows same pharmacokinetic as that of nitric oxide.

Biological Effects

1. Inhalation of nitrogen dioxide initially causes inflammation of lungs with slight pain which may go unnoticed. However, symptoms appear after about 30 minutes which include chest pain, tachycardia, cough, bronchitis, dyspnoea, fever, mucoid frothy sputum, decreased pulmonary function etc. Initial chest radiographs may appear normal but later progress to show presence of pulmonary oedema. Methaemoglobinaemia may also be seen.
2. Upon ocular exposure, nitrogen dioxide quickly solublises in lacrimal fluid to form nitric acid resulting in redness, pain and severe burning sensation.
3. Dermal exposure causes irritation, pain, redness and burning sensation.

Uses

1. Used to bleach flour.
2. Used as an intermediate in the production of nitric acid and sulfuric acid.

Carbon Monoxide (CO)**Properties**

Colour	: Colourless
Odour	: Odourless
State	: Poisonous gas
Solubility	: Soluble in water
Flammability	: Flammable

Source

Released from tobacco smoke, incomplete burning of carbon containing compounds like wood, kerosene, gasoline coal etc., internal combustion engine and automobile exhaust.

Pharmacokinetics

Soluble in water and hence displace oxygen in blood resulting in various health issues.

Biological Effects

1. Inhalation of carbon monoxide displaces oxygen in the blood and deprives the vital organs (heart, brain, lungs etc.) of oxygen.
2. Large amounts of carbon monoxide in vital organs can make the patient suffocate and lose consciousness.
3. Initial symptoms of CO poisoning include tightness in chest, headache, fatigue, dizziness, drowsiness or nausea.
4. Patients with angina may feel sudden pain in chest.
5. Prolong exposures may worsen the above symptoms and cause vomiting, confusion, collapse, unconsciousness and muscle weakness.
6. Most susceptible persons to CO poisoning include people at high altitudes, smokers, foetus, young children, elderly people and patients suffering from cardiac or pulmonary disorders.

Uses

Due to its poisonous nature it finds no use in the pharmaceutical industry.

First Aid Measures

First aid measures in case of excess exposure to air pollutants like SO_2 , NO, NO_2 , CO etc., has been listed below.

1. Call the emergency number or ambulance or poison control centre immediately.
2. Bring the victim to fresh air immediately. Avoid crowding near the victim to allow fresh air to him.
3. Check the pulse and respiration of victim and start cardiopulmonary resuscitation (CPR) immediately.
4. If the poison has spilled into the eyes or onto the skin of the victim, wash it off thoroughly with plenty of water immediately.
5. Loosen the clothes and assure the victim that he is in safe hands.
6. If the victim is unconscious, vomiting should be avoided and the patient should be placed in three quarter prone position.

7. If the victim is conscious, vomiting should be induced by tickling the back of the throat with blunt object or finger. If this fails, give him copious warm water or saline solution or any emetic drug. While inducing vomiting, the victim should be made to lie on his side.
8. Hospitalize the victim immediately or seek medical aid.

2. NUTRITION

Nutrition is defined as the science of food and its relationship to health. It is an input as well as foundation for health. It is a science which investigates metabolic and physiological responses of the body to food. It is also called as nourishment or aliment and referred to as "balanced for requirement". *Nutrie* means to nurse or to breast feed.

Food is defined as the substance or a mixture of substances which helps to provide nutrition or nourishment to the body. It is also known as nutrient. Food provides heat or energy to the body and regulates its growth.

Requirements of Food or Nutrients

1. It must supply adequate amounts of energy so as to perform metabolic, muscular and other functions of the body.
2. It should supply energy essential for the synthesis of structural component of the body.
3. It should also provide essential agents required for various biochemical reactions of the body.

Recommended Daily Allowance (RDA)

The quantity of nutrients or food necessary for maintaining good health of the body is expressed in terms of RDA (Recommended Daily Allowance) or recommended daily intake.

RDA is different for different nutrients and also varies with age (infants, adults, elderly), special conditions (pregnancy, lactation, diseased states) and sex.

Energy Value or Nutrient Value

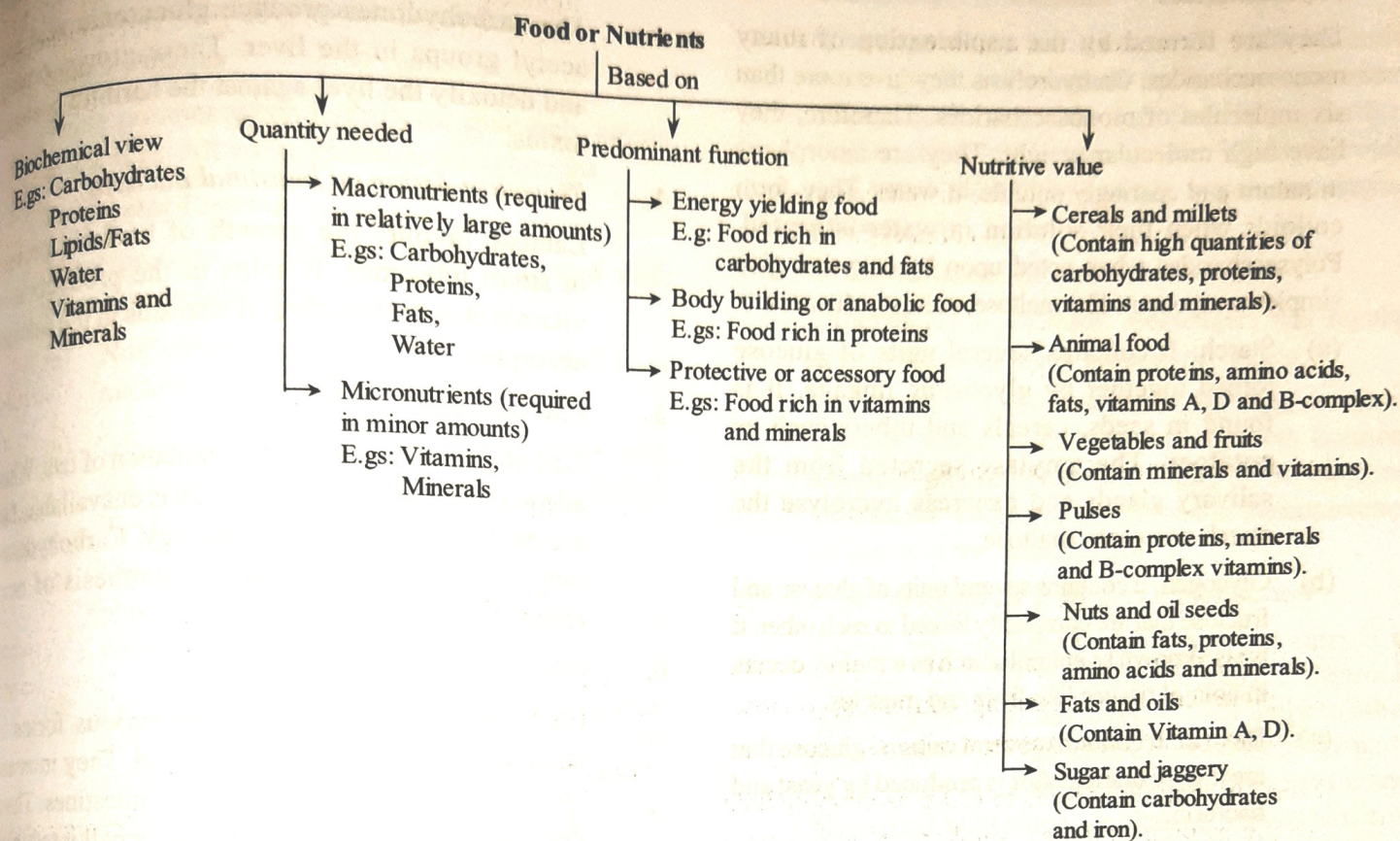
Energy value or nutrient value of nutrients or food is expressed in the terms of calories (C).

Calorie is defined as the amount of heat or energy required to raise the temperature of 1000 g (1 kg) of water by 1°C i.e., from 15° to 16°C .

Energy value or nutrient value for 1g of main food is shown in the table below:

Nutrient	Food value in calories (C)
Carbohydrates	3-75
Fats	9.3
Proteins	4.1

The various food requirements are classified as under.



Carbohydrates

Carbohydrates, as the name suggests, are the compounds that contain carbon, hydrogen and oxygen. They are also known as *saccharides* and their general formula is $C_n(H_2O)_n$. Chemically they are the ketones and aldehydes of polyhydric alcohols.

Classification of Carbohydrates

1. Monosaccharides

These are the simplest form of sugars that do not yield any sugar on hydrolysis. These are optically active crystalline substances that are insoluble in organic solvents like ether and acetone but freely soluble in water. They contain 2 to 10 carbon atoms in their structure. The monosaccharides that contain 5-6 carbon atoms are pentoses and hexoses respectively are physiologically significant. Examples of monosaccharides include glucose, fructose, galactose and mannose.

2. Disaccharides

These are the sugars that are formed by the combination of two monosaccharides. Therefore on hydrolysis they yield two monosaccharides that may be same or different. They are colourless crystalline substances that are soluble in water.

- (a) **Maltose:** It is formed by the hydrolysis of starch and constitutes two units of D-glucose. It is a reducing sugar as it contains a free aldehyde group.
- (b) **Lactose:** It constitutes a unit of D-glucose and a unit of D-galactose and is found in milk. It is a reducing sugar as it contains free aldehyde group.
- (c) **Sucrose:** It constitutes a unit of D-glucose and a unit of D-fructose. It is found in cane sugar, carrot and beetroot. It is a non-reducing sugar as it does not contain free aldehyde group.

3. *Polysaccharides*

They are formed by the combination of many monosaccharides. On hydrolysis they give more than six molecules of monosaccharides. Therefore, they have high molecular weight. They are amorphous in nature and sparingly soluble in water. They form colloids when their solution in water is heated. Polysaccharides when acted upon by enzymes give simpler components like maltose, sucrose, glucose etc.

- (a) **Starch:** It contains several units of glucose joined together by glycosidic linkage. It is found in seeds, cereals and tubers such as potatoes. The amylase secreted from the salivary glands and pancreas hydrolyse the starch units into maltose.
- (b) **Glycogen:** It contains several units of glucose and fructose that are compactly linked to each other. It is also known as animal starch as it mainly occurs in animal tissues like liver and muscles.
- (c) **Dextrin:** It contains several units of glucose that are highly branched. It is produced by yeast and bacteria.

Sources of Carbohydrates

Carbohydrates are present in rice, wheat, maize, potatoes, yam, tapioca, pulses, jaggery, sugar, honey, vegetables, fruits like apple, banana, etc.

Role of Carbohydrates

Carbohydrates are degraded to glucose and fructose by gastric juices. This glucose is oxidized to produce energy in the muscles. Carbohydrates supply approximately half the energy used by the body. 1g of carbohydrate produces 4 kJ of energy. Glucose, that is not instantly used is stored in liver in the form of glycogen. Glucose is also converted and deposited in the form of fat.

1. *Source of Energy*

Carbohydrates play an important role by supplying energy to body tissues and muscles. They are required for regular working of the muscles and brain. Energy can also be generated from fatty acids but the erythrocytes and nervous tissues depend only on the glucose supply. Immediate requirement of energy can be fulfilled by intake of carbohydrates.

2. *Protein Sparing Effect of Carbohydrates*

Carbohydrates are chiefly utilized from diet to produce energy and the proteins are left behind to be used for other necessary requirements. This is known as protein sparing effect. If carbohydrates do not meet the requirements of the body, then proteins are converted to fatty acids and utilized to produce energy.

3. *Protective Action in Liver*

The carbohydrates produce glucuronic acid and acetyl groups in the liver. These groups protect and detoxify the liver against the harmful bacterial toxins.

4. *Protective Action on Intestinal Bacteria*

Lactose favours the growth of bacteria present in small intestines. It helps in the production of vitamin B in the intestine. It also aids in the calcium absorption.

5. *Fats and Amino Acids*

Carbohydrates are used in the oxidation of fats. When adequate amount of carbohydrate is unavailable, fats are broken down to derive energy. Carbohydrates play an important role in the synthesis of non-essential amino acids.

6. *Others*

Carbohydrates are available in various forms in nature. They add flavour to the food. They increase the bulk of the diet in stomach and intestines. Thus, they help to control the motility of small intestines. They also increase the roughage and help in evacuation of the bowel.

Dietary Requirements

400-500 g/day

Proteins

Proteins are made up of carbon, hydrogen, oxygen and nitrogen. They differ from carbohydrates as they also contain nitrogen atoms in their structure. Proteins contain approximately 16% of nitrogen by weight. Proteins contain a small amount of sulphur and phosphorous, they may also contain iron, copper and iodine. When proteins are hydrolyzed they yield about twenty three smaller units called amino acids. Amino acids contain an acidic carboxyl group ($-\text{COOH}$) and a basic amino group ($-\text{NH}_2$). These amino acids are linked together by means of a bond between carboxyl group of one amino acid and the amino group of another amino acid. Hence, when these amino acids are combined by peptide linkages in various sequences, it yields a variety of proteins.

The amino acids which are synthesized by the body and whose requirement is met by utilizing the dietary sources are called essential amino acids. The essential amino acids are alanine, leucine, isoleucine, lysine, methionine, threonine, phenyl alanine, valine, tryptophan and histidine. The non-essential amino acids are those which can be produced by the body and are not necessarily required in the diet.

E.g.s: Glycine, proline and glutamic acid.

Classification of Proteins

Proteins are mainly classified as follows...

1. Simple Proteins

These proteins when hydrolysed give only amino acids. E.g.s: Albumin, globulins and glutelins.

2. Conjugated Proteins

These proteins are combined or conjugated with other non protein groups.

- Nucleoproteins : Proteins conjugated with nucleic acid. E.g: Nuclein.
- Glycoproteins : Proteins conjugated with oligosaccharides by covalent bonds. E.g.s: Collagen, mucin and lectins.
- Lipoproteins : Proteins conjugated with phospholipids. They are found in milk, egg yolk and blood serum.
- Phosphoproteins : These are the serine or threonine groups that are bound to phosphoric acid through the hydroxyl group of the amino acid. They are present in casein (from milk) and vitellin (from egg yolk).
- Chromoproteins : Proteins conjugated to groups that impart colour to the substance. They are found in haemoglobin and flavoproteins.
- Metalloproteins : Proteins combined with metal ions such as Fe, Zn, Cu, Co, Mn etc. These proteins act as enzymes and the metal ions work as activators.

3. Derived Proteins

These proteins are formed by the partial digestion or physical and physiological changes due to heat or chemicals. E.g.s: Meta proteins, coagulated proteins, peptones and peptides.

Sources of Proteins

Proteins can be obtained from both vegetables and animal sources. Vegetable sources of proteins are beans, oil seeds, cereals, pulses, etc., and animal sources are milk, eggs, fish, meat, etc.

The animal sources constitute all the essential amino acids but the vegetable sources lack few essential amino acids. Hence, the animal sources are considered superior over vegetable sources.

Role of Proteins

Physiologically proteins play an important role. They serve as a structural support, help in movement and defence mechanism of the body. Enzymes, hormones and antibodies are made up of proteins. Thus, proteins are involved in major functions of the body as discussed below:

1. Proteins Act as Enzymes

These proteins act as catalyst in biochemical reactions (i.e., they speed up the reaction without changing themselves). E.g: The lactose (milk) is broken down by lactase and the ingested proteins and starch are broken down by pepsin and amylase respectively.

2. Proteins Act as Hormones

Proteins act as chemical messengers that regulate the functions of many tissues and organs.

E.g: Insulin is responsible to regulate the blood glucose levels. Somatotropin, a growth hormone regulates protein production during the development of muscles. Oxytocin is involved in the contraction of uterus at the time of birth.

3. Proteins Regulate Transport of Substances

Carrier proteins bind to the ligand and carry it to the target site. E.g: Cytochromes transfer electrons. Haemoglobin transfers oxygen from lungs to other parts of the body and carbondioxide from the parts of the body to the lungs. Albumin transports many biological substances including medicines and lipoproteins transport cholesterol and fat.

4. Storage Proteins

These are the storage proteins E.g: Casein found in milk and albumin in egg white.

5. Proteins Act as Receptors and Involve in Signalling Functions

Membrane bound receptors and signaling molecules are made up of proteins. Proteins across the cell membrane transfer signals in and out of the cell. E.g: Rhodopsin is a protein present in eye that detects light stimuli and helps in vision. Acetylcholine and insulin are proteins associated with the stimulation of receptors.

6. Proteins Constitute the Supportive Structures

Proteins are the main constituents of tissues, muscles, bones, cartilages, nails and skin. These proteins are constantly degraded to nitrogenous compounds and are resynthesized. E.g: Collagen is present in tendons, keratin in hair and elastin in ligaments.

7. Proteins Aid in Contraction and Motor Activity

Actin and myosin are the proteins present in the muscle that cause contraction and relaxation and hence help in the movement of the body.

8. Proteins in Defence Mechanism of the Body

Antibodies, made up of specialized proteins, constitute the immune system of the body. Proteins cause the immobilization of the antigens, that are later engulfed by the white blood cells.

9. Proteins Serve as Building Block and Source of Energy

Proteins are primarily used for growth and formation of tissues. They are the sources of amino acids that are constantly used for the generation of new cells. The excess proteins are broken down to amino acids and stored in the form of sugar and fat. The proteins from the muscles are used to supply energy only during starvation after the stored carbohydrates and fats have been utilized.

Dietary Requirements

The dietary proteins should supply the essential amino acids necessary for the body. They play an important role in the growth of infants and children. The amount of essential amino acids required reduces as the age increases. The daily requirement of all age groups is given below :

Table: Recommended Dietary Allowance (RDA)

Age Group	Total Daily Requirement
Infants (<1 year)	1.5-2.3 g/day
Children	
(i) From 1 to 10 years	1.3-1.8 g/day
(ii) From 10 to 12 years	1.15-1.25 g/day
Teenagers	
From 13 to 18 years	0.9-1.1 g/day
Adults	
(i) Males	1g/kg body weight
(ii) Females	1g/kg body weight
(iii) Pregnant women and lactating mothers	15-25 g/day extra along with 1g/kg body weight

Lipids/Fats

Lipids are commonly known as fats. Fats are solids at 20°C (room temperature). Liquified fats at this temperature are known as oils. Fats are also made up of carbon, hydrogen and oxygen atoms similar to that of carbohydrates, but they contain higher percentage of carbon and hydrogen and low percentage of oxygen when compared to carbohydrates. Each molecule of fat contains carbon-76%, hydrogen-12% and oxygen-12%.

Fats are soluble in organic solvents such as chloroform, petroleum ether and insoluble in water. Chemically fats are made of glycerol and different types of fatty acids. A true fat is an ester of one molecule of glycerol and three molecules of fatty acids. These are called triglycerides.

Triglycerides are physiologically important as they get deposited in the adipose tissue and constitute about 15% of an ideal body weight. About 7700 kcal of energy can be supplied by 1kg of adipose tissue.

Classification of Lipids

Lipids can be classified as follows.

1. Simple Lipids

These are formed by the ester bonds between fatty acids and alcohols.

- Neutral Fats:** These are the esters of three units of fatty acids and one unit of glycerol. They are called triacylglycerols or triglycerides.
- Waxes:** These are the esters of fatty acids and monohydroxy aliphatic alcohols other than glycerol. Various types of waxes are formed by esterification of acids and alcohols as given below:

Table: Types of Waxes

Waxes	Acids	Alcohol
True waxes	Fatty acid straight chain	Cetyl alcohol/ higher alcohols
Cholesterol esters	Fatty acid	Cholesterol
Vitamin A and Vitamin D esters	Stearic acid	Vitamin A and Vitamin D

2. Compound Lipids

These are the esters of fatty acids and alcohol but also contains additional groups like carbohydrates, phosphates, sulphates etc.

- Glycolipids** - These lipids do not contain a glycerol unit. They contain an alcohol unit called sphingosine or spingol and fatty acid. In addition to this, they contain a carbohydrate moiety and a nitrogenous base.
- Phospholipids** - These lipids contain fatty acids and glycerol. In addition to this, they contain a nitrogenous base, phosphoric acid group and substituents such as lecithins, cephalins and plasmalogens.
- Lipoproteins** - These are the lipids in which the lipid itself acts as a prosthetic (tightly bound component) of the proteins.
- Sulfolipids** - These lipids contain sulphate group in their structure.

3. Derived Lipids

When the simple and compound lipids are hydrolysed or acted upon by enzymes, they give derivatives. These derivatives also exhibit the general features of lipids and are called derived lipids.

Table: Examples of Derived Lipids

Derived lipids	Examples
Fatty acids	Stearic acid, linoleic acid.
Alcohols	Glycerol, cetanol.
Sterols	Cholesterol, ergosterol, sitosterol.

Sources of Lipids

Essential fatty acids are found in vegetable oils. Linoleic acid is mainly found in safflower, sun flower, corn, sesame and soyabean oils. It is also found in ground nut, palm and mustard oils. Soyabean oil also contains linolenic acid. Meat, egg and milk fat are the sources of arachidonic acid.

Role of Lipids1. *Source of Energy*

Fat is stored in the form of adipose tissue in the body. When the body needs energy, these fats are degraded to give free fatty acids and glycerol. 1 gram fat gives 9 calories of energy. This is double the amount of energy (i.e., about 4 calories) produced by carbohydrates. Fats are utilized after 20 min of exercise when the calories from carbohydrates are used up.

2. *Carrier for Vitamins*

The fat soluble vitamins such as vitamin A, D, E and K are carried up and stored in the fatty food. These vitamins are digested, absorbed and transported only when they are associated with the fats.

3. *Protective Action*

The adipose tissue surrounds the organs, particularly heart, kidneys and intestines to provide a cushioning effect. The adipose tissue holds the organs in place and also provide protection against jerks and injuries.

4. *Essential Nutrients for the Body*

The essential fatty acids that are not synthesized by the body should be taken through diet to meet the requirements. Essential fatty acids play an important role in controlling inflammation and clotting of blood.

5. *Development of Brain, Nerves and Cells*

Fats contribute in the development of brain.

They are the important constituents of the cell membrane without which the cells would not function. They are also present in brain cells and in myelin sheath (which insulates the nerve fibres) and also helps in rapid transmission of signals.

6. *Components of Hormones*

Fats are present in the structural components of many hormone-like substances and prostaglandins that control the functions of the body. They also affect the release of sex hormones.

7. *Maintenance of Skin and Hair*

Fats contribute to maintain the skin and hair. Dry skin with flakes indicates deficiency of fats. The fat present in skin insulates the whole body and maintains the body temperature.

8. *Buffering the Effects of Harmful Exogenous Substances*

When the concentration of disease causing substances exceeds the safe levels in the blood stream, they are mobilized and stored in the adipose tissue. This dilutes the effects of harmful substances in the body and temporarily protects the vital organs from their damaging effects. These substances are later mobilized and removed from the body by means of excretion.

9. *Add Flavour to Food*

Fats not only supply nutrition to the body, but also add flavour and give an appealing look to the food.

10. *Importance of Fat*

In general, fats are responsible for weight gain and are usually avoided. According to the dietary guidelines, about 20-30% of total calories of the body should be derived from fat hence, they cannot be avoided totally. Fats are also found to improve the night vision.

The saturated fats and trans fats (formed by partial hydrogenation of vegetable oils i.e., vanaspati) increase the chances of acquiring a disease.

These fats and dietary cholesterol increase the cholesterol levels in blood. On the other hand, the monounsaturated and polyunsaturated fatty acids reduce the risk of diseases.

Dietary Requirements

The dietary requirements of fat is ideally 22 g/day. In India, fat intake varies from 20-30 g per day.

Water

Water is the main constituent of protoplasm of the living cells. There is no life without water. Almost 2/3rd of the total body weight is comprised of water. Average daily consumption of water by an individual ranges between 2 to 3 liters. Health standard of an individual mainly depends on the quality, quantity and purity of water.

Water serves as the main source, reservoir and mode of transmission for many water borne communicable diseases. Hence, provision for safe, potable and clean drinking water is essential to maintain good health.

Water is regarded as safe when it does not harm the consumer even if taken continuously for prolonged periods. It is regarded as potable when water is safe as well as wholesome to drink. Wholesome water is such water which is agreeable to use i.e., it does not possess any unpleasant colour, taste and odour.

Specifications or Standards for Drinking Water

1. Water should be free from any disease causing microorganisms or pathogens.
2. It should neither smell nor have any unpleasant taste or odour.
3. It should be fit for domestic use.
4. It should contain adequate amounts of minerals and must be free from any contaminants.

According to the Environmental Protection Agency (EPA), Indian standards or specifications for drinking water are as follows.

Table: Specifications for Water

Contaminant	Concentration
Aluminium	0.05-0.2 mg/l
Chloride	250 mg/l
Copper	1.0 mg/l
Colour	15 colour units
Corrosibility	non-corrosive
Hardness	300
Fluoride	2.0 mg/l
Foaming agents	0.5 mg/l
Iron	0.3 mg/l
Manganese	0.05 mg/l
Odour	3 threshold odour number
pH	6.5-8.5
Silver	10 mg/l
Sulfate	250 mg/l
Total dissolved Solids	500 mg/l.
Zinc	5 mg/l
Microbial organisms or pathogens	Less than one/100 ml

The concentrations mentioned in the above table are the maximum contaminant level goal (MCLG) for the contaminants i.e., it is the adequate margin of safety at which no adverse effects on the health of consumer would occur.

Vitamins

Vitamins are also called micronutrients because they are required in very small amounts and possess no calorific value. These are defined as organic substances required in small amounts for the maintenance and growth of living organisms. Their deficiency may lead to certain specific diseases or symptoms which can be cured by the administration of that specific vitamin only.

Vitamins are essential to human body. Vitamins D, K and biotin cannot be synthesized in the body. Vitamin D is synthesized in the body by the irradiation of sterols in the skin by UV rays. Many plants and microorganisms can synthesize vitamins except humans and some other animals. Hence, they are required to be supplied through diet to the human body. Vitamins are required in small amounts because their inactivation in the body is very slow.

Vitamins are mainly involved in the enzymatic reactions by participating in the enzyme systems. Most of the vitamins are present in required quantities or amounts in the fresh and natural foods (both plant and animal sources).

They play a catalytic role in many metabolic reactions of the cells. They act as coenzymes or part of coenzymes and enzyme systems. Some vitamins act as hormones and exert their actions by acting at intracellular receptor sites (E.g: Vitamins A and D).

Vitamins were first discovered by Funk. He coined the term *vitamine* for these essential food factors (it was named so because they were considered to be amines that are vital for life). However, it was later found that not all the vitamins contain nitrogen hence it was modified to *vitamin* by Drummond.

The names given to vitamins were based on their order of discovery. Alphabets like A, B, C, D, E, K, H, P were used to designate the vitamins. Subgroups of these vitamins were designated using subscripts 1, 2, 3, 4, 5 etc.

E.g: Vitamin B₁, B₂, B₃, B₆ and B₁₂; Vitamin A₁, A₂; Vitamin D₂, D₃; Vitamin K₁, K₃

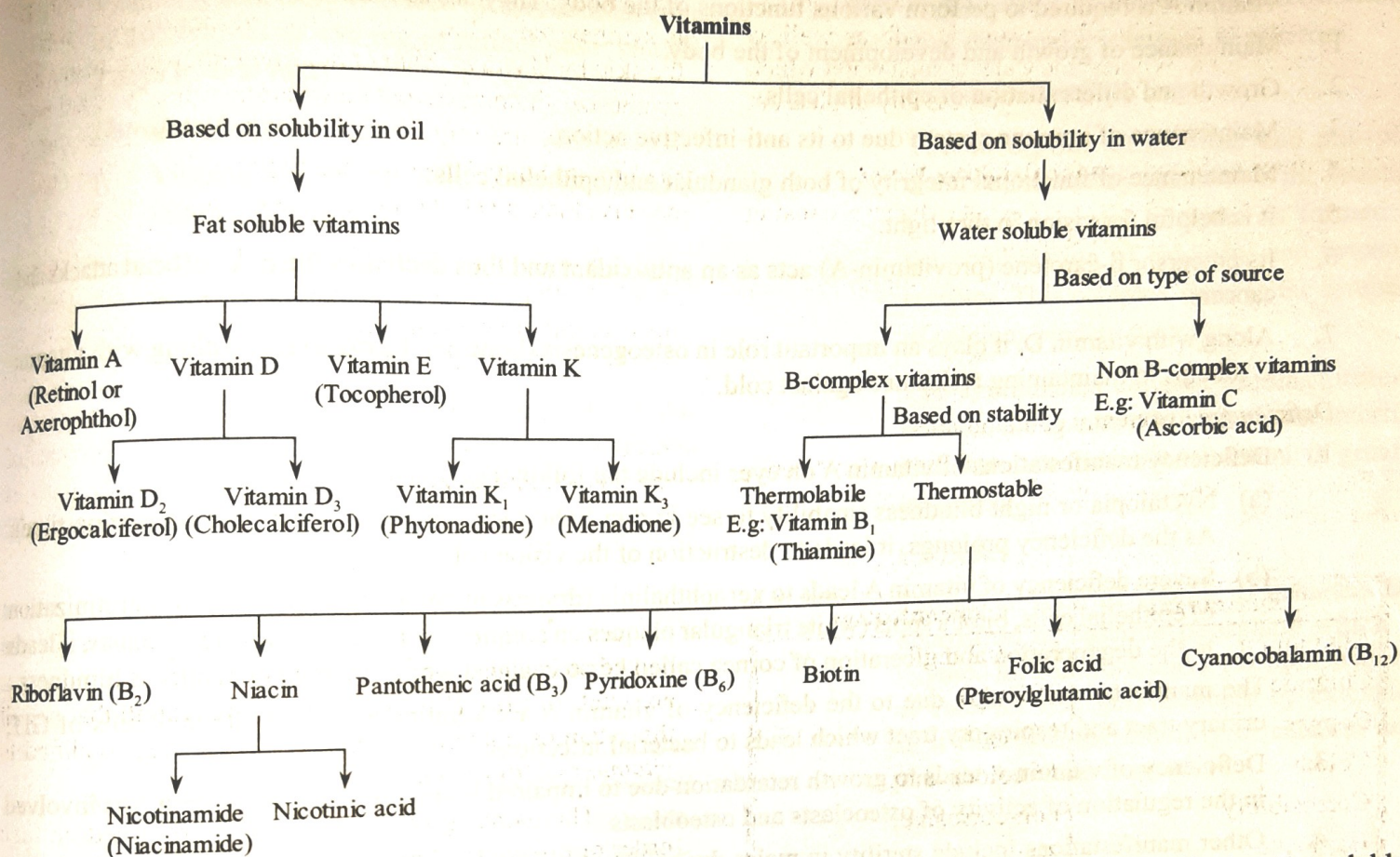
Fat soluble vitamins are stable at cooking temperatures, while the water soluble vitamins are destroyed. Usually, deficiencies do not occur when the daily requirements of vitamins are balanced by their dietary intake. Deficiency of vitamin K and biotin is very rare because these are synthesized by the intestinal flora (microorganisms) of the body. Hence, diet devoid of these vitamins may not cause any deficiency.

Factors influencing daily requirement of vitamins include age (infants, children, adults), sex and physical condition (pregnancy, lactation, stress, fever etc.).

Causes of Vitamin Deficiency

1. Intake of diet deficient of vitamins or diet containing low content of vitamins
2. Chronic alcoholism (liver diseases and biliary tract diseases)
3. Malabsorption
4. Impaired absorption due to diarrhoea or by other interacting drugs
5. Food allergies, anorexia (loss of appetite).

Classification of Vitamins



In 1915, Mc Collum and Davis classified the vitamins based on their solubility in water or oil (fats) as Fat soluble vitamins and Water soluble vitamins.

1. Fat Soluble Vitamins

Fat soluble vitamins structurally resemble partially cyclized isoprenoid polymers. They mainly include vitamins A, D, E and K. These vitamins are soluble mainly in lipids or oil and hence called fat soluble vitamins.

Absorption and transportation of fat soluble vitamins in the body are mainly associated with the lipids in the intestine. Liver and adipose tissue are the main storage sites for fat soluble vitamins. They are eliminated slowly from the body because of their lipophilic character (excretion is slow). High intake of fat soluble vitamins may lead to their accumulation in the body (hypervitaminosis) due to their delayed elimination rate. This accumulation of vitamins results in toxic effects.

Vitamins K and D are synthesized in the body. Vitamin K is synthesized by intestinal flora (microorganisms in intestine) while vitamin D is synthesized by irradiation (UV light) of ergosterols (7-dehydro cholesterol) in the skin. Vitamin E is ubiquitous (found everywhere) in plant foods. Vitamin A is not synthesized in the body, hence, it is required to be supplied through diet regularly.

Retinol (Vitamin A)

It is also called retinol (as it is unsaturated primary alcohol) and axerophthol (as it is used in treating xerophthalmia). It is mainly derived from the plant pigment β -carotene which is predominantly found in carrots. Hence, β -carotene is referred to as provitamin A.

Sources

Vitamin A is present in animal sources like dairy products (milk, butter, cheese), egg yolk, liver, kidneys, fish liver oils (cod liver oil, halibut, tuna fish liver oil etc.).

Vegetable sources of vitamin A include yellow and green leafy vegetables, yellow fruits (papaya, mangoes etc.), tomato, carrots etc.

Functions of Vitamin A

Vitamin A is required to perform various functions of the body. They are as follows:

1. Maintenance of growth and development of the body.
2. Growth and differentiation of epithelial cells.
3. Maintenance of immune system due to its anti-infective action.
4. Maintenance of functional integrity of both glandular and epithelial cells.
5. It is helpful for vision in dim light.
6. Its precursor β -carotene (provitamin-A) acts as an antioxidant and thus decreases the risk of heart attacks and cancers.
7. Along with vitamin D, it plays an important role in osteogenesis (bone cell formation) and along with vitamin C it helps in maintaining resistance against cold.

Deficiency Diseases

1. Deficiency manifestations of vitamin A on eyes include the following:
 - (a) Nyctalopia or night blindness (inability to see in dim light due to increase in the dark adaptation time). As the deficiency prolongs, it leads to destruction of the vision cells.
 - (b) Severe deficiency of vitamin A leads to xerophthalmia (dryness in cornea and conjunctiva) keratinization of epithelial cells, bitot's spots (white triangular plaques on conjunctiva). If this deficiency persists, it leads to the degeneration and ulceration of cornea called keratomalacia which ultimately results in blindness.
2. The manifestations of skin due to the deficiency of vitamin A are keratinization of epithelial cells of GIT, urinary tract and respiratory tract which leads to bacterial infections.
3. Deficiency of vitamin A leads to growth retardation due to impaired bone formation as vitamin A is involved in the regulation of activity of osteoclasts and osteoblasts.
4. Other manifestations include sterility in males due to degeneration of germinal epithelium, anorexia (loss of appetite) and susceptibility to infections.

*Dietary Requirements***Table: Recommended Dietary Allowance (RDA)**

Category	Age	RDA ($\mu\text{g/day}$)
Infants	0-6 months	400
	7-12 months	500
Children	1-3 years	300
	4-8 years	400
Males	9-13 years	600
	14-18 years	1000 (5000 IU)
	Upto 70 years	1000 (5000 IU)
	> 70 years	1000 (5000 IU)
Females	9-13 years	600
	14-18 years	800 (4000 IU)
	Upto 70 years	800 (4000 IU)
	> 70 years	800 (4000 IU)
Pregnant women	-	Higher than that in normal women.
Lactating women	-	Higher than that in normal women.

Treatment of Deficiency Diseases

Vitamin A deficiency is treated by the administration of 200,000 IU or 110 mg of retinol palmitate for 2 days by oral route.

Therapeutic Uses

1. Vitamin A is mainly used in the treatment of vitamin A deficiency.
2. It is also used in the treatment of the following diseases or symptoms:
 - (a) Xerophthalmia
 - (b) Dermatological diseases and lesions (due to suppression of keratin synthesis and secretion of mucous).
 - (c) Cold, warts, corns and calluses (skin infections).
 - (d) Acne and persistent follicular hyperkeratosis of arms.

Calciferol (Vitamin D)

Vitamin D is a pro-hormone i.e., it is a substance which possesses minimal hormonal effect by itself and acts as a precursor for the synthesis of hormone. Chemically, it is a sterol. It is known for its anti-rachitic property (treatment of rickets). It is also known as *sunshine vitamin* as the sterols present in the skin can be converted into vitamin D with the help of U.V rays emitted from the sun.

Vitamin D is mainly of two types:

- (a) Vitamin D₂: It is also called calciferol or ergocalciferol.
- (b) Vitamin D₃: It is also called cholecalciferol.

Sources

Vitamin D₂: It is obtained by irradiation of ergosterol (7-dehydrocholesterol).

Vitamin D₃: It occurs naturally. It is preformed and is found in animal fats, fish liver oils, milk, egg yolk, plant foods and vegetable oils.

Functions of Vitamin D

The prominent role of vitamin D is to maintain the homeostasis of calcium and phosphorous. Vitamin D performs its activities by promoting the movement of calcium and phosphorous ions by increasing the absorbing capacity of small intestine and by reducing their excretion through kidneys. Vitamin D possess hormone-like activity as it is produced at one area and its activity involves the diffusion process to the target area.

Vitamin D₂ and D₃ are biologically inactive whereas their metabolites 1,25-dihydroxy cholecalciferol is the active form and it is termed as calcitriol.

1. On Gastrointestinal Tract

The absorption of calcium and phosphorous is enhanced by calcitriol in the intestine. Calcitriol-receptor complex is formed by the combination of calcitriol and cytosolic receptor. This complex leads to the synthesis of calcium-binding proteins.

The synthesized calcium binding proteins enhance the uptake of calcium in the intestine and thus absorption of calcium is greatly increased.

2. On Bones

The active form of vitamin D enhances the deposition of calcium phosphate which is required for bone formation. The plasma levels of calcium also gets elevated by calcitriol as it enhances the mobility of calcium and phosphorous ions from bones.

3. On Kidneys

Vitamin D enhances the reabsorption of calcium ions and decreases their excretion. Thus vitamin D is able to maintain calcium and phosphorous homeostasis.

Deficiency Diseases

Vitamin D deficiency occurs very rarely, since it is adequately synthesized in the body. Deficiency of vitamin D occurs when food with less nutrients is consumed (insufficient amounts of vitamin D), less exposure to sunlight, malabsorption of vitamin D due to disorders like hepatic and renal related nephrotic syndrome, hepatobiliary syndrome, pancreatic disorders, abnormal metabolism, anticonvulsant therapy etc.

Vitamin D deficiency causes rickets in children and infants while osteomalacia occurs in adults. Both rickets and osteomalacia are similar in character and the symptoms are specified as follows:

In children, delayed closure of fontanelles (an opening in the skull of foetus/young infant due to incomplete ossification of bones in cranium), softening of the skull, soft weakened bones or pliable bones, ankle, wrist and knee joints are enlarged, muscles are poorly developed, restlessness, irritation etc. can be observed.

Deficiency of vitamin D leads to improper or decreased absorption of calcium and phosphorous ions which leads to demineralization of bones. This leads to formation of soft bones that cannot withstand the weight of the body or other stress and thus lead to malformation of skeletal structures.

Dietary Requirements

Table: Recommended Dietary Allowance (RDA)

Category	Age	RDA ($\mu\text{g/day}$)
Infants	Less than one year	5
Children	One to eighteen years	5
Adults	19 to 50 years	5
	51 to 70 years	10
	> 70 years	15

Therapeutic Uses

1. Vitamin D is sufficient enough in the treatment of hypoparathyroidism and in vitamin D deficiency diseases like rickets, osteomalacia etc.
2. Vitamin D acts as a preventive measure for a number of diseases.
3. Several autoimmune diseases like multiple sclerosis, insulin dependent diabetes mellitus, rheumatoid arthritis are decreased by vitamin D intake.
4. Investigational use of vitamin D include treatment of breast and colon cancers, as well as to treat psoriasis (chronic skin disease where scaly patches can be seen on elbows, knees, scalp etc.).
5. Analogues of vitamin D are developed which have less tendency to cause hypercalcaemia and hypercalciuria.

Tocopherol (Vitamin E)

Vitamin E is also known as *tocopherol* (*tokos* = for child birth, *phero* = to bear, *ol* = alcohol). It is an antisterility vitamin. It exists in four different forms i.e., alpha, beta, gamma and delta. Alpha tocopherol is the active and the most abundantly found form of vitamin E.

Sources

The dietary source of vitamin E (tocopherols and tocotrienols) includes whole grains, peanut, butter, goat milk, eggs, green leafy vegetables and vegetable oils such as wheat germ oil, sunflower oil, corn oil, soyabean oil, olive oil and cotton seed oil. Oats, chestnut, walnut oil, coconut oil are also good sources of vitamin E.

Functions of Vitamin E

Vitamin E plays an important role, as an antioxidant and works to protect the cells of the body from the damage caused by free radicals. Free radicals are highly reactive and destructive compounds which are formed as a result of oxidative deterioration (metabolism) of polyunsaturated fats. Factors contributing for the free radical generation in the body include smoking and exposure to ultraviolet radiations.

Deficiency Diseases

A number of disorders may result due to deficiency of vitamin E, few of them are listed below:

1. Deficiency of vitamin E causes poor nerve conduction in the body. This leads to various neurological problems such as Alzheimer's disease and Parkinson's disease.
2. Deficiency of vitamin E may lead to birth of infants with very low birth weight.
3. Deficiency of vitamin E causes muscle weakness, blindness due to degeneration of the retina and haemolysis of erythrocytes.
4. Poor absorption of dietary fat and vitamin E is due to inherited disorder of fat metabolism called '*Abetalipoproteinaemia*'.

Dietary Requirements

The recommended dietary allowance (RDA) for vitamin E is 10 mg to 30 mg.

Therapeutic Uses

1. Vitamin E is used as a component of multivitamin preparation.
2. Vitamin E may be helpful in the prevention or delaying of coronary heart disease by limiting the oxidation of LDL-cholesterol (bad cholesterol).
3. Vitamin E is used to suppress the development of age-related muscular degeneration (AMD).
4. Vitamin E is helpful in protecting the retina from glaucomatous damage.
5. Vitamin E in combination with vitamin C is used as a prophylactic in Alzheimer's disease.
6. Tocopherols are widely used in cosmetic and food industry as an inexpensive preservative.

Naphthoquinone (Vitamin K)

The term vitamin K originated from German word '*Koagulation*' (coagulation, clotting of blood) as it is mainly involved in the formation of blood clotting factor prothrombin in liver.

1. Natural Forms- E.g.s: Phylloquinone or vitamin K₁, Menaquinone or vitamin K₂.
2. Synthetic Forms - E.g.s : Menadione or vitamin K₃, Menadiol sodium diphosphate or vitamin K₄.

Sources

Vitamin K is available from various natural sources among which most commonly available are leafy vegetables like brassica, kale, borecole, cauliflower, broccoli, alfalfa and other vegetables belonging to cabbage family. Raw food materials like Swiss chard, water cress, carrot tops, mayonnaise and vegetable oils like soybean oil, olive oil, cotton seed oil, canola oil are the rich sources of vitamin K₁.

Vitamin K₂ is available from putrefied fish meal and it is also synthesized in the intestine by microbial bacteria.

Functions of Vitamin K

Vitamin K plays a vital role in controlling haemorrhagic disorders by activating the blood clotting factors (proteinacious in nature). Apart from blood clotting action other functions of vitamin K are activation of various types of proteins by carboxylation of glutamic acid residue at the amino end of the protein.

Deficiency Diseases

Vitamin K is available in plenty from various sources and it is also synthesized in the intestine by microbes. Recycling of vitamin K also conserves excess amount of vitamin K and is supplied to the body when required. Hence, deficiency of vitamin K is very rare.

Despite of all the above sources deficiency of vitamin K occurs due to the ingestion of vitamin K antagonists (warfarin or dicoumarol) by people suffering from hepatic disorders, malabsorption due to decreased bile salts, disturbed intestinal uptake like obstruction of bile duct, diarrhoeal condition where vitamin K is lost in faeces, intake of antibiotics that kill microbes which synthesize vitamin K.

Hypoprothrombinemia is the primary disease that occurs in vitamin K deficiency. This disorder is characterized by bruising (discolouration of area from which blood is lost). Bleeding manifestations are observed in nose, gums of teeth, haematuria, blood in stool, menstrual bleeding, intracranial haemorrhage. Calcification of soft bone tissues, malformation of bones, calcification of cartilage, calcium deposition in arteries (atherosclerosis) are other consequences of vitamin K deficiency.

Deficiency of vitamin K is known to cause a dreadful disease in infants called as vitamin K deficiency bleeding (VKDB). Infants are more prone to vitamin K deficiency as their intestine do not possess microbes that synthesize vitamin K and also vitamin K is not transported through placental barrier to foetus.

The deficiency of vitamin K can be overcome by proper diet intake with rich nutrients containing vitamin K. Vitamin K supplements must be taken by the individuals suffering from its deficiency.

Dietary Requirement

Table: Recommended Dietary Allowance (RDA)

Category	Sex	Age	RDA (µg/day)
Infants	Male	< 1 year	2 to 2.5
	Female		
Children	Male	< 13 years	30 to 60
	Female		
Adolescents	Male	14 to 18 years	75
	Female		
Adults	Male	19 years and above	120
	Female		

Pregnant women are recommended to take sufficient amounts of vitamin K in order to protect themselves from vitamin K deficiency. The pregnant women who are above 19 years of age must take 90 mcg per day. The same amount is recommended for breast feeding women also.

Therapeutic Use

It is used in the treatment of vitamin K deficiency in patients suffering from malabsorption.

2.

Water Soluble Vitamins

Water soluble vitamins are a group of substances which are derived from endogenous substances. These substances include sugars, amino acids, pyridines, purines and pyrimidines. In other words, these substances act as precursors for the synthesis of water soluble vitamins such as vitamin B complex and vitamin C.

They are mainly found in yeast, liver, rice polishings, green vegetables etc. Water soluble vitamins act as coenzymes in many metabolic reactions wherein they are not involved in their natural form but they undergo phosphorylation or coupling with nucleotides.

Examples:

1. In decarboxylation of α -ketoacids and reversible reactions, vitamins like thiamine, biotin and pyridoxine acts as coenzymes.
2. Pantothenic acid and folic acid play an important role as coenzymes in condensation reaction and carrier functions.

Excess intake of vitamins may not lead to toxicity because of rapid rate of elimination (urinary excretion) from the body. But when administered chronically in higher amounts, this may lead to considerable toxicity.

All water soluble vitamins constitute important redox systems and thus they are involved in reversible oxidation-reduction processes.

E.g: Existence of riboflavin and porphyrins in both oxidized and reduced states. Sometimes, these vitamins may occur together but are involved in the regulation of different stages of metabolic reactions. Deficiency of a vitamin may complicate the dietary deficiency of other vitamins of the group. So, the treatment usually given is the administration of vitamin B complex preparation. Although they differ in their chemical structure, they are grouped under single class because of their common feature

i.e., water solubility. As the dietary sources are different, vitamin C is not included under vitamin B complex. Conditions like fever, diarrhoea, injury, hyperthyroidism, chronic alcoholism etc., if left untreated may cause deficiency of water soluble vitamins.

Thiamine (Vitamin B₁)

It is also known as *aneurin*. It is mainly required for the utilization of carbohydrates in the body and for the maintenance of good appetite.

It can withstand temperature of 100°C for a short period only. Above 100°C it loses its potency and activity.

Sources

Animal sources like milk, pork, liver, heart, kidneys and plant sources like leafy green vegetables (broccoli), beans, sweet corn, brown rice etc.

Functions of Vitamin B₁

The active form of vitamin B₁ in the body is thiamine-pyrophosphate (TPP). It is involved in citric acid cycle and acts as prosthetic group for decarboxylases. It is also involved in transketolation reaction and decarboxylation of α -keto acids.

Deficiency Diseases

1. Polyneuritis

Causes : It occurs in birds due to the deficiency of thiamine which leads to altered metabolic pathways in brain and increased influx of pyruvic acid into the brain due to altered blood brain barrier function.

Manifestations : Muscular paralysis, which results in inability to fly, walk or even stand. As thiamine inhibits these neuritic symptoms, it is also called antineuritic factor.

2. Beri beri

Cause : Deficiency of thiamine in the body.

Manifestations : Polyneuritis, muscular atrophy, cardiovascular changes, oedema and gastrointestinal upsets.

Symptoms : Weakness, fatigue, headache, insomnia, dizziness, constipation, loss of appetite, sensory disturbances, paralysis of limbs, palpitation, tachycardia, oedema, confusion and depression.

Depending on the symptoms, beri beri is classified into four types:

(a) Dry Beri beri

It includes mainly the symptoms of nervous origin such as peripheral neuritis, muscular atrophy in adults numbness, burning sensation of legs, wasting muscles and paralysis in children.

(b) Wet Beri beri

It mainly includes the cardiovascular symptoms like oedema, congestion in legs, increased cardiac output and cardiac failure.

(c) Infantile Beri beri

It includes the symptoms like tachycardia, cardiac failure, convulsions, vomiting, greenish stools, sudden death in infants.

(d) Wernick's Encephalopathy (Cerebral Beri beri)

Cause : Severe deficiency of thiamine.

Manifestations: Peripheral neuropathy, tremors and convulsions. As thiamine is used in the treatment of beri beri, it is also called *anti beri beri factor*.

Dietary Requirement

The recommended dietary allowance for vitamin B₁ is 0.2-0.3 mg/1000 calories.

Therapeutic Uses

1. Vitamin B₁ (thiamine) is mainly used in the prophylaxis or treatment of diseases like alcoholic neuritis.
2. Cardiovascular diseases and gastrointestinal symptoms (due to deficiency), neuritis of pregnancy and beri beri are also treated by giving vitamin B₁.

Riboflavin (Vitamin B₂)

Chemically, vitamin B₂ resembles yellow water soluble pigments, flavins.

It is termed as riboflavin due to the presence of ribitol or ribityl group (sugar alcohol) in its structure and as lactoflavin as it is isolated from milk (lactose sugar).

Sources

Animal sources like milk, dairy products (cheese, yoghurt), eggs, meat, poultry and yeast contain riboflavin.

Functions of Vitamin B₂

Riboflavin acts as a precursor for the biosynthesis of the coenzymes like flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD). They act as flavoproteins in combination with enzymes and also act as oxidases and dehydrogenases. They also act as hydrogen acceptors and hence assists in the functioning of enzymes like CYP or cytochrome P450, amino acids and xanthine oxidases. They act as components of electron transport system in biological oxidations.

Riboflavin and its coenzymes are involved in the oxidation of carbohydrates, amino acids and other metabolic products. They are essential for tissue building and its maintenance.

Deficiency Disease

Ariboflavinosis - It is a vitamin B₂ (riboflavin) deficiency disease characterized by a group of symptoms and it occurs due to the following causes:

1. Severe deficiency of vitamin B₂ (riboflavin).
2. Chronic alcoholism in combination with other vitamin deficiencies.
3. Drug therapy (phenothiazine, tricyclic antidepressants, probenecid).

Dietary Requirements

The recommended dietary allowance (RDA) for vitamin B₂ is 0.6 mg/1000 calories.

Therapeutic Use

In the treatment and prevention of ariboflavinosis. A recent investigation has found that it is effective in treating migraine.

Niacin (Vitamin B₃)

It is heat stable water soluble vitamin which includes nicotinic acid (a white crystalline substance), which is a simple derivative of pyridine and its amide form, nicotinamide. Nicotinamide is the active form of niacin.

(Niacin is chemically related to nicotine but exhibits different physiological properties.)

Sources

Rich sources include liver, meat, eggs, milk and cereals. Other sources such as potatoes and green vegetables contain small amount of niacin.

Functions of Niacin

NAD^+ and NADP^+ are the coenzymes of niacin. Along with flavoproteins, they are involved in the biological oxidations i.e., they act as components of electron transport system. (They play an important role in biosynthesis of fatty acids and various steroids, dehydrogenation reactions occurring in mitochondria, cytosol and endoplasmic reticulum (tissue respiration). Hence, niacin is essential for the fat synthesis, growth and maintenance of healthy skin.)

Nicotinamide is devoid of pharmacological actions but nicotinic acid causes peripheral vasodilation (due to relaxation of smooth muscles, vitamin-induced histamine release), lowering of serum cholesterol levels and activation of fibrinolysis. Other pharmacological actions include gastro-intestinal disturbances, nausea, activation of peptic ulcers, glucose intolerance and hyperuricaemia. NAD^+ and NADP^+ are also involved in the metabolism of carbohydrates, proteins and fats etc.

Deficiency Diseases

Deficiency of nicotinic acid along with riboflavin and thiamine causes pellagra. It is characterized by dermatitis, diarrhoea and dementia.

Deficiency may occur in chronic alcoholism, malnutrition and oral contraceptive therapy in women, which leads to excessive salivary secretions, motor and sensory disturbances of peripheral nerves.

Deficiency symptoms include mental disturbances, nervous dysfunction, pigmentation of skin, anorexia, lethargy, mental confusion and hallucinations. In humans, deficiency results in red and ulcerative tongue, while in dogs, black tongue may appear.

Dietary Requirement

The recommended dietary allowance (RDA) for niacin is 10-15 mg.

Therapeutic Uses

1. Both nicotinic acid and nicotinamide are used in the treatment or prevention of niacin deficiency (pellagra).
2. Nicotinic acid is used in hyperlipidaemia as it lowers triglyceride and cholesterol levels in blood.
3. Along with potassium iodide, nicotinamide is used as iodine supplement to the body.

Pantothenic Acid (Vitamin B_5)

It is known for its antidermatitis property as it prevents dermatitis in chicks. Chemically, it is a dipeptide of alanine and butyric acid.

It promotes the growth of yeast and bacteria. Many microorganisms and plants can synthesize pantothenic acid.

Sources

All animal and plant foods including meat, fish, seafood, pulses (lentils, dried beans) and nuts contain vitamin B_5 .

Functions of Pantothenic Acid

1. Pantothenic acid is the main constituent of coenzyme A and hence it is involved in a number of metabolic reactions/processes like:
 - (a) Activation of fatty acids prior to β -oxidation.
 - (b) In Krebs's cycle
 - (c) In the biosynthesis of aromatic rings, terpenes and steroids.
2. It is also a component of fatty acid synthase complex and acyl carrier protein.

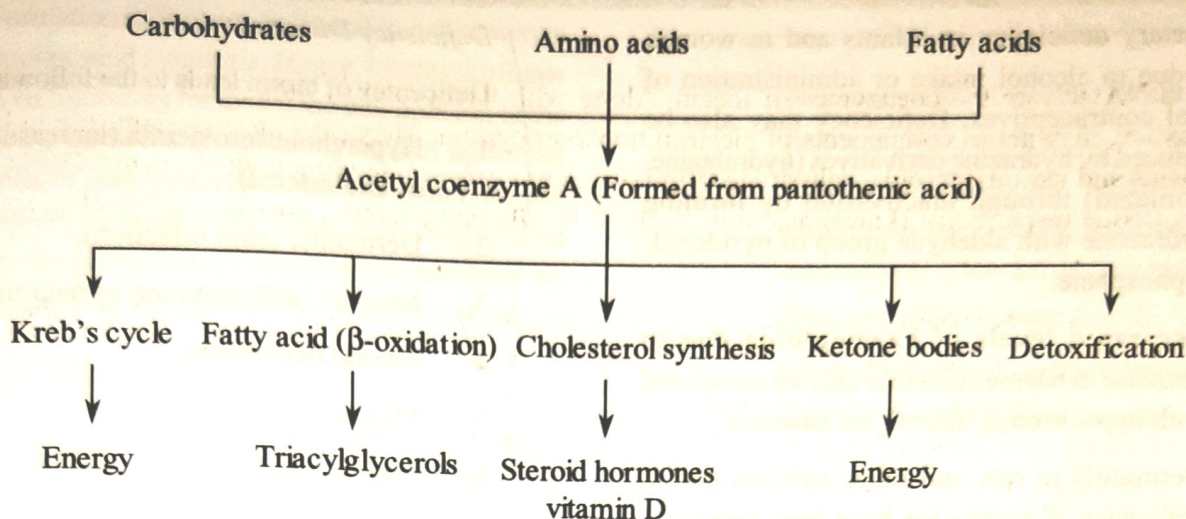


Figure: Physiological Role of Pantothenic Acid in the Body

Deficiency Disease

This condition occurs rarely. It is characterised by numbness in toes and painful burning sensation in the feet. It can be corrected with supplementation in the diet. Deficiency symptoms of pantothenic acid include fatigue, malaise, headache, sleep disturbances, nausea, abdominal cramps, epigastric distress and vomiting. Decreased resistance to infection, skin abnormalities, infertility and irritability are other conditions due to deficiency of pantothenic acid.

Dietary Requirement

The recommended dietary allowance (RDA) for vitamin B₅ or pantothenic acid is 10 mg.

Therapeutic Use

In the treatment of general nutritional deficiency.

Pyridoxine (Vitamin B₆)

Pyridoxine (a pyridine derivative), *pyridoxal* and *pyridoxamine* constitute vitamin B₆. All the three are interconvertible in their phosphorylated forms and exhibit similar physiological activities.

Sources

Meat, fish, cereals, banana, nuts, wheat germ and green vegetables.

Functions of Vitamin B₆

The physiologically active form of vitamin B₆ is pyridoxal-5-phosphate. It acts as a coenzyme for the enzymes that are involved in the biosynthesis of niacin, coenzyme A and haemoglobin. It is also involved in reactions like transamination, amino acid decarboxylation, dehydration, desulfuration and metabolism of unsaturated fatty acids. These reactions in turn regulate the production of histamine, serotonin, catecholamine and GABA neurotransmitters of the nervous system. Pyridoxal-5-phosphate also acts as coenzyme in the formation of serotonin from tryptophan, of the nervous system. Pyridoxal-5-phosphate also acts as co-carboxylase in the decarboxylation of DOPA to dopamine. It also functions as co-transaminase in transamination reactions.

Deficiency Diseases

1. Deficiency of pyridoxine leads to neurological symptoms like depression, irritability, nervousness, mental confusion.
2. Severe deficiency leads to convulsions and peripheral neuropathy due to decreased synthesis of biogenic amines (serotonin, GABA and catecholamines). Demyelination of neurons, defective sexual behaviour due to reduction in accessory reproductive organs are other manifestations.
3. Vitamin B₆ deficiency also results in a condition called paraesthesiae (abnormal tingling sensations).

4. Dietary deficiency in infants and in women is due to alcohol intake or administration of oral contraceptives. Deficiency may also be induced by hydrazine derivatives (hydralazine, isoniazid) through inactivation by forming hydrazone with aldehyde group of pyridoxal-5-phosphate.
5. Decreased levels of haemoglobin due to decrease in haeme synthesis may be associated with hypochromic microcytic anaemia.
6. Dermatitis in rats and other animals due to deficiency of pyridoxine have been reported.

Dietary Requirement

The recommended dietary allowance (RDA) of the vitamin B₆ in different categories is as follows.

Category	RDA (µg/day)
Infants and children	0.3-1.5
Adult male	2.2
Adult female	2.0

Therapeutic Uses

1. Pyridoxine is mainly used to treat or prevent the deficiency of vitamin B₆. It is also administered in combination with isoniazid and cycloserine to reduce their toxicity.
2. In premenstrual syndrome (headache, depression, irritability, weight gain).
3. It is used as prophylactic (2mg/day) in patients suffering from other vitamin B deficiency diseases.
4. It is also used in the treatment of sideroblastic anaemia (A type of anaemia characterized by the presence of ringed sideroblasts) in doses of 100-400 mg/day.

Biotin

Chemically, biotin is a derivative of valeric acid (organic acid). It contains imidazole and thiophene rings in its structure.

It is a racemic mixture, of which dextro form is active.

Sources

It is mainly present in egg yolk. Other sources include liver, kidney, peas, yeast and cauliflower.

Functions of Biotin

It functions as a coenzyme for several metabolic reactions involving carboxylation (addition of CO₂) and decarboxylation (removal of CO₂).

Deficiency Diseases

Deficiency of biotin leads to the following disorders.

1. Hypercholesterolaemia (increase in the levels of cholesterol).
2. Dermatitis (skin infection).
3. Neuritis (inflammation of neurons).
4. Mental depression.
5. Muscular pain.
6. Nausea and fatigue

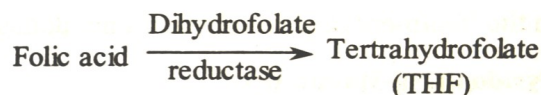
Dietary Requirement

The recommended dietary allowance (RDA) for biotin is 10-15 mg.

Folic Acid (Vitamin B₉)

Folic acid is chemically pteroylglutamic acid i.e., it contains pteridine and glutamic acid moieties in its structure. Active form of folic acid is tetra hydrofolic acid (THF).

In the body, folic acid is converted into tetrahydrofolic acid (THF) by dihydrofolate reductase enzyme.



Sources

Folic acid is found in all green vegetables, broccoli, brussels sprouts, spinach, asparagus, nuts, dried beans, oranges, whole grain, bread etc.

Functions of Folic Acid

N₅-methyl tetrahydrofolic acid is the active form of the vitamin (folic acid) in the body. It is mainly involved in the one-carbon transfer reactions, where it acts as carrier for one-carbon unit.

It is involved in a number of metabolic reactions such as:

1. Biosynthesis of purine and pyrimidine nucleotides
2. Conversion of an amino acid into other amino acid:

E.g.s: (i) Homocysteine → Methionine
(ii) Serine → Glycine
(iii) Histidine → Glutamic acid

3. Formation of formate units and its utilization in nucleic acid synthesis. Hence, tetrahydrofolate is an important factor for the cell division in the body, particularly erythrocytes and epithelial cells of gastrointestinal mucosa which are the rapidly dividing cells. Thus, folic acid is used in the treatment of macrocytic anaemia by controlling the production of erythrocytes.

Deficiency Diseases

Deficiency of folic acid results in glossitis, weight loss, diarrhoea, megaloblastic anaemia, impaired growth, pernicious anaemia, depression and spina bifida in infants.

Deficiency of folic acid may be due to inadequate diet, chronic alcoholism, pregnancy, malabsorption of vitamin etc. In alcoholism, deficiency is mainly due to impaired enterohepatic reabsorption.

Macrocytic anaemia is due to blockade of DNA synthesis (decreased production of purines).

Dietary Requirement

The recommended dietary allowance (RDA) for folic acid is 100-400 µg.

Therapeutic Use

It is mainly used in the treatment of folic acid deficiency.

Cyanocobalamin (Vitamin B₁₂)

Vitamin B₁₂ contains a central cobalt atom to which corrin ring is attached in the similar way as Fe⁺⁺ with tetrapyrrole ring in haeme. Vitamin B₁₂ is synthesized by the microorganisms in intestine of humans. Vitamin B₁₂ is also called *antipernicious anaemia vitamin* as it is used in the treatment of pernicious anaemia. It is also called *cyanocobalamin* as it contains a cobalt atom and a CN group attached to the corrin ring. Vitamin B₁₂ can be obtained as commercial product from the fermentation of microorganisms like *Streptomyces griseus*, *Streptomyces olivaceus* and *Streptomyces aureofaciens*. The required daily allowance (RDA) of vitamin B₁₂ in humans is 1.5-2.5 µg.

Sources

Meat, poultry, fish, eggs, dairy products (milk, cheese etc.). Vitamin B₁₂ is absent in plant foods.

Functions of Vitamin B₁₂

1. Replacement of cyano group of cyanocobalamin with methyl or 5'-deoxyadenosine moiety results in the formation of methyl cobamide or 5'-deoxyadenosyl cobamide respectively. They act as coenzymes in plasma, liver and other tissues.
2. Methyl cobamide acts as methyl group donor in many methylation reactions.
E.g.s:
(i) Formation of methionine from homocysteine.
(ii) In the biosynthesis of DNA, methyl cobamide introduces a methyl group at 5th position of thymine to form thymidine (a nucleoside).
3. 5'-deoxy adenosyl cobamide acts as a coenzyme for mitochondrial mutase, which converts methyl malonyl CoA to succinyl CoA.
4. Sulphydryl groups of some enzymes are maintained in reduced form by vitamin B₁₂.
E.g: Glutathione.
5. Vitamin B₁₂ is concerned with the storage of folic acid in erythrocytes, formation of normal RBC, epithelial cells in mouth and gastrointestinal tract. It also has growth promoting effects.

Deficiency Diseases

The deficiency of vitamin B₁₂ leads to functional disturbances in the following systems

1. Erythropoietic System
Deficiency of vitamin B₁₂ leads to abnormal DNA synthesis by affecting the role of tetrahydrofolate in DNA synthesis. It ultimately leads to abnormality in precursor cells in bone marrow resulting in macrocytic anaemia.
2. Gastrointestinal System
Vitamin B₁₂ is important in the maintenance and functioning of rapidly proliferating cells. Hence its deficiency results in gastrointestinal symptoms like anorexia, indigestion, diarrhoea and atrophic glossitis.

3. Nervous System

As 5'-deoxyadenosine cobalamin and methyl cobalamin are involved in the synthesis of myelin sheath, the deficiency of vitamin B₁₂ leads to demyelination of nerves and neurological lesions. Neurological abnormalities (degeneration of nerve cells in spinal cord and cerebral cortex irritation, loss of memory, confusion, hallucinations or psychosis, swelling of myelinated neurons) are due to abnormal functioning of brain and nerve cells.

Dietary Requirement

The recommended dietary allowance for vitamin B₁₂ is 1 to 1.5 µg.

Therapeutic Uses

1. In the treatment of megaloblastic anaemia and psychiatric disorders.
2. It is used life long by the patients with pernicious anaemia.
3. It is used to treat the deficiency of vitamin B₁₂ caused due to malabsorption, prolonged chemotherapy and by fish tapeworm infestation.
4. In surgical operations, the site of intrinsic factor (IF) production or the site of vitamin B₁₂ absorption is removed. Therefore, it is used prophylactically after such surgeries.

Ascorbic Acid (Vitamin C)

Vitamin C is also called *ascorbic acid*. It is one of the water soluble vitamins, mainly found in citrus fruits. It is also called ascorbic acid due to its antiscorbutic action. It undergoes reversible oxidation-reduction reaction, therefore easily undergoes oxidation to form dehydroascorbic acid. Vitamin C consists of a chiral center and hence exists in different optical isomeric forms. Levo form is biologically active whereas dextro isoascorbic acid is not effective as antiscorbutic due to its rapid elimination from the tissues.

Sources

Fresh and raw fruits (strawberries, guavas, kiwi), fruit juices, oranges, lime, grapes, lemon, green and red pepper, tomato, broccoli, potatoes and green vegetables.

Function of Vitamin C

Vitamin C plays an important role in the formation of collagen by stimulating the synthesis of collagen peptides. Relatively high concentration of ascorbic acid is found in collagen. It is involved in the synthesis of collagen precursor peptides which are important in the formation of dentin. Vitamin C is involved in the following functions.

1. Cellular respiration
2. Maintenance of functional integrity of sulphhydryl groups of glutathione.
3. Conversion of proline to hydroxyproline and lysine to hydroxylysine.
4. Biosynthesis of epinephrine from dopamine in adrenal glands and brain.
5. Formation of haemoglobin, erythrocyte maturation by improving the absorption of iron from gastrointestinal tract.
6. Conversion of folic acid to tetrahydrofolate.
7. In immunological reactions (recovery from viral infections).
8. Metabolism of carbohydrates and oxidation of phenylalanine and tyrosine. Decrease in vitamin C leads to hyperglycaemia, decreased glucose tolerance and resistance to insulin.
9. Biosynthesis of adrenocorticoid hormones.
10. Conversion of cholesterol to cholic acid and in hydroxylation reactions.
11. In microsomal drug metabolism.
12. Maintenance of structural integrity of teeth, matrix of bone, capillary walls.
13. Healing of bone fractures.
14. Ascorbic acid blocks the formation of active carcinogens from its precursors. It also acts as an antioxidant in the body.

✓ Deficiency Diseases

Deficiency of vitamin C mainly results in scurvy (tendency to haemorrhage) due to decreased formation of collagen, decreased structural integrity of capillary walls and gums of teeth. Bleeding from capillaries is due to defective formation of precapillary fibrous tissue. It also results in brittleness of bones due to reduced structural integrity of bone matrix.

Dietary Requirement

The recommended dietary allowance (RDA) for vitamin C or ascorbic acid is 40 - 60 mg.

Therapeutic Uses

1. Vitamin C is used in the treatment of adult scurvy.
2. It is used in the treatment of idiopathic methaemoglobinaemia.
3. It is also used in the treatment of few microcytic anaemias (as vitamin C increases absorption of iron from GIT).
4. In combination with methylamine, ascorbic acid increases its antibacterial effect.
5. Ascorbic acid increases iron chelation with desferoxamine and hence used in chronic iron toxicity.
6. It is used as an antioxidant in natural flavours and colours.

Minerals

Minerals are the chemical elements present in the body. They constitute about 1/20th of the total body weight. They are required for the growth, repair of tissues and performance of vital functions of the body.

These are divided into three main classes.

1. **Macro Elements** - These are required in large amounts by the body.
E.g.s: Calcium, magnesium, phosphorus, potassium and sodium.
2. **Micro Elements** - These are required in very small quantities, less than few mg/day by the body.
E.g.s: Iron, iodine, copper, cobalt, chromium, fluorine, manganese, molybdenum, nickel, selenium, silicon, tin, vanadium and zinc.
3. **Trace Elements** - This class includes elements whose function in the body is unknown.
E.g.s: Mercury, boron, aluminium, barium.

Calcium

Calcium is the predominant constituent of protoplasm of the cell. An average of 1200 gms of calcium is present in the human body of which almost 99% is present in the bones. It is also found in blood, teeth, muscles, lymph and cerebrospinal fluid.

Sources

Milk, milk products, eggs, cheese, fish, fruits, cereals, green leafy vegetables and drinking water.

Functions of Calcium

1. It is essential for the formation, growth and maintenance of bones and teeth.
2. It helps in coagulation or clotting of blood.
3. It is required for contraction of cardiac muscle, skeletal muscle, smooth muscle and regulation of neuromuscular excitation.
4. It acts as a catalyst in various enzymatic reactions involving lipases, ATPases.
5. It is required for the regulation of capillary permeability.
6. It is needed for transforming light impulses into electric impulses in the retina.

Deficiency Diseases

Deficiency of calcium leads to similar manifestations as that of vitamin D. It causes rickets in children and osteomalacia in adults (mainly in pregnant women).

It also delays clotting of blood and may sometimes give rise to tetany (carpopedal spasm of the hands).

Dietary Requirement

Category	RDM (μ g/day)
Adults	400-500
Pregnant and lactating Women	1000
Children and infants	500 - 600

Phosphorus

Phosphorous is a very important mineral which performs more functions than any other mineral. About 80% of total phosphorus content in the body is found in bones and teeth.

Sources

Meat, fish, milk, milk products, nuts and poultry.

Functions of Phosphorus

1. It is essential for the formation of teeth and bones.
2. It is a major constituent of the buffer system of blood (helps to maintain pH).

3. It is the important component of the enzymes which help in transferring and storing ATP (ATPases).
4. It plays a vital role in nerve functioning and muscle contraction.
5. It is a major constituent of DNA and RNA (nucleic acids).

Deficiency Diseases

Deficiency of phosphorus leads to malformation of teeth, bones and nucleic acids.

Dietary Requirement

The recommended dietary allowance (RDA) for phosphorus is 0.88 mg.

Potassium

It is an important and the main cation of intracellular fluid.

Source

Almost all the food stuffs contain potassium.

Functions of Potassium

1. It helps in maintaining intracellular osmotic pressure.
2. It is one of the constituents of buffer system of blood (helps in maintaining pH).
3. It helps in carrying carbondioxide via chloride shift.
4. It inhibits the contraction of muscles (including cardiac muscles) and prolongs their relaxation.

Deficiency Diseases

1. Deficiency of potassium leads to fragility of bones.
2. It may also develop sterility.
3. It may effect the normal functioning of cardiac and skeletal muscles.

Dietary Requirements

The recommended dietary allowance (RDA) for potassium is 4g/day.

Sodium

Sodium is an important constituent of extracellular fluids. It is the only salt consumed in diet via sodium chloride (NaCl).

Source

Common salt (NaCl), foods, milk and vegetables.

Functions of Sodium

1. It is a major ion which helps in the maintenance of muscle and nerve excitability.
2. It strongly affects the distribution of body water through osmosis.
3. It plays a vital role in the maintenance of acid-base balance of the body.
4. It is an important constituent of bicarbonate system of the body.

Deficiency Diseases

Deficiency of sodium is quiet uncommon. Decreased concentrations of sodium lead to decrease in the extracellular fluid, plasma volume, cardiac output and finally to cardiac failure. It causes disturbances in acid-base balance and decrease in the excitability of nerves and muscles.

Dietary Requirements

The recommended dietary allowance for sodium is 1-2 mg.

However, the average daily intake of sodium chloride by man ranges from 8-10 mg. Maintenance of optimum sodium concentration is very important because excess of sodium leads to hypertension and oedema.

Iron

Iron is an important element of the body. About 2-6 g of iron is present in the body of which almost 70% is present in the haemoglobin of RBC (erythrocytes). Very small amount (about 2%) is present in myoglobin of muscle and blood plasma.

It is stored in the form of ferritin in bone marrow, spleen and liver which constitute 24% of iron.

Sources

1. **Animal Sources** - Iron obtained from animal sources constitutes haem iron.
E.g.s: Liver, meat, egg yolk, kidney and fish.
2. **Vegetable Sources** - Iron obtained from vegetable (plant) sources constitutes non-haem iron.
E.g.s: Green leafy vegetables, cereals, peas, jaggery, legumes, honey, dates and fruits.

Functions of Iron

1. It is required for the synthesis of haemoglobin that carries oxygen to different parts of the body.
2. It is necessary for regulation of body temperature, metabolism of catecholamines and for muscle activity.
3. It is required for the maintenance of immune system.
4. It is needed for cell respiration.
5. It catalyzes various enzymatic reactions.
6. It is essential for the development of brain.
7. It is also a component of muscle myoglobin, cytochrome enzyme system and catalase.

Deficiency Diseases

1. Iron deficiency leads to anaemia (a condition where haemoglobin levels fall below normal).
2. It decreases body's resistance towards diseases due to impaired cell mediated immunity.
3. It also decreases the work performance of an individual.

*Dietary Requirement***Table: Recommended Dietary Allowance (RDA)**

Category	RDA (mg/day)
Males	0.9
Females	0.7
First trimester of pregnancy	0.8
Second trimester of pregnancy	3.5
During menstruation	2.8
Children and infants	0.7 - 1.0

Iodine

Iodine is a very essential micronutrient. An adult body contains 50 mg of iodine of which 8-12 mg is present in the blood.

Sources

Sea foods like sea salt, sea fish, cod liver oil, sea weeds, milk, vegetables, cereals and water.

Functions of Iodine

1. Iodine is essential for the synthesis of thyroid hormones.
2. Small amount of iodine is required for the growth and development of the body.

Deficiency Diseases

Deficiency of iodine commonly leads to :

1. Goitre and hypothyroidism.
2. Myxoedema in adults and cretinism in children.
3. Mental and growth retardation.
4. Spontaneous abortion.

Dietary Requirement

The recommended dietary allowance (RDA) for iodine is 150 µg.

Fluorine

Fluorine is very highly reactive and most abundantly found mineral in the nature. About 96% of the total fluorine present in the body is found in bones and teeth. Due to its reactivity, it occurs in combined form (fluoride). Excess of fluorine leads to dental and skeletal fluorosis.

Sources

Cheese, drinking water, tea and sea fish.

Functions of Fluorine

1. It is needed for the mineralization of bones.
2. It is essential for the formation of dental enamel.
3. It helps in improving tooth structure.

Deficiency Disease

Deficiency of fluorine leads to tooth decay (dental caries).

Dietary Requirements

The recommended dietary allowance (RDA) for fluorine is 0.5-0.8 mg/litre.

Zinc

Zinc is the trace element found in almost all tissues and in many enzymes. It is the constituent of the enzyme carbonic anhydrase.

Sources

Milk, meat and fish.

Functions of Zinc

1. It is also required for the functioning of the enzymes like dehydrogenase and carboxypeptidase.
2. It helps in the synthesis of insulin.
3. It plays a very important role in the metabolism of proteins and glucose.
4. It is essential for the proper functioning of immune system.

Deficiency Diseases

Deficiency of zinc causes alopecia (hair fall), sexual impotency, growth retardation, skin infections, delayed healing of the wound, multiple infections and taste disorders.

Dietary Requirement

The recommended dietary allowance (RDA) for zinc is 5-12 mg

Copper

Copper is another trace element which plays an important role in the physiological functions of the body. Copper is required for the incorporation of iron into haemoglobin. It is present in some of the enzymes.

Sources

Bananas, brain, common salt, liver, milk, plants, green leafy vegetables and sea water.

Deficiency Diseases

1. Deficiency of copper leads to a condition called *Wilson's disease*. It is characterized by decreased plasma ceruloplasmin concentration and an increase in the concentration of copper in brain and liver leading to neurological changes and hepatic damage.
2. Its deficiency also leads to malformation of elastic tissue and its matrix.

Dietary Requirement

The recommended dietary allowance for copper is 2.2 mg/day.

3. NUTRITIONAL DISEASES

3.1 INTRODUCTION

Nutritional deficiency disorders are one among the major health problems of the world. They are more prevalent in developing countries like India. A vast population is affected with these diseases. Poor and disadvantaged individuals particularly young children and women at reproductive age are at high risk. Nutritional deficiency also termed as under nutrition occurs when the dietary intake and uptake of nutrients is less in relation to body requirements over a period of time. The time period after which symptoms of nutritional deficiencies become evident depends upon the degree of deprivation, magnitude of tissue stores, and rate of nutrient consumption and excretion.

Poor diet and diseases such as persistent diarrhoea, and AIDS that impair the absorption and metabolism of nutrients are mainly responsible for nutritional deficiencies.

Other causes include poor knowledge regarding nutritional value of food, poor economy, stress, repeated pregnancies, unhygienic living conditions, poor health services, inadequate care of children, unequal distribution of food etc.

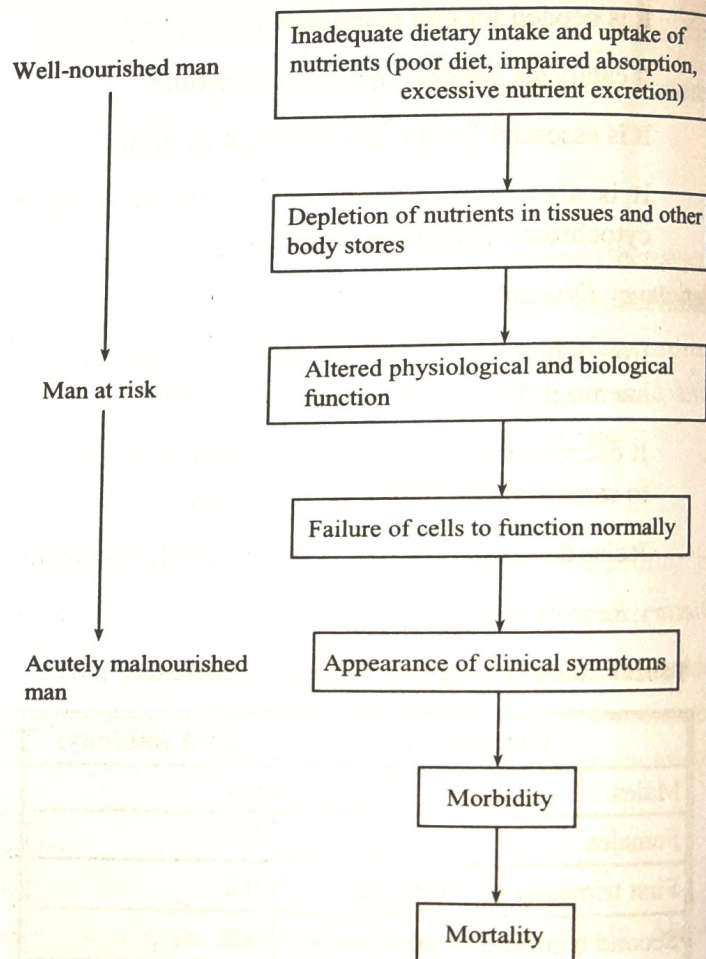


Figure: Development of Nutritional Deficiency Disorders

Types

Nutritional deficiency disorders are classified as,

1. Overnutrition

E.g: Obesity

2. Undernutrition

Undernutrition disorders are further classified as,

- (a) Multinutrient deficiency in which the body lacks adequate nutrients and energy and thus fails to function normally.
- (b) Specific micronutrient deficiency in which the body lacks a specific nutrient (E.g: Vitamin B) due to which specific clinical and biochemical conditions occur.

3.1.1 Obesity

Obesity is a disorder caused by excessive deposition of fat leading to increased body weight. It is generally caused by overeating coupled with lack of physical activity.

Obesity can be assessed quantitatively by calculating the Body Mass Index (BMI). It is calculated by dividing the weight of body (kilograms or pounds) by height (meter² or inches²). Ideally, the BMI should be in the range of 19.5 to 25.0.

$$\text{BMI} = \frac{\text{Weight of body (kg)}}{\text{Height (m}^2\text{)}}$$

or

$$\text{BMI} = \frac{\text{Weight of body (pounds)}}{\text{Height (inches}^2\text{)}} \times 703$$

Based on the recommendations of the World Health Organization (WHO), obesity is categorized as follows,

1. Grade 1 Obesity (overweight) – BMI of 25 to 29.9 kg/m²
2. Grade 2 Obesity – BMI of 30 to 39.9 kg/m²

Grade 3 Obesity (Morbid obesity) – BMI ≥ 40 kg/m².

Morbid obesity has been further categorized as follows.

1. Severe obesity - BMI - 40 kg/m²
2. Morbid obesity - BMI - 40 - 50 kg/m²
3. Super obese - BMI > 50 kg/m².

Obesity in the upper part of the body is called as android, apple-shaped or upper body obesity, while obesity in the lower part is called as gynoid, pear-shaped or lower body obesity. The upper body obesity is considered as a serious health hazard when compared to obesity in the lower part of the body. Further, it has been reported that patients with abdominal circumference of more than 102 cm in men and 88 cm in women or high waist-hip ratios (> 1.0 in men and > 0.85 in women) have a risk of health complications such as hypertension, diabetes mellitus, insulin resistance, stroke, dyslipidemia, coronary artery disease, arthritis, gall bladder disease and early death.

Aetiology

Obesity is a complex multifactorial chronic disorder developing from interactive influences of several factors like social, behavioral, physiological, cellular, molecular and metabolic. Environment is considered as the major determinant of overweight and obesity. Environmental influences on obesity are primarily related to food (calorie

intake) and physical activity (energy output). Sedentary daily routines consisting of sitting at work and sitting in front of computer and television for long durations are the major environmental promoters of obesity. Diets largely derived from fats and carbohydrates, excess eating habits and genetic factors also account for obesity. Besides these causes, obesity may also result due to the presence of diseases like hypothyroidism, polycystic ovarian syndrome, Cushing's disease, hypothalamic disorders, insulinoma etc.

Pathogenesis

Adipose tissues consists of specialized fat cells or adipocytes. It is found in subcutaneous layer of the skin, around kidneys, heart, joints, in bone marrow etc. The functions of adipose tissue include storage of fat (energy reserve), reduce heat loss through skin, give shape to body organs, support and protect organs from injury or damage etc.

The main role of adipocytes is to store fat. However they are also involved in releasing endocrine-regulating molecules like leptin (energy regulatory hormone), angiotensin (blood pressure regulating agent), prothrombotic factors, TNF-α and interleukin-6 (cytokines) and insulin sensitivity regulators like adiponectin, RBP4 and resistin.

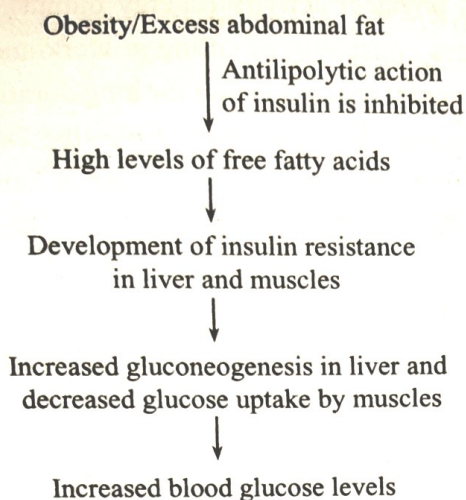
Any increase in the number or size of adipocytes or excess of intracellular lipid deposition increases the size of adipose tissue which leads to obesity. The exact molecular mechanism and pathogenesis of obesity is not yet clearly understood. However two obesity genes namely *ob* gene and its protein product *leptin* and *db* gene and its protein product *leptin receptor* have been identified. These genes are thought to play a role in altering eating and physical activities that lead to obesity. The roles of environmental factors, behavioral influences (on metabolic factors important in obesity) and gene-environment interactions in progression of weight gain to obesity are still under study.

Complications

Obesity being a serious health hazard is likely to predispose to the following clinical disorders and pathological changes.

1. Type-2 Diabetes Mellitus

The basic underlying cause for the occurrence of type-2 DM is insulin resistance (peripheral tissues do not respond to insulin). This mainly occurs due to obesity.



2. Hypertension

Hypertension in obese people is perhaps due to sodium retention and associated increases in blood volume, vascular resistance and cardiac output.

3. Stroke

Ischaemic stroke is found to be associated with obesity. It has been shown that ischaemic stroke risk is 75% higher in women with BMI > 27 and 137% higher in women with BMI > 32, when compared with women having a BMI < 21.

4. Cholesterol

There has been a strong association between obesity and high cholesterol. In women, the hypercholesterolemia increases with an increase in BMI. Also the total cholesterol levels appear to be higher in people with predominant abdominal obesity. Obese people also have high levels of triglycerides, low levels of high density lipoproteins (HDL) and normal to high levels of low density lipoproteins (LDL).

5. Cardiac Disorders

Overweight, obesity and elevated abdominal fat predisposes to development of cardiovascular risk factors including hypertension, coronary heart disease, congestive heart failure atherosclerosis, myocardial infarction etc.

6. Cholelithiasis

Due to increased levels of total body cholesterol, the incidence of cholelithiasis (gall stones) in obese people is about six times higher than in normal weighed people. Women with BMI > 40 are about 20% more likely to have gall stones than women with BMI < 24.

7. Cancer

Studies have shown that obesity is directly related to mortality from breast cancer, especially in post menopausal women. Gall bladder cancer and colon cancer are also associated with obesity in women and men respectively. Obesity also increases the risk of endometrical cancer three times more than normal weighed women.

8. Osteoarthritis

Obese or overweight individuals are at higher risk of development of osteoarthritis. The risk of development of knee osteoarthritis is more in women than in men.

9. Hypoventilation Syndrome

In obese people, hypoventilation (breathing at an abnormally shallow and slow rate) is characterised by CO₂ retention leading to dizziness, tightness across chest, hypoxia and eventually right-sided heart failure.

3.1.2 Multinutrient Deficiency Disorders

Multinutrient deficiency disorders have been identified as a major health problem in India. It can be defined as a group of clinical conditions that arise when body's requirement for nutrients and energy cannot be met through diet. In other words, multinutrient deficiency denotes a general lack of food in contrast to specific micronutrient deficiency. This condition is also known as 'protein-energy malnutrition' and 'protein-calorie malnutrition'.

Protein-energy malnutrition mainly arises due to low consumption of food with respect to both quantity and quality. It occurs in children belonging to poor communities, in adults as a consequence of severe and prolonged illness and in people of all ages during famine. It is classified into following types based on the relative intake of protein to energy and clinical symptoms.

1. Marasmus: Energy deficiency with no oedema
2. Kwashiorkor: Protein deficiency with oedema.
3. Marasmic kwashiorkor: Chronic energy deficiency and acute or chronic protein deficiency with oedema.

Marasmus

Marasmus is a Greek term meaning wasting. It arises as a result of deficiency of proteins, carbohydrates and fats in the diet. It is usually seen in infants who are deprived of breast milk and in children below 5 years of age. It is characterised by wasting of muscles, lack of subcutaneous fat, rapid loss of body weight (about 60%), sparse, thin and dry hair, dry and thin skin, distended abdomen, protruded ribs and stick like limbs. In advanced cases, loss of brain weight and atrophy of heart is also observed.



Figure: Marasmus

Kwashiorkor

Kwashiorkor was first described by Cecily Williams. The term kwashiorkor means 'red boy'. It is caused due to inadequate consumption of proteins in the diet. It mainly affects children in the age group of 1-4 years but may occur in any age. It is characterised by marked growth retardation, muscle wasting with retention of some subcutaneous fat, psychomotor changes (mental apathy, inertness, social withdrawal, dullness and anorexia), pitting oedema particularly in the feet and legs, skin lesions and dry, brittle and pigmented hair.

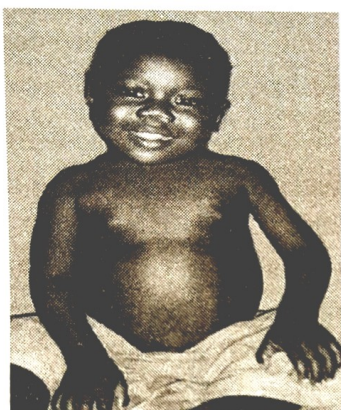


Figure: Kwashiorkor

Marasmic Kwashiorkor

This condition includes clinical characteristics of both marasmus (E.g: Muscle wasting) and kwashiorkor (E.g: Oedema). When the treatment is initiated at an early stage, oedema disappears and only clinical symptoms of marasmus exist.

Prevention and Control of Malnutrition Deficiency Disorders

For primary prevention,

1. Breast feeding must be encouraged
2. Children should be fed with protein rich diet
3. Good hygiene and proper sanitary conditions must be encouraged
4. Supplementary foods should be provided to children, if weight gain is not satisfactory after 6 months of age
5. Health education programmes should be conducted.
6. For secondary and tertiary prevention, early diagnosis and treatment must be done.
7. Treatment involves correction of fluid and electrolyte balance, correction of vitamin-A deficiency, consumption of diet containing 125 – 150 kcal and 3 – 4 g of protein /kg B.W/day.

3.1.3 Specific Micronutrient Deficiency Disorders

Deficiency of a specific micronutrient in the body is an important cause of disease, disability and death. This condition occurs due to relative or absolute lack of a single nutrient in the diet. They result in clearly defined biochemical and pathological changes which may be limited to certain tissues.

The various specific nutrient deficiencies are as follows.

1. Vitamin Deficiency Diseases
2. Iron Deficiency
3. Iodine Deficiency
4. Calcium Deficiency

These topics have been discussed in detail in the previous sections.

3.2 STARVATION

Starvation is basically a condition wherein the body is deprived of all the essential nutrients that are necessary for its survival and proper functioning. Starvation is an extreme form of malnutrition. Some of the various causes of starvation include poverty, famine, deliberate fasting as seen in individuals with religious or political intentions, persons with anorexia nervosa (models) or due to any conditions which impair the digestion and assimilation of food such as liver diseases, infections, inflammatory conditions (Crohn's disease) etc.

Starvation has been classified as complete, incomplete, absolute and partial. It is considered to be complete when only water is consumed, incomplete when insufficient amount of food is being consumed when compared to that actually required by the body and absolute when neither food nor water is consumed. Starvation is considered to be partial or qualitative when there is insufficient intake of individual nutrients such as vitamins, proteins, minerals etc. Effects produced by starvation for shorter durations (1-4 days) are quite different from those on long-term starvation (14-60 days). Short-term starvation is responsible for inducing appreciable weight loss in initial days, hence it is a part of many weight reduction programmes. Long-term starvation done under the supervision of therapists is utilised for inducing weight loss in morbidly obese patients. Pathologic long-term starvation is seen in poor famished families, chronic diseases of the vital organs, malabsorption syndromes and in cancer patients.

Clinical Manifestation

In a starving individual, excitation of the food centre results in a sensation of hunger which is the earliest manifestation. In complete starvation, after few days of fasting the sensation of hunger disappears and in some cases, the food centre is so drastically suppressed that its activation warrants special measures. In incomplete starvation, the food centre remains active throughout, due to which there is periodic hunger sensation. Other manifestations of starvation include presence of saggy, loose and dry skin, a wasting of muscles and atrophy of internal organs.

Pathophysiology

In normal individuals, glucose obtained from diet is the most preferred energy source of the body. Continuous supply of glucose for normal functioning of the body is heavily dependent on carbohydrates obtained from diet. Excess glucose is stored in the form of glycogen in liver and muscles. In presence of sufficient amounts of glucose, proteins sourced from diet are utilised for synthesizing enzymes, hormones, transport proteins, antibodies and also in increasing the muscle mass. When the diet provides excessive amounts of nutrients such as carbohydrates, proteins and fats, then these are stored in the form of fats in the adipose tissue.

Short-term starvation exceeding for about a day initiates the process of glycogenolysis as the body glucose stores soon dry out within a day. Glycogenolysis that takes place in the liver, is a process of breakdown of stored glycogen into glucose to maintain normal blood glucose levels. This process predominates within 4-8 hours. When the glycogen stores fail to maintain adequate glucose levels, then the process of glyconeogenesis gets initiated. Glyconeogenesis, also takes place in the liver and is a process wherein non-carbohydrate sources such as amino acids, lactate, pyruvate and glycerol moiety obtained from fats are used for synthesizing glucose. Amino acids for such synthesis are sourced from skeletal muscles while fats from the adipose tissue. Breakdown of proteins is also predominant during the early stages of starvation to yield amino acids which in turn can be converted to glucose via gluconeogenesis. In kidneys, glucose is produced from glutamine in an attempt to maintain the required glucose levels. However, upon prolonged starvation the body begins to adapt itself to nutrient deficiency by decreasing the rate of protein breakdown and decrease the basal metabolic rate by about 20-25%. Fatigue sets in, which decreases the expenditure of energy and also makes physical activity difficult. Due to continuous deficiency of glucose, body begins to adapt itself in relying on fatty acids as fuel rather than glucose.

In liver, fatty acids are converted into ketone bodies which are consumed as fuel by most of the cells and partly by the brain (60%) although it does require some amount of glucose (40%). Long term starvation is responsible for fluid loss, decrease in adipose tissue and lean body mass. Functioning of even vital organs is severely affected like for example, CO_2 excretion decreases due to respiratory muscle wasting. There is also a reduction in cardiac output and cardiac mass. After all the body fat sources have been exhausted, body's last resort is the breakdown of muscle protein which eventually results in fatal consequences.