UNIT 11 BIOCHEMISTRY AND NUTRITION

Structure

11.0 OBJECTIVES

After studying this unit, you should be able to:

- describe the cell structure and its Biochemical function
- know regarding food enzymes
- learn about nutritional aspects of food and energy requirements
- describe the general physiology of humans
- explain the significance of carbohydrates, fats and proteins
- identify the factors responsible for various deficiencies
- describe the loss of nutrients from food due to processing and cooking

11.1 INTRODUCTION

Biochemistry is the study of chemical substances and chemical properties of living things and nutrition is basic need for physical, mental and psychosocial development of human beings. The food we eat is digested and assimilated for growth, energy, body repair, maintenance and protection of the body. Food also provides enjoyment and stimulation. The foods contain chemical constituents known as nutrients i.e. carbohydrates, proteins, fats, vitamins and minerals. The sound science-based information about food, nutrients, energy values of foods, the role of vitamins and minerals in the human nutrition are very essential to select nutritive food to consume. The knowledge of losses of nutrients during processing & cooking has

a prime importance to prevent the losses as far as possible and the foods, which have antinutritional factors, or processed in such a way that inhibitors are inactivated before consumption. Balanced diet should contain sufficient amount of protein, protective bioagents and should supply all the dietary essential elements in required quantity. The diets consumed by the majority of our population are based on energy yielding foods mainly and are deficient in essential nutrients. The food shortage or inadequate intake results in malnutrition and diseases, weight loss, wasting and death from starvation. The problem of over coming the malnutrition and improving nutritional status of the vulnerable section of our population has been engaging the attention of Government agencies and several national health programmes have been started. A brief account of the various aspects of food & nutrition, nutritional requirement, for function of vitamins, minerals and anti nutritional factors are discussed.

11.2 CELL STRUCTURE AND BIOCHEMICAL FUNCTION OF SUB-CELLULAR COMPONENTS

Plant or animals, differ in shape, size and appearance. Plants and animals contain billions of cells and carry out a number of functions, which are same like nutrition, respiration, growth and reproduction.

Cell Structure

All plant and animal cells have three main parts: (1) Cell membrane (2) cytoplasm and (3) nucleus (Fig 1 (a) and 1 (b).

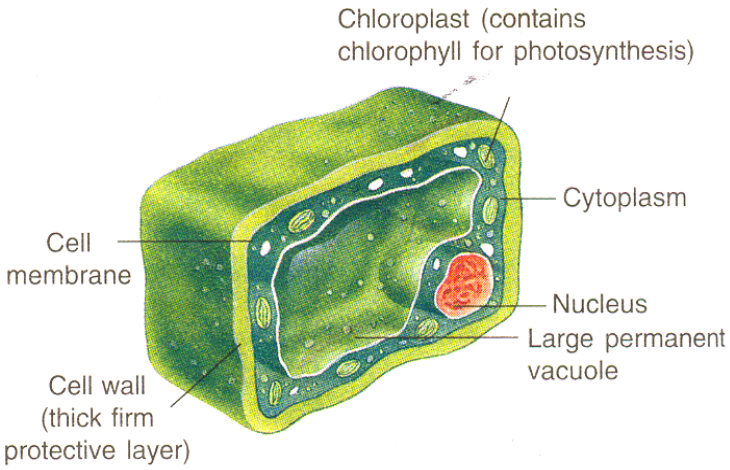

Fig. 1(a): Plant Cell

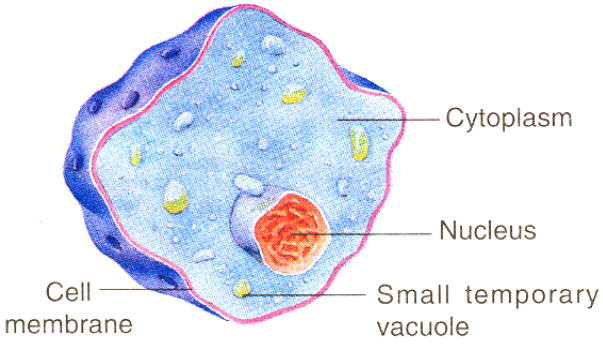

Fig. 1(b): Animal Cell

1. Cell membrane: Also called the plasma membrane, it is a very thin skin covering the cell. There are very tiny holes in the cell membrane. It surrounds cytoplasm and nucleus together to constitute the (proto = first; plasma = liquid). Protoplasm includes the cytoplasm and the nucleus. 99 % of protoplasm by weight is made up of carbon, hydrogen, nitrogen and oxygen. Other elements like phosphorus, sulphur and calcium are also present. These elements combine to form compounds like water, proteins, carbohydrates, fats and nucleic acids which provide the living nature of protoplasm to it.

The plasma membrane performs following functions: (i) protects the cell. (ii) provides shape to the cell. (iii) allows materials to enter and leave the cell through the tiny holes. (iv) contains active transport system for sodium, potassium, glucose, amino acids and other nutrients, as well as a number of important enzymes to convert nutrients into biochemical energy i.e. ATP

2. Cytoplasm: The cytoplasm is a jelly-like substance occupying most of the space inside the cell. It occupies the space between the cell membrane and the nucleus. All the life functions take place in the cytoplasm. The cytoplasm contains many important tiny structures called the organelles, which perform the various life functions.

3. Nucleus: The nucleus is present inside the cell, surrounded by the cytoplasm. The nucleus controls everything that happens in the cells. Most cells have only one nucleus. Cells like the muscle cells have more than one nucleus.

Nucleus is a spherical body consisting of four parts: (i) Nuclear membrane (ii) Nuclear sap or nucleoplasm (iii) Nucleolus (plural nucleoli) (iv) Chromosomes

The outermost covering layer of the nucleus is called the nuclear membrane. It separates the nucleus from the cytoplasm. Nuclear membrane, like the cell membrane, has tiny holes which allow exchange of substances between the nucleoplasm and the cytoplasm. The jelly-like fluid inside the nucleus is called the nucleoplasm. Chromosomes and nucleoli are present in the nucleoplasm. Chromosomes are thread-like structures, which play an important role in the inheritance of characters from one generation to another, that is, from the parents to the children.

Functions of the Nucleus: Transmission of characters from one generation to another. (ii) Controls all the life functions taking place inside the cell.

Organelles: A number of organelles occur in the cytoplasm. These are : (1) Mitochondria (rod or spherical in shape) (2) Chloroplasts (present only in plant cells) (3) Endoplasmic reticulum (4) Golgi complex (5) Lysosomes (6) Ribosomes. The functions of Organelles are shown in table 1.

Table 1: Function of Organelles

	Organelles	Function (s)
1.	**Mitochondria** (singular **mitochondrion**)'Power houses of the cell'	Performs the function of respiration, provide the cell with energy.
2.	**Chloroplasts** (present only in plant cells)	Contain a green pigment called **chlorophyll;** helps in food manufacture (photosynthesis)

3.	**Endoplasmic** reticulum	Being a network of membranes, it provides a large surface area for life functions to take place.
4.	**Golgi** complex	It collects distributes the substances made in the cell (for example, protein); synthesis and secretion of many materials.
5.	**Lysosomes** (suicide bags)	Contain enzymes, which help in breaking down or destroying the various materials.
6.	**Ribosomes**	Site of protein synthesis.

Cell Wall: The cell wall is an extra covering that surrounds the cell membrane of a plant cell. It is made of a stiff, non-living material called cellulose. Cell wall is lacking in animal cells.

It provides rigidity and protection to the cell.

Vacuoles: As a result of various life functions taking place inside a cell, a number of chemical products accumulate within the cell. These are generally stored inside clear areas or spaces present in the cytoplasm, which are surrounded by a membrane are called vacuoles. Vacuoles are generally absent from animal cells, and if present they are smaller in size and lesser in number. In plant cells, vacuoles are larger in size and more in number.

Features shared between plant and animal cells

- Plasma membrane present in both.
- Nucleus present in both.
- Mitochondria present in both.
- Endoplasmic reticulum, golgi complex, lysosomes and ribosomes present in both.

11.3 FOOD ENZYMES

Enzymes are complex proteins that act as catalysts in almost every biochemical process that takes place in the living cells of plants and animals. Food enzymes are present in raw foods and they initiate the process of digestion in the mouth and upper stomach. Food enzymes include proteases for digesting protein, lipases for digesting fats and amylases for digesting carbohydrates. Amylases in saliva contribute to the digestion of carbohydrates while they are being chewed, and all enzymes found in food continue this process in the stomach also. Humans normally eat an enzyme-poor diet; comprised primarily of cooked food, use their own enzymes secreted from the pancreas and other digestive organs.

Plant and animal foods have their own enzymatic activities of which largely survives harvest and slaughtering. Fruits, vegetables and grains after harvest and during storage still possess the properties of respiration, germination, and growth-all enzyme-controlled functions. Enzyme activity persist throughout the entire useful life of many natural and manufactured foods and enzymatic reactions are delicately balanced in the normal functional of living plant but the balance is upset when the plant is harvested. Unless heat, chemicals, radiation, or some other means

inactivates these enzymes, they continue to catalyze chemical reactions within foods after harvest. Some of these reactions are highly undesirable and weaken the tissues to reach the point of rotting. This can happen in the field, supermarket, and home refrigerator, given sufficient time. Inherent food enzymes are probably the second greatest cause of spoilage. Heat, cold, drying, application of certain chemicals and radiation are the principal means used to inactivate damaging inherent food enzymes. When coding environment is used, it retards the activity of natural food enzymes. Polyphenolase and peroxidases present in fruits and vegetables cause undesirable enzymatic browning during cutting, peeling, slicing and processing. Anthocynase results in the loss of colour pigments of fruits and vegetables after harvest. The quality of some foods is destroyed due to the conversion of starch into free sugar by amylase, phosphorylase and invertase enzymes. Pectinase cause softening of tissues, lipases and lipoxidase oxidizes free fatty acids and produce rancidity in foods, ascorbic acid oxidase destroys the ascorbic acid of fruits.

Enzymes are used in food processing, dairy and meat industries to improve the quality of the processed products. Important enzymes used in food processing industry are: amylases, isomerases, glucoamylase, invertase, cellulase, pectinase and protease for production of value added products and to improve texture, colour and taste etc. Renin, lipases and proteases are used in dairy industries to make and ripen cheese and lactase is used for hydrolysis of lactose. Proteolytic enzymes such as papain, bromelin and trypsin are used for tenderizing the meat.

11.4 ENERGY VALUE OF FOODS

In human food, the chief sources of energy are carbohydrates (starch), fats and proteins, which are obtained from cereals, pulses, fruits, vegetables, milk, meat, eggs and their products. We get maximum energy (9.3 Kcal/gm) from fats and about 4.0 Kcal/gm from carbohydrates and proteins. Energy values of some important foods are given in Table 2.

Table 2: Energy values of important foods (K.Calories/100g)

Foodstuffs	K.Calories
CEREALS	
Rice (raw, milled)	345
Rice, flakes	346
Wheat, flour (whole)	341
Wheat, semolina	348
Wheat, bread, white	245
Maize (dry)	342
PULSES	
Bengal gram, whole	360
Bengal gram (dhal)	372
Bengal gram, roasted	369
Black gram (dhal)	347
Cow pea	323
Green gram (dhal)	348

Lentil	343
Rajmah	346
Red gram (dhal)	335
Soybean	432
LEAFY VEGETABLES	
Bathua leaves	30
Chana sag	97
Cabbage	27
Coriander leaves	44
Drumstick leaves	92
Fenugreek leaves	49
Mint	48
Mustard leaves	34
Radish leaves	28
Spinach	26
OTHER VEGETABLES	
Beet root	43
Carrot	48
Colocassia	97
Potato	97
Radish	17-32
Sweet Potato	120
Bitter Gourd	25
Onion	50-60
Bottle Gourd	12
Brinjal	24
Cauliflower	30
Cucumber	13
Ladies Fingers	35
Parwar	20
Ridge Gourd	17
Tomato	21
Chilli dry	246
Turmeric	349
FRUITS	
Aonla	58
Apple	59
Banana (ripe)	153
Grapes	71
Guava	51

Lime sweet (Musambi)	43
Mango (ripe)	74
Orange	48
Papaya (ripe)	32
MILK, EGG and MEAT	
Egg (hen)	173
Mutton (muscle)	194
Pork (muscle)	114
Milk, buffalo's	117
Milk, cow	67
Mother milk	65
Curd (cow milk)	60
Goat meat	118
Buffalo meat	114
Fish	90-111
Khoa	413
Cheese	348
Whole milk powder	496
FATS and OILS	
Butter	729
Ghee (cow)	900
Ghee (buffalo)	900
Cooking oils	900
Sugar	398
Jaggery	383
Honey	319

11.5 NUTRITIONAL ASPECTS AND NUTRITIVE VALUE OF FOODS

Foods differ widely in nutrients contents and are broadly divided into following groups depending on their nutritive value. (1) Cereals, (2) Legumes and Pulses (3) Oilseeds, (4) Fruits and Vegetables (5) Fats and Oils, (6) Milk and Milk products (7) Meat and meat products. The nutritive values of different categories of foods are discussed.

1) **Cereals:** Cereals form the staple foods and include wheat, rice, maize, barley, ragi, bajra, oats & rye. These are rich source of starch and carbohydrates and good source of proteins, invisible fat, vitamins, minerals and amino acids. Cereals are the major source of food in India and they contain, starch (70-80 %), protein (8-15 %), fat (1.5 – 2.5 %), minerals (1.5-2.0 %) and fibre (2-2.5 %). 100g of cereals also contain calcium (10-344 mg), iron (1-8 mg) and they are also good source of riboflavin (0.05 –0.25 mg), niacin (0.6-4.0mg), â-carotene (2-132 mg), thiamine (0.5 –0.42 mg), pyridoxine, and pantothenic acid and

fair source of riboflavin but poor source of niacin. Cereals are deficient in vitamins A, D, B_{12} and C.

2) **Pulses (Legumes):** Pulses are important source of proteins in the diet of Indians, and these are grouped as (a) grams: bengal gram, black gram (b) peas: cow peas, peas (c) beans: *rajmah*. Pulses are consumed as a whole seed, de-husked split (*dhal*) and flour. Pulses are rich source of proteins (17-43 %) and also rich sources of lysine in which cereal are deficient. However these are poor source of sulpher containing amino acids (cysteine & methionine) and tryptophan of which cereals are good source. Pulse proteins supplement effectively cereals proteins. Pulses also contain carbohydrates (50-60 %) and fats (1-6 %), however soyabean have about 20 % fats. 100 gms of pulses contain calcium (60-260 mg) maximum in rajmah and minimum in bengal gram and iron (2.7 –9.5 mg) maximum in cowpea, fair source of â-carotene (12-189 mg), thiamine (0.2-52 mg), riboflavin (90.15 –0.27 mg) and niacin (1.3-3.5 mg)/100g. Pulses are deficient**:** in vitamin A, D, B_{12} and C.

3) **Oilseeds:** Oilseeds contain major nutrients**:** Proteins, fat, essential fatty acids, vitamin B-complex, calcium, iron, thiamin, niacin, folic acid and iron. Oilseeds are the main source of oils however they are also rich source of proteins and are used for protein supplement in Indian diet. The most important oilseeds are groundnut, soybean, Mustard (*serson)*, sunflower and sesame. Oilseeds contain about 42-50 % oil and 20-30 % proteins. 100 gms of Oilseeds are also good source of vitamins such as â-carotene (0-425 mg), thiamine (0.25-1.0 mg), riboflavin (0.01-0.40 mg) and niacin(0.08-20 mg) and minerals such as calcium (50-490 mg) and iron (5-11 mg). Soyabean contain about 43 % protein and maximum amount of iron and carotene.

4) **Milk and milk products:** The milks of cow and buffalo are used for feeding infants and as a supplement to the diet of children and adults in India. However the milk of goat, sheep and camel are also used in very small quantity. Milk contains proteins, fat, vitamin B_{12} and calcium.The fat contents of cow and buffalo milks are 4-7 % and 7-10 respectively however they are poor source of essential fatty acids. Vitamin A contents varies from 700 to 1200/ 100 g milk fat. The protein content ranged between 3.5 to 4.5 % and milk protein is rich source of essential amino acids. Carbohydrates are very less (4.4 –7.4 %) and human milk has maximum lactose. The contents of vitamin per 100 g milk are as follows: vitamin A (150-200 mg), thiamine (40-50 mg) , riboflavin (150-200 mg), niacin (70-80-mg), vitamins B_{12} 0.4-0.5 mg, folic acid 3.3-5.6 mg, carotene 160-170 mg and ascorbic acid 2-25 mg. Milk is a main source of lactose (4.5-5.0 %), and calcium (0.12-0.19 %) however it is also a good source of phosphorus (100-130 mg/100g).Milk is poor source of iron. Cheese is good source of protein (25 %), fat (24 %), calcium (790 mg/100 g)/100gm and phosphorus (520 mg/100 gm).

5) **Fruits and vegetables:** Fruits and vegetables are eaten as raw or cooked foods and they contain sugars, starch, acids, carotenoids, vitamin C, vitamin B, iron and fibre. Fruits contain total sugars, 3-18 %, depending upon the fruit. Main sugars are sucrose, glucose and fructose and organic acids are citric, malic and tartaric acids. The ascorbic acid content of fruits varies depending on fruits and oranges, lemons, papaya, guava are good source and apple, banana, pears and grapes are poor source. Some fruits are good source of â-carotene and ripe mango, papaya and oranges contain 2-3, 1.5 and 0.25 mg, respectively per 100gm. The fruits have average contents of carbohydrates (3-27 %), protein (0.2-1.9 %), fat (0.1-1.0 %) and ascorbic acid (5-200 mg/ 100 g), â-carotene (0-3 mg/100 g), thiamine (0.02- 0.20 mg/100 g), riboflavin

(0.03-0.25 mg/100 g), niacin (0-1.3 mg/100 g), calcium (10 –32 mg/100 g) and iron (0.20-7.9 mg/100 g). Vegetables are called protective foods as they are rich source of vitamins and minerals and they are grouped into a) green leafy vegetables, b) roots and tubers and c) other vegetables and they contained carbohydrates (6-22 %), protein (0.2-8 %), fat (0.1-1.7 %) and ascorbic acid, â-carotene (0-54 mg/100 g), thiamine (0.03- 0.20 mg/100 gm), riboflavin (0.03-0.55 mg/100 g), niacin (0.02-1.9 mg/100 g), calcium (10–1130 mg/100 g) and iron (0.20-40 mg/100 g). Green leafy vegetables had maximum of carotene, calcium and iron, and roots and tubers vegetables contain more carbohydrates.

6) **Meat and meat products:** Meat includes the muscle or flesh of cattle, sheep, goat, hogs, other animals and poultry birds are used as human foods. The meat is good source of protein and varies from 12-18 %, fat 14-45 %, glycogen 1 %, and water 42-60 %. Pork contains more fat and less protein than other meats. The collagen nitrogen content forms about 10-17 % of total nitrogen in muscles. Myoglobin content varies from 0.07-0.46 % and it is the chief pigment responsible for pink and red colour of muscles. Meat of poultry birds contains protein 15-20 % and fat 12-33 %. Fish have 9-20 % protein and fat 8-20 %. Meat also provide calcium (3-150 mg/100 g), phosphorus (150-350 mg/100 g) and iron 1-6 mg / 100 g and it also contains thiamine and riboflavin and niacin.

Check Your Progress 1

Note: a) Use the spaces given below for your answers.
b) Check your answers with those given at the end of the unit.

1. What are the main parts of the cell?

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2. What are high-energy foods?

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3. What are the major nutrients found in cereals, pulses and oil seeds?

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11.6 ENERGY REQUIREMENTS

Energy Requirements

Energy requirements for humans, depends upon: (1) Physical activity; (2) Body size and composition; (3) Age and sex: (4) Physiological state and (5) Climate and environment. In view of the lower body size and warm climate of tropical countries, the calorie requirements for the corresponding age groups are lower. Persons living in India and other tropical regions require more energy as compared with those

living in temperature climate. The Table 3 shows daily average energy requirements (Kcal) recommended by the Nutrition Expert Group (I.C.M.R) are as follows: Infants (0 to 12 months) 105-120/kg body weight; Children (1 to 12 years) – 1200-2100 Kcal; Adolescents- Boys (13-15 years) 2500-3000Kcal; Girls (13 to 18 years) 2200 Kcal; Adult male: 2400 to 3900 Kcal depending on physical activity. Adult females: 1900 to 3000 Kcal depending on physical activity; pregnant woman 2200, and lactating woman 2600 Kcal.

Table 3: Recommended Energy Intake

Category	Age (Years)	Weight (Kg)	Height (Cm)	Energy requirements (with range) Kcal
Infants	0.0-0.5	6	60	Kg x 115 (95-145)
	0.5-1.0	9	71	Kg x 105 (80–135)
Children	1-3	13	90	1200 (900 – 1800)
	4-6	20	112	1600 (1300 – 2300)
	7-10	28	132	2400 (1650 – 3300)
Males	11-14	45	157	2700 (2000-3700)
	15-18	66	176	2800 (2100 – 3900)
	19-22	70	177	2900 (2500-3300)
	23-50	70	178	2700 (2300-3100)
	51-75	70	178	2400 (2000-2800)
	76+	70	178	2050 (1650-2450)
Females	11-14	46	157	2200 (1500-3000)
	15-18	55	163	2100 (1200 –3000)
	19-22	55	163	2100 (1700-2500)
	23-50	55	163	2000 (1600 –2400)
	51-75	55	163	1800 (1400 –2200)
	76 and more	55	163	1600 (1200-2000)
Pregnancy				2400 (2000-2800)
Lactation				2600 (2200-3000)

11.7 GENERAL PHYSIOLOGY

General physiology is an area of science, which explains the physical and chemical factors that are responsible for origin, development, and progression of life. Human physiology in particular is concerned with the specific characteristics and mechanisms of the human body that make it a living being. It explains the normal function of different body systems viz digestive, cardiovascular, neuromuscular, respiratory, excretory, reproduction etc. The goal of these different systems is to provide adequate balanced nutrients to all cells of the body. Different body systems seek to maintain the body's internal environment within certain physiological limits. For the body cells to survive, the composition of the surrounding fluids must be precisely maintained at all times. This state of homeostasis occurs when internal environment of an organism contains the optimum concentration of gases, nutrients, ions and water; has an optimal temperature and has an optimal pressure for the health of the cells. When this is disturbed, ill health results. If the internal environment is not corrected eventually death may occur.

The physiological process of digestion involves four stages i.e. ingestion, digestion, absorption and elimination. During digestion nutrients are released and converted to forms capable of passing through a membrane and enter into cells and provide energy to human body. Physiological mechanisms are involved in hunger, appetite and satiety and in regulation of food intake. The hypothalamus and central nervous system sites control appetite or the feeling of hunger.

11.8 NUTRITIONAL SIGNIFICANCE OF CARBOHYDRATE, FATS AND PROTEINS

Carbohydrates: Carbohydrates are the main sources of energy for doing work. The carbohydrates commonly occurring in foods are starch, sucrose, glucose, fructose and milk sugar (lactose). About 50-70 % of total energy required for human beings is provided by carbohydrates. They are the cheapest source of energy. Glucose derived from the digestion of carbohydrates is used as the main source of energy in the body. Hence, the diets should contain adequate amounts of carbohydrates to meet a greater part of the energy needs.

Functions of Carbohydrates

(i) Carbohydrates supply energy (4 Kcal/g) for human body functions and for doing work; (ii) they are essential for the oxidation of fats; (iii) they exert a sparing action on proteins; the dietary protein is saved for tissue building instead of being oxidized as a source of energy. (iv) Glucose is the main source of energy for central nervous system. (v) provide the carbon skeleton for the synthesis of some non-essential amino-acids; (vi) add flavour to the diet; and (vii) starch which forms the main source of carbohydrates in the average diets has a bland taste and is non-irritant. Many foods contain non-digestible carbohydrates like cellulose, hemi-cellulose, gums, pectin and lignin and are designated as dietary fibre.

Fats: Fats and oils are naturally occurring substances composed of carbon, hydrogen and oxygen characterized by their insolubility in water. At normal temperature, fats are in solid and semisolid form whereas oils are in the form of liquid. These are also important constituents of foods and supply more than twice the energy supplied by carbohydrates. In the presence of adequate supply of carbohydrate, fat is stored in the fatty tissues.

Fat is essential for maintaining good health, as absence of fat leads to the development of a deficiency disease affecting the skin known as phrynoderma. In food, lipids are a source of essential fatty acids, give energy, act as carriers for flavours and fat-soluble vitamins, contributes to texture and mouth feel, are a pre-cursors of flavour. The body can produce most of the fatty acids which it requires. It cannot make some polyunsaturated fatty acids which are essential like linoleic and linolenic acid. The dietary sources of fats may be classified as:

a) Animal fats: *e.g;* butter, ghee, milk, cheese, eggs and fat of meat and fish.
b) Vegetables fats: some plant store fat in their seeds, *e.g;* groundnut, mustard, sesame, coconut, etc.
c) Other sources**:** Small amounts of invisible fats are also found in most of other foods such as cereals, pulses, nuts and vegetables.

Functions of Fat

(i) It is a concentrated source of energy (9.3 kcal/g) yielding more than twice the energy supplied by carbohydrate. By supplying energy, fats spare proteins from

being used for energy. *(ii)* Fats are essential for the absorption of vitamins A, D, E, K, and especially carotenoids (Provitamin A) present in foods of vegetables; *(iii)* Some animal fats, *e.g.*, fish liver oils, butter and ghee contain vitamin A and many vegetable fats contain vitamin E and red palm oil is a good source of carotene *(iv)* Fats contain essential fatty acids, *viz.*, linoleic, linolenic and arachidonic acids which are essential for maintaining tissues in normal health; *(v)* Fats help to reduce the bulk of the diet as starchy foods absorb lot of water during cooking; *(vi)* Fats improve the palatability of the diet and give satiety value, *i.e.*, a feeling of fullness in the stomach; *(vii)* Fats are essential for the utilisation of galactose present in lactose; *(viii)* Phosphatides and other complex lipids are essential constituents of nervous tissue; and *(ix)* Fats are deposited in the adipose tissue and this deposit serves as a reserve source of energy during starvation. Further, adipose tissue functions like an insulating material against cold and physical injury.

Proteins*:* Proteins are required for growth and maintenance of body weight. Proteins also provide energy. Proteins constitute about 20 per cent of the body weight. Body proteins are derived from the dietary proteins. The body loses continuously some quantity of proteins and this loss has to be made up by dietary proteins. Proteins are made up of amino -acids. The amino-acid contents of proteins have been found to differ from one protein to another. The nutritional value of proteins depends on their amino-acid contents. The nitrogen in protein is used for the synthesis of purines, pyrimidines, nucleic acids, adenosine triphosphate (ATP), hemoglobin, and cytochromes. Depending on age and gender, humans require different levels of protein in their diet. Humans need the amino acids which the body cannot synthesize. These are known as essential amino acids and include: phenylalanine, tryptophan, histidine, isoleucine, lysine, methionine, valine leucine, threonine and arginine

Function of Proteins

i) Replace the daily loss of body proteins. They are major and indispensable constituents of muscles, organs, and endocrine glands. skin, nails, hair, bone, bone matrix, blood cells, etc.

ii) Provide amino-acids for the formation of tissue proteins during growth, (3) to provide the amino-acids necessary for the formation of enzymes, blood proteins, niacin, choline, folate and nucleic acids and certain hormones of protein nature (4) Synthesis of certain substances like antibodies, plasma proteins, haemoglobin, enzymes, hormones and coagulation factors require proteins and (5) Provide amino-acids for growth of foetus in pregnancy and for the production of milk proteins during lactation.

11.9 MINERALS AND TRACE ELEMENTS

Minerals

Human body contains about 24 minerals, all of which must be provided by the diet. These include calcium, phosphorus, potas-sium, sodium, chlorine, magnesium, iron, manganese, copper, iodine, cobalt, zinc, aluminum, arsenic, bromine, fluorine, nickel, chromium, cadmium, selenium, silicon, vanadium, and molyb-denum. These minerals are necessary for the different functions: (1) Formation of bones and teeth, *e.g.*, calcium, phosphorus and magnesium, (2) Formation of body cells of soft tissues such as muscles, liver, etc., *e.g.*, phosphorus. (3) Soluble salts which give to the body fluids and cell contents, their composition and stability which are both essential for life, *e.g.*, sodium, potassium, chloride and phosphorus.

Some minerals are required in small quantities for specific functions, *e.g; (a)* iron and copper-formation of hemoglobin, *(b)* iodine- -formation of thyroxine, (c) zinc-constituent of an enzyme, *e.g;* carbonic anhydrase and a hormone, *e.g.*, insulin, *(d)* cobalt- constituent of a vitamin, *e.g.*, vitamin B_{12} and *(e)* some other elements are essential for the activity of various enzymes.

The poor diets consumed by human beings cause deficiencies of calcium and iron. Iodine deficiency occurs in people living in certain hilly tracts in India and where the soil and water are deficient in iodine. Addition of extra sodium chloride to the diet is of special importance in tropical countries, as the loss of sodium chloride in sweat is high. The deficiencies of other minerals do not normally occur in average diets. The details of some important minerals are described.

Calcium: Calcium is a major element of the body and 99 % of calcium is present the skeleton and remaining 1 % in soft tissues. Adult body contains about 1000-1200 g of calcium and all is deposited in bones during growth of the body. The best natural sources of calcium are milk and milk products (butter milk, skimmed milk, cheese and curd), eggs and fish. Most of the cereal and millets are only fair sources but *ragi* is especially rich in calcium. Rice is a poor source of calcium. Green leafy vegetables like amaranath, spinach, fenugreek and tapioca are rich in calcium. If the calcium is the not taken in sufficient amount, diseases like osteoporosis occurs. The daily requirement of calcium for children (0-15 years) is, 500-700mg; adolescents (16-19 years), 500-600 mg, adults, 400-500 mg, and during pregnancy and lactation,1000 mg/day.

Function: Calcium is essential for:

- formation of bone and teeth.
- clotting of blood.
- contraction of heart and muscles.
- regulate the permeability of capillary wall,
- regulate the excitability of nerve fibres and nerve centers.

Phosphorus: An adult human body requires about 400 to 700 g of phos-phorus for the formation of bone and teeth and the rest in other tissues. Phosphorus is present in the body as inorganic salts of phosphoric acid or in combination with organic compounds. Inorganic phosphorus is present as calcium phosphate in bones and teeth and as phosphates of sodium and potassium in soft tissues and body fluids.

The important food sources are milk and milk products, eggs, meat and fish. Vegetables are a fair source. A greater part of the phosphorus present in cereals, pulses, nuts and oilseeds exists in the form of phytic acid or phytin. Phytic acid is a compound of inositol and phos-phoric acid and phytin is Ca, Mg salt of phytic acid.

Functions:

1. Phosphorus is necessary for the formation teeth and bones.
2. It is a constituent of certain coenzymes, *e.g.*, Coenzyme I, and Co-carboxylase, which take part in the enzyme systems concerned in the oxidation of carbohydrates, fats and proteins.
3. It is necessary for the formation of phospholipids-lecithin and cephalin, which

are integral parts of cell structure and also act as intermediates in fat transport and metabolism.

4. It is essential for carbohydrate metabolism as phos-phorylation of glycogen requires inorganic phosphorus and phosphoric esters like adenylic acid, adenyl pyrophosphate and creatine phosphate.
5. It is an essential constituent of nucleic acid and nucleoproteins, which are integral parts of the cells

Magnesium: The adult human body contains about 25 g of magnesium. About half this quantity is present in the bones in combination with phosphate and carbonate and about one-fifth of the total magnesium in the body is present in the soft tissues. The average daily intake from the diet by adults is about 300-400 mg. A greater part of this (40-50 per cent) is not absorbed and excreted.

Functions: 1) Magnesium is found in certain enzymes e.g; co-carboxylase which decarboxylates pyruvic acid. 2) It acts as an activator of several enzymes, e.g; alkaline phosphatase, all phosphorylating enzymes. 3. It is required as a co-factor for oxidative phosphorylation.

Sodium: The adult human body contains about 100 g of sodium ion. It is distributed entirely in the extracellular fluid (plasma, tissue fluid and lymph) of the body. On the average, 5-10 g of sodium equivalent to about 10-20 g sodium chloride (common salt) is ingested per day in an average diet.

Functions: (1) Regulation of acid-base balance of the body, (2) Regulation of the osmotic pressure of the plasma or tissue fluids and (3) Sodium ions play a special role in originating and maintaining the heart beat.

Potasium: The adult human body contains about 250 g potassium which is present almost entirely in the cells of different tissues, muscle, etc. Only small quantities are present in extracellular fluid. While plasma contains only traces of potassium, the red blood cells contain large amounts of potassium ion. Potassium is the major basic ion of the body cells and apparently serves in the cells the same functions as sodium in the extracellular fluids. Potassium occurs in abundance in foods and so potassium deficiency seldom occurs in normal human beings.

Functions: (1) Regulation of pH of cell contents, (2) Regulation of the osmotic pressure of cell contents and (3) Potassium ion increases the relaxation of heart muscle which is antagonized by calcium ion.
Potassium deficiency causes weakness and muscular paralysis. In animals, hypertrophy of the heart has been observed. Consumption of excessive amounts of potassium causes muscular weakness and apathy-symptoms similar to those of potassium deficiency.

Iron: The total iron content of the normal adult man (70 kg wt) is estimated to be about 4-5 g. A greater part of the iron in the body is present as haemoglobin. Most of the body iron exists in complex forms bound to protein either as porphyrin or heme compounds or as ferritin and transferring. Free inorganic iron occurs in the body only in very small amounts. The hemoprotein and flavo-protein enzymes also contain iron.

Some compounds of biological importance containing iron are given below:

1. Iron porphyrin (heme) compounds: Blood haemoglobin, myoglobin (in muscle).
2. Heme enzymes: Cytochromes, catalase, peroxidase
3. Flavin-enzymes: Succinic dehydrogenase, xanthine oxidase, DPNH-Cytochrome C reductase, Iron chelate enzyme aconitase and
4. Transport and storage of iron : Transferrin (2 Fe+lobulin), ferritin hemosiderin (Ferric hydroxide plus non-nitrogenous compound)

Trace Elements

Many elements occur in tissues and foodstuffs in small quantities (traces) and thus have been termed 'Trace Elements'. The important trace elements are copper, iodine, zinc, cobalt, manganese, molybdenum, fluorine, selenium, nickel, chromium, cadmium, silicon, vanadium and strontium. Some of these are discussed below:

Copper: Copper is essential for the formation of haemoglobin and is a constituent of several enzymes. It is also found as a complex with some proteins in blood.

Zinc: The importance of zinc for the growth and well being of humans is known. Zinc is a constituent of the enzyme carbonic anhydrase. Zinc has also been found in some other enzymes. It is also found in insulin.

Manganese: Nutritional importance of manganese is that it involve in growth, skeletal development, reproduction and the functioning of cereabls nervous system.

Cobalt: Addition of small amounts of cobalt to the diet prevented the diseases. It was also shown that vitamin B_{12} contained cobalt and cobalt deficiency can be cured by injecting vitamin B_{12}.

Fluorine: Interest in the importance of fluorine in nutrition was created by the discovery of high incidence of chronic endemic fluorosis in humans in 1931 in certain parts of India. A link between fluorine deficiency and dental caries was reported

Chromium: Chromium occurs in traces in human and recent studies have shown that chromium may be a co-factor for insulin.

Check Your Progress 2

Note: a) Use the spaces given below for your answers.
b) Check your answers with those given at the end of the unit.

1. Write the major functions of carbohydrate, protein and fat.

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2. What are the major functions of phosphorus and calcium?

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3. Name the important trace elements required for humans.

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11.10 FUNCTIONS AND DEFICIENCY DISEASES OF VITAMINS

Vitamins are essential dietary factors and required in small quantities for the growth and maintenance of good health in human beings and whose absence results in deficiency disease. Vitamins may be classified into two groups: *(a)* fat-soluble vitamins: Vitamin A, Vitamin D, Vitamin E and Vitamin K *(b)* water-soluble vitamins: Vitamin BI (thiamine), Riboflavin, Niacin, Pyridoxin (Vitamin B_6), Pantothenic acid, Folic acid, Biotic, and Vitamin B_{12}, Vitamin C (Ascorbic acid) and Vitamin P (Bioflavonoids)

VITAMIN A [Retinol] and Carotene: Vitamin A or retinol and its derivative, are formed from their parent substance carotene which is called provitamin carotenes and cryptoxanthine occur in plants but not in animals. Thus green leafy vegetables are good source of provitamin for retinol synthesis Milk, animal fat ,eggs, fish, liver, etc are the good sources of vitamin A. Cod liver oil is the richest natural sources of this vitamin. Being fat soluble, vitamin A can be stored in the body up to six months.

Functions:

- It plays a crucial role in normal vision.
- It supports growth, especially skeletal growth.
- Vitamin A deficiency increases the susceptibility to infection and lowers immune response of the body.
- Vitamin A has been found to protect against some epithelial cancers such as bronchial cancers.

Deficiency diseases of vitamin A:

1. **Night blindness:** In advanced deficiency, one cannot see objects in dim light. Vitamin A deficiency is one of the most common causes of night blindness and blindness.
2. **Keratinisation**: Retinol deficiency causes keratinisation of the epithelial cells. The conjunctiva becomes dry, thickened, wrinkled and pigmented. The pigmentation gives the conjunctiva a smoky appearance.
3. **Xerosis cornea:** When dryness spreads to cornea, it takes on a dull, hazy and lustreless appearance.
4. **Bitot's spots:** Greyish or glistening white plaques formed of desquamated thickened conjunctival epithelium, usually triangular in shape and firmly adhering to the conjunctiva are frequently found in children having other signs of vitamin A deficiency.

THIAMINE (Vitamin B_1): Thiamine is present in almost all natural foods. Important sources are whole grain cereals, whole-wheat flour, legumes and pulses,

nuts especially groundnuts. Milk, meat, fish, eggs, vegetables and fruits also provide small amounts.

Functions:

(i) Thiamine pyrophosphate plays an important role as co-enzymes for enzymes involved in carbohydrate metabolism, essential for the oxidation of intermediate products in carbohydrate metabolism and (ii) It is essential to maintain the nerves in healthy condition. It is essential for utilization of carbohydrates in the body. Its deficiency causes neurological and mental disturbances, a disease known as beri-beri.

Deficiency diseases:

Thiamine deficiency causes wet beriberi and dry beriberi in adults. Beriberi which affects infants is called infantile beriberi. In wet beri-beri, in addition to the above signs and symptoms, *o*edema in the legs, enlargement of the heart and palpitation and breath-lessness also occur. In dry beri-beri, the loss of appetite, numbness of the legs and hands and difficulty in walking take place. Infantile beriberi: the early symptoms are restlessness, sleeplessness and loss of appetite. Palpitation and breathlessness and loss of appetite develop, as the disease advances, due to the enlargement of the heart. Death may occur suddenly if treat-ment is delayed.

RIBOFLAVIN (Vitamin B_2)

Riboflavin is synthesized by green plants and animal can obtain it by eating plants. The rich sources of riboflavin are milk, eggs, liver and green leafy vegetables, Fish contain only small amounts. It is stable on boiling in acid solution. It gets decomposed by heat and exposure to sun light

Functions: Riboflavin plays an important role in many enzyme systems involved in the metabolism of carbohydrates, fats and proteins. Riboflavin has a fundamental role in cellular oxidation. It is a factor in a number of coenzymes (*viz.* FAD and FMN) concerned with protein and energy metabolism**.**

Deficiency diseases:

Deficiency of riboflavin results in dark red tongue, dermatitis, cheilosis and glossitis. Eyes become sensitive to light and easily tired with itching and burning leading to blindness (cataract)

VITAMIN D: Vitamin D is derived by irradiation from different forms of provitanum D, which occurs in epidermal layers of animal issues.

Functions:

- It promotes the absorption of calcium and phosphorus from the small intestines and calcification of bones.
- It promotes intestinal absorption of calcium and phosphorus from digested food.
- Mineralization of bone is stimulated by vitamin D.
- It enhances the bone resorption.
- Vitamin D increases the tubular absorption of phosphorus.

Deficiency diseases:

Rickets: Vitamin D deficiency causes the disease ‘rickets’ in children and osteomalacia in adults.The disease is characterised by bone deformities such as ‘pigeon breast’, bow legs and knock knees.

Osteomalacia: It is generally occurs in pregnant women whose diets are lacking in vitamin D. Bone deformities due to the weight of the body occur in pelvis, legs and ribs and generally occurs.

VITAMIN E (Tocopherol): Vitamin E is chemically known as *tocopherol* (Greek- tocos = child, phero = to bear, of = alcohol). It is widely distributed in all foods. Three compounds, viz., Foods rich in poly-unsaturated fatty acids are also rich in vitamin E. The rich sources of vitamin E are wheat germ oil, soybean oil, corn oil, egg yolk rice bran oil and butter, etc.

Functions: *(i)* Act as antioxident *(ii)* Prevents peroxidation of polyunsaturated fatty acids in tissues and cell membranes; *(iii)* It protects red blood cells from haemolysis by oxidising agents; and *(iv)* It offers protection to liver injury caused by carbon tetrachloride poisoning *(v)* Converts toxic hydroperoxides into harmless primary and secondary alcohols. It also maintains integrity of cell membrane.

Deficiency diseases: Vitamin E deficiency causes the following disorders in animals: (i) Reproductive failure; (ii) Haemolysis of red blood cells and (iii) Muscular dystrophy.

VITAMIN B_{12} (Cyanocobalamin)

It is also essential for the formation of haemoglobin. It is present only in foods of animal origin and kidney, meat, fish, liver, milk are good sources of this vitamin. Cheese are also a good source and it is relatively heat stable and only little is lost on cooking. As it is not present in vegetable foods, some amount of animal foods like milk and egg must be included in the diet.

Functions:

- Vitamin B_{12} promotes the maturation of red blood cells.
- It is involved in the formation of white blood cells and blood platelets.
- It cures the neurological symptoms of pernicious anaemia.
- It acts as a coenzyme in the synthesis of methionine and acetate.
- It is also required for proper functioning of cebreals nervous system and for metabolism of folic acid.

Deficiency diseases

Vitamin B_{12} deficiency causes the disease 'pernicious anaemia' as it is not absorbed in this disease due to the absence of Intrinsic factor in the stomach. The principal signs and symptoms of the disease are as follows: (1) Red blood cells (RBC) count and haemoglobin is very low (2) Maturation of the RBC is affected. (3) Soreness and inflammation of the tongue are commonly observed and (4) Numbness and tingling of fingers and toes and signs of degeneration of the spinal cord are observed.

NIACIN (Vitamin B_5): Niacin is the official name of nicotinic acid and nicotinamide or niacinamides are its active forms. It is widely distributed in plants and animal tissues. Protein rich foods such as poultry, fish, meat, peanuts, beans and peas are rich in niacin. All grains are also fair sources. Milk is poor in niacin but its protein is rich in tryptophan which is converted into niacin in the body . Niacin is comparatively resistant to heat and cooking causes little destruction of niacin

Functions:

- Nicotinic acid is essential for the normal functioning of the skin, intestinal tract and the nervous system. .
- Nicotinamide is a coenzymes for dehydrogenases enzymes which are essential for the metabolism of carbohydrates, fats and proteins.

Deficiency diseases:

Nicotinic acid deficiency causes the disease 'pellagra' in human beings. The disease is characterized by three D's-der-matitis, diarrhoea and dementia. The der-matitis and diarrhoea are two important symptoms of pellagra. The dermatitis occurs in skins of hands, feet and neck, which are exposed, to sunlight. Dementia is the common mental distur-bance in acute pellagra.

Folic Acid

Folic acid is present in almost all natural foods. Eggs, meat, liver, cereals, pulses, green leafy vegetables are good sources. Over cooking destroys folic acid and thus contributes to folic acid deficiency in human beings. Next to iron, folic acid deficiency is a common cause of nutritional anaemia. Which is usually found during pregnancy and lactation when requirement of folic acid increases. Therefore, during these stages intake of fresh green vegetables should be increased.

Functions

- Essential for the maturation of red blood cells.
- Acts as a coenzyme in the synthesis of purines and pyrimidins for synthesis of nucleic acids and serine, glycine and methionine amino acids.
- Required for the formation of heamoglobin.

Deficiency diseases: Nutritional megaloblastic anaemia in adults

VITAMIN B_6 (Pyridoxine): Pyridoxine is water soluble, stable to heat and acids but sensitive to light and alkalies. It is widely distributed in foods, *e.g.*, milk, liver, meat, fish, egg yolk, whole grain cereals, legumes and vegetable. In addition to pyridoxine, two other closely related compounds, pyridoxal and pyridoxamine occur in animal and human body. These two com-pounds possess the same vitamin activity as pyridoxine. It is readily soluble in water. .

Functions: It plays an important role in the metabolism of amino acids, fats and carbohydrates. The coenzyme form (*pyridoxal phosphate*) is required for the metabolism of amino acids and conversion of tryptophan to niacin. Prevents and cures dermatitis disease Pyridoxine is essential for maintaining the nerves in normal conditions.

Deficiency diseases: Skin lesions developed around the eyes, nose and mouth. The patients also developed nausea, vomiting, weakness and dizziness. Infants receiv-ing low amount of pyridoxine, developed nervous irritability and convulsive seizures.

11.11 EFFECT OF COOKING, PROCESSING AND STORAGE ON NUTRITIVE VALUE OF FOODS

The important methods of cooking and processing are: boiling in water, steaming, baking, roasting, frying , dehydration and canning.

The main objective of cooking and processing of foods are to improve the digestibility and appearance, develop new flavour and destory harmful microorganism.

Effect of cooking, processing and storage on nutritive values of foods:

Carbohydrates: Starch is the major source of carbohydrates in all the foods and for its digestion cooking is essential. The moist starch granules swell and burst and gelatimised during cooking. Cooked starch is digested more readily than the raw starch due to the hydrolysis by amylases enzymes. During storage no significant losses in starch and carbohydrates occur in cereals and pulses however losses take place in fruits and vegetables.

Proteins: Moderately cooked proteins are more easily digested than raw proteins however severe cooking such as roasting, baking and frying affect adversely the nutritive values of protein due to their denaturation. The adverse effect is due to unavailability of essential amino acids because they combine with reducing sugars during processing at high temperatures. The availability of lysine and other amino acids from the heated proteins are less than the unprocessed proteins. However ,the nutritive value of the proteins of some legumes and vegetables is improved considerably due to the destruction of proteinase inhibitors and heamagglutinase during cooking. Cooking also helps in breaking the cell walls in vegetables which facilitates digestion of proteins. There are significant losses in free amino acids and proteins contents during storage of fruits and vegetables.

Fats: Ordinary cooking has very little effect on the nutritive values of fats and free fatty acids but the prolonged heating such as frying destroy the essential fatty acids and toxic polymerised products are formed. During storage of foods rancidity develops due the oxidation of fats which reduces the nutritive values of fats.

Vitamins: Vitamins such as carotene, thiamine, riboflavin, nicotinic acid, pantothenic acid, pyridoxine, folic acid and vitamin-B_{12} and ascorbic acid (Vitamin C) are destroyed slightly during cooking, frying and roasting due to oxidation by air, and dissolution and leaching in the cooking water when excess cooking water is discarded. During storage, the loss of vitamin take place but the losses are much more in fruits and vegetables particularly of vitamin C and carotenes.

Minerals: Losses of calcium, phosphorus, iron, sodium, potassium and trace elements during cooking occur when excess of cooking water is discarded.

11.12 LOSS OF DIFFERENT NUTRIENTS DUE TO COOKING AND PROCESSING WITH SPECIAL REFERENCE TO CEREALS AND PULSES

Cereals and pulses are the major foods in Indian diet and they are milled and cooked or processed before consumption. The grains consist 3 main parts: (i) Endosperm – rich in starch & fair source of protein (ii) germ or embryo - rich in protein and oil. (iii) bran consist of pericarp, testa or seed coat, hyaline and aleurone cell layers. During milling, different products such as flour or grain, splits, germ and bran are obtained. The heat processing effect adversely the quality of proteins. During milling of cereals such as wheat and pulses & germ is removed and there is a great loss of proteins because germ contains about 80 % of the proteins.

Rice: The paddy consists of 20 % husk and 80 % rice. The milling of rice consists dehusking (shelling) and polishing (milling). Paddy is also parboiled, dried and then shelled. The loss of nutrients are high in raw milled rice. However, losses are very less in milled parboiled rice. During cooking or heat processing of cereals, Vitamin-B-1 is destroyed to a great extent. During the process of parboiling of the paddy, scutellum gets fixed to rice grain and a greater part of thiamine present in aleuronic layer passes into endoscopies and hence not removed during milling. The starch gelatinized and the cooking quality of rice is improved. Polishing of rice grain decreases the thiamine and niacin contents significantly; however in parboiled rice the decrease is very less. There are different degree of polishing i.e. 5 to 10 %, as the polishing is increased amount of vitamin is decreased in rice grains. At 10 % polishing the decrease in thiamine & niacin is about 50 % and 90 % in raw rice where as the decease was only 15 & 55 % in parboiled rice. Rice is generally washed and then cooked in excess of water and gruel present is usably drained off which cause losses of starch, vitamin-B_1, nicotinic acid and other vitamins-B and cooked parboiled rice is a good source of vitamins.

When raw rice is processed into rice flakes, carbohydrate and proteins decreased about 2 and 5 % respectively whereas fats, minerals and vitamins (thiamine, niacin and riboflavin) increased manifolds (100 to 200 %). Rice puffed had more proteins (9 %), minerals (45-100 %) and vitamins (23 %) and low fats (75 %) and carbohydrate (5 %) as compared to raw milled rice.

Thiamin is lost from rice during milling process with the removal of the bran layer. The resulting polished rice although attractive in appearance but 75 per cent of thiamin loss occurs in this process. It is advisable to eat parboiled or less polished rice.

Wheat: The milling of wheat consists in the separation of bran (13 %) and germ (2-3 %) from the endosperm (83-85 %) and reduction of endosperm to fine flour. The degree of milling of wheat is known as extraction rate and whole meal flour is called as 100 % extraction. In 85 % & 70 % extractions, 15 % & 30 % bran & other parts of wheat are removed, and called whole wheat flour and white wheat flour respectively. During 85 & 70 % extractions, proteins, fat, phytate-phosphate, cellulose, hemicellulose loses and vitamins, thiamine, riboflavin and niacin decreased significantly, however carbohydrates contents increased slightly. The decrease in nutrients in low (70 %) extraction as more than high (85 %) extraction. But low extraction flour has many advantages over high extraction flour such as it contains low fat which improves keeping quality and also contains low phytate P- and hence calcium and iron absorption is more. The brown bread contained low amount of protein, fat and carbohydrates, minerals and vitamins as compared to whole wheat flour. Similarly semolina has about 45 % less fat, protein and fat 5 %, minerals 6-8 % and vitamins more than 70 % as compared to whole wheat flour. Fibre contents also decreased in processed whole wheat flour. Wheat is generally processed into bread, biscuits and cereals flakes. The nutrients contents of bread on weight basis are about 75 % that of flour, in biscuits protein is lower about 5-8 % and in cereals thiamine is lost and protein quality adversely affected. The brown bread contained low amount of protein, fat and carbohydrates, minerals and vitamins as compared to whole wheat flour. Fibre contents also decreased in processed whole wheat flour. There is a loss of vitamins during baking on wheat processed products, bread, biscuit and breakfast cereals.

Pulses: Pulses are generally milled or decorticated to remove outer husk to obtain

spilts to use as *dhal,* cooked before eating. Milling improves appearance, texture, cooking quality & palatability. The milling removes germ also which results in loss of protein however it improves the digestibility and net protein utilization is much higher than whole seed. Nutrient availability is also increased due to the reduction of fiber. Dehusking removes the major amount polyphenols and antinutritional factors. Black grams are generally processed into dhal and puffed. Dhal contained higher amount of protein (20 %), fat (5 %) phosphorus (35 %) and thiamine (60 %) where as carbohydrate (2 %) calcium (70 %) iron (7 %) and niacin (10 %) and riboflavin (50 %) decreased in dhal as compared to whole grains. In puffed gram (without outer husk), protein and phosphorus contents increased about 30 % and fat, carbohydrate, minerals & vitamins decreased manifolds. Cooking and heat processing of pulses improved the nutritive values by inactivating the trypsin and growth inhibitors and heamagglutinns. The protein efficiency ration (PER) values of heat processed pulses protein increased more than 2.5 times Whole pulses (with seed coat) cooked as such will loose very small amount of nutrients during cooking. The losses of vitamin- B are appreciable of *dhal* when cooked in excess water and cooked water is discarded. Use of baking powder in cooking destroys vitamin B-complex pressure cooking maintains good amount of vitamins as cooking time is short and vapour loss and exposure to oxygen is minimum**.**

11.13 ANTINUTRITIONAL FACTORS

Many plant foods contain anti-nutritional factors, which interfere with the assimilation of nutrients contained in them. Anti-nutritional factors are the substances which might (a) Cause impaired and reduced growth or produce acute and lethal effects (b) Reduce the availability of otherwise good proteins in the diet (c) Causes diseases or illness. The important anti-nutritional factors are trypsin inhibitors, hemagglutinins (lectins), goiterogens, phytates, oxalates and tannins. They interfere with the utilization of other nutrients like protein, minerals like iron, zinc, calcium and iodine. There are practically no reports of any significant levels of anti-nutritional factors in the cereal crops. However the anti-nutritional factors are present in legumes, oil seeds and some vegetables. Most of the anti-nutritional factors are heat labile and do not pose any serious problem if the foods are consumed after cooking, heating and baking. Some of the heat labile anti - nutritional factors are:

Trypsin inhibitors: Trypsin inhibitors are low molecular weight proteins distributed widely in plant foods like legumes (pulses soyabean, lima and kidney bean) and some vegetables (potato). They generally inhibit the activity of trypsin enzyme by inhibiting their intestinal proteolysis in the gut and interfere with digestibilities of dietry proteins and reduce their utilization. Trypsin inhibitors from other *dhals* are easily inactivated and do not pose any problem.but more drastic heat treatment is necessary to inactivate trypsin inhibitors of soya, lima and kidney bean. This heat treatment inactivates the trypsin inhibitors and improves considerably the utilization of protein present in these foods.

Lathyrism: The seed of *Lathyrism stativus* (kesheri dal) contain neurotoxic substance (B- oxalyamino alanine) which cause paralysis of leg muscles and walking become impossible. Soaking the grains and leaching out in washing water and discarding the water remove the toxic factor.

Haemagglutinins: a protein having the peculiar property of being able to cause the red blood cells to agglutamate and have been know to be present in soybean, jackbean, navybean and lentil. Since this factor is also heat labile.

Goitrogens: It has bee recognized for a long time that certain substances present in plant foods interfere with iodine uptake by thyroid gland and may contribute to development of iodine deficiency disorders. Compounds that are termed 'goitrogens', include Thiocynate, isothiocyanates and their derivatives. These compounds occur in leaves and vegetables like cabbage, cauliflower, rape leaves radish, rapeseed-mustard,brussels sprout, turnips, etc. Soya bean and other legumes, bajra, peanut, lentils, common bean also contain goitrogens.

Phytate: Phytate is hexa phophate of inositol. It is widely districted in seeds. Unrefined cereals and millets are richest source of phytates. These phytates bind iron, zinc, calcium and magnesium forms insoluble complexes. Phytates present in cereals contribute significantly to poor absorption of iron from cereal based diets. Unrefined cereals contain more phytates than refined or polished cereals (rice). On germination of the grains, the phytate content reduces due to enzymatic break down of phytate. Improved iron availability in germinated grains can be partly attributed to a reduction in phytate content.

Tannins: Tannins are widely distributed in plants. They are present in high amount in seed coat of most legumes, spices, millets (bajra, ragi, sorghum) and certain vegetables and fruits. Tannins bind with iron irreversibly and interfere with iron absorption. A typical Indian diet based on cereals, legumes, vegetables and spices may contain tannins. Tannins are also known to bind proteins and reduce their availability. Inhibition of many different enzymes has been reported and may be due to the protein binding nature of tannins. Tannins can cause gastrointestinal inflammation and may be tumorigenic. It is generally accepted that tannins reduce the nutritional quality and reduce the biological value of some millets and legumes.

Oxalates: Oxalic acid or its salts (oxalates) are widely distributed in plant foods. Rich source of oxalates are green leafy vegetables and green vegetables and some legumes (Horsegram and *khesari dhal*). Oxalates are known to interfere with calcium absorption by forming insoluble salts with calcium. High oxalate excretion may predispose to oxalate crystals leading to urinary stones.

Check Your Progress 3

Note: a) Use the spaces given below for your answers.
b) Check your answers with those given at the end of the unit.

1. What are the main deficiency diseases caused by vitamin A and carotene?

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2. What are fat soluble vitamins?

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3. What are the antinutritional factors present in pulses?

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11.14 LET US SUM UP

Human body contains billion of cells and they carry out number of functions like nutrition, respiration, growth and reproductions. Food is a prime necessity of life and it consists of carbohydrates, proteins, fats, vitamins and minerals. While carbohydrates, proteins and fats provide energy to work vitamins and mineral if not consumed in sufficient quantities may cause diseases and illness. Many vitamins, mineral, and trace elements are required for the optimum activities of enzymes involved in food digestion, assimilation and synthesis of reserve foods to be utilized during starvation. Some essential nutrients are destroyed / lost during processing and cooking and to prevent these losses minimal processing & cooking is advised. Some pulses contain anti nutritional factors and they cause diseases & illnesses if these are not eaten after proper treatments, cooking and processing.

11.15 KEY WORDS

Carbohydrate : They are polyhydroxy aldehyde or ketones or as substances which yield one of these compounds on hydrolysis**.**

Fats and Oils : Fats and Oils used to refer to extracted lipids. When solid at room temperature they are called fats and when liquid as oils.

Food : Substances which are taken in by mouth which maintain life and growth i.e. supply energy.

Health : Health is a state of complete physical, mental and social well being and merely the absence of disease.

Malnutrition : It is a state of health resulting from inadequate intake of one or more nutrients or some defect in metabolism, which prevents the body from utilizing the nutrients properly.

Milling : The conversion of cereals and pulse grains into it derivatives i.e. wheat into flour, brown rice to rice and pulse into dhal .

Nutrients : Essential dietary factors for human beings.

Nutrition : The study of food in reletion to the needs of living organism.

Protein : The macromolecular polymers composed of amino acids as the basic units**.**

Starch : Complex storage polysaccharide of higher plants which are composed of glucose units.

Texture : Combination of physical properties perceived by senses of kinaesthesis, touch, sigh and hearing.

Vitamins : Naturally occuring organic substance which is essential in very small amount for normal function of living cell and whose absence results in deficiency dieseases in humans.

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11.17 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

Your answer should include the following points:

1. • Cell membrane, cytoplasm and nucleus
2. • Fats and oils, such as butter, ghee, cooking oil etc.
3. • Starch, protein, fats, vitamin and minerals

Check Your Progress 2

Your answer should include the following points:

1. • Energy, essential for oxidation of fats, protein, growth and maintains of muscles and other organs of the body and syntheses of enzymes and antibodies.
   • Absorption of vitamin A,D, E & K. and essential fatty acids such as linoleic and linolenic acid.
2. • Necessary for the formation of bones and teeth.
3. • Copper, iodine, zinc, manganese, fluorine etc.

Check Your Progress 3

Your answer should include the following points:

1. • Night blindness or total blindness.
2. • Vitamin A,D,E & K.
3. • Trypsin inhibitors and lathyrism.