UNIT 1 FOOD AND NUTRITION

Structure

1.0 OBJECTIVES

When we complete this unit, we will be able to:

- define food, nutrition, and nutrients, and diet
- list the functions of food,
- understand the vital role of nutrition
- Identify the types of nutrients we get from food, and their functions.

1.1 INTRODUCTION

Every single cell in the human body is an outcome of the food we have ingested. Our mind and body are made of the food we eat and it continues until we live. The body parts, organs, muscles, blood and bones are all made from the food we have eaten. Food gives energy and stamina for work. It also gives emotional stability and security. Our appearance and feeling of good health and happiness also depends on the right kind of food and the quantity of food that we eat. Lot of research is being done and new findings published every day to increase our knowledge about food and nutrition, and to find ways to apply this knowledge in choosing the right foods to eat, so that our body is well nourished and healthy.

1.2 DEFINITION OF FOOD, NUTRITION, NUTRIENTS and DIET

Food is the very basis of our life. It contains different nutrients that are needed by the body for survival and sustenance. The food we eat is digested and converted into nutrients. These nutrients are absorbed and transported to different parts of the body, and utilized for the day-to-day functioning. At the end they are disposed of by further metabolism and transformed into the end products. We need to consume a variety of foods in order to remain healthy.

Thus, we can define **food** as any solid or liquid which when eaten can supply any of the following:

- Material from which the body can produce movement, heat or other forms of energy,
- Material for growth, repair and reproduction,
- Substances necessary to regulate the production of energy or the processes of growth and repair.

The components of foods which have these functions are called **nutrients.** In other words nutrients are vital in keeping a living thing alive and helping it to grow.

The **diet** consists of those foods or mixtures of foods in the amounts which are eaten daily. A good diet provides adequate amounts of all the nutrients, without harmful excesses, from a wide range of foods. Dietary habits are dependent on geographical and cultural traits and vary accordingly.

Nutrition is the process by which living things receive the food necessary for them to be healthy. The science of **nutrition** is a study of all the processes of growth, maintenance and repair of the living body which depend upon the digestion and absorption of food and the study of that food.

A **nutritionist** is an expert on the relationship between food and health and a **dietitian** is an expert on what one should eat under different conditions.

1.3 FUNCTIONS OF FOOD

Let us now get acquainted with the major functions of food. As we know we eat when we are hungry, but food not only removes hunger, it also gives us a feeling of satisfaction and renewed strength. We also share food to express happiness, friendship, love and unity. Most families bond over mealtimes. Most meetings and important discussions in companies happen over lunches and dinners. Thus, food has many important functions in our lives. When we understand these functions, we appreciate how they affect our food intake and our physical and mental well-being.

1.3.1 Physiological functions

The most important function of food is to build our body. We have seen that we probably weighed somewhere between 2.5 to 3.2 kg at birth and now weigh between 45 to 60 kg. This growth is the result of the food we ate from birth to adulthood. Now as an adult, our weight is constant which shows that we have achieved optimum growth. At this stage, the food we eat helps to maintain and renew worn out cells of our body and keep the body in good condition.

Secondly, food provides the energy, our body needs for all its activities, voluntary and involuntary. We know that even when we sleep, many of our body's activities continue, like breathing, heartbeat, digestion, absorption of food, etc. These keep us alive without any effort on our part and are called involuntary activities.

The work or activities we do when we are awake and our mind is in it like studying, walking, cooking or working at the desk, or playing a game of badminton, is called voluntary activity. The amount of energy we need for all these depends on the kind of activity and the time and energy we spend doing it.

The third function of food is to regulate all the activities of the body and protect it from diseases and infections. Examples of some of the activities which regulate the body are given below:

- Beating of our heart for circulation of blood
- Maintenance of our body temperature
- Muscle contraction for voluntary and involuntary movements
- Removal of waste from the body in form of sweat, urine and feces, etc.

Apart from these, vital nutrients in food also help to protect the body from various infections, diseases and from wearing out.

1.3.2 Psychological functions

In addition, to meeting our physical needs, food also satisfies certain emotional needs. These include a feeling of security, love and attention. We feel secure when familiar foods are served which are also known as comfort foods. When a child comes home from school the mother knows that he/she is hungry and serves food. Thus, she expresses her love and attention. Many times, we miss our mother because of the attachment to her cooking.

When we share our lunch with a colleague, we express acceptance and friendship. If we are amongst friends, we try unfamiliar foods and enlarge our food experience. These are some of the positive aspects of food acceptance. There are occasions when we are hungry, but are unable to eat even a nutritious meal, because the foods are unfamiliar or we are unhappy or lonely. We need to understand these aspects about food acceptance, so that when we plan meals, we will not only think of nutrition, but also the persons for whom we plan.

1.3.3 Socio-cultural Functions

We know how important food is in our social and cultural life. We serve refreshments at meetings and seminars or to visitors to create a relaxed atmosphere for an exchange of ideas. In most of our festivals and celebrations we have lunch and dinner with family and friends which binds us together. Food is also used as an expression of happiness. For example, we distribute sweets when we pass examinations, buy a car or when there is a marriage feast. We also celebrate birthdays, anniversaries, promotions etc. by cutting cakes and enjoying food at parties. In religious functions like Easter, Ramzan, Rajo, Nuakhai, etc. we make special preparations to distribute food offerings. Thus, food helps to strengthen our social and cultural ties.

1.3.4 Food Habits

Food intake is related to food habits, which is a powerful force in deciding what we eat. We tend to eat according to our set food habits and like all habits these may be good or bad. Formation of food habits have to be understood so that we can take appropriate measures towards building good food habits.

- **Regional and Community Variations:** Food habits are affected by food production and supply. For example, rice is the staple food in the East, West and South of India whereas wheat is popular in the North. This is because of agricultural practices of the region. Then the amounts and kinds of foods we eat depend on the money that one can spend. The geographic region, religion, community and family beliefs and practices that have developed over several generations, heavily influences a family's eating pattern.

  Inspite of all these variations, all regional patterns can meet the nutritional needs of people if sufficient food from each group is included. A particular food chosen and the way it is prepared and seasoned is a matter of personal choice. Social customs like when and with whom and what to eat, will affect our exposure and hence our acceptance pattern.

- **Personal Factors:** The atmosphere in which we eat may modify our attitude towards food. A happy or an unhappy atmosphere affects our reactions to food and eating. Everyone has a personal response to the taste of foods. We may like pungent foods or acid foods while our friends may prefer mild or astringent foods. These basic influences affect our food habits, as we tend to adopt the food practices of our family. Our selection of foods should be based on the knowledge of food values. Convenience of food preparation also affects food habits of the present generation.

- **Other Factors :** Many other influences modify our food habits. When we move away from our region for education or work, we are exposed to new foods and our eating pattern is modified. Travelling within our food region and outside also influences our food habits. Media also has a large role to play in food choices today. Though food habits are affected by many influences, individual food intake is dependent on personal preferences that are an important factor in deciding our nutritional status.

  The best time to develop good and healthy food habits is in childhood. As food habits are closely associated with sense of security, so any modification, particularly in the adult stage, will require a strong motivation.

  We know that energy need decreases with age hence modification in food habits need to be made to reduce energy intake as people grow older. When we see old people who are overweight, we can see that they have not made the required adjustment. We also see many people, who are not overweight, but eat foods that do not meet their need for other nutrients, except calories. It is difficult for such people to see the need for change because they maintain their weight and do not associate any symptoms of poor health they may have due to their eating habits. Generally, cause and effect are not easily noted.

One must be cautious while approaching people to modify their food habits. We will need to understand the background of their food habits before we can help them to improve or change their diet. The desire for good health is universal. It can be used as a motivating force to help others.

1.3.5 Food misinformation

We spend a considerable part of our time and income to select and purchase foods. Besides food habits, our choices are also affected by prevalent misconceptions, we have about foods and food products. We are exposed to a variety of views about the foods and their nutritional contribution--through conversation, and through newspapers, magazines and books. People see and hear advertisements about foods and drinks. So their ideas about food are indirectly modified by what they hear and see. The internet, television and other multimedia sources also influence food habits to a great extent.

Water: Some people think drinking water can help them lose weight but water cannot wash away the fat from the cells, or those extra calories we get from overeating. If we drink water instead of the calorie-rich soft drinks, we might cut down on our calorie intake. When a person or a child suffers from diarrhea and vomiting, some people restrict their water intake with the hope of stopping it, which is very wrong. We know it is very important to feed clean, boiled, cooled water, with added sugar, salt and lemon, to a person who has suffered loss of body fluids due to diarrhea or vomiting. Water intake in such a condition is crucial to prevent dehydration especially in children.

Cereal and cereal products: There is a wrong notion that starchy foods, such as rice and bread, are high in calories. Many dieters frequently reduce or cut out cereals from their diet. We need to remind them that basic cereals and plain breads (like chapatti) are not very high in calories. The calories come from the foods they add such as ghee, butter, cheese, jam, sugar, oil, chutney, etc. It is the extra calorie foods that they should omit, not the breads and cereals.

Another misconception is that weight reduction is possible if we eat bread or chapati instead of rice. Actually, both rice and wheat contain about the same number of calories. It is the total calorie intake that needs to be reduced not calories from a particular food.

We have noticed that many people cut the sugar from tea or coffee to reduce their calorie intake but do not skip the biscuits, cake, or other snacks that are served with the tea or coffee. The teaspoon of sugar they skip is only 20calories, and the snacks they eat may add *50*- 100 'calories. So they end up having 2 to 5 times the calories than sugar.

Fats and oils: All vegetable oils (except coconut and olive oil) contain a high amount of PUFA (poly unsaturated fatty acids). It is important to understand that vegetable oils do not contain any cholesterol. To say that a particular brand of vegetable oil contains no cholesterol is intended to misguide us to think that other brands of vegetable oils contain cholesterol. The nature of the oil of fat (unsaturated or saturated, fatty acid content, cholesterol content, etc.) is not to be confused with their calorie value. We know that all oils, ghee and vanaspati provide the same calories i.e. nine calories per gram. Therefore, we realize that when there is an advertisement of oil that contains less or low calories, we must know that it is not true.

Other foods and food products: Weaning food products are advertised as 'Doctors recommend' or 'more nourishing food for growth'. The fact is that there is nothing special about these products. Most of these are made from the cereals we use at home, to which they add some milk powder, sugar, minerals and vitamins.

Some brand of biscuits claim they are the best food for children. Actually, most biscuits are made from maida (refined wheat flour), with the addition of varying amounts of fat and sugar. Thus, biscuits have lot of calories. When we feed children with these instead of a meal, it does not provide the child with all the nutrients it needs.

Another group of products advocated is a variety of synthetic drinks and carbonated beverages. These contain only sugar, flavor, color and acid and provide only energy. A few may have a little vitamin C, and nothing else. When these are taken with fast food and junk food they create health hazards in the long run. Instead, if we make traditional cool drinks at home and other snacks and food items it will cost a fraction of the price we pay for commercial weaning foods and children's snacks and drinks. Another advantage would be that children would develop healthy food habits in this way, which will help them through the lifetime.

1.4 NUTRIENTS

Understanding nutritional needs and translating it into practical diets requires a sound knowledge of nutrition. For that first, we need to review the nutritional components of the foods that we eat. The following paragraph will focus on this aspect.

1.4.1 Classification of nutrients

All foods are classified into three broad categories:-

- Energy yielding foods (Carbohydrates and Fats)
- Body building foods (proteins)
- Protective and regulatory foods (vitamins, minerals and other foods)

1.4.2 Types of nutrients

The foods that we consume are composed of varying quantities of the following nutritionally important components:

1) Carbohydrates
2) Proteins
3) Lipids
4) Water
5) Minerals
6) Vitamins
7) Fibre
8) Phytochemicals and anti-oxidants
9) Detoxifying agents

If these nutritional components are consumed daily in the amounts and proportion required, then the chances are that we will maintain a good health.

1.4.3 Functions of nutrients

We use foods such as wheat, rice, dal, vegetables, fruits, milk, eggs, fish, meat, sugar, oils, on a daily basis in our diet. These foods are made up of the nutrients mentioned earlier. Let us get to know the functions of these nutrients in our body.

Carbohydrates: We get about 70-80 per cent of our energy from carbohydrates. The energy content of foods is expressed in calories. One gram of carbohydrate provides four calories. If we take these in excess of our body's need, the unused part is stored as glycogen in the muscle or converted to fat and stored for later use. The main carbohydrates in our diet are starches found in cereals, dals and tubers, sugar from sugarcane and fruits. Cereals and dals also provide a large part of the proteins, some minerals and vitamins.

Proteins: As we know, proteins are present in all living tissues-both plant and animal. Next to water, protein is the most abundant component of our body. About one-sixth our body weight is protein. The main function of protein is building of new tissues, and maintenance and repair of those already built. Further, a number of regulatory and protective substances (enzymes, antibodies, hormones) in the body are made from proteins.

We get about 8 to 15 per cent of our total energy from proteins. Energy supply is thus a secondary function of our dietary proteins. Each gram of protein gives four calories of energy to our body. Protein is present in vegetables and animal sources. Among the former, pulses, nuts and soybeans are good sources of protein. Among the latter, milk, fish, egg, meat, chicken and liver are rich sources. Paneer and khoa (condensed milk) are also good sources of protein.

Fats: In India, about 10 to 30 per cent of the energy needs are met from oils and fats. One gram of oil or fat gives nine calories of energy to the body. Please remember that the fats and oils are concentrated sources of energy. We need fats as a medium for the absorption of fat- soluble vitamins. We need essential fatty acids, which vegetable oils provide. The oil we use in seasoning, the ghee or butter used as a spread, and the fat in eggs and meat, are the major sources of fats in our

diet. The oilseeds and nuts we use in food preparations also contribute some fat. Remember if we take more energy than our body needs, in any form, be it fats, carbohydrates 'or proteins, it is stored in our body as fat.

Minerals: Our bones and teeth need minerals for their formation and maintenance. Iron is needed for formation of the red pigment in the blood. Minerals have an important role in the regulation of a number of body processes, e.g. muscle contraction, nerve stimulation, respiration, etc. we get the minerals that we need from a variety of foods. For example, we get calcium from milk and leafy vegetables, iron from leafy vegetables, dals and eggs, sodium from salt and other foods.

Vitamins: We need different vitamins, for example, vitamin A, B-complex, C, D, etc. Our body needs these to grow and develop, to help our eyes, nerves and skin to remain healthy, and to protect us from infections. We need very small amounts of these vitamins. We get these from a variety of foods like leafy vegetables, carrots, amla, guava, masumbi, oranges, pulses, whole grain cereals and eggs.

Water: Our body contains approximately 60 to 65 per cent water. Hence, it is an essential part of our body structure. We know, water is a universal solvent. It carries food into the body, helps in the digestion and absorption of food and ensures elimination of waste from the body. Water helps to regulate body temperature. It acts as a lubricant in the mobile parts of our body, such as joints and prevents friction. We need about 5 to 6 glasses of water each day. We get it from the water we drink and beverages such as tea, coffee, etc.

1.4.4 Assimilation of food in the body

We learnt about all the nutrients that the body needs. What we eat becomes flesh and blood. The process by which the nature of food is changed in the body **is** called digestion. The digestive tract is nature's (or our body's) ingenious way of extracting nutrients from the food we eat. The digestive tract is selective. It breaks down the materials that are nutritious for the body into particles that we can assimilate. Those particles that are left undigested pass out from the other end of the digestive tract.

Our body needs energy to perform its various activities, protein to replace the cells it has lost and to grow, various vitamins and minerals for bone and blood formation and for the body to work efficiently and smoothly.

The digestive system:

When the body requires food, it signals us to eat. This signal is hunger. The moment we eat something the digestive journey starts. As we swallow, the food slides across the gullet or esophagus passing over the entrance to our lungs. Whenever we swallow, the body automatically closes off all air passages, so that we do not choke. When we chew food, we break it up (grind it) into small particles with our teeth.

From the mouth, the food goes into the stomach, where it stays for a few hours. The stomach breaks the food into still smaller particles, mixing it at the same time with acid and the enzyme pepsin, which chemically alters the protein in the food. From the stomach, the food enters the intestines.

We have a small intestine and a large intestine. The small intestine is actually not small at all. It is actually a 20 feet coiled tube within the abdomen. From here, food enters the large intestine. In the colon (latter portion of the large intestine), the body withdraws water, leaving behind semi-solid waste. The waste is held back here because of the strong muscles (called sphincter muscles) of the rectum. It would be inconvenient and embarrassing if one had to excrete continuously. When the body chooses to defecate, this muscle is relaxed and the waste material is voided.

The path that food follows in the body is like this:

Mouth (epiglottis)→ Gullet (esophagus) → Stomach→ Small intestine → Large intestine →Rectum (anus).

- For food to pass smoothly through the system, it must be mixed with water. If we drink too little water, the food becomes compact and moves very slowly.
- For digestive enzymes to work on food, it should be finely divided and suspended in water so that every particle is accessible to the enzymes. Once digestion is complete and all the essential nutrients are absorbed, the residue which remains is excreted. It would be wasteful and inconvenient to excrete large amounts of water with this

residue. So your body withdraws some water, leaving a semi-solid mass just smooth enough and easy to pass. This shows that food is altered physically in the digestive tract.

- The enzymes of the digestive tract break down or digest carbohydrates, protein and fat into smaller units. This is chemical alteration of food.

The body needs many nutrients, which it absorbs from food through the digestive tract. The digestive tract digests only carbohydrates, fats and proteins although the food we eat contains many other substances like vitamins, minerals, preservatives, colors, etc.

Certain glands in the body contribute the digestive juices or enzymes .These are the salivary glands, gastric glands, the liver and the pancreas. The enzymes from these glands break down proteins, fats and carbohydrates.

Physical Alteration of Food: we chew or masticate food, and grind it. Chewing food helps to

(i) Increase the surface area of food,
(ii) Break the cell walls of cells, releasing the nutrients.

In the mouth, the tongue helps to mix the food with saliva. In the stomach, food is mixed and altered further by contraction and relaxation of stomach muscles (known as peristalsis). Fat, we know, does not mix with water but contraction and relaxation of the stomach muscles breaks up the fat into small particles and disperses it in the watery medium or liquid in the stomach. This dispersion of fat in the liquid is called emulsification.

Refer to figure 1.4.4a for the digestive system

Digestion of food:

Carbohydrates, fats and proteins that are in the food are much too large to be of use to the body. Before the body can use them, it has to break them down into units, which are small enough to be absorbed into the bloodstream.

One of the commonest forms of carbohydrate in food is starch. Starch is made up of many small units called glucose. All carbohydrates must be broken down into small soluble units for utilization by the body.

Digestion of carbohydrate starts when you begin chewing food. When we chew some bread or rice, we find it tastes sweeter as we keep chewing. This is because saliva contains a starch-splitting enzyme called ptyalin mixes with the starch in the food. In the stomach, little break down of carbohydrate occurs. In the intestines, however, the carbohydrate is completely hydrolyzed to glucose.

Hydrolysis means break down of a large substance into smaller ones with the addition of water.

Just like starch in the rice must be hydrolysed, so also the protein in the pulses. Protein digestion begins in the stomach due to the action of the enzyme, pepsin. However, pepsin by itself does not complete the digestion. In the small intestine, protein digestion is completed by other enzymes (proteases) which are secreted by the pancreas.

Fat digestion occurs mainly in the small intestine. Bile from the gall bladder breaks the fat into small particles. Thus, the enzymes have more access to the fat to hydrolyze them. Fats are also hydrolyzed during digestion. Just like carbohydrate and protein, digestion of fat takes place gradually, in stages. Digestion of any one carbohydrate, protein or fat is like starting with a large chain of beads and splitting this into pieces by removing one bead at a time. Not everything we eat needs to be digested, e.g., vitamins and minerals or simple sugars like glucose.

However, many times, the minerals and vitamins are bound to the fat, protein or carbohydrate in your food. Thus for these vitamins and minerals to be available for absorption, first they need to be separated from the complexes in which these are found in the food. Fat-soluble vitamins need to be dissolved in fat in order to be absorbed. Before absorption, the other nutrients are dissolved in water. Therefore, water is essential for absorption of most nutrients. Enzymes speed up hydrolysis just like a mixer hastens the grinding of food into smaller units. For hydrolysis to occur, water is necessary..

Any food that has not been digested and absorbed from the small intestine goes into the large intestine. Fibre is one substance in our diet that remains undigested. Fibre is present in fruits, vegetables, in the outer skin of cereal grains and pulses. Fibre has the property of absorbing water and swelling. It is not digested; it only increases the bulk (amount) of undigested material. In addition, it soaks up water like a sponge. As a result, if we eat sufficient fibre everyday, we can ensure that the muscles of our intestines are stimulated and defecation occurs regularly and constipation can be prevented.

In the large intestine, no new enzymes are produced and therefore no further digestion takes place. The main task of the large intestine is to remove excess water from the undigested material. Remember that most of the break down stages in digestion involve hydrolysis and therefore need water. A lot of water passes into the large intestine. After this water is removed. The undigested material is removed from the body or excreted through the anus.

Absorption of nutrients:

Absorption is the process by which the products of digestion pass out of the digestive tract through the cells in the intestinal wall, into the bloodstream.

Most nutrients are absorbed directly into our blood, which is then distributed to different parts of the body. Some nutrients are absorbed in the stomach, for example vitamin B 12. Minerals like calcium and iron are absorbed in the first portion of the small intestine. Most end products of digestion of carbohydrates, fats and proteins are absorbed in the small intestine.

Absorption of carbohydrates, fats and proteins takes place after they are hydrolyzed into their smallest units: Glucose, fatty acids, and amino acids, respectively.

Utilization of nutrients:

After being absorbed in the small intestine, the smaller units of carbohydrates (glucose), proteins (amino acids) and fats (fatty acids) are carried to the various parts of the body through the bloodstream. In the body cells, carbohydrates and fats are broken down or burnt to produce energy in the form of heat. Carbohydrates that are in excess of the body's needs are converted into fat and are stored in the body. Proteins are used for building new cells during periods of growth and for repairing old and worn out ones when growth is complete. The smaller units of proteins, left over after completing this function are converted to body fat. However, if the calories produced by the fats and carbohydrates are not adequate for the body, proteins are also converted to energy.

Refer to figure no.1.4.4b for digestion and absorption of food.

1.5 NUTRITION

Nutrition science is defined by *Robinson* as:

"The science of foods, nutrients and other substances therein; their action, interaction and balance in relation to health and disease; the process by which an organism ingests, digests, absorbs, transports and utilizes nutrients and disposes off their end products".

Thus, the entire gamut of what foods are needed for maintaining *good health,* how they are processed to provide us the wherewith to carry out our daily activities, and how the end products of the foods we ingest or eat are eliminated constitute the science of nutrition.

The body's needs change through the various stages of the life cycle. It is necessary to know how to meet these needs by proper selection and intake of foods. A person's growth rate and size is decided by two main factors, one's inborn capacity to grow and environmental conditions. Nutrition is one of the major environmental conditions because if our genes decide how tall we should be then our nutrition decides whether we reach such height or not.

Nutrition affects our body size, our performance and our longetivity and good and bad nutrition can be gauged from assessment of these three parameters.
Body size means our height; weight and skin fold thickness (to measure fat and lean muscle). Measurement of height, weight and skin fold thickness are broad parameters to know whether we are in tune with genetic inheritance and are well nourished.

Nutrition affects our ability to learn and retain information. As the brain is the fastest growing organ in the body, most of its growth is over by the time a child is around two years old. So providing good nutrition to a pregnant and lactating mother, an infant and a preschooler is very vital. After that age, it will be too late. Our ability to work is also an important aspect and it totally depends on our nutrition. Underweight and malnourished individuals have physically weak bodies, low memory and low immunity that often make them sick.

Nutrition affects the longetivity of a person. Certain life threatening diseases like tuberculosis, anemia, and other childhood ailments increase mortality. Well-fed individuals are resistant to such diseases and live longer thus improving the country's health status and productivity.

Hence, nutrition is important from conception to old age for a disease free and long life.

1.5.1 Normal nutrition

Our nutrition depends on many factors. Each one of us should have certain type of nutrition best suited for his or her body types. Normal nutrition leads to good health. Good health has been defined as not only freedom from diseases but also a state of complete physical, mental and spiritual well being. The requirements for good health are many and they are :

1. Optimal growth and development during childhood and adolescence that leads to the full expression of an individual's genetic potential. Growth is defined in terms of physical features such as height and weight while development includes all aspects of physical and mental development.
2. Maintaining structural and functional integrity of body tissues throughout life that leads to an active and productive life. Examples include moist, bright and sparkling eyes for good vision, smooth and soft skin that prevents the entry of infections through the body surface, thus maintaining the integrity of internal organs like the gastrointestinal tract and the liver for proper digestion and assimilation of foods and removal of toxic waste products.
3. Ability to perform mental tasks efficiently: Good nutrition is essential for children to develop cognitive skills, learn school-oriented tasks well, perform optimally, and stay on in school. Similarly good nutrition is important in sustaining attention and memory in adults as well.
4. Ability to withstand the process of ageing with minimal disability.
5. Ability to combat diseases and resist infections, and to minimize the effects of environmental pollutants. To maintain positive health, it is essential that we combine and consume a variety of foods in such a way that the nutrient needs for the above functions are all provided.

Although the principles of nutrition apply throughout the lifespan, greater emphasis is to provide enough food and care for the younger age groups. Young people from infancy through adolescence grow continuously -- a characteristic that we adults do not share. A child gets taller and grows out of his clothes. Within two decades of life, a man increases about 20 times in weight and about 4 times in height (in comparison to his birth weight and height). Growth means increase in size of the body as well as development and maturation of the organs and systems of the body. Increase in size is visible externally whereas the development of organs and systems that takes place internally cannot be seen.

Critical periods of growth:

Our body grows in a set pattern with different tissues and parts of the body growing and maturing at different times. There are three periods in a child's life, which are critical because intensive growth occurs here. Intensive growth includes development of bones muscles and fat, development of other internal organs like brain, liver, kidney and hormonal glands and sexual maturation. If there is any adverse influence at these times; growth is affected and will slow down.

The three periods are:

- Prenatal period (nine months in the mother's womb)
- First year of infancy
- Adolescence (between 12 and 18 years)

We can see the distinct differences in growth changes in both heights and weights of children in the following tables.

Refer to table no 1.5.1a and 1.5.1b for growth pattern in critical stages

Apart from these three stages, other critical stages where nutrition plays a vital role are pregnancy and lactation. These will be taken up in detail in further units.

We need to consume a variety of foods in order to remain healthy and that calls for a balanced diet.. A simple thumb rule is to classify foods into different food groups. The basic seven-food groups' concept is useful in getting a balanced diet that helps us to remain healthy. These basic seven food groups are:

1) Cereals and cereal products
2) Pulses (also meat and meat products)
3) Milk and milk products
4) Vegetables and fruits
5) Nuts and oil seeds
6) Fats and oils, and
7) Sugars

An easy way to understand the balanced consumption of these seven food groups is represented as four steps to a healthy diet. Our daily diets for maintaining good health should be made up of generous amounts of vegetables and fruits, adequate amounts of cereals, pulses, milk and milk products, moderate amounts of meat and flesh foods and limited quantities of fats and oils, nuts and oil seeds and sugars. The figure below shows general dietary guidelines for Indians, which provide a foundation to nutrition and health.

EAT SPARINGLY	**Fat, Oils & sugars**
EAT MODERATELY	**Meat & flesh foods**
EAT LIBERALLY	**Vegetable & Fruits**
EAT ADEQUATELY	**CEREALS , PULSES, MILK**

Refer to table no.1.5.1c for the food pyramid

1.5.2 Malnutrition

Malnutrition is a state of improper nutrition balance in the body. While some people eat less than what they need others consume too much. Inadequate intake of food or a specific nutrient leads to under nutrition, while over nutrition means that a person eats more food than he/she needs. Both under nutrition and over nutrition are two manifestations of malnutrition.

Under nutrition:

Under nutrition affects growth in children, their physical and intellectual capacity and work performance as well as resistance to infection. It may even determine how long a person lives. Food is vital to life. If a child does not have enough food, it will not grow as it should. Naturally, such a child will be smaller in stature. If the deprivation is in the first two or three years of life, the child's brain will not grow fully. In addition, bones will not harden and new bones will not form.

An individual's capacity to work and perform depends on he or she being in the best state of health. Hungry children cannot concentrate on their studies. Lack of sufficient food may reduce the desire or motivation to work. Under nutrition, therefore, can compromise physical, intellectual and emotional performance. Deficiency of a single nutrient also has similar effects. People who have inadequate food are generally thin and underweight. Food provides with substances that protect us against disease. Undernourished people will not be able to resist infection effectively. If we are ill , we do not feel like

eating much. The more severe the illness, the greater will be our lack of appetite and the less our food intake. At the same time our body needs more food in order to combat infection. If we have diarrhea or worms, we will not be able to absorb nutrients as we do normally. This will eventually lead to under nutrition and diseases.

Over nutrition and obesity:

Over nutrition is consumption of more food than we need. The most common problem of over nutrition is overweight and obesity. When we consume more energy than we spend, i.e. more than we need, our body stores the extra energy as fat.

A comparison of weight is done with standard tables, which gives "ideal" weight according to height, age and sex. If weight is more than 10 per cent above the 'ideal" weight, then the person is considered overweight and if it is 15 or 20 per cent more, then obese. Over nutrition and obese people tend to suffer from hypertension, stroke, diabetes, heart disease etc. They feel uneasy because of excess fat around their chest and tire easily. Fat people may also die at a young age.

Reducing the amount of food so that the energy intake is less than energy expenditure is the best way to counter overweight problems. One kg of fat in the body stores 7700 kcals. One can lose this extra kg of weight in two weeks by consuming 500 kcals less. These 500 kcals can be reduced by curtailing one's intake of oily foods, sweets, starchy foods, and if necessary, some cereals and dals. Such a person can be advised to have a well balanced diet when he is trying to reduce weight. One should also be advised to do some exercise and be active so that he increases his energy expenditure.

Refer to table no. 1.5.2a for weight for height for males (overweight & underweight limits)

Refer to table no. 1.5.2b for weight for height for females (overweight & underweight limits)

Detection of malnutrition:

Apart from physical symptoms and diet assessment, malnutrition has to be assessed clinically before prescribing diet changes.

One of the first steps in detecting malnutrition is to check the person's diet. This is then compared with the daily food guide. This will show whether one is getting too little or too much of a particular food group. Next, the weight of the person is compared with the standard available. If the person is slightly underweight it may not matter much, but if he is drastically underweight, it means that he is undernourished. Next simple physical check up of the person's mouth, skin, eyes, inner lining of the eyelids, tongue and lower limbs is done. Lack of many nutrients affects these parts of the body. If the skin is rough and scaly or if there are cracks at the corners of the mouth, cracks on the lips, bleeding gums, it could be due to lack of several vitamins. If the inner lining of the eyelid is pale, the person could be anemic. All these changes occur because of taking insufficient food.

1.5.3 Nutritional status

Nutritional status is the level of nourishment of our body. Each of us would like to have a good nutritional status. So far, we have learnt that nutrition affects our body size, our brain development, our performance, our capacity to work and life span. Nutritional status shows the kind of nourishment our body gets from the foods we eat. If foods provides for our body's needs optimally, we look and feel healthy and enjoy a good nutritional status.

Indicators of good nutritional status are:

1. Measurement of body size:

We have learnt that body weight and height indicate our body size. In addition, the head, chest and mid arm circumferences give an idea of growth and development, especially of small children (0-5 years). Therefore, we record these body measurements at various stages of development to study the growth pattern and check the nutritional status.

- **Weight:** Weight is a commonly used indicator of body size, as it reflects the level of food intake.

  The weight of children is recorded regularly to check if there is a normal gain. The weight can be plotted against age to see if the pattern of growth is normal, by comparing it with the normal curve. If a child fails to gain weight, and does

not follow a normal pattern of growth, we must find the reason and take remedial action. We can do the same with adults by comparing their weights with their corresponding heights in order to know their nutritional status.

Linear Measurements: Measurements of height, circumferences of head, chest and mid-arm, and skin fold thickness are also known as linear measurements.

2. Dietary assessment:

We have learnt that nutritional status is affected by the amounts and kinds of foods we normally eat. We take physical measurements to assess the nutritional status (condition). If the condition is not satisfactory, we will want to modify the diet. This is done by assessing the present food intake pattern of the individual to be able to modify it suitably. Hence, the dietary assessment needs to be carried out.

When and How to Record Food Intake:

We need to know the normal or habitual pattern of food intake. Therefore, we select three normal working days to record the food intake, which does not include Sundays, holidays, festivals as generally these days have special menus, and the schedule of eating is different. We write down the foods they eat each day at each meal. The snacks, fruits and beverages they take between the meals or with the meals are also recorded. Record the amount of each preparation eaten and also the time when it was eaten. The amount can be recorded in volume or weight. Later we can convert all the amounts into weights.

Evaluation of Food Intake Data

We can evaluate the food intake to check how the food selection compares with the daily food guide. This is qualitative check and will help to identify if any of the food groups are missing from the day's intake. Secondly, one can compare the amounts of foods taken with the suggested minimum number of servings to see if the amounts of foods included are insufficient. This evaluation will help to decide what changes need to be made in the diet to improve the nutritional status.

1.6 SUMMARY

Consumption of nutritious diet in right (ideal) amount and proportion helps in maintenance of good health. Therefore, a good knowledge and understanding of the food sources of these various nutritional components, their metabolism, and their requirements for different age and physiological groups is an essential prerequisite for maintaining good health. This course is an attempt to provide this knowledge and skills.

The last three decades has seen a tremendous progress in nutrition. Although the importance of nutrition in growth, development and the prevention of nutritional deficiency diseases was well recognized it is only in the last three decades that the frontiers of nutritional science has expanded to include newer and more dimensions of health such as prevention of chronic degenerative diseases, retardation of ageing and promotion of mental well being.

Human beings require a large number of nutrients, about 40, for many of which the requirements are well established. In addition, recent advances have shown that the diet components like carotenoid pigments, phenolic compounds, flavonoids, anthocyanins, lignins etc.are bioactive compounds with a potential role in the prevention of degenerative diseases and in detoxification.

The earlier dictum that if the diet provided adequate energy to meet our requirements, then it is likely to be adequate in other respects, is no longer true. We have to make conscious efforts to have a healthy diet. If we are a nutrition professional or a dietitian, then we also 'have the responsibility of planning diets for others both for health and in diseases and in addition, we will be counseling a large number of people on appropriate diets.

1.7 GLOSSARY

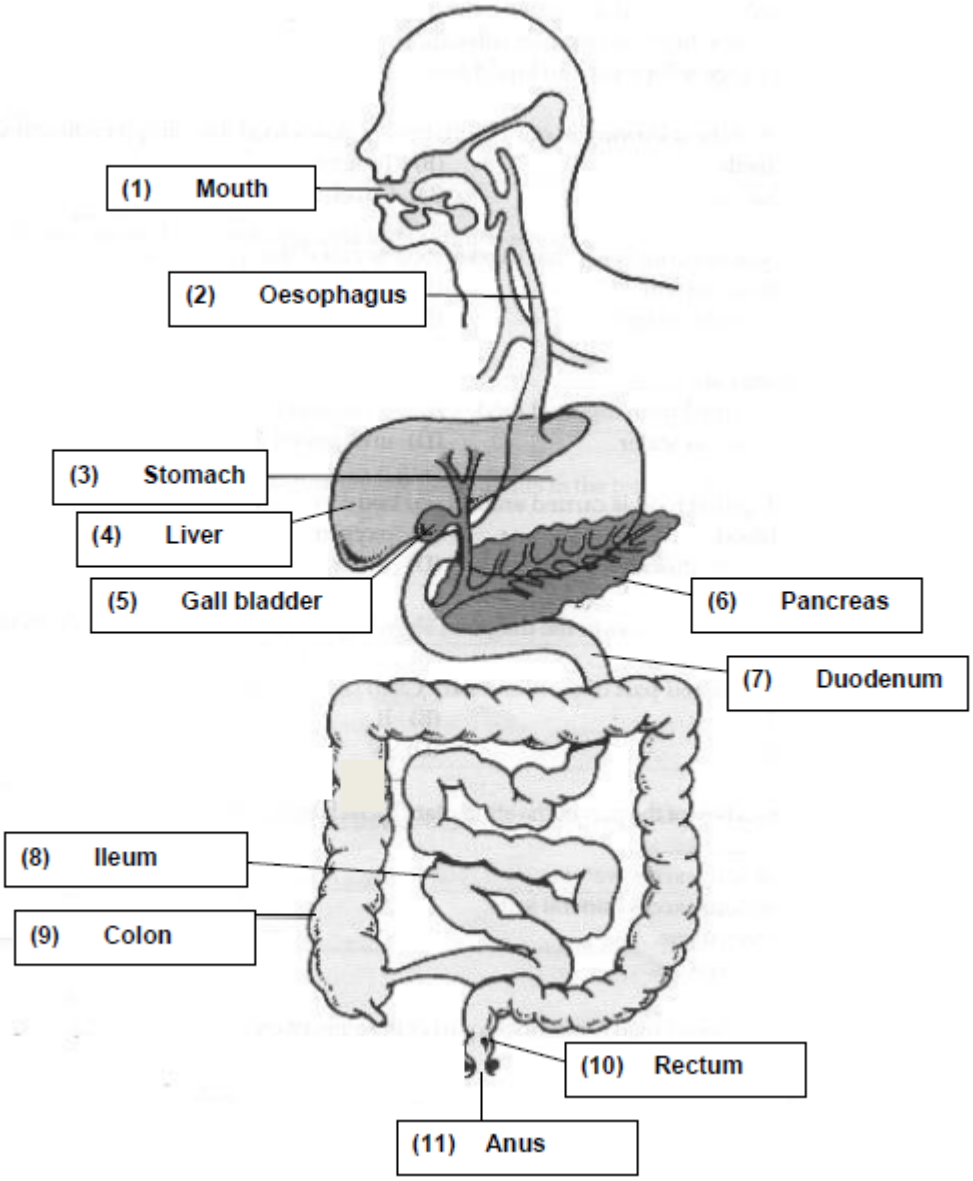
Words	Meanings
Absorption	The uptake of the products of digestion through the cell membrane of the digestive tract into the blood and lymph circulation.
Calorie	One calorie is the amount of heat required to raise the temperature of 1litre of water through 1°c. The unit used in Nutrition & Food Composition tables is kilocalories (kcal). It is 1000 times the unit of calorie used in Physics.
Diet	(Noun)-All the foods eaten and drinks taken (Verb)-to eat only prescribed foods.
Digestion	Mechanical and chemical breakdown of food to simple substances which can be absorbed and used by the body cells.
Essential fatty acids	Fatty acid that cannot be synthesized by our body and thus has to be supplied by our diet.
Glycogen	Chief storage form of carbohydrate in human beings and animals. Found mainly in liver and muscles.
Health	State of complete physical, mental and social well-being and not just absence of disease or infirmity.
Nutrient	A substance essential for the growth, maintenance, function and reproduction of a cell or organism.
Regulation of body temperature	Ensuring that the normal body temperature is maintained (about 37C).
Respiration	The exchange of oxygen and carbon dioxide in the lungs, between the cell and its surrounding which ultimately releases energy.
Solvent	A medium in which other substances dissolve.
Vitamin	Organic compound occurring in minute amounts in foods and essential for metabolic reactions.

1.8 CHECK YOUR PROGRESS.

1. Define food and nutrition. (refer to point no. 1.2)
2. Describe the functions of food. (refer to point no. 1.3)
3. What influences formation of food habits? (refer to point no. 1.3.4)
4. What is food misinformation? Give a few examples.(refer to point no.1.3.5)
5. What are nutrients and what are their functions?(refer to point no. 1.4)
6. List the nutrients provided by food and an important source of each nutrient.
   (refer to point no. 1.4.2 and 1.4.3)
7. Water is an indispensable nutrient. Why? (refer to point no.1.4.3)
8. List two functions of proteins and minerals. (refer to point no.1.4.3)
9. How is food assimilated in the body? (refer to point no.1.4.4)
10. Differentiate between normal nutrition and mal nutrition.(refer to points 1.5.1 and 1.5.2)
11. What is malnutrition and its manifestations? (refer to point no. 1.5.2)
12. What is nutritional status and how is it measured? (refer to point no. 1.5.3)
13. How can over nutrition led to diseases? (refer to point no. 1.5.2)

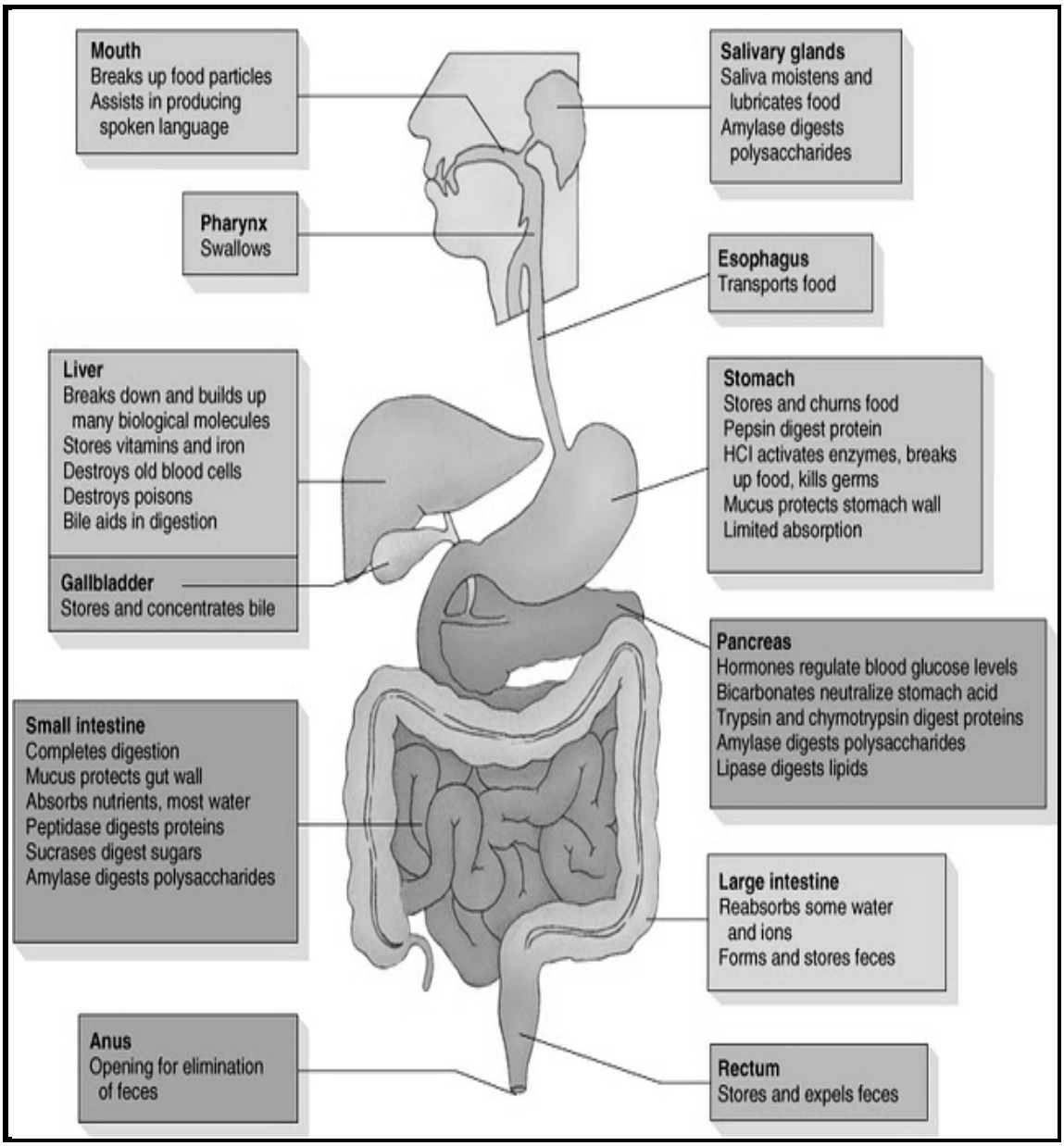
ANNEXURE - 1

Figure 1.4.4a **The digestive system**



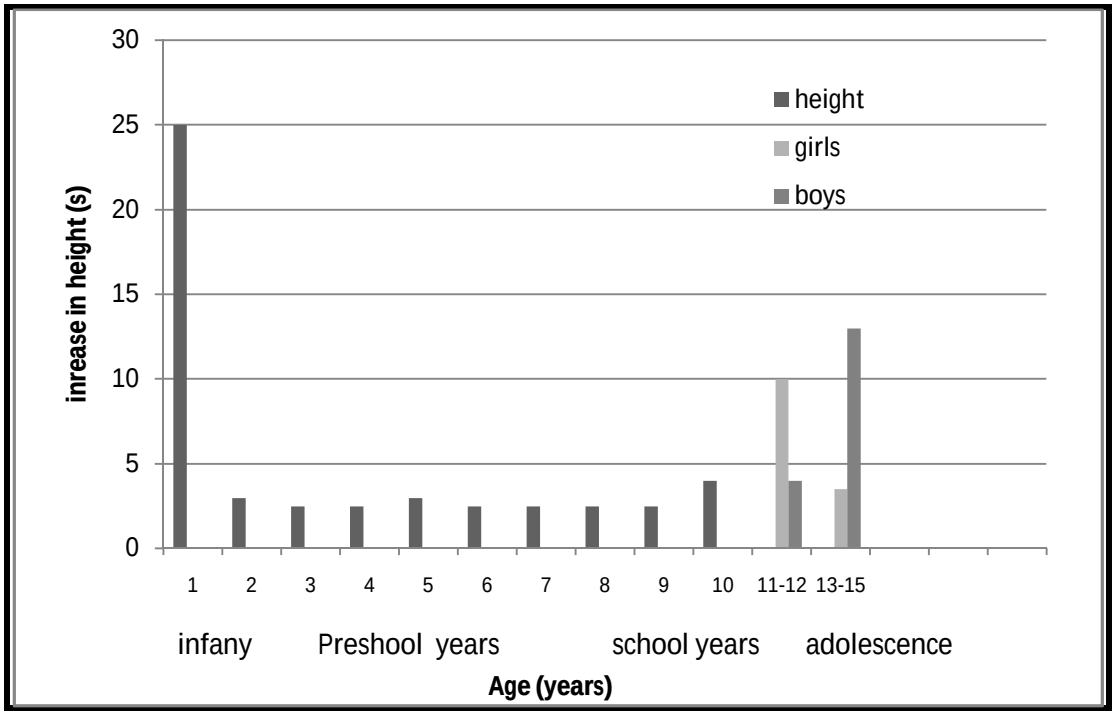
Source: www. http://digestive.niddk.nih.gov/

Figure: 1.4.4b **Digestion and absorption of food**



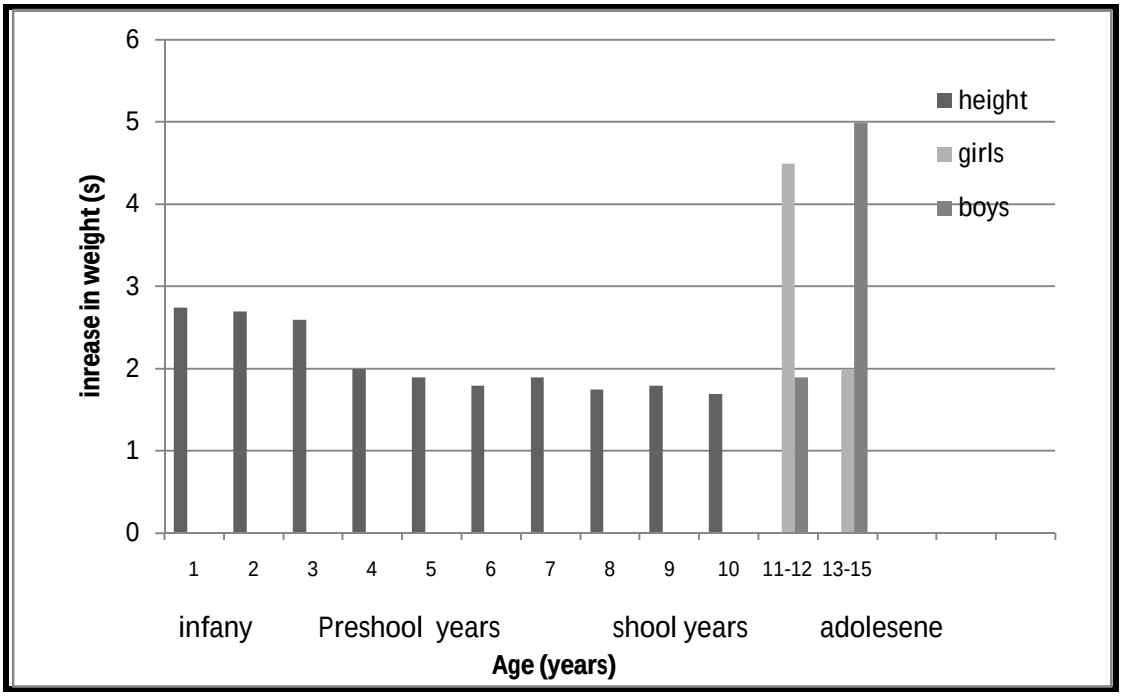
Source: www. http://digestive.niddk.nih.gov/

Table no. 1.5.1a Growth of Children at Different Ages (height)



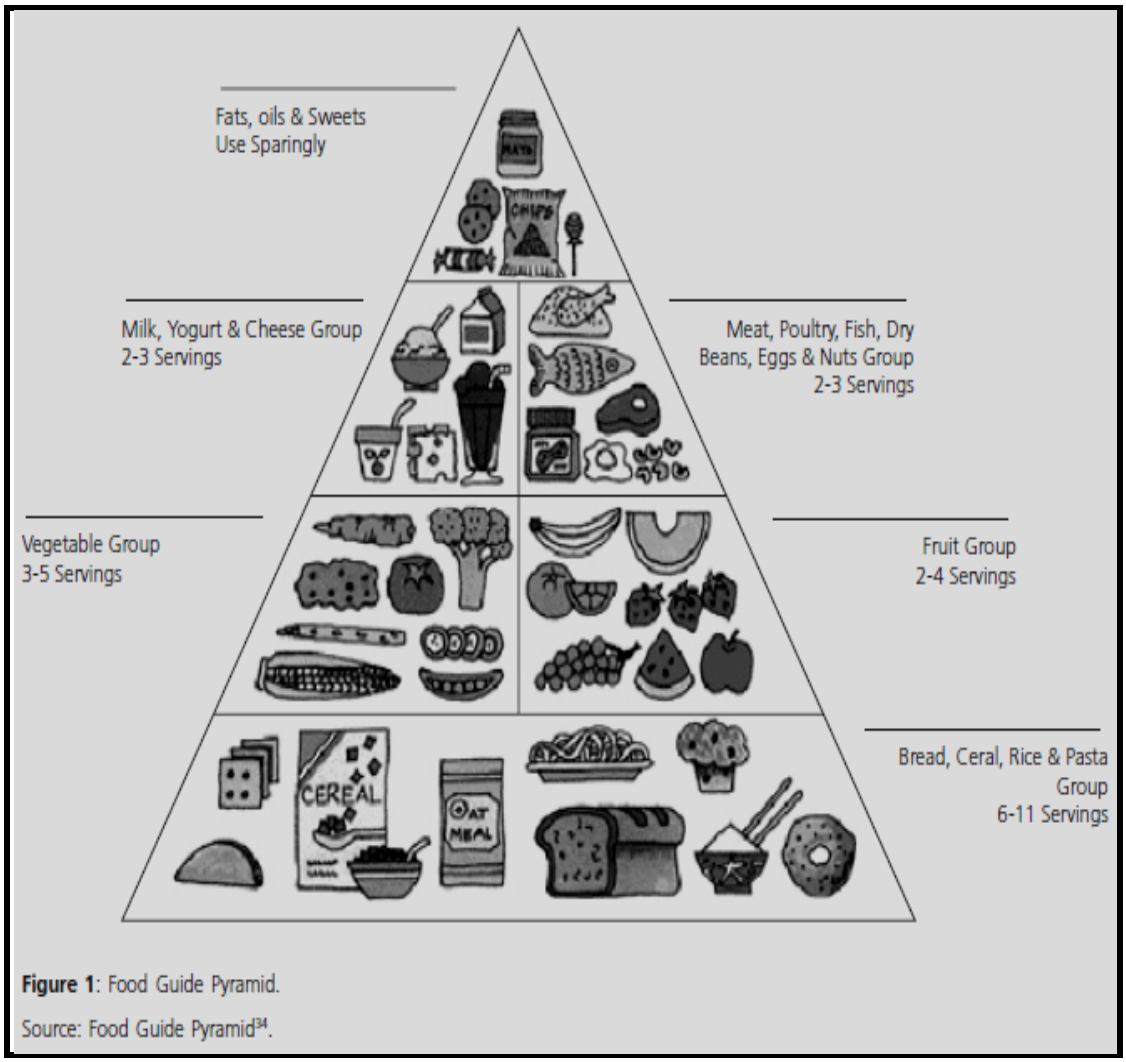
Source: Manual of ICDS, New Delhi

Table no 1.5.1b Growth of Children at Different Ages (weight)



Source: Manual of ICDS, New Delhi

Figure no.1.5.1c **The food pyramid**



Source: http://www.diabetesdiabeticdiet.com/food_pyramid.htm

Table no.1.5.2a **Weight for height for males**

(Overweight & underweight limits)

Height (cm)	Weight (kg)	Overweight limit (+20%) (kg)	Underweight limit (-20%) (kg)
148	47.5	57.0	38.0
152	49.0	59.0	39.0
156	51.5	62.0	41.0
160	53.5	64.0	43.0
164	56.0	67.0	45.0
168	59.0	71.0	47.0
172	62.0	74.5	49.5
176	65.5	78.5	52.4
180	68.5	82.0	55.0
184	72.0	86.5	57.5
188	75.5	90.5	60.5
190	77.5	93.0	62.0

Weights have been rounded off to the nearest half kilogram. Overweight and underweight limits are calculated from weight in column 2, by adding or subtracting 20%

Table no. 1.5.2b **Weight for height for females**

(Overweight & underweight limits)

Height (cm)	Weight (kg)	Overweight limit (+20%) (kg)	Underweight limit (-20%) (kg)
148	46.5	56.0	37.0
152	48.5	58.0	39.0
156	50.5	60.5	40.5
160	52.5	63.0	42.0
164	55.0	66.0	44.0
168	58.0	69.5	46.5
172	60.5	72.5	48.5
176	64.0	77.0	51.0
180	67.0	80.5	53.5
184	70.5	84.5	56.5
188	74.0	89.0	59.0

Source: Life Insurance Corporation, agent's manual

UNIT 2 Classification, composition and sources of ENERGY YIELDING FOODS and BODY BUILDING FOODS.

Structure

2.0 Objectives

After completing this unit, you will be able to:

- Differentiate between different kinds of foods (energy yielding and body building)
- Identify their sources
- Understand the composition of these foods and their effect on the human body
- Evaluate their role in nutrition, and their digestion, absorption and utilization in the body,
- Understand their roles in health and certain disorders.

2.1 Introduction

So far, we have learnt about the needs of the body and the role of food in fulfilling those needs. Food being the most important thing for survival after air and water, it is hence important for us to understand its components and their effects in human body and its functioning. In this unit, we shall learn about the classification of food, their composition, function and sources. This study shall also provide the basis for planning menus and modifying diets for normal individuals as well as patients.

Classification of foods:

All foods are classified into three broad categories:-

- Energy yielding foods (Carbohydrates and Fats)
- Body building foods (proteins)
- Protective and regulatory foods(vitamins, minerals and other foods)

We will learn about energy yielding foods and body building foods in this chapter.

Energy yielding foods as the name suggests provide your body with energy to perform all tasks (voluntary or involuntary). These foods contain energy giving nutrients like carbohydrate and fats. To some extent protein in the body can also be used by the body to generate energy but that happens only in cases where there is shortage of the other two nutrients. While carbohydrates are an instant source of energy, fats are concentrated form of energy and are stored as reserves as body fat and used when required.

Body building foods are which help an infant to grow into an adult and an adult to maintain health. Such foods are protein rich foods as they perform the vital function of growth, repair and maintenance of your body. They include dairy products, meat, fish and poultry and soya bean.

2.2 Classification of Carbohydrates

Energy must be supplied regularly to us through the diet for our survival and maintenance of life and to carry out all activities jointly termed as work. Our body derives energy from the catabolism of energy-yielding nutrients: carbohydrates, lipids and proteins. Among these, carbohydrates are the single most abundant source of dietary energy comprising 50-70% of the total energy intake in different populations. We will learn about the different types of carbohydrates, their utilization by the body and how glucose homeostasis is maintained. In addition, the health benefits of dietary fiber and carbohydrates not absorbed in the small intestines will also be covered in this unit.

Carbohydrates are divided into three major groups:

- Sugars,
- starches,
- Cellulose and related material.

Carbohydrates are compounds of carbon, hydrogen and oxygen and their chemical structures are all based on a common unit of glucose. The units are linked together in many ways and in different numbers to form different carbohydrates. The classification of carbohydrates depends primarily on the number of units, which may vary from one to many thousands. While sugars and starches are a major source of your food energy, cellulose is one of the main constituent of dietary fibre found in food.

2.2.1 Sugars

- Monosaccharide or simple sugar:
  - Glucose, also known as dextrose is found naturally in fruits and plants juices and in the blood of living animals. Most carbohydrates in food are ultimately converted to glucose after digestion. Glucose can also be manufactured from starch by the action of acid or specific enzymes. Artificially manufactured glucose syrups also known as liquid glucose are used to manufacture foods like soft drinks, jams and sugar confectionary.
  - Fructose also occurs naturally in some fruits and vegetables and especially in honey. It is the sweetest sugar. It is also a component of sucrose and is also present in commercial 'high fructose' syrups.
  - Galactose is a part of lactose and does not occur in free state.
- Disaccharides

  Disaccharides consists of two monosaccharides linked together minus the elements of water.
  - Sucrose occurs naturally is sugar cane and sugar beet and in lesser amounts in fruits and some root vegetables like carrots. It is chemical combination of glucose and fructose. The 'sugar' that we eat, whether white or brown and essentially pure sucrose.
  - Maltose is a combination of 2 glucose units and is formed during the breakdown of starch by digestion. Malt is also formed when grain is germinated for production of malt liquor(beer).
  - Lactose is a combination of glucose and galactose and occurs only in milk, including human milk. It is less sweet than sucrose or glucose.
- Properties of sugars
  - All sugars (monosaccharides and disaccharides) dissolve in water and are varying sweet in taste. They form white or colourless crystals and their taste can be modified by cooking (caramelization). Sugars are a readily available source of energy and sweetness and also widely used in food industry like jam making, canning, freezing (as preservatives), biscuits, cakes, soft drinks, chocolates (to provide texture and consistency).

2.2.2 Starch

Starches are polysaccharides are composed of large number of glucose units linked together to form both straight and branched chains. They exist in granules of a size and shape characteristic for each plant. So the starch of a potato is different from the starch found in flour 9wheat0. In the raw form they are indigestible but when heated or cooked in the presence of water, the starch granules swell and eventually gelatinize. This makes them more easy to digest.
Glycogen is similar to starch in composition but is made from glucose only by animals and not by plants. Small amounts are stored in the liver and muscles which act as an energy reserve.

2.2.3 Cellulose and related materials

These polysaccharides provide structure to vegetables, fruits and grains and make them rigid and fibrous. These structures enclose the starch granules. They are insoluble in water. Together with lignin (which is not a carbohydrate), they are the main component of dietary fibre. Cellulose consists of many thousands of glucose units. It cannot be digested by man, but is a food of cows and other nutrients. Cellulose and certain other indigestible polysaccharides add bulk to faeces because of their water binding capacity and assist in passage of indigestible materials and waste products through the intestines which is very important to human health.

2.2.4 Sources and functions of carbohydrates

Sources: Plants form sugars in their leaves by the action of sunlight and store them in their roots, stems, tubers, and seeds as starch. This starch is a major energy reserve for most plants and thus in turn provides a major part of man's food energy as well. Apart from sugars like lactose and fructose which are available from milk and fruits and honey respectively, other sugars would not have been available through diet without the addition of sucrose and glucose syrups in jams, cakes, biscuits, ice cream etc.which are a part of our daily diet today.
Hence main sources of
Sugars in diet are sugar, sweets, chocolates, milk, fruit, fruit products, biscuits, cakes and main sources of
Starches are bread, potatoes, cereal products
Fibre are vegetables and cereal products.

Refer to Table 2.2.4 for different types of carbohydrates and their sources.

Functions: Carbohydrates in the body function primarily in the form of glucose, although a few have structural roles. Important functions of carbohydrates are:

- ***Source of energy***: Glucose is a major source of energy for all the body cells. One gram of carbohydrate provides 4 Kcal. RBCs are particularly dependent on glucose. It is also indispensable for the maintenance of functional integrity of the nerve tissue and under normal circumstances; it is the sole source of energy for the brain. Similarly, glucose is important for heart muscles. Although fatty acids are the preferred regular fuel of heart muscle, glycogen in cardiac muscle is an important emergency source of contractile energy. In a damaged heart, poor glycogen stores or low carbohydrate intake may cause cardiac symptoms of angina.
- ***Protein sparing effect***: Carbohydrates help in regulating the protein metabolism. Presence of sufficient carbohydrates to meet energy demands prevents the channeling of too much protein for this purpose. This protein sparing action allows the major portions of protein to be used for its basic structural purpose of tissue building. Therefore, patients who are unable to eat are temporarily administered 5% glucose solution intravenously.
- ***Antiketogenic effect****:* Presence of carbohydrates is necessary for normal fat metabolism. In the absence of sufficient carbohydrates, larger amounts of fat are used for energy than the body is equipped to handle. This results in incomplete oxidation and accumulation of ketone bodies. This may in turn lead to acidosis, sodium imbalance and dehydration. In extreme conditions such as starvation (carbohydrates are inadequate) and uncontrolled diabetes (where carbohydrates are unavailable for energy needs), ketoacidosis is a common complication.
- ***Excretion of toxins****:* Glucuronic acid, a metabolite of glucose, combines with chemical and bacterial toxins and some normal metabolites in the liver and thereby helps in their excretion.

- ***Act as precursors****:* Carbohydrates and their derivatives serve as precursors to compounds such as nucleic acid, connective tissue matrix and galactoside of nerve tissue.
- ***Overall positive health****:* Non-glycemic carbohydrates including non-starch polysaccharides are beneficial for the function and physiology of gastrointestinal tract and thus have a positive effect on the overall health.

2.2.5 Digestion and Absorption

Dietary carbohydrates, which are primarily present as polysaccharides (starch) followed by disaccharide and free monosaccharide, supply 60-70% of energy to the body. However, monosaccharides are present in very small amounts in our diet. To be absorbed from the gut, carbohydrates must be broken down to their constituent monosaccharide units. Let's see how these carbohydrates are digested in the gut.

Refer to Table 2.2.5 for Digestion of carbohydrates.

Glucose and galactose are absorbed into the mucosal cells. Glucose and galactose cannot attach to the carrier until it has been preloaded with sodium as illustrated ill Figure 3.2. Hence, you would realize that oral rehydration syrup (ORS) always contains sodium chloride and glucose / sugar. *Fructose* is absorbed by a *facilitated transport,* involving a specific transporter- GLUT-5.GLUTS or human glucose transporters are the integral proteins, which penetrate and span the lipid bilayer of plasma membrane.

Following absorption, the monosaccharides enter the portal circulation and are carried to the liver. Both galactose and fructose are converted to glucose in the hepatocytes. A part of glucose is converted into glycogen while some is catabolized for energy in the liver. The remainder of glucose passes on into the systemic blood supply and is distributed among other tissues such as skeletal muscle, adipose tissue and kidney.

Glycemic Index

We know that some carbohydrates are rapidly digested and absorbed, some are digested slowly while some are not digested at all. Thus, it is obvious that different carbohydrates will raise blood glucose levels to a different extent. *The ability of carbohydrates to raise blood glucose is, referred to as "Glycemic Index" (GI).* GI is a quantitative assessment of foods based on postprandial blood glucose response (i.e. blood glucose level after a meal) expressed as a *'percentage of the response to an equivalent carbohydrate portion of a reference food'.* The reference food is white bread with a GI set at 100.

Knowing about GI of foods helps us in prescribing therapeutic diets like diabetic and energy-controlled diets You would realize that the dietary GI provides an indication of the rate at which, carbohydrate foods are digested. It allows ranking of foods from those which give rise to the highest blood glucose and insulin responses (high glycernic food) to those associated with the lowest blood glucose and insulin responses (low GI foods).High GI foods lead to a rapid rise in blood glucose and insulin levels. Hyper- insulinemia in turn may down regulate insulin receptors and therefore reduce insulin efficiency resulting in insulin resistance. On the contrary, low GI foods result in reduced peak insulin concentrations and reduced insulin demand thus decreasing the risk of type I1 diabetes.

The health benefits include reduced insulin demand, improved blood glucose control and reduced blood lipid levels. All these factors play an important role in the prevention and management of chronic diseases including diabetes, coronary heart disease and certain cancers

2.2.6 Nutritional requirement and health aspects

In our daily diet almost 60-70% of energy is contributed by carbohydrates. Majority of them are comprised of starch (from cereals, millets, pulses and root vegetables), while a small amount is also contributed by sucrose (sugar), glucose and fructose (fruits), as well as, lactose (milk and milk products).

In certain disorders changes need to be made.

- ***Lactose intolerance****: I*n case of lactose intolerance, the ingestion of lactose leads to passage of the sugar to the large bowel, where it is fermented to produce SCFA and gases, which causes discomfort. Lactose is present in dairy products such as milk, cheese, yoghurt, ice cream etc. Hence, these foods need to be avoided.

- ***Diabetes mellitus**:* Diabetes may be diagnosed as an exaggerated response in blood glucose concentration following ingestion of a fixed amount of glucose (glucose tolerance test). The most common forms of diabetes are *insulin-dependent diabetes mellitus (IDDM or type I diabetes) and non-insulin-dependent diabetes mellitus (NIDDM or* type 2 *diabetes)*.IDDM results from the autoimmune destruction of the a-cells the endocrine pancreas, the consequence of which is insulin insufficiency. In this, the patient requires exogenous supply of insulin. The amount of carbohydrate and frequency of feeding is modified and depends on the insulin dose, type of insulin and the weight of the person.

Health aspects:

The main work of all sugar and starches (carbohydrates) are to provide energy to the body but they also have physiological impact as well. Excessive consumption of sugars is associated with tooth decay, obesity, heart diseases and bowel diseases like appendicitis and bowel cancer. However, when low fat diets are eaten, energy can be supplied by fiber rich starchy foods rather than sugar diets. For some people especially children, digesting lactose is a problem and results in digestive disturbances. This is also known as lactose intolerance.

Blood glucose regulation:

Normally after a meal, when blood glucose levels increase, the peptide hormones (such as cholecystokinin) secreted from enteroendocrine cells within the mucosa of the small bowel amplify the response of the b-cells of pancreas resulting in the secretion of insulin. Insulin facilitates the transport of glucose by glucose transporter - GLUT 4 into the adipocytes and muscle cells and stimulates glycogenesis (synthesis of glycogen) and fatty acid biosynthesis, thus returning the blood glucose to homeostatic level.

This is when the glucose level is high in blood. However, when glucose level falls in case of post absorptive state, the fall in blood glucose level signals the reversal of the pancreatic hormonal secretion i.e. decreased insulin and increased glucagon release. Blood glucose levels are maintained by the breakdown of glycogen and in this way, the glucose demands of brain, RBCs and testis are met.

Too much of fluctuation in this process leads to diabetes.

Diabetes, which is a metabolic disorder and effects the normal lifestyle of an individual is also related to the amount of glucose in the blood. Diabetics have to monitor and control their total carbohydrate intake in order to keep diabetes under check.

Refer to table 2.2.6 for regulation of blood glucose

Carbohydrate malabsorption: Carbohydrates malabsorption is usually caused by *an* inherited or acquired (intestinal infection, celiac disease, PEM) defect in the brush border *oligosaccharidases,* the most common being 'lactose intolerance'. In such individuals, ingestion of lactose leads to passage of the sugar to the large bowel, where it is fermented to produce short chain fatty acids (SCFA) and gases. In humans, lactase activity declines as individuals grow.

2.3 Classification of Fats

Here we will learn in detail the types and functions of fats and oils, their requirements and significance in our overall health. Today changing dietary patterns and sedentary lifestyles are leading to high risk of some diseases, especially heart diseases. On the other hand, smart decisions on qualitative and quantitative aspects of fat in diet can in fact prevent the onset of certain diseases associated with today's lifestyles.

At the end of this unit, there are self assessment exercises to recapitulate various dimensions of knowledge regarding dietary fats and oils. You will acquire adequate skills and confidence to prescribe fats and oils to any community. Tips are given to reduce fat intake in diets which will come handy in counseling patients of obesity, heart diseases, diabetes and cancer. You will be able to modify fat intake of patients with fat malabsorption and liver diseases.

Fats and oils, are also chemically known as lipids. ***Lipids which are solid at room temperature are referred to as fats and those which are liquid at room temperature are called oils.***

In nutrition textbooks, fats and oils are referred in diets and lipids are referred in body fluids, like, serum lipid profile. Chemically, lipids are the organic molecules poor in oxygen content, soluble in organic solvents but insoluble in water. They are classified as:

- Simple lipids
- Compound lipids and
- Derived lipids

Let us get to know each one of these.

- ***Simple lipids*** are fatty acid esters of glycerol, called *triacyglycerols* or *triglycerides* (for e.g. fats and oils) or higher alcohols (for e.g. waxes).Triglycerides is the major form of lipids present in human diets. They are the major sources of fatty acids to the body.
- ***Compound lipids*** are the simple lipids which combine with proteins (lipoproteins), carbohydrates (glycolipids), phosphates (phospholipids) etc.
- ***Derived lipids*** refer to fatty acids, glycerol, cholesterol and other derived compounds including fat-soluble vitamins, hormones and bile. Man can synthesize cholesterol in the body but some amount also comes from the diet. Cholesterol is present only in foods of animal origin.

Nature of fatty acids present in the triglyceride determines the physio-chemical properties and biological significance of the lipid. Triglycerides made of saturated fatty acids are solids at room temperature and are called *fats.* If unsaturated fatty acids are present, they are liquid at room temperature and are called *oils.* What do we mean by *saturated* and *unsaturated* fatty acids? Let us understand fatty acids in a little more detail.

2.3.1 Fatty acids

Fatty acids are categorized as:

- Saturated and Unsaturated, -
- Short chain, medium chain and long chain,
- Essential fatty acids, and
- Trans-fatty acids.

These categories are more suitable from the nutritional standpoint of view and are not essentially exclusive as the fatty acids may overlap in these categories but their applications in normal and therapeutic diets warrants this classification. For example, a dietitian prescribes medium chain triglycerides in liver disorders but on the other hand, saturated fatty acid intake should be limited in normal diets for prevention of heart diseases.

So, then, let us now get to know them.

Saturated fatty acids (SFA) are those fatty acids which lack double bond, like palmitic acid (16:0), stearic acid (18:O) etc. Animal fats, coconut oil, palm oil and vanaspati are good sources of SFA.

Monounsaturated fatty acids (MUFA) contain a single double bond.

The examples include palmito oleic acid (16: 1) and oleic acid (18: 1). Its sources are olive oil, canola oil, groundnut oil, rice bran oil, red palm oil and sesame oil.

Polyunsaturated fatty acids (PUFA) contain more than one double bond in their structure. These double bonds can be counted from **-COOH** end or **-CH3** end. ***Linoleic***

acid (C18:2, n-6) and ***Linolenic*** acid (18:3, n-3) are essential fatty acids, which are

not synthesized in the body. They are obtained from oils rich in PUFA content. PUFA is present mostly in vegetable oils but fish oil is particularly rich. Linoleic acid is also known as as omega 6 fatty acid and linolenic acid as omega 3 fatty acid.

.

Short chain fatty acids are less than six carbon chain length i.e. smaller than caproic acid (C6:O). Butter contains small chain fatty acids. They are also obtained during fermentation.

Medium chain fatty acids are 6-10 carbon chain length. They are present in butter and coconut oil. They are recommended in liver disorders due to ease in their absorption.

Long chain fatty acids contain more than 12 carbon chain. Essential fatty acids are all long chain fatty acids.

What are essential fatty acids and their roles in our body?

Essential Fatty Acids (EFA)

There are two essential fatty acids - *linoleic* and *linolenic acid* as mentioned above. Their structures are depicted in Box 5.2. They are both 18 carbon compounds with more than one double bond. Omega - **3** (n-3) and omega-**6** (n-6) fatty acids need to be derived from the daily diets. These are known to be cardio-protective and are also present in fish oil. Omega 3 and Omega 6 fatty acids are part of vital body structures and have an important role in immune system, formation of cell membrane and in production of hormone-like compounds called *eicosanoids.* These hormone-like compounds include prostacyclins, prostaglandins, thromboxanes and leukotrienes. These compounds are potent regulators of vital body functions like blood pressure, child birth, blood clotting, immune response, inflammatory responses and stomach secretions.

What do we mean by *trans-fatty acids?*

Trans fatty acids

Trans-fatty acids are produced when vegetable oils are hydrogenated to make margarines, partially hydrogenated vegetable shortening and vanaspati. Hence, major sources of trans-fatty acids to hurnan diets are commercially baked products, deep fried snacks in vanaspati and sweets. Small amount of trans-fatty acids are also present in milk fat. Metabolically, trans-fatty acids and saturated fatty acids raise blood cholesterol levels.

Refer to table 2.3.1 for different types of fats and oils & their fatty acids

2.3.2 Sources of fats and functions of fats

Vegetable sources: In plants fats are formed from carbohydrates. When seeds such as sunflower and cottonseed ripen, their starch content decreases as their fat content rises. Oilseeds such as these and ground nuts, coconuts, rapeseeds, palm kernels and soya beans contain about 20 to 40 percent of oil and are chiefly used in manufacture of margarine.

Animal sources: Animals including man store excess energy almost entirely in deposits of fat, the amount of which is variable. Like in plants this fat can be made from carbohydrates. But animals can also lay down fat from their dietary fat. Fat in diet comes mainly from milk and milk products, fatty fish, meat and poultry which are all animal sources.

Functions of Fats:

- Fats contribute to *texture, flavour; taste and increase palatability* of the diet. They provide an effective medium of heat transfer in deep-frying and transfer of flavours from Indian spices.
- Fats have highest *heat energy density of 9 Kcal/g.* It is the major storage form of energy in body requiring least space and minimum water or hydration as compared to protein in muscle.
- Fats are essential for *meeting nutritional needs of essential fatty acids* like linoleic acid (n-6) and alpha linolenic acid (n-3). Saturated fatty acids, monounsaturated fatty acids and cholesterol can be synthesized in the body, hence the diet only adds-on to their total amount available in the body.
- Fats promote *absorption of fat soluble vitamins like vitamin A, D,* E and *K.*
- Fat intake ensures *satiety.* It imparts feeling of fullness and satisfaction and thus delays onset of hunger. In low fat diets, satiety can be ensured by high fibre and fluid intake.
- Fats along with proteins constitute *structural components* of *cell membrane and some body fluids.* Lipoproteins also have an important role in transport of lipids in blood.

- Fats serve as *thermal insulator in the subcutaneous tissues and certain organs.* Some lipids act as electrical insulators allowing rapid propagation of depolarization waves along the myelinated nerves. The fat content of the nervous tissues is particularly high. In anorexia nervosa, the body fat falls dangerously low (< 5%) shows problems in insulation. Body hair stands erect to trap air and simulate insulation.
- Some dietary fats contain *antioxidants.* Most of them contain antioxidants which confer stability to the oil and prevent rancidity. For example, *OryznnoE* (1.2-1.7%) in physically refined rice bran oil helps to elevate HDL, decrease plasma cholesterol, treat nerve imbalance, menopause disorders, retard ageing and acts as anti-dandruff and anti-itching agent. Tocotrienols, tocopherols and squalene are antioxidants conferring oxidative stability to the oil.

2.3.3 Nutritional requirement of fats and health aspects

Just like the other macronutrients, requirements of visible fats for all age groups are computed and guidelines are given for selection of fats. For this, we must consider the total fat intake, which includes both visible and invisible fat in food. Let us take a look at the total fat requirements to meet minimum essential fatty acid requirements in all age groups. We start with adults.

- **Adults**

A desirable amount of a linoleic acid to be consumed by a normal adult is **3en**% (ICMR, 1990). The invisible fat present in the usual Indian foods is high in linoleic acid content (rice, wheat, bengal **gram,** red gram). Hence an average Indian has sufficient linoleic acid in his diet. 5 en% in a 2400 Kcal diet works out to be 12 g / day. This implies that 3 tsp of cooking oil or table fat a day meets adult requirements.

- **Pregnancy and Lactation**

Linoleic acid requirements should be raised to 4.5 en% during pregnancy This can be met from 30 g/d of oil which has >20% linoleic acid. Similarly, linoleic acid requirement during lactation rises to 5.7 en% which corresponds to 45 g oil intake which has > 20% of linoleic acid.

- **Infancy**

Adequate breast-feeding ensures 30 g fat intake by infants, of which 10% is linoleic acid and 1% is linolenic acid, which meets EFA needs of infants of 6-enpercentage. Infants who are weaned completely or partially should be given enough vegetable oil with a high linoleic acid content to ensure 6 en% of linoleic acid. Research indicates that n-3 fatty acids are highly essential for infants as they are particularly important for brain development. Hence it is important to include DHA or docosa-hexaenoic acid .

- **Young and Older Children**

Young children need 3 en%, which can be easily met from 8-10 g of oil in diet. However, more visible oil is needed to improve energy density of diets otherwise cereal based diets become bulky. ICMR (1990) recommends 20 g/d in children's diet from oil which has at least 20% linoleic acid.

Refer to table 2.3.3 for fat requirements of Indians.

Choice of Cooking Medium in Indian Diets

ICMR (1998) has given dietary guidelines to maintain n-6: n-3 ratio of 5:10, which ensures long term health. For ensuring the appropriate balance of fatty acids in cereal-based diets and in the diets of those who do not eat fish and are primarily vegetarians like in the case of many Indian diets, we need to depend on plant foods rich in linolenic acid for ex. wheat, bajra, blackgram, cowpea, rajmah, soybean, green leafy vegetables, fenugreek and mustard seeds .

The choice of cooking oil should be:

a) Moderate linoleic acid content oils like groundnut oil, rice bran oil or sesame oil

Or

Soyabean oil (containing both linoleic and alpha linolenic acid), and

b) Combination of two oils in approximately equal proportion like High linoleic acid oils like sunflower oil, safflower oil and cottonseed oil with palm oil (low linoleic acid)

Or

Mustard Oil.(containing alpha-linolenic acid) along with any other cooking oil (this will reduce erucic acid from mustard oil and thereby its undesirable health effects)

Changing Trends in Dietary Intake of fats

A minimum amount of fat according to guidelines is essential for the body and is calculated above but the fact that diseases like obesity, heart diseases and cancer are on a rise especially in affluent societies can be attributed to the changing dietary and lifestyle practices coupled with stress. Now there is a need to decide on the upper limit of fat consumption as well. Contemporary society is showing nutritional transition and access to fast foods and fried snacks while eating out is in vogue. This leads to an increased intake of saturated fatty acid, milk and milk products, flesh foods and sugar instead of whole cereals, millets and pulses. This is likely to decrease EFA intake from invisible sources and raise SFA. The total calories are also high, especially if accompanied by alcohol consumption.

We have already discussed that fried foods and baked products could be a source of trans-fatty acids. Further, the quality and source of frying oil is not known. May be the oil used is highly reused and abused. It is always better to select dishes prepared by other cooking methods like boiling, steaming, braising etc. than frying for lesser oil intake. *Dish selection* and *behavior modifications* are vital to avoid high fat intake.

Health aspects:

Diseases due to excessive consumption of fat and their preventive methods:

Three diseases have shown close link to excessive dietary fat intake: *obesity, heart diseases* and *cancer.*

- ***Obesity:***

In obesity, cutting down total energy intake or increasing output to ensure energy balance is the basic principle of prevention. Fat being energy dense is always dangerous in large amounts.Selection of foods and modified cooking methods further prevent excessive fat intake. Low fat diets should be given with high fibre and fluid diet to ensure compliance and satiety.

- ***Heart disease:***

Heart diseases show strong links to fat and cholesterol intake. Foods rich in cholesterol are of animal origin .Higher dietary cholesterol increases blood cholesterol but high blood cholesterol with family history does not necessarily gain on cholesterol-free diet. Both drug and low cholesterol diet is recommended. *Vegetable oils have no cholesterol.*

The reference of 'good' and 'bad' cholesterol to dietary fats is in reference to the effect in blood lipids and HDL/LDL ratio. High intakes of n-6 polyunsaturated fats have been associated with the reduced total cholesterol and LDL cholesterol concentrations that are associated with low risk of CHD. In general, epidemiological studies have demonstrated an inverse association between n-6 polyunsaturated fatty acid intake and risk of CHD. N-3 polyunsaturated fatty acids (particularly, eicosapentaenoic acid [EPA] and docosahexaenoic acid [DHA]) have been shown to reduce the risk of CHD and stroke by a multitude of mechanisms:

- by preventing arrhythmias,
- reducing atherosclerosis,
- decreasing platelet aggregation,

- lowering plasma triacylglycerol concentrations,
- decreasing proinflammatory eicosanoids,
- modulating endothelial function and
- decreasing blood pressure in hypertensive individuals.

ICMR (1998) suggests:

- Use more than one source of cooking oil,

- Limit use of ghee, butter and vanaspati,

- Eat linolenic acid rich foods like green leafy vegetables, spices like fenugreek seeds and mustard seeds in a predominantly cereal pulse diet,

- Eat fish more frequently than meat and poultry,

- Limit or avoid organ meats like liver, kidney and brain,

- Skimmed milk and low fat milk is preferred instead of whole milk.

- ***Cancer***

Role of fat in cancer is debatable. High fat intake is indicated as a risk factor to cancer of breast, colon etc. Saturated fat intake is seen as a cause in many cancer events. Cooking in re-used oil produces free radicals in body, which promote carcinogenesis.

Reducing fat intake

- Avoid baked foods except bread. Avoid buttered toasts. Avoid eggs as they are rich in cholesterol.
- Reduce number of cooked preparations. Each Indian preparation needs a lot of fat.
- Modify standard Indian recipe for low fat cooking. Use non-stick pan, less greasy gravy and topping of extra ghee. Dry roasting should be preferred over frying using plenty of ghee..
- Limit non-vegetarian foods, prefer fish.
- Prefer skimmed milk, even in yoghurt, cottage cheese etc.
- Avoid eating out on a regular basis or purchasing food. Do not select fried foods, pizza with extra cheese, creamed soups, fried rice and noodles.
- When eating out, keep in mind hygienic handling and select soups (no cream or butter), sprout salads, fruits, cocktails.
- Prefer cooking methods like steaming, boiling, stewing. Avoid frying. Indian curry making includes frying of onion, ginger and garlic paste in a good amount of fat.
- Among desserts, prefer fresh fruit and non-thickened milk puddings made from skimmed milk. Avoid pastries, ice creams, egg custard, kheer, kulfi etc.
- Aim ***to eat no more than 3 tsp of fat per day through cooking.***

2.4 Classification of Proteins

We know that proteins are essential for maintaining and sustaining life. Proteins contain carbon, hydrogen, nitrogen, sulphur and some also contain phosphorus. Proteins are chains of amino acids held together by peptide bonds, only about 20 different amino acids are used but the number of ways in which they can be arranged is almost infinite. It is the specific and unique sequence of these units which gives each protein its characteristic structural and enzymatic properties. Let us consider the two very familiar proteins. One of them is the egg white protein, which is very sensitive. It denatures on heating, dissolves easily in water and is quite reactive, while the other one is keratin of nails and hoofs, is wholly insoluble, tough and chemically inert and resistant. Hence, it is not easy to classify proteins. Besides classifying proteins on the basis of *soluble* and *insoluble,* proteins have been further classified based on the following attributes:

- **Classification based on chemical nature**

i) Simple proteins (albumin, globulin, glutelin, prolamin, fibrous protein, histones)
ii) Conjugated proteins (glycoproteins, lipoproteins, nucleoproteins)
iii) Derived proteins (metaproteins, coagulated proteins, proteoses, peptones, peptides)

- **Classification based on chemical properties**

i) Monoamino mono carboxylic acids
ii) Mono amino dicarboxylic acids
iii) Diamino mono carboxylic acids
iv) Sulphur containing amino acids
v) Aromatic and heterocyclic amino acids

- **Classification based on amino acid content**

i) Essential (indispensable)
ii) Conditionally essential
iii) Non essential (dispensable)

2.4.1 Amino acids

As we have already discussed proteins are made of amino acids. These amino acids can be broadly divided into two types: essential and non essential. Essential amino acids cannot be made in the body at least in amounts sufficient for health and must therefore be present in the food. Non essential amino acids are equally necessary but they differ in that it is possible for them to be made from any excess of certain amino acids in the diet.

The 8 amino acids essential for adults are:

Isoleucine phenylalanine leucine methionine

Threonine tryptophan valine lysine

And another amino acid histidine is also essential for infants.

The remaining amino acids which are widespread in proteins are:

Alanine arginine aspartic acid cysteine glutamic acid

Glycine proline serine tyrosine

Refer to table no.2.4.1 for classification of amino acids.

2.4.2 Sources and function of proteins

The important sources of proteins in the diets of low-income groups are cereals and legumes but the overall proportion of amino acids in any single vegetable food differ from those needed by man. These proteins are therefore known to have low biological value.Most animal proteins like meat, fish, eggs and milk are important sources of proteins and have high biological value. Oilseeds, oilseed meals and soy are also rich sources of proteins. Because there isno way in which excesses of amino acids can be stored in the body, they can be most efficiently used if a complete assortment is supplied to the body.this can be achieved by eating a mixed diet. Mixture of animal and vegetable protein like cereals with milk, bread and cheese, fish and chips etc provide a sound physiological basis.

Refer to table no.2.4.2 for protein content of some important foods.

Each of the various proteins in the body serves a specific function in the maintenance of life. Any loss in body protein, in reality, means a loss in cellular function. In contrast to lipids and carbohydrates, proteins have no true body reserve. Humans when deprived of or insufficiently supplied with protein, compensate for this dietary deficiency by catabolizing

some, but not all, of their tissue functionality. Cells, tissues, organs and whole systems cannot exist without proteins serving their various functions.

So let us get to know the varied functions of proteins in our body.

- ***Bodybuilding functions of proteins****:* The primary functions of proteins are tissue growth and maintenance. Protein contains amino acids- the building blocks -t hat our bodies use to build and maintain muscles, bone, skin, blood and other organs. Thus, proteins play an important role in growth and body-building.
- ***Protein as an energy source****:* If diet does not furnish enough calories from carbohydrates and fats, proteins contribute to the body's energy need by catabolizing. One gram protein yields 4 Kcal. But it is important to understand that this is not the *major function* of *proteins.* This only happens when the diet does not supply enough energy-giving nutrients.
- ***Proteins as enzymes:*** From conception to death, living cells use oxygen and metabolize fuel. Cells synthesize new products, degrade others, and generally are in a state of metabolic flux. For these processes to occur, catalysts are needed .These catalysts called ***'enzymes'*** are proteins. Enzymes are the largest and the most specialized class of proteins. Each enzyme is unique and catalyzes a specific kind of reaction. In the cell, enzymes are found in cellular compartments (cytoplasm, nucleus, mitochondria, etc.), as well as, the membranes within and around the cell wall. The location of an enzyme is one of its characteristics and dictates, in part, its role in metabolism.
- ***Proteins as carriers:*** A large variety of compounds are carried in the blood between tissues and organs of the body. Some of the compounds require specific protein for their transport. Not only is this specific protein necessary for the transport of compounds insoluble in blood, but it is also necessary to protect these compounds from further reactions that take place during the transport process.
- ***Proteins as regulators of water balance****:* As substrates and solutes are transferred or exchanged across membranes, water has a tendency to flow to maintain equal osmotic pressure on each side of the membrane. If osmotic pressure is not maintained, the individual cells either shrink from lack of internal water or burst from too much. *Albumin* plays a significant role in maintaining the osmotic pressure because of its size and abundance.The protein hormone particularly the Anti-Diuretic Hormone (ADH) plays a role in controlling water balance. The effect of protein is on the distribution of water amongst the various body compartments than on the total body water.
- ***Proteins as biological buffers:*** Proteins have the ability to accept or donate hydrogen ions and by doing so they serve as biological buffers. In blood, there are three important buffering systems - *plasma proteins, hemoglobin and carbonic acid bicarbonate.*
- ***Proteins as structural elements and structural units:*** Proteins function as enzymes, carriers, binding or receptor sites or entry ports for a large variety of materials binding, entering or leaving the cell. Thus proteins serve as the structural and functional units of the cell membrane. Proteins are also important intracellular stnictural units. The most important structural function of protein is related Lo skin and connective tissue. The skin is composed of epithelial tissue which covers not only the exterior of the body but also lines the gastrointestinal tract, respiratory tract and the urinary tract. One of the major protein found in the skin is 'melanin'. *Collagen* and *elastin* are the two distinct types of proteins in the connective tissue. Muscle is composed of *20%* protein, 75% water and *5%* inorganic material, glycogen and other organic compounds. The major proteins in muscle are m*yosin* - a large globular protein, and *actin* – a smaller globular protein.
- ***Proteins as lubricants****:* Tbe mucous of the respiratory tract, oral cavity, vaginal tract and the rectal cavity reduces the irritation which might be caused by materials moving through these passages. This mucous is a mucoprotein, a conjugated protein which contains *hexosamine..* Proteins as lubricants also surround the joints and facilitate their movement.
- ***Proteins in the immune system****::* Proteins such as y-globulin serve to protect the body against foreign cells. The immunoglobulins produced by lymphocytes are large polypeptides having more than one basic monomeric unit.

2.4.3 Nutritional requirement of proteins and health aspects

The FAO/WHO Committee (1973) expressed the protein requirements in terms of egg or milk proteins. The committee defined safe level of protein intake as ***'the amount necessary to meet the physiological needs and maintain the health of nearly all the individuals in a specified age/sex group.*** The term protein requirement means that ***amount of protein which must be consumed to provide the amino acids for the synthesis of those body proteins irreversibly***

catabolized in the course of the body's metabolism'. The intake of nitrogen from protein must be sufficient to balance that excreted; this basic concept is called ***nitrogen balance***. This concept is useful in understanding the minimal need for protein in the diet.

Protein requirement is greatly influenced by many factors such as age, environmental temperature, energy intake, gender, micronutrient intake, infection, activity, previous diet, trauma, pregnancy and lactation. Let us take up each of these factors in detail.

- ***Age****:* Protein in excess of maintenance needs is required, when a new tissue is being formed. Certain age periods, when growth is rapid, require more dietary protein than other periods.Full term infants have indicated that a protein intake of *2.0* to *2.5g/* kg/day is needed for satisfactory weight gain whereas older infants and children, whose growth rate is not as rapid as the premature or new born infant, require considerably less protein (1.25g/kg/day). As growth rate increases during adolescence, the protein needs increase. As the human completes his growth, the need for protein decreases until it arrives at a level which is called the *'maintenance level'.* It is at this level that the concept of body protein replacement by dietary protein applies.
- ***Environmental temperature****: As* environmental temperatures rise or fall above or below the range of thermic neutrality; animals begin to increase their caloric expenditure to maintain their body temperature. An increase in energy needs is accompanied by an increase in the protein requirement for maintenance. In addition, nitrogen is lost during profuse sweating that occurs in very warm environments which accounts for more protein intake in diet.
- ***Previous diet:*** The effects of previous diet in the determination of protein requirements is quite profound. Malnourished people have a higher protein requirement than well-nourished people. Every protein in the body has a function and if some of these proteins are lost, there is a loss in body function. Support for this concept is seen in the reduced ability of protein depleted animals to fight infection or respond to the metabolic effects of trauma.
- ***Physical activity:*** In a number of studies, the athletic performance of subjects could not be directly related to the quantity of protein consumed above the minimum requirement unlike a popular fad that that heavy muscular work required a heavy protein diet. Generally as the energy requirement is increased to support the increase in muscular activity, so too is the protein requirement in much the same manner as described above for the effects of rise in body temperature.

As can be anticipated, males due to their greater physical activity and larger body size have a larger protein requirement than females. Pregnancy, lactation and trauma increase the protein requirements. So, now you realize that a large number of factors play a role in determination of protein requirement.

Refer to table no. 2.4.3 for nutritional requirements of protein for Indians in different age groups and physiological stages as suggested by the ICMR.

Proteins apart from growth, repair and maintenance also lend a hand in providing energy, if such a situation arises. Excesses of amino acids are converted into glucose in the liver or directly oxidized to provide heat and energy. So proteins can be a source of energy, if required.

Newborn infants can absorb proteins intact from their mother's milk, including antibodies that provide protection from infection. On the other hand, there are individuals who are susceptible to reaction with certain other proteins for ex. Those with celiac disease react to gluten and some to cow's milk protein. In addition, some beans like rajmah and soya beans contain proteins, which are harmful unless well cooked.

Deficiency of protein is one of the most common nutritional disorders in the world today and affects both adults and children especially in less developed nations.The symptoms vary and in many situations, it is difficult to separate protein deficiency from energy deficit. In children, one may observe the different symptoms and visualize them all as parts of a continuum called protein-energy or protein calorie malnutrition (PEM or PCM) rather than distinctly different nutritional disorders.

2.5 Let us sum up

We studied about carbohydrates, its functions and types. We learnt that carbohydrates provide energy (4 cal/g). They are formed plants in bewildering array of possible single unit and polymer structures. Humans have the ability to digest only a few of the many possible bonds linking carbohydrate units with each other and with other types of organic molecules. About 80% of edible carbohydrates are absorbed as single glucose unit and metabolized.

For optimum function of nervous system and cells, blood glucose concentrations are tightly controlled by hormones (insulin in the absorptive phase; glucagon, adrenaline and cortisol in the post absorptive phase) utilizing several possible metabolic pathways for glucose anabolism and catabolism.

Depending on the structure, non-digestible carbohydrates pass into the colon. They are fermented in varying degrees to short-chain fatty acids, carbon dioxide, hydrogen and methane in the large bowel. Absorbed short chain fatty acids are metabolized in colonic epithelial, hepatic and muscle cells. Thus, these perform a number of beneficial functions.

Intakes of optimum amounts of different types of carbohydrates are associated with good health through effects on energy balance, digestive function, blood glucose control and other risk factors for several chronic diseases.

We learnt about the classification of fats, the major difference between fats and oils and the concept of visible and invisible fats. We generally consume fats in the form of triglycerides. Our diets also provide cholesterol, which is present only in foods of animal origin.

We then learnt about lipid digestion and absorption, where we discussed that long chain fatty acids, cholesterol and phospholipids are absorbed through the lymphatic vessels after emulsification by bile. Short and medium chain fatty acids are absorbed directly into blood. We also got to know about '.good' and 'bad' cholesterol.

The good cholesterol or HDL is cardio-protective and can be raised by exercise, avoidance of smoking, maintaining normal weight and eating pattern, Fats have an important role in human nutrition and some amount of it should be present in daily diet. Use of 2-3 different oils while cooking is good for health. Eating out or eating prepackaged or fast foods often should be avoided as it leads to an increase in consumption of fats especially trans-fatty acids.

We also learnt that excessive fat intake could lead to major health diseases such as obesity, heart diseases and cancer. Hence, a judicious fat intake with a healthy lifestyle and correct eating habits like consumption of fruits and vegetables that inhibit LDL oxidation must be chosen to prevent the risk of these diseases.

We learnt that proteins are vital to all body cells, tissues, organs and functions of organ systems. The process of digestion, absorption and metabolism of protein are complex and involve several nutritional and non-nutritional factors. Proteins are widely distributed in nature, the richest vegetarian source being soybeans. Egg protein has the highest biologic value.

Several methods can be employed to determine the protein content of foods, the most popular being those based on growth and body weight changes. Protein quality in the diet can be improved by mutual supplementation of protein rich foods and cereals. Nutritional requirements of proteins vary with age and physiological activity. Deficiency of proteins leads to the twin disorders of marasmus and kwashiorkor and can be cured by dietary intervention.

2.6 Glossary

WORDS	MEANINGS
CARBOHYDRATES	
Diverticular disease	a condition in which small pouches called diverticulae, develop at the weak spots in the wall of the colon, that eventually bulge out to form pouches the integral proteins which penetrate and span the lipid bilayer of plasma membrane. a product of average glycemic index total carbohydrate intake. also called as piles; these are the small troublesome tumors or swellings with a painful mass of dilate veins in

	anal tissue.
Glucose transporters	the protrusion of part of the stomach through the diaphragm.
Glycemic load	the ability of fibre to bind water.
Haemorrhoids	simple lipids which combine with other molecules such as proteins, carbohydrates and phosphates
Hiatus hernia	fatty lipids, glycerol, cholesterol and other derived compound.
Water holding capacity	those fatty acids that cannot be synthesized in body and are needed in daily diet. Linoleic acid and linolenic acids are two essential fatty acids.
FATS	fats that are present as an integral component of different foods such as milk, meat, egg, cereals, pulses etc.
Compound lipids	an EFA; also called Lin or LA content of fats.
Derived lipids	Chemically, it is omega-6 (n-6); C18:2, cis-9, 12 octadecenoic acid.
Essential Fatty Acids EFA	an EFA also, called Len content of fats or ALNA (alpha linolenic acid). Chemically, it is omega-3 (n-3), C18:3;cis 9, 12, 15 octadecenoic acid.
Invisible fats	any particle in blood containing a core of lipids with a shell of protein. It can freely move in an aqueous medium of blood.
Linoleic acid	all naturally occurring fats in the body are cis isomers; Trans-isomers differ in structure and properties but have same formula.
Linolenic acid	fats that are used as such at the table or for cooking. They are of both plant and animal origin.
Lipoprotein	disease caused in persons unable to form melanin pigment.
Trans-fatty acid	the building blocks of proteins composed of
	carbon, hydrogen, oxygen and nitrogen.

Visible fats	Accumulation of water in the interstitial space.
PROTEINS	amino acids that are indispensable and are not synthesized in the body.
Albinism	blending two or more proteins so that the excess of essential amino acids present in one protein makes up the deficiencies of the same amino acids in another protein
Amino acids	amino acids that are dispensable and can be synthesized in the body.
Oedema	amount of protein which must be consumed to provide the amino acids for the synthesis of those body proteins irreversibly catabolized in the course of the body's metabolism
Essential amino acids	proteins which contain only amino acids or their derivatives and no prosthetic group
Mutual supplementation	foods used to enhance the nutrients present in a person's diet or menu.
Non-essential amino acids	
Protein requirement	
Simple proteins	
Supplements	

2.8 Check your progress:

1. What are carbohydrates? Classify them. (Refer to point no. 2.2)
2. List some important functions of carbohydrates. (Refer to point no.2.2.4)
3. Classify (fats) lipids, giving examples. (Refer to point no. 2.3)
4. Why is LDL referred to a s bad cholesterol? (Refer to point no. 2.3.3)
5. Write the functions of lipids? (Refer to point no.2.3.2)
6. What are the benefits of blending oils? Which oils are blended together? (Refer to point no. 2.3.3)
7. What are methods to reduce fat intake. (any 8). (Refer to point no. 2.3.3)
8. How is high fat and cholesterol intake related to heart disease? List five item rich in cholesterol. (Refer to point no.2.3.3)
9. Give ICMR (1998) guidelines for the prevention of heart disease. (Refer to point no.2.3.3)
10. Classify proteins.(Refer to point no.2.4)
11. What are amino acids? Classify them. (Refer to point no.2.4.1)
12. What are the food sources of proteins? (Refer to point no.2.4.2)
13. What are the functions of proteins? (Refer to point no.2.4.2)
14. What are the factors influencing protein requirement? (Refer to point no.2.4.3)
15. What is protein intolerance and protein deficiency?(Refer to point no.2.4.3)

Table 2.2.4: Different types of carbohydrates and their sources

Sl no.	Class	Examples	Component Monosaccharide	Sources
1.	Monosaccharides	Glucose Fructose Galactose		Fruit, honey etc. Fruit,honey etc. Milk and milk products
2.	Disaccharides	Maltose Lactose Sucrose	Glucose (2 molecules) Glucose + Galactose Glucose + Fructose	Glucose syrup Milk and milk products Sugarcane, and sugar used as additive
3.	Trisaccharides	Raffinose Maltotriose	Glucose, Fructose, Galactose Glucose (3 molecules)	Chick peas, legumes, pulses Glucose syrup
4.	Tetrasaccharides	Maltotetrose Stachyose	Glucose (4 molecules) Galactose (2 molecules) Glucose, Fructose	Glucose syrup Beans, Legumes
5.	Pentasaccharides	Verbascose		Beans, Legumes
6.	Sugar alcohols	Sorbitol Xylitol Mannitol		Exclusively present if used as food ingredients

Table 2.2.5 Digestion of carbohydrates

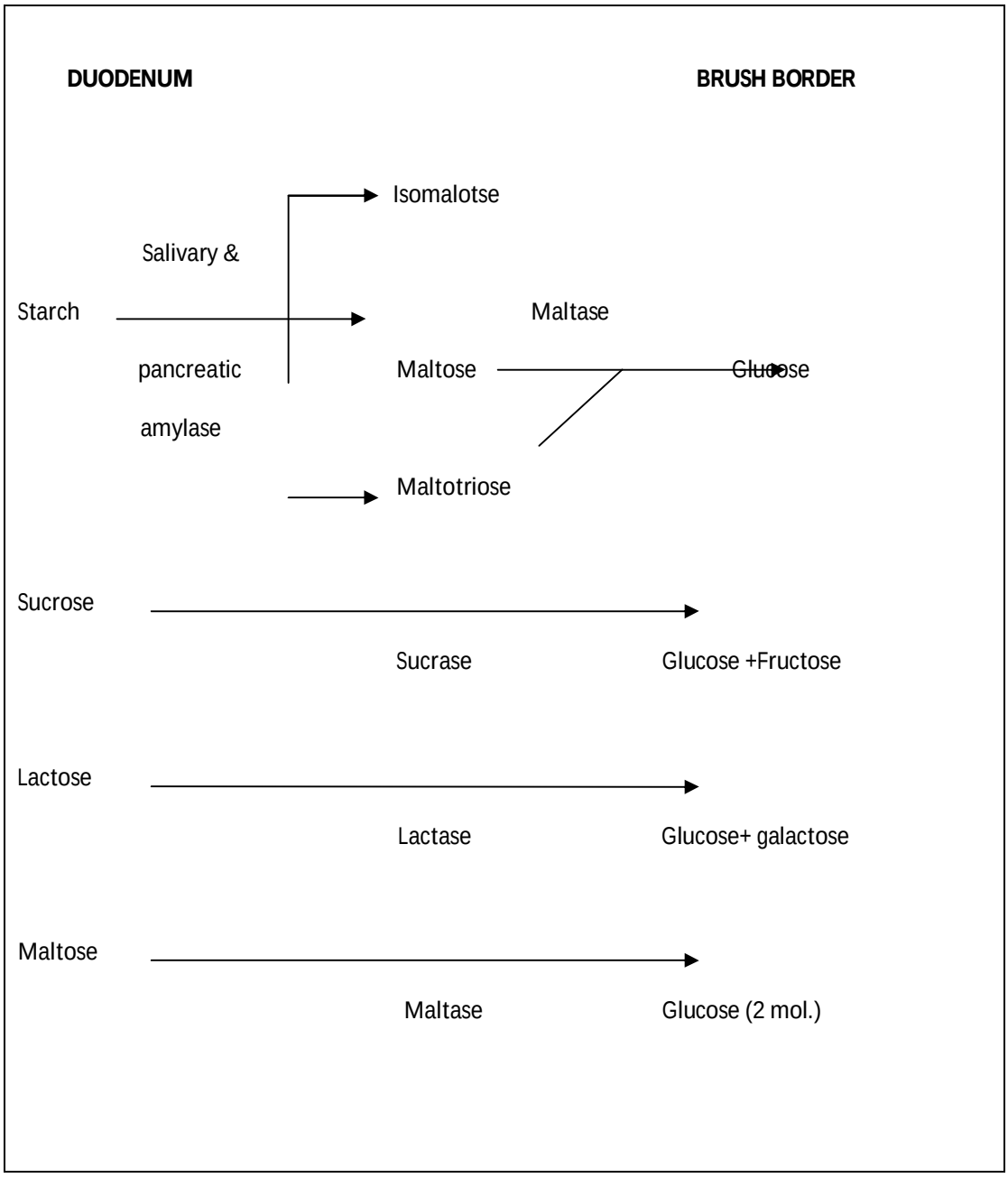


Table 2.2.6 Regulation of blood glucose

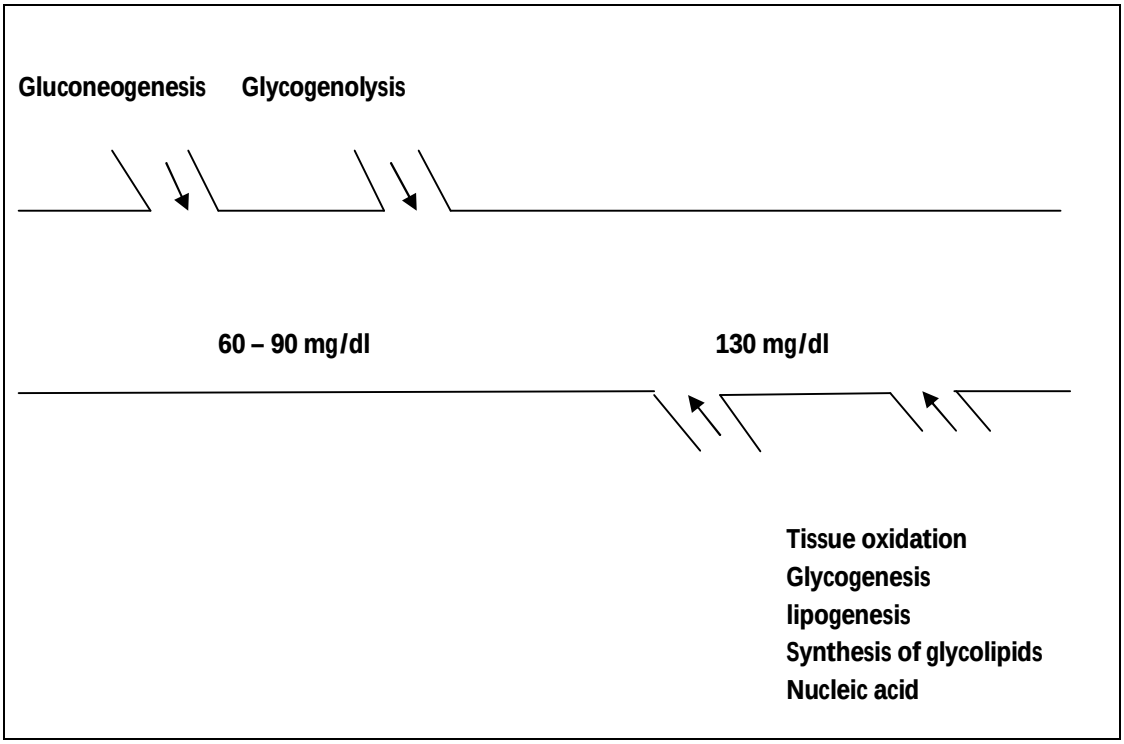


Table 2.3.1: Different types of fats and oils and their fatty acids

Saturated Fatty Acids	Monounsaturated Fatty Acids	Polyunsaturated Fatty Acids	
		Linoleic (n-6)	Linolenic (n-3)
Ghee/ butter Coconut (89%) Palm kernel (86%) Palm oil (51%) Vanaspati (24%)	Olive (77%) Canola (58%) Groundnut (50%) Rice bran oil (45%) Sesame (42%) Palmolein Red Palm oil (40%)	***Low* (40%):** Red Palm oil Palmolein Olive oil ***Medium*(<35%)** Groundnut oil Rice Bran oil Sesame oil ***High:*** Safflower.oil Sunflower oil Cottonseed oil Soya bean oil Sesame oil Corn oil	Mustard oil (10%) Canola (8%) Soya bean oil(5%) Rice bran oil (1%)

Table 2.3.3: Fat requirements of Indians

Group	EFA Requirement en %	Invisible Fat "en%	Minimum Visible" Fat		Suggested Desirable Visible Fat Intake	
			En%	g/day	g/day	En%
Adults	3	10	5	12	20	9
Older children	3	10	5	12	22	9
Young children	3	10	5	8	25	15
Pregnant woman	4.5	10	12.5	30	30	12.5
Lactating woman	5.7	10	17.5	45	45	17.5

Table 2.4.1 Classification of amino acids

Essential (indispensable)	Conditionally-essential	Non-essential (dispensable)
Methionine Tryptophan Valine Isoleucine Leucine Phenylalanine Lysine Threonine Arginine Histidine (only for infants)	Tyrosine Cystine Aspaltic acid Serine	Glutamic acid Alanine Proline, Hydroxyproline Glycine

Table 2.4.2 Protein content of some important foods

Foods	Proteins (g/100g)	Foods	Proteins (g/100g)
Cereals	06-14	Milk	53.5-4.0
Legumes	18-24	Milk powder(full cream)	26-27
Soybean	43	Milk powder(skimmed)	35-38
Nuts and oilseeds	18-40	Fish	18-20
Oilseed meals	45-55	Meat and liver	18-22
Egg, hen	12-13		

Table 2.4.3 Nutritional requirements of proteins

Group	Particulars	Body Weight(kg)	Protein g/d
Man	Sedentay work Moderate work Heavy work	60	60
Woman	Sedentary work Moderate work Heavy work	50	50
	Pregnant woman	50	+15
	Lactation *0* - 6 months	50	+25
	6 - 2 months		+18
Infants	0 - 6 months	5.4	2.05kg
	6 - 12 months	8.6	1.65lkg
Children	1 - 3 years	12.2	22
	4 - 6 years	19.0	30
	7 - 9 years	26.9	41
Boys	10 - 12 yews	35.4	54
Girls	10 - 12 years	31.5	57
Boys	13 - 15 years	47.8	70
Girls	13 - 15 ycars	46.7	65
Boys	16 - 18 years	57.1	78
Girls	16 - 18 years	49.9	63

UNIT 3 PROTECTIVE AND REGULATORY FOODS

Structure

3.0 Objectives

After studying this unit, you will be able to:

- describe the functions of vitamins and minerals and classify them,
- identify the food sources and learn about their absorption, storage and excretion,
- recognize the nutritional requirement during various physiological stages, and
- Understand the various health aspects (consequences of deficiency and toxicity).

3.1 Introduction to protective and regulatory foods

Vitamins and Minerals together form the category of protective and regulatory foods. As the name suggests it means that these two categories of nutrients in food protect the body from diseases and infections and also help it to function optimally.

Vitamins are *the organic substances* that act as coenzyme and/or regulator of metabolic processes. There are 13 known vitamins, most of which are present in foods while some are produced within the body. Depending on the property of solubility, vitamins are divided into two groups, namely, water-soluble and fat-soluble.

Water-soluble vitamins include vitamin B-complex, which is a group of B *Vitamins,* and *vitamin C* or *ascorbic acid* while the fat-soluble vitamins comprise of 4 vitamins- *A, D,* E *and* K. Fat-soluble vitamins A, D, E and K, are termed so because they are found in nature in close association with fatty foods such as butter, cream, vegetable oils, meat, poultry and fish and their products. While fat-soluble vitamins -Vitamin A, D, E and K- dissolve in fat before they are absorbed **in** the blood stream to carry out their functions, water-soluble vitamins i.e. B-complex group and vitamin **C** dissolve in water.

Excesses of fat soluble vitamins are stored in the liver whereas water soluble vitamins are not stored; hence a continuous supply of them is required in our diets.

Minerals are required by humans for optimal functioning. Most minerals can be detected in the body and only 15 of them are known to be essential and must be derived from food. These mineral elements are broadly divided into two classes i.e. macro and micro minerals.

Macro minerals, also referred to as major minerals are distinguished from micro minerals by their occurrence in the body. While macro minerals constitute at least 0.01% of the total body weight or at least 5 g in a 60 kg body i.e. they are required in amounts greater than 100 mg per day whereas on the other hand, requirement of micro minerals varies from a only few milligrams to micrograms per day.

Macro minerals are Calcium, phosphorus, magnesium, sodium, potassium and chloride and micro minerals are iron, zinc, copper, selenium, chromium, manganese, iodine and fluorine.

3.2 Classification of Vitamins, their sources, digestion, absorption, functions and nutritional requirements

We shall discuss about vitamins first and then move onto minerals. Vitamins are classified as water-soluble and fat-soluble vitamins depending on their solubility. Fat-soluble vitamins -vitamin A, D, E and K dissolve in fat before they are absorbed **in** the blood stream to carry out their functions. Excesses of these vitamins are stored in the liver. Because they are stored, they are not needed every day in the diet. By contrast, water-soluble vitamins dissolve in water and are not stored. They are eliminated in urine. We need a continuous supply of them in our diets. The water-soluble vitamins are the B-complex group and vitamin C.

3.2.1 Vitamin A

The chemical name of vitamin A is retinol. *Retinol* is referred to as p*re-formed vitamin A,* as it is present in foods already in the active form and does not require any conversion. Retinol itself is found only in animal foods but milk and some vegetable foods also contain the deep yellow or orange carotenes which can be converted in the body to retinol and are therefore sources of vitamin A activity. The most important of these is beta carotene which is the primary and most efficient pro vitamin A or carotenoid.

- **Sources:** *Vitamin A or retinol is* found only in foods of animal origin, such as milk, cheese, cream, butter, ghee, egg, fish, kidney and liver, liver oils of fish such as halibut, cod and shark. *Provitamin* A (so called because it is a precursor and has to be chemically transformed into retinal) or B-*carotene* is found primarily in plant foods, which contain orange or yellow-colored pigments called *carotenoids. B*-carotene is the most widely distributed carotenoid in plant foods. Palm fruit and red palm oil are the richest source of beta-carotene and dark green leafy vegetables, ripe fruits such as mango, papaya, apricots and yellow orange vegetables like carrot, pumpkin and sweet potato are rich in B carotene.

- **Functions:** Vitamin A (retinol) is an essential nutrient needed in small amounts by humans for the normal functioning of the visual system, growth and development, and maintenance of epithelial cellular integrity, immune function, and reproduction.
    1. Vitamin A deficiency is the leading cause of preventable severe visual impairment and blindness, and the most vulnerable are preschool children and pregnant women, particularly in our country. It is ironical that a small amount of less than 10 gm of green leaves can meet the day's requirement of vitamin A of preschool children. Yet an estimated 250,000 to 500,000 VAD children world over become blind every year, and about half of them die within a year. Administration of large doses of vitamin A to children at-risk has been the most popular approach to control nutritional blindness.

       The next function of great significance is the role of vitamin **A** in differentiation of cells.

2. **Role in growth and cellular differentiation**: The growth and differentiation of epithelial cells throughout the body are especially affected by vitamin A deficiency. In addition, goblet cell numbers are reduced in epithelial tissues and as **a** consequence, mucous secretions diminish. Cells lining protective tissue surfaces fail to regenerate and differentiate; hence they flatten and accumulate keratin. Xerosis and xerophthalmia are such diseases due to deficiency of vitamin A.
3. **Role in immune response:** Cells lining protective tissue surfaces fail to regenerate and differentiate; hence they flatten and accumulate keratin.Both factors - the decline in mucous secretions and loss of cellular integrity reduce the body's ability to resist invasion from potentially pathogenic organisms. Pathogens can also compromise the immune system by directly interfering with the production of some types of protective secretions and cells.
4. **Integrity of epithelial tissues**: Vitamin A is essential for the integrity of the mucous-secreting cells. In fact, vitamin A maintains the health of epithelial cells that line internal and external surfaces of the lungs, intestines, stomach, vagina, urinary tract and bladder, eyes and skin. These cells act as important barriers to bacteria. Certain epithelial cells secrete mucous to keep the skin, eyes and other mucous membranes moist. In deficiency, the epithelial tissues are keratinized. The tissues affected are salivary glands, respiratory tract, eyes, skin and sex organs.
5. **Role as antioxidant:** vitamin A and related nutrients may collectively be important in protecting against conditions related to oxidative stress, such as aging, air pollution, arthritis, cancer, cardiovascular disease, cataracts, diabetes mellitus and infection. Antioxidants protect our cells against the effects of free radicals, are potentially damaging compounds produced as by-products of metabolism, as well as, through exposure to toxins and pollutants (e.g. smoking).
6. **Bones and nerves**::T he role of vitamin A in bone formation and the association of its deficiency with the degeneration of myelin sheath is currently being explored.
7. **Role in protein metabolism and growth**: Severe vitamin A deficiency results in abnormal RNA metabolism and protein synthesis and hence interferes with growth. Hence vitamin A is also called growth vitamin.
8. **Role in the synthesis of mucoproteins and macro polysaccharides:** Vitamin A is vital for the synthesis of mucoproteins and glycoproteins and incorporation of inorganic sulphate in mucopolysachharides and their synthesis.
9. **Role in reproduction**: Deficiency of Vitamin A leads to infertility in the male and failure of' thc female to conceive or resorption or abortion of the fetus, chiefly in animals.

- **Nutritional requirement and RDA for Vitamin A**

The RDA suggested for vitamin A is given in Table 7.l (a). You can observe from the values given in the table that the requirements are highest during lactation. This is due to the fact that human milk, particularly colostrum is a rich source of vitamin A. It is also evident that the intake recommended for pre-schoolers and older children are equal to that recommended for adult man and woman. This high level has been suggested keeping in mind the high prevalence rate of clinical vitamin A deficiency in this segment of the population. The recommendations have been based on the fact that what level of vitamin A is required to prevent deficiency and also maintain health. In calculating the safe intake, a normative storage requirement equivalent to 434 mg RE/day was taken into consideration as anything more than that could also lead to toxicity.

- **Health aspects**

Deficiency:

*Vi*tamin *A* deficiency (VAD), as you already know, leads to impairment in the vision, severe infections and even death. It encompasses the full spectrum of clinical consequences associated with sub optimal vitamin A status. These disorders are known to include reduced immune competence resulting in increased morbidity and mortality (largely from increased severity of infectious diseases), night blindness, corneal ulcers, keratomalacia and related ocular signs and symptoms of xerophthalmia; exacerbation of anemia through sub optimal absorption and utilization of iron and other conditions not yet fully identified or clarified (e.g. retardation of growth and development).

Toxicity

Because vitamin A is fat-soluble and can be stored, primarily in the liver, routine consumption of large amounts of vitamin A over a period of time can result in toxic symptoms, including liver damage, bone abnormalities and joint pain, alopecia, headaches, vomiting and skin desquamation. In fact, symptoms that occur due to intakes in excess of those recommended over a prolonged period are referred to as symptoms of ***hypervitaminosis.***

3.2.2 Vitamin B complex

The major group of water-soluble vitamins is the B-complex group of vitamins. Examples include thiamin, riboflavin, niacin, pyridoxin, folic acid, cyanocobalamin etc. Although the chemical structure of each is quite different, and they have several features in common. They act as "co-factors" in different enzyme systems in the body; they tend to occur in the same foods; and being water soluble, they are not stored for long in the body. These characteristics mean that diets containing too little B-vitamins can lead to multiple deficiency diseases within a few months.

3.2.3 Thiamin (vitamin B1 or Aneurin)

Thiamin is one of the earliest recognized vitamins. It is necessary for the steady and continuous release of energy from carbohydrate. Thiamin requirements are thus related to the amount of carbohydrate and more or less to the amount of energy in the diet.

- **Sources:** It is widely distributed in both animal and vegetable foods.

  Rich sources : Rice polishings, wheat germ, dried yeast, yeast extract.

  Good sources: Whole cereals, whole wheat, millets, raw and hand-pounded or parboiled rice, pulses, soya bean, dried beans, oilseeds and nuts.

  Fair sources: Meat, fish, eggs, milk, vegetables and fruits.

  It is to be noted that cooking may result in considerable losses from these foods. Fats, sugars and alcoholic drinks contain no thiamin at all. It is depleted by use of coffee, tannin from black teas, nicotine and alcohol.

- **Absorption, storage and elimination:** After a meal, thiamin is found in the intestine in the free form. Its absorption involves two mechanisms- both active and passive. It is absorbed primarily from the upper jejunum by diffusion and by an active transport mechanism but can also occur in the duodenum and ileum. After absorption, only a small part passes into circulation as free thiamin while a greater part is converted into thiamin pyrophosphate (TPP) in the liver and intestinal mucosa. A small quantity of thiamin is also converted into thiamin triphosphate (TTP).It is then excreted in urine.

- **Functions of Thiamine:**

  Thiamin has a key metabolic role in the cellular production of energy; mainly in glucose metabolism i.e. it helps the body cells convert carbohydrates into energy. Thiamin is also essential for the functioning of the heart, muscles, and nervous system. Other functions are:

  1. **Regulator of enzyme activity***:* Thiamin regulates the enzymes involved in carbohydrate metabolism.
  2. **Coenzyme in enzyme catalyzed reactions***:* Thiamin functions as the coenzyme thiamin pyrophosphate (TP?) in the metabolism of carbohydrates and branched chain amino acids.
  3. **TPP and TTP are vital for the nerves and cardiac tissues***:* TPP and TTP are inter convertible and are involved in carbohydrate metabolism. When there is insufficient thiamin, the overall decrease in carbohydrate metabolism and its interconnection with amino acid metabolism has severe consequences, such as a decrease in the formation of acetylcholine for neural function. Thus, deficiency in the tissues affects energy metabolism in nervous tissue and cardiac muscle.
  4. **Role in the conversion carbohydrates to fats:** Thiamin helps in the initial steps of fatty acid and sterol production. In this way, thiamin also helps convert carbohydrate to fat for storage of potential energy.

- **Recommended Dietary Allowance:** As thiamin facilitates energy utilization, its requirements have been expressed on the basis of energy intake, which can vary depending on activity levels. Therefore, the RDA recommendation by ICMR for adults is 0.5 mg per 1000 Kcal, or an intake of at least than 1 mg per day is advised. The individual intake for thiamin, for an adult man is 1.2 mg per day and adult woman is 0.9 mg per day.

- **Health aspects:**

Deficiency

Deficiency leads to beriberi in human beings, which has been classically considered to exist in *dry* (paralytic) and *wet* (edematous) forms. The early clinical features are anorexia and dyspepsia, associated with heaviness and weakness of the legs. There is tenderness of the calf muscles on pressure with complaints of 'pins and needles' pain and numbness in the legs. The person feels weak and get easily exhausted while working. If not treated, he or she may develop *polyneuritic beriberi,* that is, inflammation of many or all of the peripheral nerves. **A** detail discussion on the different forms of beriberi follows:

Wet beriberi*:* Edema is the important feature of wet beriberi. It may develop rapidly and involve not only the legs but also the face, trunk and serous cavities. Palpitation and breathlessness are present. The calf muscles are frequently tense, slightly swollen and tender on pressure.

Dry beriberi*:* Early symptoms are similar to those found in wet beriberi. The muscles become progressively wasted and weak and walking becomes difficult.

Infantile beriberi*:* Infantile beriberi is commonly seen in many South-East Asian countries where the diets consist mostly of "polished rice" and are deficient in thiamin.

Toxicity:

Thiamin toxicity is not a problem because renal clearance of the vitamin is rapid. Since the body stores of thiamin are very low, we must ensure adequate daily intake.

3.2.4 Riboflavin (vitamin B2)

Riboflavin was discovered in milk as a pigment possessing a bright yellow green color and is essential for the utilization of energy from food. Although it is widely distributed in foods, especially animal foods, about one third of intake comes from one source i.e. milk. Riboflavin is destroyed by ultraviolet rays hence exposure of milk to sunlight is not advised.

- **Sources:** The food sources of riboflavin include:

Rich sources: Liver, dried yeast, egg powder, milk powder.

Good sources*:* Whole cereals, millets, pulses, green leafy vegetables, oilseeds and nuts, meat, fish, eggs and milk.

Fair sources: Milled cereals and cereal products, roots and tubers, other vegetables and fruits.

- **Absorption, storage and elimination:** Riboflavin is absorbed from the small intestine through the portal vein and is passed to all tissues via general circulation. Absorption occurs in the upper part of the gastrointestinal tract by specialized transport. Riboflavin is also synthesized by intestinal bacteria and then absorbed by the colon. Riboflavin is not stored in the body. A major part is excreted in urine and the rest is broken down in the tissues.

- **Functions of Riboflavin: R**iboflavin plays an important role in human metabolic processes and in maintaining good health.
    1. **Precursor of co-enzymes:** The major function of' riboflavin is to serve as the precursor of the coenzymes FMN (flavin mononzicleotide) and FAD (flavinadenine dinucleotide and of' the covalently bound flavins.
    2. **Role in respiratory clzailz**: The flavocoenzymes (FMN aud FAD) participate in oxidation-reduction reactions in metabolic pathways and in energy production via the respiratory chain.
    3. **Drug and lipid metabolism:** Flavoproteins catalyze dehydrogenation reactions,as well as, hydroxylations, oxidative decarobxylations, deoxygenatio~ls and reduction of oxygen to hydrogen peroxide.
    4. **Antioxidant activity**: Flavoproteins also have powerful antioxidant activity from their role as precursors to FMN and FAD.
    5. **Protective role:** Riboflavin protects the octodei~nalt issues and prevents lesioils of the skin, eye and nervous system. Riboflavin ameliorates cardiac damage and also has anti malarial effects.
    6. **Regulatory functions**: Riboflavin helps with the regulatory functions of some hormones involved in carbohydrate metabolism.
    7. **Other functions:** Riboflavin interrelates with ocher B vitamins, notably niacin, which requires FAD for its formation from tryptophan, and vitamin B6 which requires FMN for conversion.

- **Recommended Dietary Allowance:** Several nutritional and physiological factors govern riboflavin requirements. Negative nitrogen balance reduces riboflavin requirements and excretion. Physical activity reduces urinary riboflavin excretion. Hence, the dietary requirement is increased by exercise and increased physical activity. Therefore, the RDA for individual intake follows the similar pattern as for thiamin. RDI for riboflavin for adults are 0.6 mg/ 1000 Kcal, i.e. for adult males, the requirements are 1.4 mg/day while for adult females, it is 1.1 mg per day and increase up to 1.3- 1.4 mg per day during pregnancy and lactation.
- **Health aspects:**

Deficiency:

Deficiency of Riboflavin results in the condition of *hypo-* or *aribc?flavi~iosis*w, ith sore throat, hyperaemia (condition in which the blood collects in a part of the body), oederna of the pharyngeal and oral mucous membranes, cheilosis (cracking of the corner of the mouth), angular stomatitis (inflammation at the corner of the mouth), glossitis (inflammation or the infection of the tongue), seborrheic dermatitis and normochromic, normocytic anaemia associated with pure red cell cytoplasia of the bone marrow. As riboflavin deficiency almost invariably occurs in combination with a deficiency of other B-complex vitamins, some of the symptoms (e.g. glossitis and dermatitis) may result from other complicating deficiencies. The major cause of *hyporiboflavinosis* is inadequate dietary intake as a result of limited food supply, which is sometiines exacerbated by poor food storage or processing. Children in developing countries demonstrate clinical signs of riboflavin deficiency during periods when gastrointestinal infections are prevalent. Soine cases of riboflavin deficiency have been observed in south-east Asian school children infected with hookworm.

Toxicity

Riboflavin toxicity is not a problem because of the limited intestinal absorption of this vitamin.

3.2.5 Niacin

Nicotinic acid and nicotinamide are two forms of another B-vitamin (known collectively as niacin) which is involved in the utilization of food energy. Nicotinaimide is required for the synthesis of the active forms of niacin i.e NAD and its phosphate which functions as a cofactor for various coenzymes in our body. Nicotinic acid was first isolated from rice polishing and shown to be a component of coenzyme I and II and several transporting enzymes in the tissues.

- **Food sources of Niacin**

Niacin is widely distributed in plant and animal foods mainly as the pyridine nucleotides NAD and NADP. The food sources of niacin are highlighted herewith:

Rich sources*:* Dried yeast, rice polishings, peanuts, liver.

Good sources*:* Whole cereals legumes, meat and fish.

Fair sources*:* Milled cereals, maize, roots and tubers, vegetables, milk, eggs.

Whole cereals are good sources of niacin, but the removal of the bran in the milling of wheat reduces the niacin content of white wheat flour to a low level. Niacin is readily soluble in water, but is resistant to heat, oxidation and alkalis. It is, in fact, one of the most stable vitamins.

- **Absorption, storage and elimination :**

Nicotinic acid and nicotinamide are rapidly absorbed from the intestine rather than the stomach. NAD and NADP, the main dietary forms of niacin are hydrolyzed by enzymes in the intestinal mucosa to release nicotinamide. The intestinal mucosa is rich in niacin conversion enzymes such as glycohydrolase. Niacin is methylated in the liver and excreted in the urine along with oxidation products. The pattern of niacin products excreted depends on the amount and the form of niacin ingested and the niacin status of the individual.

- **Functions of Niacin :**
    1) **Protective role**: Nicotinic acid is vital to the normal functioning of the skin, intestinal tract and nervous system. It protects the tissues from pellagraic lesions.
    2) **Coenzyme activity:** NAD is required for transfer reactions involved in DNA repair and calcium mobilization. NAD functions in intracellular respiration and with enzymes involved in the oxidation of fuel substrate.
    3) **Metal chelating ability**: This explains its biological interactions with essential trace metals. It is a part of the proposed glucose tolerance factor, an organo chromium complex that may potentiate insulin response in man.

- **Recommended Dietary Allowance:**
  There are various factors an which niacin requirements depend. These **are** energy utilization, body size and dietary tryptophan. The efficiency of conversion of tryptophan to niacin is affected by various factors including the amount of tryptophan and niacin ingested protein and energy intake, as well as, vitamin B6 and **B2** status. ICMR recommended RDI for individual intake of niacin as niacin equivalents (NE) for adult is 6.6 mg per 1000 Kcal. For a sedentary male and sedentary female it is 16 and 12 mg per day, respectively. With pregnancy and lactation, the RDA increases to about 14- 16 mg per day.
- **Health aspects:**
  Deficiency:
  The disease is characterized by 3 D's- dermatitis, diarrhoea and dementia. Niacin (nicotinic acid) deficiency classically results in pellagra which is a chronic wasting disease associated with a characteristic erythematous dermatitis,a dementia after mental changes including insomnia and apathy preceding an overt encephalopathy, and diarrhea resulting from inflammation of the intestinal mucous surfaces.

  Toxicity
  Although therapeutically useful in lowering serum cholesterol, administration of chronic high oral doses of nicotinic acid can lead to hepatotoxicity, as well as, dermatologic manifestations.

3.2.6 B6 (pyridoxine)

Vitamin B6 or pyridoxine is involved in the metabolism of amino acids including the conversion of tryptophan to nicotinic acid; the requirements are thus related to the protein content of the diet. Pyridoxine or vitamin B6 is one of the B complex vitamins which prevents and cures dermatitis in rats fed on vitamin B6 deficient diets.

- **Food sources of pyridoxine:**
  Vitamin B6 occurs widely in food, especially in meats and fish, eggs, whole cereals and some vegetables. The main sources in the diet are potatoes and other vegetables, milk and meat.

  Raw foods contain more of this vitamin than cooked foods. The food sources include:

  Rich sources*:* Rice polishings, wheat bran, wheat germ, dried yeast, liver.
  Good sources*:* Whole cereals, legumes, nuts and seeds, milk powder, meat, egg, leafy vegetables.
  Fair sources*:* Milled cereals, vegetables and fruits.

  Long storage, canning, roasting or stewing of meat, food-processing techniques, use of alcohol are destructive to this vitamin.

- **Absorption, storage and elimination:**

  Absorption occurs primarily in the intestine (jejunum) by passive diffusion. The vitamin is transported in blood both in plasma and in red cells, mainly bound to albumin in plasma and hemoglobin in erythrocytes. Eighty percent of vitamin B6 is present in muscle. Excretion is through the urinary pathway.

- **Functions of Pyridoxines:**
  1. **Formation of amines:** Pyridoxal phosphate (PLP) and pyridoxamine phosphate (PMP) are vital for the formation of several amines that are functional in nervous tissues, for the biosynthesis of haem, formation of sphingolipids and phosphorylation of glycogen.
  2. **Growth purposes**: Pyridoqal5-phosphate (PLP) is essential for growth of infants and prevents degeneration of the nerves.
  3. **Coenzyme activity**: Pyridoxal phosphate acts as a coenzyme.
  4. **Muscle phosphorylase**: Pyridoxal phosphate is a component of muscle phosphorylase.
  5. **Dehydrases**: These enzymes are vital to the catabolism of threonine, seine and homoserine and contain pyridoxine.
  6. **Anti-atherosclerotic effect:** Vitamin B6 deficiency precipitates hypercholesterolemia and atherosclerosjs.
  7. **Immune bodies**: Vitamin B6 deficiency is associated with impairment in both humoral and cell mediated immunity.
  8. **Coenzyme A synthesis**: Pyridoxine is involved in the synthesis of coenzyme A from pantothenic acid.

- **Recommended Dietary Allowance:**

  Average requirements for pyridoxine vary with age, sex and physiological conditions such as protein status, pregnancy and lactation. The ICMR recommendations for individual intake of pyridoxine for adult males and female, is 2.0 mg per day. During pregnancy and lactation, the recommended level of intake is2.5 gm per day.

- **Health aspects:**

  Deficiency:

  Deficiency of vitamin B6 alone is uncommon because it usually occurs in association with a deficit in other B-complex vitamins. but women who are pregnant or taking oral contraceptives may benefit from increased intakes of this vitamin. Infants are especially susceptible to insufficient intakes, which can lead to epileptic form convulsions. Skin changes include dermatitis with *cheilosis* and *glossitis.* Moreover, there is usually a decrease in circulating lymphocytes and sometimes anaemia as well.

  Toxicity:

  Very high intakes however are dangerous. Though toxicity related to pyridoxine intake are rare, but use of high doses of pyridoxine for the treatment of pre-menstrual syndrome, carpal tunnel syndrome (compression of the median nerve at the wrist resulting in numbness, tingling, weakness in the hand and fingers), and some neurologic diseases has resulted in neurotoxicity. An upper limit (UL) of 100 mg per day has been adopted by the FAO/WHO 2004.

3.2.7 B12 (Cyanobalamin)

Vitamin B12 is a mixture of several related compounds all of rich contain the trace element cobalt. Vitamin B,, (cobalamin, cbl) is a unique vitamin in human nutrition, since its malabsorption leads to the fatal syndrome of pernicious and megaloblastic anaemia with demyelinating lesions of the central nervous system.

- **Food Sources of cyanobalamin:**

  Vitamin B I2 is unique among vitamins in the sense that it is mostly found in foods of animal origin but is not generally present in plant products.

  Rich sources*:* Liver (goal, sheep, ox, pig).
  Good sources*:* Meal, fish, egg, kidney, brain.
  Fair sources*:* Fresh milk, milk powder and cheese.

  Most microorganisims including bacteria and algae, synthesize vitamin B12,a nd they constitute the only source of the vitamin. The vitamin **BI2** synthesized in microorganisms enters the human food chain through incorporation into food of animal origin. In many, animals, gastrointestinal fermentation supports the growth of these vitamin **B12** synthesizing microorganisms, and subsequently the vitamin is absorbed and incorporated into the animal tissues. This is particularly true for the liver, where vitamin B,, is stored in large concentrations. Products from herbivorous animals, such as milk, meat and eggs, thus constitute important dietary sources of the vitamin. Humans, therefore, derive dietary Vitamin B12 almost exclusively from animal tissues or products (i.e. milk, butter, cheese, eggs, meal, poultry).

- **Absorption, storage and elimination:**

  Vitamin **B12** in food is bound to proteins and is only released by the action of a high concentration of hydrochloric acid present in the stomach. Once released from foods, vitamin **B12** absorption involves contact with two proteins: intrinsic factor (IF) and R-binder. Vitamin B12 is the only B vitamin our body can store. The average adult body contains 2 to 5 mg of vitamin B12 with 80 percent of this stored in the liver.

- **Functions of Vitamin B12 :**

The functions of cyanocobalamin are:

1. It promotes the maturation of erythroid cells,
2. It acts on other bone marrow elements and increases WBC and platelet count,
3. It stimulates the appetite and general health of the subject,
4. It cures neurological symptoms of pernicious anemia. It is involved in the manufacture of the myelin sheath, a fatty layer which insulates nerves,
5. It is necessary for the production of nucleic acids, which make up DNA, the genetic material of the cell,
6. It functions as a coenzyme for enzymes methionine synthase and methybnalonyl coenzymze (CoA) mutase.

- **Recommended Dietary Allowance:**

Vitamin B12 deficiency is common in true vegans who can be treated with small doses since the daily requirement is only 1.0 g per day, recommendations for vitamin B12 for all age groups. However, the requirements do increase in lactation by 0.5 g per day.

- **Health aspects:**

Deficiency:

Because plants do not synthesize vitamin B 12, individuals who consume diets completely free of animal products (vegan diets) are at risk of vitamin B12 deficiency. This is not true of lacto-ovo vegetarians, who consume the vitamin through eggs, milk and other dairy products. Persons living exclusively on vegetarian diets (vegans) have low serum levels of vitamin B12 and develop specific symptoms such as sore tongue, paraesthesia and signs of degeneration of the long tracts of the spinal cord as a result of low intakes of vitamin B12. Megaloblastic anaemia is not so common when folic acid intake is adequate. The anemia results from decreased DNA synthesis and failure of the cells to divide properly, coupled with the continued formation of RNA.

Toxicity

Intake of 1000 pg vitamin B12 has never been reported to have any side-effects. Similar large amounts have been used in some preparations of nutritional supplements without apparent ill effects.

3.2.8 Folic acid (Vitamin B9)

Folic acid or folate has several functions including its action with vitamin B12 in rapidly dividing cells. Folate is a generic term which includes naturally occurring food folate and folic acid in supplements and fortified foods. The term folk acid relates specifically to the fully oxidized monoglutamate form of the vitamin synthesized for commercial use in supplements and fortified foods.

- **Food sources of folic acid:**

Folate occurs naturally in foods. Although folate is found in a wide variety of foods, it is present in a relatively low density except in liver. Diets that contain adequate amounts of fresh green vegetables (i.e. in excess of tlvee servings per day) will be good folate sources. folate derived from animal products is subject to loss during cooking. Some staples, such as' white rice are low in folate.

Rich sources: Liver, dried yeast, leafy vegetables, wheat germ and rice polishings.

Good sources: Whole cereals, dried legumes (pulses have twice as much folic acid as cereals), nuts, fresh oranges, green leafy vegetables,

Fair sources: Milled cereals, other vegetables, milk and fruits.

- **Absorption, storage and elimination:**

  Folic acid is readily absorbed from the small intestines througli the portal vein and passed onto the tissues through general circulation. Following absorption, folic acid is largely reduced and methylated in the liver. Folate transport across membranes into cells in kidney, placenta and choroid plexus, occurs via membrane-associated folate binding proteins that act as folate receptors and facilitate cellular uptake of folate.

- **Functions of Folic acid:**

  Folate, also known as folic acid, is essential for good health. Its functions are:

  1. **Folate is involved in the de novo synthesis of purines**: synthesis of purines (adenine and guanine), requiring the folate form: Folate requiring reactions also include those involved in phases of amino acid metabolism,
  2. **Folate specially helps in reducing the risk of heart disease** and stroke by lowering the level of the amino acid homocysteine in the blood (by forming methionine).
  3. **Folate is essential for the nervous system:** Myelin basic protein is methylated which acts as insulation for nerve cells. When the methylation cycle is interrupted, as it is during vitainin B12 deficiency, one of the clinical consequences is the demyelinatioll of nerve cells resulting in a neuropathy which leads to ataxia (lack of coordination), paralysis, and, if untreated, ultimately death.
  4. **Folate is also important for pregnant women.** Low blood levels of folate during pregnancy can cause neural tube defects-anencephaly (a defect in the closure of the neural tube) and spina bifida (a congenital defect in which the spinal column is imperfectly closed so that part of the meninges or spinal cord protrudes, often resulting in hydrocephalus and other neurological disorders).
  5. The dependency of methionine synthase on both folate and cobalamin explains why a single deficiency of either vitamin leads to the same megaloblastic changes in the bone marrow and other tissues, with rapidly dividing cells.

- **Recommended Dietary Allowance:** The individual requirement of folate for both the sexes recommended by ICMR is 100 mcg per day, which increases during pregnancy and lactation to 400 and 150, respectively. The requirements are expressed as dietary folate equivalents (DFE). One DFE is equal to 1 mcg of food folate. As natural folates are much less stable, chemically pure folic acid (pteroylmonoglutamate) can be used to provide part of the RNI, by way of fortification or supplementation.
- **Health aspects:**

  Deficiency:

  If there is inadequate dietary folate, the activity of both the DNA and the methylation cycles, will be reduced. A decrease in the former will reduce DNA biosynthesis and thereby reduce cell division. The deficiency will be most obvious in cells that rapidly divide like the red blood cells, thereby producing megaloblastic anaemia characterized by large, abnormally nucleated erythrocytes that accumulate in bone marrow. This results in an increased susceptibility to infection, decrease in blood coagulation, and intestinal malabsorption. Decrease in activity of the methylation cycle is an independent risk factor for cardiovascular disease and stroke.

  Pregnant women are at a higher risk of developing folate deficiency because of increased demand for folate. In addition to megaloblastic anaemia, inadequate folate intake is associated with poor pregnancy outcomes like cleft lip and palate, limb deficiencies and the outflow tract defects of the heart.. Impaired folate status is associated with increased risk of pre-term delivery, infant low birth weight and foetal growth .and retardation. Low folate status has been associated with an increased risk of colorectal cancer. Thus, it is evident that folate is very essential for good health.

  Toxicity:

  An upper level of 1000 yg has been prescribed. There is probably no great risk of toxicity at a range of intake between 400 and 1000 yg of folic acid per day, with the exception of some increased difficulty in diagnosing pernicious anaemia.

3.2.9 Pantothenic acid

Pantothenic acid is necessary for the release of energy from fatand carbohydrate. Animal products like meat, milk and meat products, cereals and legumes are rich sources of this vitamin. Dietary deficiency of this vitamin is rare or unlikely because it is so widespread in food.

3.2.10 Biotin

Biotin is also essential for the metabolism of fat. Very small amounts are required and sufficient may well be made by the bacteria normally inhabiting the large intestine. It is therefore probable that no additional biotin be provided in the diet, except in the very unusual situation when large quantities for raw eggs are consumed. Raw egg white contains avidin which combines with biotin making it unavailable to the body.
Rich sources of biotin include offal and egg yolk. Smaller amounts are obtained from milk and dairy products, cereals, fish, fruit and vegetables.

3.2.11 Vitamin C

Ascorbic acid is also known as the anti-scurvy vitamin. Its chemical names are ascorbic acid and ascorbate. It is a derivative of carbohydrate.

- **Food Sources**

Food sources of vitamin C include:

Rich sources:	Amla and guava.
Good sources:	Drumstick leaves, other leafy vegetables and fruits such as cashew fruit melons, berries, pine apple and tomatoes.
Fair sources:	Apples, banana, grapes.

Vitamin C is found in many fruits and vegetables. Citrus fruits and juices are particularly rich sources of vitamin C but other fruits including honeydew melons, cherries, kiwi fruits, mangoes, papaya, strawberries, tomatoes, and water melon also contain variable amounts of vitamin C. Vegetables such as cabbage, broccoli, brussels sprouts, bean sprouts, cauliflower, mustard greens, red and green peppers, peas, and potatoes may be more important sources of vitamin C than fruits, given that the vegetable supply often extends for longer periods during the year than does the fruit supply.

Vitamin C content of food is influenced by season, transport to market, and length of time on the shelf and in storage, cooking practices, and the chlorination of the water used in cooking. Cutting or bruising of produce releases ascorbate oxidase. Blanching inactivates the oxidase enzyme and helps to preserve ascorbate, Heating and exposure to copper or iron or to inildly alkaline conditions destroys the vitamin, and too much water leaches it from the tissues during cooking.

- **Absorption, storage and elimination:**

Ascorbic acid is absorbed from the intestines primarily by active transport. Simple diffusion contributes to a small extent of its absorption from the mouth and stomach. It passes through the portal vein to the general circulation and to all tissues. Each organ or tissue has an optimal saturation level of ascorbic acid. It is not stored to any appreciable extent in the body. Unabsorbed vitamin C may be metabolized by the intestinal flora. Pectin and zinc are a few substances that impair its absorption. Excess is excreted in urine.

- **Functions of Vitamin C:**

The vitamin C is involved in several physiological and biochemical functions in the body.

1. **Enzyme function:** Vitamin **C** acts as an electron donor for 11 enzymes out of which eight are found in humans.
2. **Protective role as an antioxidant:** Vitamin **C** is a powerful antioxidant because it can donate a hydrogen atom and form a relatively stable ascorbyl free radical.

3. **Synthesis of hormones**: Ascorbate is involved in the amidation, thereby conferring stability to hormones.
4. **Formation of collagen and inter cellular cement substance**: The vitamin is required in the formation of collagen and in the formation of intercellular cement substances for capillaries, teeth, bones etc. When the vitamin is deficient, these tissues are not formed fully.
5. **Absorption of iron and incorporation of plasma iron in .ferritin**: A common feature of vitamin C deficiency is anemia. The antioxidant properties of vitamin C may stabilize folate in food and in plasma. Vitamin C promotes absorption of soluble non-haem iron.
6. **Reduced cancel- risk**: Concentrations of vitamin C appear to be high in gastric juice. Vitamin C present in gastric juice may prevent the formation of N-nitroso compounds, which are potentially mutagenic. High intakes of vitamin C correlate with reduced gastric cancer risk, and diets with high vitamin C content have been associated with lower cancer risk, especially for cancers of the oral cavity, esophagus, stomach, colon and lung.
7. **Bone formation**: Ascorbate is vital for bone formation. In deficiency, though calcification is unaffected, formation of bone matrix and ground substance is defective. Osteoblasts invading the area of calcification change histologically into fibroblasts. The bone matrix is abnormal, as it lacks ossification.
8. **Wound healing**: Ascorbic acid deficiency delays healing of wounds, as collagen formation is affected. The rapid healing of wounds requires the formation of strong connective tissue on the scar.
9. **Cholesterol metabolism**: vitamin C plays a protective or curative role in diseases resulting from atherosclerosis through its effect on cholesterol metabolism. It protects low density lipoproteins against oxidation.

- **Recommended Dietary Allowance:**

The ICMR recommendation is 40 mg per day for both adult males and females. The requirements go up by another 40 mg (total 80 mg) during lactation.

- **Health aspects:**

Deficiency

Severe ascorbic acid deficiency results in the development of the disease known as scurvy. Three important manifestations of scurvy -gingival changes, pain in the extremities and hemorrhagic manifestations – precede edema, ulcerations, and ultimately death. The disease occurs in adults and infants. In infants scurvy is seen at the sites of most active bone growth, like pseudo paralysis of the limbs caused by extreme pain on movement and hemorrhages as well as, swelling and hemorrhages of the gums surrounding erupting teeth

Symptoms of scurvy in adults include:

1) General weakness: The first symptoms are weakness, easy fatigue and listlessness. These are followed quickly by shortness of breath, pain in bones, joints and muscles of the extremities.
2) Swollen and tender joints and hemorrhage in various tissues: Haemorrhages occur deep in muscle, particularly in calf, thigh, buttocks and forearm, causing pain in surrounding tissues.
3) Bleeding gums and loose teeth: As ascorbic acid deficiency advances, the gums become swollen, blue-red, spongy and very friable. They may become infected by bacteria. The teeth loosen in the alveolar bone.

Toxicity

Excessive doses of vitamin C relates to intra intestinal problems and to the effects of metabolites in the urinary system. Intakes of 2-3 g/day of vitamin C produce unpleasant diarrhea. Further, oxalate is an end-product of ascorbate catabolism and may cause kidney stone formation.

3.2.12 Vitamin D

Vitamin D is a generic term and can either be made in the skin from a cholesterol-like precursor (7-dehydrocholesterol) by exposure to sunlight or can be provided pre-formed in the diet. The version made in the skin is referred to as *vitamin D* whereas the dietary form can be either vitamin D3 or a closely-related molecule of plant origin known as *vitamin* D2.

- **Food Sources of Vitamin D**

  Vitamin D, also called the sunshine vitamin is easily manufactured in the skin from 7-dehydro cholesterol on exposure to sunlight, as already mentioned above .Small amounts are present in dairy products such as milk, cheese, butter, margarine and cream, egg yolk, liver, oysters and certain varieties of fish. So we have seen that it is not just through diet, sunlight can also help us to manufacture vitamin D.

- **Absorption, Storage and Elimination**

  As we have already mentioned earlier, all fat-soluble vitamins share a common metabolic fate. Vitamin D is absorbed along with fats from the duodenum and jejunum. Bile too is essential for the effective absorption of fats and therefore of vitamin D. Vitamin D formed in the skin by the direct irradiation of the provitamin present in the skin is directly absorbed into the blood stream. The vitamin is stored in concentrated quantities in the liver and to a lesser extent in the skin, spleen, lungs, brain and kidney. The main pathway of excretion of vitamin D is through the bile into the small intestine and consequent faecal excretion. Only less than four per cent of the intake of the vitamin is excreted by the urinary pathway.

- **Functions:** Vitamin D is required to maintain normal blood levels of calcium and phosphate, which are in turn needed for the normal mineralization of bone, muscle contraction, nerve conduction d general cellular functions in all cells of the body.
  1. **Mobilization of' bone calcium and phosphorus:** The functions of vitamin D are mediated by this vital vitamin D hormone by a homeostatic mechanism which involves the hormone acting on the intestines, kidney and bone to increase serum calcium and phosphorus levels. This helps to achieve a normal blood calcium concentration and maintenance of calcium homeostatis.
  2. **Mineralization and .formation of new bone:** Vitamin D plays a role in the synthesis of a prominent non collagenous protein, osteocalcin, a vitamin K dependent protein found in the bone matrix and dentine - which is associated with new bone formation.
  3. **Bone growth and development-calcification of osteoid tissue:** Vitamin D participates in metabolic processes associated with bone growth and development. It is involved in calcification of osteoid tissues. Osteoid is a protein mixture which is secreted by osteoblasts. When it mineralizes, it becomes bone.
  4. **Formation of enzymcs:** Vitamin D is essential for the formation of two enzymes alkaline phosphatase in the intestinal lining (involved in calcium transport) and adenosine triphosphatase, (for collagen formation in bone matrix).
  5. **Regulation of amino acid levels in the blood:** Vitamin D helps to prevent loss of amino acids through the kidney and thus regulate the ainino acid level and also regulate the level of citric acid in tissues and bones.
  6. **Participation in muscle formation and metabolism:** Vitamin D takes part in muscle function and metabolism.
  7. **Inhibition of cancer cell proliferation and growth:** Vitamin D diminishes proliferation of abnormal intestinal, lymphatic, mammary and skeletal cells and provides a potential for the treatment of skin diseases such as psoriasis (a disorder in which there is proliferation of the keratinocytes and a failure to differentiate rapidly).
  8. **Role in the immune system:** Immune responses that are mediated by T-cells can be inhibited by large doses of calcitriol. It is a natural steroid hormone formed in the healthy body as the biologically active form of vitamin D. A deficiency of vitamin D also interferes with the T-cell mediated immunity.
  9. **Regulation of blood pressure:** The renin-angiotensin system regulates the blood pressure. The synthesis of renin is decreased by calcitriol through its interaction with the vitamin D regulator (VDR). Inappropriate activation of the renin-angiotensin system is thought to play a role in some forms of human hypertension and adequate vitamin D levels may be important for decreasing the risk of high blood pressure.

- **Recommended Dietary Allowances for Vitamin D**

  The recommendations of vitamin D are expressed as IU. 1 IU is defined as *the activity contained in* 0.025 m*cg* of *cholecalciferol.* The recommended allowances for vitamin D as suggested by ICMR for Indians is 200-400 IU**.** A vitamin **D** supplement providing 400 to 800 IUs may be essential for the elderly, particularly who consume less milk and are totally home bound.

- **Health aspects:**

  Deficiency

  Infants constitute a population at-risk for vitamin D deficiency because of relatively large vitamin D needs brought about by their high rate of skeletal growth; Breastfed infants are particularly at-risk because of the low concentrations of vitamin D in human milk. This problem is further compounded in some infants fed human milk by a restriction in exposure to ultraviolet

(UV) light for seasonal, latitudinal, cultural or social reasons. Dietary absence of vitamin D or lack of UV (sunlight) exposure causes the bone disease called *rickets* in infants and children and *osteomalacia* in adults.

Toxicity

The adverse effects of high vitamin D intakes include *hypercalciuria* (excessive urinary calcium excretion) and *hypercalcaemia* (high concentration of calcium in blood). Excessive amounts of vitamin D are not normally available from dietary sources, and hence cases of vitamin D intoxication are rare. Nevertheless, toxicity may occur in individuals on excessive amounts of supplemented vitamins, for example, drinking milk fortified with inappropriately high levels of vitamin D3**.** The signs and symptoms associated with it are anorexia, nausea and vomiting, followed by polyuria, polydipsia, weakness, nervousness and pruritis (itchiness).

3.2.12 Vitamin E

Vitamin E is the generic term for *tocopherols* and *tocotrienols.* The tocopherols and tocotrienols occur as homologues - *a, b* and y

- **Food Sources of Vitamin E**

Vitamin E is present in almost all foodstuffs. It is found in wheat germ, corn, nuts, seeds, olives, spinach, asparagus and other green leafy vegetables and vegetable oils like groundnut, soy, cottonseed and safflower are rich sources. The vitamin E content of edible oils is usually proportional to the amount of polyunsaturated fatty acid content of the oils.

- **Absorption and Storage of Vitamin E** Absorption of vitamin E from the intestine depends on adequate pancreatic function, biliary secretion and micelle formation. Conditions for absorption are like those for dietary lipid, that is, efficient emulsification, solubilization within mixed bile salt micelles, uptake by enterocytes, and secretion into the circulation via the lymphatic system. Emulsification takes place initially in the stomach and then in the small intestine in the presence of pancreatic and biliary secretions. Tocopherol esters, present in processed foods and vitamin supplements, must be hydrolyzed in the small intestine before absorption.

Vitamin E is transported in the blood by the plasma lipoproteins and erythrocytes. From a nutritional perspective, the most important form of vitamin E is a-tocopherol. It is absorbed faster and retained better than other forms. T11is is due to the action of binding proteins that preferentially select the *a* form over other forms.

- **Functions of Vitamin E**

Vitamin E is the major lipid-soluble antioxidant in the cell antioxidant defense system and is exclusively obtained from the diet. The main role of vitamin E and the biological activity of tocopherols are due to its antioxidant property. This antioxidant property of vitamin E is useful for various body processes and substances.

1. ***Protection of poly unsaturated fatty acids (PUFA) from oxidative damage:*** The major biological role of vitamin E is to protect PUFAs and other components of cell membranes and low-density lipoprotein &DL) from oxidation by free radicals.
2. ***Protection of erythrocytes****:* Vitamin *E* protects erythrocytes from haemolysis by the production of oxidizing agents e.g. dialuric acid and hydrogen peroxide.
3. ***Protection of cell membrane****:* It protects the cell membrane from getting damaged from naturally occurring peroxides and toxic free radicals formed from fatty acids and oxidative tissue damage as described above.
4. ***Protection against poisoning****:* It protects liver from injury due to carbon tetrachloride poisoning.
5. ***Protection of both vitamin A and carotene****:* It protects vitamin A and p-carotene from destruction by oxidation, especially in the alimentary tract, thus sparing the supply of vitamin A available to the body.
6. ***Synthesis of enzymes and proteins:*** It serves as a co-repressor in the synthesis of certain enzymes and plays a specific role in the synthesis of haem proteins.
7. ***Protection of mitochondria:*** It protects the mitochondria1 function of the muscles and cardiac tissue. Tocopherol acts as an electron acceptor in the electron transport system and prevents the disruption of mitochondria.

8. ***Reduction in free radical generation:*** Vitamin E acts synergistically with selenium thereby reducing susceptibility of LDL lo oxidation, free radical generation and membrane damage. This antioxidant role of vitamin E together with selenium protects against cardiovascular diseases especially atherosclerotic lesions.
9. ***Regulation of enzyme activities****:* Vitamin *E* regulates the activity of enzymes, a-*aminole vulinic acid* ***(AL4)*** *synthetase* in bone marrow and ALA *dehydrase* in liver,
10. ***Prevention of diseases:*** Because of its anti-oxidant function and its role in inhibiting cell proliferation of smooth muscles, vitamin E can be used for prevention and treatment of diseases. Epidemiological studies suggest that dietary vitamin E influences the risk of cardiovascular disease. It has also been suggested that vitamin E supplementation (200-400 mg/day) may be appropriate therapeutically to moderate some aspects of degenerative diseases such as Parkinson disease, reduce the severity of neurologic disorders such as *tardive dyskinesia* (potentially irreversible and involuntary movements), prevent periventricular haemorrhage in pre-term babies, reduce tissue injury arising from ischaernia and reperfusion during surgery, delay cataract development, and improve mobility in arthritis sufferers.

- **Recommended Dietary Allowances for Vitamin E**

The requirements for the vitamin E are expressed in terms of tocopherol equivalents (TE) as mentioned earlier - 8 mg for females and 10 mg for males. It has been seen that the adequacy of RDA varies with PUFA content significantly; increased intakes necessitate larger amounts of vitamin E in the diet.

- **Health aspects**

Deficiency*:*

Vitamin E deficiency in human is extremely rare. This may probably be due to its wide occurrence in natural foods. Evidence of deficiency is however seen in individuals with chronic fat malabsorption. Vitamin E deficiency is a cause of the impaired neuromuscular function, sometimes seen in patients with disorders that interfere with absorption or transport of the vitamin. Symptoms include poor reflexes, impaired locomotion, decreased sensation in the hands and feet, and changes in the retina.

We read about the consequences of low intake of vitamin E on the human body.

Toxicity:

A very high intake of vitamin E can also elicit severe adverse reactions, as described next. Vitamin E is relatively non-toxic. Adults tolerate doses as high as 100 to 1,000 **IU** per day. However, adverse effects such as muscle weakness, fatigue, nausea, diarrhea, double vision, elevation of serum lipids, impaired blood coagulation and reduction of serum thyroid hormones occur due to indiscriminate ingestion of excessive amounts of vitamin E over long periods of time.

3.2.13 Vitamin K

Vitamin K is an essential fat-soluble micronutrient; its role in health is in the maintenance of normal coagulation.

- **Food sources of Vitamin K**

The only important molecular 'form of vitamin K is *phylloquinone.* Phylloquinone is distributed ubiquitously throughout the diet, and the ange of concentrations in different food categories is very wide. In general, the highest values (normally in the range 400-700 mg / 100 g) are found in green leafy vegetables (such as spinach, cauliflower, cabbage and lettuce). The next best sources are certain vegetable oils (e.g. soybean, rapeseed and olive), which contain 50-200 mg/100g, other vegetable oils, such as peanut, corn, sunflower and safflower, however, contain much lower amounts of phylloquinone (1-10 mg/100 g). Other good sources include animal foods such as egg yolk, milk and organ meats like liver.

- **Absorption, Storage and Elimination of Vitamin K**

Dietary vitamin **K,** mainly phylloquinone, is absorbed chemically unchanged from the proximal intestine after solubilization into mixed micelles composed of bile salts and the products of pancreatic lipolysis. Vitamin K is stored in the liver, - the site of synthesis of coagulation proteins.

Phylloquinone levels are high in liver, heart and pancreas. Vitamin K is extensively metabolized in the liver and excreted in the urine and bile. About 60-70% of the amount of' phylloquinone absorbed from each meal will ultimately be lost to the body by excretion. This, therefore, suggests that the body stores of phylloquinone are being constantly replenished.

- **Functions of Vitamin K**

The functions of vitamin **K** are both physiological and biochemical. These include:

1) **Blood coagulation**: The primary function of vitamin K in the body is in the maintenance of normal blood coagulation. The vitamin K-dependent coagulation proteins are synthesized in the liver and comprise Factor IT (prothrombin), Factor VII (proconvertin), Factor IX (Christmas factor) and Factor X (Stuart factor), which have a haemostatic role i.e. they are procoagulants that arrest and prevent bleeding.
2) **Vitamin K-dependent carboxylation***:* Vitamin *K* acts as a cofactor in the synthesis of y carboxyglutamic acid (Gla) from glutamic acid residues required for the normal coagulation of blood.
3) **Vitamin K dependent proteins***:* The four vitamin K-dependent procoagulant (factor 11 or prothrombin, and factors VII, IX, and X), about which we studied above, are *serine proteases* that are synthesized in the liver and then secreted into the circulation as inactive forms (zymogens). Two other vitamin K-dependent proteins, *protein **C*** and *protein* S, play a regulatory role in the inhibition of coagulation.
4) **Prevents bone loss***:* Vitamin *K* is known to inhibit bone loss through inhibiting effect on osteoblast formation.

- **Recommended Dietary Allowances**

Recommended dietary intakes have not been suggested for different age groups or gender. The safe levels of intake is 80 mcg for adult males and 65 mcg for adult females.

- **Health aspects**

Vitamin K in excess or low intakes can have serious implications on human health. Although such conditions are rare, they can often be life-threatening. Vitamin **K** deficiency leads to a lowered prothrombin level and increased clotting time, which could lead to hemorrhages. The population groups that appear most at risk for vitamin K deficiency are newborn infants and people who have been injurecl and have renal insufficiency. The increased risk for infants fed on human milk compared with formula milk is probably related to the relatively low concentrations of vitamin K (phylloquinone) in breast milk compared with formula milks.

Refer to tables 3.2.1 to 3.2.11 for ICMR RDIs of vitamins for Indians

3.3 Classification of Minerals, its sources, digestion, absorption, functions and nutritional requirement

We have already learnt that minerals or inorganic elements are necessary for the optimal functioning of the human body. Minerals have three major functions:

a) As constituents of the bones and teeth. These include calcium, phosphorus and magnesium.

b) As soluble salts which help to control the composition of the body fluids and cells. These include sodium and chlorine in the fluids outside the cells ex. Blood and potassium, magnesium and phosphorus inside the cells.

c) As essential adjuncts to many enzymes and other proteins such as hemoglobin which are necessary for the release and utilization of energy. Iron and phosphorus act in this way along with other elements.

These seven elements are in general needed in the greatest amounts in the diet and are present in the largest amounts in the body tissues together with sulphur and are thus considered as major minerals. The remainders are equally essential but needed in small quantities and are called trace elements. Excess of most of these can be poisonous.

3.3.1 Calcium

Among minerals, calcium (Ca) is most abundantly present in humans, representing 52% of the body's mineral content and amounting to 1.2% of body weight. In the elementary composition of the human body, calcium ranks fifth after oxygen,

carbon, hydrogen and nitrogen, and it makes up 1.9% of the body by weight. Nearly all (99%) of total body calcium is located in the skeleton together with more than three quarters of the body's phosphorus. The remaining 1 % is equally distributed between the teeth and soft tissues, with only 0.1% in the extracellular fluid (ECF).

- **Food sources of Calcium:**

Dairy products are of course the primary source of calcium followed by grains and pulses. Among the millets, ragi contains a good amount of calcium.

- **Functions:**

Calcium salts provide rigidity to the skeleton and calcium ions play a role in many if not most, metabolic processes. An understanding of the role of calcium in skeletal structures requires that the process of bone formation and mineralization be clearly comprehend. Bone is unique living tissue as it is rigid and strong and at the same time light enough to be moved by coordinated muscle contractions. There are two types of bones: the *cortisone,* densely packed mineralized collagen laid down in layers and the *ti+nbecullal bone* (cancellous bones), which is spongy and provides strength and elasticity. In addition to the structural role in bones, Ca also performs other functions in the body. These functions include:

1) Clotting of blood
2) Nerve conduction
3) Muscle contraction
4) Enzyme regulation
5) Membrane permeability

Ionized Ca is chiefly involved in these functions. As the levels of serum total and ionic calcium are tightly controlled, these functions are well regulated. Bone mineral serves as the ultimate reservoir for the calcium.

- **Absorption, storage and excretion:**

Calcium (Ca) in food occurs as calcium salts e.g. calcium phosphate or is associated with other dietary constituents e.g. calcium caseinate in milk. Before absorption, Ca must be released from foods and solubilized. This is achieved by the combined actions of gastric acid, intestinal enzymes, intestinal contractions and peristalsis. When calcium intake is low, calcium is mainly absorbed by active (transcellular) transport, but at higher intakes, an increasing proportion of calcium is absorbed by simple (paracellular) diffusion. Thus, calcium is absorbed from the intestine by transcellular route and paracellular route.

Not more than 4% (8 mg) of dietary Ca is absorbed by the colon per day. The unabsorbed component which appears in the feces together with the unabsorbed component of digestive juice calcium is known as endogenous fecal calcium. The feces, therefore, contain unabsorbed dietary calcium and digestive juice calcium that was not reabsorbed. Calcium is also excreted approximately in equal amounts in urine and through intestinal secretions. Bile and other secretions into the intestine account for 150 mg calcium per day of which 30% is reabsorbed. Losses through skin, hair and nails also need to be taken into account (insensible losses). Sweat losses are minimal, about 15 mg/day. Total calcium loss may thus amount to 350 mg/day.

We must remember the fact that the amount of calcium that we eat need not be the amount of calcium that gets absorbed. Several factors affect the proportion of dietary calcium absorbed by humans, also known as *fractional absorption of dietary calcium.* ***Age*** is one factor which influences the absorption of calcium. Fractional absorption of calcium is highest in infancy @ 6O%, followed by the early pubertal period. Absorption of calcium is also increased in *pregnancy* to levels higher than 25% reported in adults. Available data suggests that in post menopausal women, absorption declines by 0.21% every year. Thus, from 50 years Lo 70 years, absorption may decline by 4%. ***Food*** is another factor. Calcium is poorly absorbed from foods that are rich in oxalic acid or phytic acid. Phytates, present in the husk of many cereals, as well as, in nuts, seeds, and legumes, can form insoluble calcium phytate salts in the gastrointestinal tract. Excess oxalates can precipitate calcium in the bowel. In comparison to calcium absorption from milk, calcium absorption from phytic acid rich grains is one half and from spinach it is only one tenth. This is so because spinach is high in oxalic acid. Majority of the calcium absorbed is stored in the bones/skeletal tissues.

- **Nutritional requirement and RDA for Calcium :**

  Requirements for calcium depend upon the rate at which calcium is incorporated into bone; they are therefore highest during periods of growth, especially during infancy and adolescence and fall after peak bone mass is achieved at about 25 years of age. The RDA for Indian adult male is based on replacing the losses of calcium in urine, stools, bile and sweat, which is estimated to be 700 mg calcium per day. The fractional absorption in adults is taken to be 20-30% in the presence of adequate vitamin D. Additional calcium for growth, pregnancy and lactation are calculated separately.

- **Health aspects:**

  Deficiency

  If there is a continued inadequate intake or poor intestinal absorption of calcium, plasma calcium concentrations will be maintained from increased bone resorption. The cumulative effect of calcium depletion on the skeleton over many years contributes to the increasing frequency of fractures with age. Prolonged inadequate calcium intake in young growing children with red~~cthee rate of accretion of the skeleton and may prevent the attainment of the genetically determined maximal bone mass. In extreme cases, Ca deficiency can give rise to rickets in children.

  Calcium and Osteoporosis: Accelerated bone loss with age is a consistent finding in both women and men. It occurs earlier in women than in men as decreased estrogen production in menopause is associated with accelerated bone loss in women, estimated at **3%** per year in the first five years after menopause. The effectiveness of calcium supplements in retarding bone loss in post menopausal women is not entirely settled. However, clinical trials in this area seem to indicate that supplements of calcium can have beneficial effect in slowing the rate of bone loss in post menopausal women.

  Calcium and Hypertension: Chronic inadequate intake of calcium may play some role in etiologies of hypertension. Calcium deficiency has been linked to hypertension

  Toxicity

  Elevated blood calcium can occur in association with high parathyroid hormone, hyper- or hypothyroid conditions, bone metastasis, vitamin D toxicity, excess intake or absorption of calcium, Addison's disease and with thiazide diuretics. High blood calcium may be asymptomatic or can cause constipation, nausea and vomiting, increased urination, thirst, muscle weakness, kidney failure, irritability, confusion, psychosis and coma. The role of calcium supplements in eliciting hypercalcaemia has always been under scrutiny. Since the efficiency of absorption from large doses is poor, no adverse effects have been found with calcium supplements providing up to 2400 mg/day. However, at such high levels, iron absorption is reduced and risk of iron deficiency increases. A practical suggestion would be not to consume high dose of calcium with meals that provide most of the iron. Supplements of calcium do not carry the risk for renal stones in ilorinal individuals but can increase the risk in patients with renal hypercaliuria. In fact, it has been suggested that dietary calcium may protect against renal calculi because it binds dietary oxalate and reduces oxalate excretion. An upper limit on calcium intake of 3 g daily is recommended by the FAO/WHO 2004.

  Refer to table no.3.1 for ICMR RDIS for calcium for Indians

3.3.2 Phosphorus

Phosphorus is the second most abundant element in the human body, comprising 30% of the total mineral content. An adult human body contains approximately 600 g of phosphorus. Most phosphorus like Ca (as calcium phosphate) is stored in the bone and teeth in an inorganic metal state. The remaining 15% is distributed in soft tissues in both organic and inorganic form. Phosphates play an essential role in the liberation and utilization of energy from food. They are also constituents of nucleic acids and some fats, proteins and carbohydrates and must be combined with B-vitamins in the body before the latter can be active.

- **Food sources of Phosphorus**

  Phosphorus is widely distributed in food. Food phosphorus is a mixture of both organic and inorganic forms although the relative amounts vary with the type of food. Both animal and plant foods are important sources and include meat, fish

poultry, egg, milk and its products, nuts, legumes and cereals. 80% of phosphorus in grains is bound with phytic acid. In milk, 33% is in the inorganic form.

- **Functions:**

Distribution of phosphorus in body clearly explains that it functions as a structural component, as well as, has a role in metabolic reactions.

Inorganic Phosphorus: The major functions of inorganic phosphorus include:

1) *Structural component of bones and teeth:* Phosphorus is a part of calcium phosphate in various crystalline. Ca forms required for ossification.
2) *Acid-base balance:* Within cells, phosphate is the main intracellular buffer.

Organic Phosphorus: It is involved in the following reactions/components:

1) *Structural component* of *nucleic acids:* It is important component of DNA and RNA.
2) *Components of cell membrane:* Phospholipids with their polar and non polar regions are important for the bi layer structure of cell membranes.
3) Phosphorus is of vital importance in intermediary metabolism of the energy nutrients contributing to temporary storage and transfer of energy.
4) *Component of coenzymes* like NADP, TPP, PLP, coenzyme A, FAD, NAD
5) Many enzymatic activities are controlled by alternating phosphorylation or dephosphorylation. Thus, it is required in regulating metabolism.

- **Absorption, storage and excretion:**

As you have seen that food contains both organic and inorganic phosphorus, but most of it is absorbed in its inorganic form. Therefore, organically bound phosphorous is hydrolyzed in the lumen by intestinal *phosphatases.* However, organic phosphate of phytic acid may not be available. Phosphorus absorption occurs throughout the small intestine, although duodenum and jejunum are important sites. Phosphorus absorption is efficient-60-70%. Ingestion of antacids containing magnesium or aluminum hydroxide can interfere with phosphorus absorption.

It is important to note that unlike calcium, absorption efficiency of phosphorus does not increase on low intake nor any adaptive mechanism is available for the same. Most phosphorus is absorbed by passive concentration dependent process. Unabsorbed phosphorus is excreted in feces. Excretion of endogenous phosphorus is mainly through kidney.

- **Nutritional requirement and RDA for Phosphorus**

The requirements of phosphorus are closely linked with those of calcium. Phosphate requirements are fully met usually when diets provide adequate calcium as these two minerals generally occur together in foods.

- **Health aspects**

Situations' may develop when the phosphate levels in blood and other tissues may increase or decrease beyond normal levels. Such disturbances in the phosphorus levels may develop with or without any effects in the calcium metabolism.

Deficiency

Inadequate phosphorus intake results in abnormally low serum phosphate levels (hypophosphatemia). The effects of hypophosphatemia may include loss of appetite, anemia, muscle weakness, bone pain, rickets (in children), osteomalacia (in adults), increased susceptibility to infection, numbness and tingling of the extremities, and difficulty in walking. Severe hypophosphatemia may result in death. Because phosphorus is so widespread in food, dietary phosphorus deficiency is usually seen only in cases of near total starvation. Other individuals at-risk of hypophosphatepia include alcoholics, diabetics recovering from an episode of diabetic ketoacidosis, and starving or anorexic patients.

Toxicity

The most serious adverse effect of abnormally elevated blood levels of phosphate (hyperphosphatemia) calcification of non-skeletal tissues, most commonly the kidneys. Such calcium phosphate deposition can lead to organ damage, especially kidney damage.

3.3.3 Magnesium

After calcium, and potassium,Magnesium (Mg) is found in abundance in body but it is the least abundant among macro minerals, the total amount in the body being 25 g. Like Ca and P, this mineral is also present in the bones but unlike them which constitute 99% and 85% of the bones, only 55-60% of total magnesium is located in the skeleton. Another 20-25% is found in muscles with remaining in other soft tissues. Only 1% of total body magnesium is extracellular. Magnesium is closely associated with cells and is second to potassium in abundance in cells.

- **Food sources:**

Magnesium is widely distributed in variety of foods and beverages. In plants it is associated with chlorophyll. Thus, green leafy vegetables are excellent sources of magnesium. Most green vegetables, legume seeds, beans, tea, coffee, cocoa and nuts are rich in magnesium, as are some shellfish, spices, and soya flour, all of which usually contain more than 500 mg/kg fresh weight. Although most unrefined cereal grains are reasonable sources, many highly-refined flours, tubers, fruits and most oils and fats contribute little dietary magnesium (<100m g/kg fresh weight). Refining of whole cereals can reduce the magnesium content by 80%.

- **Functions:** Like Ca, Mg too has a role in bone formation. Soft tissue magnesium functions as a cofactor of many enzymes involved in energy metabolism, protein synthesis, RNA and DNA synthesis, and maintenance of the electrical potential of nervous tissues and cell membranes.
    1) Between 50% and 60% of body magnesium is located within bone, where it is thought to form a surface constituent of the *hydroxyapatite* (calcium phosphate) mineral component.
    2) Within cells, Mg is bound to phospholipids of the cell membrane (plasma, mitochondria, endoplasmic reticulum). It helps in membrane stabilization.
    3) Mg is responsible for the structural integrity of the subunits forming ribosome. It also maintains double helical structure of DNA.
    4) Intracellular free Mg+2 regulate ion movements.
    5) Mg is vital for energy production as it is required b-y ATP synthesizing protein in the mitochondria.
    6) As intracellular component, it is essential for different enzyme reactions, as structural cofactor or an allosteric activator of enzyme activity.

- **Absorption, storage and excretion:**

Magnesium absorption to some extent is similar to that of Ca. Absorption of Mg occurs throughout the small intestine, although jejunum and ileum are important sites. It crosses the intestinal membrane by both active transport and passive diffusion. Colon may also play a role in its absorption. About 30-65% of dietary Mg is absorbed in healthy adults. Like Ca, absorption of Mg is also more efficient when its status is marginal or intake is low. High intake of dietary fiber (40-50 g/day) lower magnesium absorption. This is probably attributable to the magnesium-binding action of phytate phosphorus associated with the fibre. However, consumption of phytateand cellulose-rich products increases magnesium intake (as they usually contain high concentrations of magnesium) which often compensates for the decrease in absorption. Lactose, fructose and protein appear to increase its absorption. Magnesium homeostasis is maintained chiefly by controlling its excretion through urine. The kidney has a very significant role in magnesium homeostasis. Active reabsorption of magnesium takes place in the Loop of Henle in the proximal convoluted tubule. About 70% of serum Mg is filtered by kidney, but 95% of this is reabsorbed by a healthy kidney. Regulation of Mg homeostasis occurs chiefly through renal excretion.

Nutritional requirement and RDA for Phosphorus:

Since plant foods are particularly high in magnesium, a vegetarian diet with plenty of green vegetables is unlikely to cause Mg deficiency. No specific recommendation is made by ICMR for Mg intakes in Indians. However, the FAO/WHO 2004 recommended nutrient intake for magnesium as 220 and 260 mg magnesium per day for adult females and males, respectively whereas no increment for pregnancy but around 50 mg/day increment for lactation.

Health aspects
Deficiency

Deficiency of magnesium is rare for two reasons: firstly, the mineral is widely distributed in the foods; secondly, kidney is able to adjust re-absorption of filtered magnesium to body needs. Studies have shown that a decline in urinary magnesium excretion during protein energy malnutrition (PEM) is accompanied by a reduced intestinal absorption of magnesium. The catch-up growth associated with recovery from PEM is achieved only if magnesium supply is increased substantially.

Toxicity

Excessive intake of Mg is not likely to cause toxicity except in people with impaired renal function. Excessive intakes of Mg salts such as MgSO4 can lead to diarrhea.

3.3.4 Sodium, Potassium and Chloride

These three macro minerals, Na, K and Cl are related to each other and hence will be discussed together, which makes it easier to appreciate their roles in metabolism. Sodium and potassium are monovalent cations (ions that carry a positive charge) while chloride is a monovalent anion (ions that carry a negative charge). All three are known as *electrolytes* as their ions are used for generating electric charge differences across the plasma membrane of most cells. Na constitutes 2%; K 5% and C1 3% of the total mineral content of the body. These minerals exist as ions in the body fluids and are principal electrolytes in the body. Potassium is a major intracellular electrolyte while sodium and chloride are present in the extracellular fluids.

- **Food sources:**

Common salt added to our food in the form of sodium chloride is the major source of sodium and chloride. Naturally occurring sources of sodium are milk, meats, eggs and most vegetables. In addition, food additives used in processed foods such as baking powder, preservatives etc. contribute towards dietary sodium intake. Therefore, it is important to take note of all these while calculating the sodium content of diets, On the other hand, potassium is abundant in unprocessed foods, fruits, many vegetables and fresh meats. Also many salt substitutes contain potassium instead of sodium.

Functions:

- **Absorption, storage and excretion:**

All these three elements are readily absorbed from the small intestine with almost 90-100% efficiency. They are excreted primarily via urine, although feces and sweat are other sources of elimination. It is important to note that profuse sweating can result in substantial losses of these elements. Potassium is absorbed in the.smal1 intestine as a consequence of bulk fluid absorption.

Both sodium and potassium are absorbed in the distal colon. Renal excretion and retention of these elements is closely regulated. The total content of body sodium especially the concentration in the extracellular fluid (ECF) is under homeostatic control. The regulation of chloride is achieved indirectly through sodium regulation. Like sodium, the maintenance of **K** balance also depends on the kidney. Unlike sodium, the transport of K is bi-directional during the passage of the filtrate through nephrons. In the proximal tubule and loop of Henle, major portion of filtered K is reabsorbed. In the distal tubule, it can be reabsorbed from the filtrate or can be secreted into it depending on the body's need. Aldosterone acts reciprocally on Na and K. This hormone stimulates sodium reabsorption, but it accelerates the secretion of potassium and thus increases its excretion. It is important to note that body's ability to conserve sodium by restricting loss in the urine is more efficient than its ability to conserve potassium. Also, sodium is absorbed more efficiently from the gastrointestinal than potassium**.** Therefore, potassium deficiency will appear before sodium deficiency.

- **Nutritional requirement and RDA for Na, K and Cl and Health aspects**

Deficiency

Hyponatremia and Hypernatremia: Serum concentration of sodium is normally regulated within the range of 135 to 145 milimole per litre (mM/L). Hyponatremia is defined as a Na level under 130 *mM/L.* When plasma Na level falls below 120 mM/L, symptoms such as headache, confusion, seizures and coma can occur. *Hvpernatremia* occurs less commonly and is defined as *serum sodium level above 145 mM/L.* The initial symptoms include irritability, lethargy and restlessness. Seizures and death may occur when plasma levels rise above 160 mM/L.

Hypokalemia and *Hyperkalemia:* Normal serum *K* ranges from 3.5-5 mM/L.

Hypokalemia or *low plasma* K *levels* can occur with a net shift of potassium from the plasma to the cells. This shift can occur in alkalosis. Overall depletion of body's K, which occurs in vomiting, prolonged fasting can also result in this shift. Mild hypokalemia results in weakness and muscle cramps and can cause arrhythmias in patients with heart diseases. Severe hypokalemia *(<2.5* mM/L of **K)** can result in paralysis. *Hyperkalemia* occurs when serum K levels are greater than 5 mM/L. High plasma K results in cardiac arrhythmias. A potassium level of 8.0 mM/L can cause cardiac arrest and death.

Refer to tables

3.3.5 MICRO MINERALS

A trace element or micromineral can be defined as a chemical or element present in minute quantities; especially one used by organisms and essential to their physiology. It is an organic compound essential in minute amounts for the growth and health of an animal. Like macro minerals, micro minerals must also be present in the body in optimal range for normal functioning. Whenever, the concentration is too low or too high, body functions are impaired. Knowledge of the exact roles and dietary requirements for these minerals is incomplete as some of them have been recently found to be essential, for some their dietary deficiencies are unknown and for some the utilization of them in the body may be affected by the amount of other elements present.

3.3.5.1 IRON

Iron is one of the most investigated minerals in nutrition. We associate iron with its presence in blood and that its deficiency results in low hemoglobin levels and hence anemia. In humans, the total quantity of iron in the body varies with hemoglobin concentration, body weight, gender and the amount of iron stored in various tissues. Healthy adults contain about 3 to 4gm of iron more than half of which is in the form of hemoglobin, the red pigment of blood. Iron is also present in the muscle protein myoglobin and is stored to some extent in organs such as the liver.

- **Food sources of Iron:**

Iron is found in foods in one of the two forms i.e. *haem* or ***non-haem.*** In the human diet, the primary sources of hem iron are the hemoglobin and myoglobin from consumption of meat, poultry and fish whereas non-hem iron is obtained from dried apricots, raisins, cereals, pulses, legumes, fruits and vegetables. Dietary non-hem iron accounts for about 85% of the total iron intake even among non-vegetarians.

Functions:

Iron has several vital functions in the body. It serves as a carrier of oxygen to the tissues from the lungs by red blood cell hemoglobin, as a transport medium for electrons within cells, and as an integrated part of important enzyme systems in various tissues. The general classification of the reactions in which iron is involved includes:

- Oxygen transport and storage
- Electron transfer
- Substrate oxidation- reduction

Iron participates in a large number of biochemical reactions. However, for iron to perform any function, it first needs to be taken up by the cells. Cell membranes contain a protein specific for binding transferrin called ***'transferrin receptor'***. Transferrin containing two ferric ions, binds to this receptor. Within the cell, iron is released from transferrin.

As a part of hemoglobin, iron is required for the transport of oxygen, to all cells in the body. Thus, hemoglobin is critical for cell respiration. Most of the iron in the body is present in the erythrocytes as hemoglobin, a molecule composed of four units, each containing one hem group and one protein chain. The structure of hemoglobin allows it to be fully loaded with oxygen in the lungs and partially unloaded in the tissues like in the muscles.The iron-containing oxygen storage protein in the muscles, ***myoglobin,*** is similar in structure to hemoglobin but has only one haem unit and one globin chain. As myoglobin, iron functions as a ready source of oxygen to the muscles.

Hence Iron is thus crucial for the survival, growth and normal functioning of the human system.

- **Absorption, storage and excretion:**

Like other minerals, we obtain iron from the diet, which is absorbed from the gastrointestinal tract. **A** unique feature of iron metabolism is that the body re utilizes quantitatively the iron released from the degradation of erythrocytes, with very little being excreted. Hence, it is very frequently mentioned that once iron enters the body, the body holds on to it tenaciously.

Before it can be absorbed, iron whether it is in the form of haem or non-haem, must be released from the food matrices where it is bond with other constituents. Proteases (the enzyme) in the stomach and small intestine hydrolyze haem iron from the globin portion of haemoglobin or myoglobin. In the case of non-haem iron, gastric secretion including HCl and pepsin aid its release from food components. Most non-haem iron is present in the ferric form which is reduced to ferrous form in the acidic environment of the stomach.

The body has three unique mechanisms for maintaining iron balance. The first is the continuous *reutilization of iron* from catabolized erythrocytes in the body. The second mechanism involves access to the specific storage protein, *ferritin.* This protein stores iron in periods of relatively low need and releases it to meet excessive iron demands. This iron reservoir is especially important in the third trimester of pregnancy. The third mechanism involves the regulation of absorption of iron from the intestines; decreasing body iron stores trigger increased iron absorption and increasing iron stores trigger decreased iron absorption. Iron absorption decreases until equilibrium is established between absorption and requirement.

Transferrin is a glycoprotein and has two binding sites for Fe3+. It acts as an iron transport protein. Normally, in plasma it is one-third saturated with ferric ions. It distributes iron throughout the body to wherever it is needed, mostly to erythrocyte precursors in the bone marrow. Any absorbed iron in excess of body needs is stored in the liver, in two forms, as ***ferritin*** and ***haemosiderin.*** Ferritin and haemosiderin are the two major iron storage proteins. Our body has a limited capacity to excrete iron once it has been absorbed. Daily losses in adult man are between 0.9 to 1.05 mg. About 0.08 mg is lost via urine, 0.2 mg via skin, and remaining in the feces. Women in the reproductive age lose more iron owing to menstrual cycles.

Nutritional requirement and RDA for Iron:

The requirements for iron, as recommended by ICMR, for various age-groups, are based on iron absorption of 3% in adult men, adolescent boys and children; *5%* in adult women, adolescent girls, lactating women, and 8% in pregnant women.

- **Health aspects:**

Deficiency

Iron deficiency is one of the most prevalent nutritional deficiencies in the world today. It is estimated that 2 billion people worldwide suffer from different degrees of iron deficiency, about half of them, manifesting iron deficiency anemia. Iron deficiency and iron deficiency anemia are often incorrectly used as synonyms. Iron deficiency is defined as *a hemoglobin concentration below the optimum value in an individual,* whereas iron deficiency anemia implies that *the hemoglobin concentration is below the 95th percentile o f the distribution of hemoglobin concentration in a population.*

The progression from adequate iron status to iron deficiency anemia develops in three overlapping stages. The *first stage* is depletion of storage iron with serum ferritin levels starting to decline. However, the transferrin saturation, erythrocyte protoporphyrin and hemoglobin are within normal limits. As iron stores get increasingly depleted, iron deficiency develops

which is the *second stage.* During this stage, in addition to low serum ferritin levels, transferrin saturation is also reduced and erythrocyte protoporphyrin is elevated. Hemoglobin may be normal. Eventually when iron deficiency progresses to anemia, hemoglobin levels start declining; this is the *third and final stage* of iron deficiency.

The functional effects of iron deficiency anemia result from both a reduction in circulating hemoglobin and a reduction in iron-containing enzymes and myoglobin.

These include:

- fatigue, restlessness and impaired work performance,
- disturbance in thermoregulation,
- impairment of certain key steps in immune response,
- adverse effects on psychomotor and mental development particularly in children,
- Increased maternal and perinatal mortality and morbidity.

In humans, about 10% of brain-iron is present at birth; at the age of 10 years, the brain has only reached half its normal iron content and optimal amounts are first reached between the ages of 20 and 30 years. Several groups have demonstrated a relationship between iron deficiency and attention, memory and learning in infants and small children. 70% or more of the pre-school children, 90% or more of pregnant women and adolescent girls suffer from either iron deficiency or iron deficiency anemia in India. The serious functional effects of iron deficiency anemia on learning, cognition and physical performance in children and productivity in adults, as well as, increased maternal 'and pre-natal mortality in pregnant women make it imperative to prevent and or treat iron deficiency as a priority. There is a major National programme, the *National Nutritional Anemia Control Programme* that aims to prevent and treat anemia in pregnant women using a public health approach. Iron (100 mg elemental iron) and folic acid (0.5 mg) in the form of tablets are provided to all pregnant women for 100 days during a pregnancy through the ICDS. Nutritional iron deficiency implies that the diet cannot supply enough iron to coves the body's physiological requirements for this mineral. Worldwide, this is the most common cause of iron deficiency. In many tropical countries, infestations with hookworms lead to intestinal blood losses that in some individuals can be considerable.

Toxicity:

An excessive body burden of iron can be produced by greater-than-normal absorption from the alimentary canal, by parenteral injection or by a combination of both. For instance, people with genetic defects develop iron overload as it occurs in *idiopathic hemochromatosis.* It is *a hereditary disorder of iron metabolism characterized by abnormally high iron absorption owing to a failure of the iron absorption control mechanism at the intestinal level.* High deposits of iron in the liver and the heart can lead to cirrhosis, hepatocellular cancer, congestive heart failure and eventual death.

Refer to Table no.3.3.5.1 for ICMR RDIs of iron for Indians

3.3.5.2 ZINC

Zinc is present in all body tissues and fluids. The total body zinc content has been estimated to be 30 mmol or 2 g. Skeletal muscle accounts for approximately 60% of the total body content and bone mass, with a zinc concentration of approximately 30%. The concentration of zinc in lean body mass is approximately 0.46 mmol/g .Plasma zinc has a rapid turnover rate and it represents only about 0.1% of total body zinc content. This level appears to be under close homeostatic control. High concentrations of zinc are found in the choroid of the eye (4.2 mmol/g) and in prostatic fluids (4.6-7.7 mmol/l or 300 -500 mg/L).

- **Food sources of Zinc:**

Zinc is normally associated with the protein and or nucleic acid fraction of foods.

Thus, foods high in proteins are good sources of zinc. Lean red meat, whole-grain cereals, pulses and legumes provide the highest concentrations of zinc: concentrations in such foods are generally in the range of 25-50 mg/kg of raw weight. Processed cereals with low extraction rates, polished rice, and chicken, pork or meat with high fat content have moderate zinc content, typically between 10 and 25 mg/kg. Fish, roots and tubers, green leafy' vegetables, and fruits are only modest

sources of zinc, having concentrations < 10 mg/kg. Saturated fats and oils, sugar and alcohol have very low zinc contents. Zinc is present in high amounts in nuts and red meat. Among seafood, oysters are very high in zinc. Other good animal sources include poultry, pork and dairy products. Among the foods of plant origin, legumes, whole grain cereals and vegetables (leafy vegetables and roots) are the good sources. Refining of cereals reduce the content to a large extent.

- **Functions:**

Zinc is an essential component of a large number of enzymes participating in the synthesis and degradation of carbohydrates, lipids, proteins and nucleic acids, as well as, in the metabolism of other micronutrients. Zinc stabilizes the molecular structure of cellular components and membranes and in this way contributes to the maintenance of cell and organ integrity. Furthermore, zinc has an essential role in polynucleotide transcription and thus, in the process of genetic expression. Zinc also plays a central role in the immune system, affecting a number of aspects of cellular and humoral immunity.

- **Absorption, storage and excretion:**

Like iron, zinc also needs to be liberated from food prior to absorption. During digestive process; proteases, nucleases and hydrochloric acid all appear to release zinc bound to proteins and nucleic acids. Zinc is absorbed throughout the small intestine, with absorption being most efficient in the jejunum. Zinc given as aqueous solution to fasting subjects is absorbed to the extent of 60-70%. However, absorption from solid diets is less efficient and varies widely depending upon the content of the zinc in the meal and the composition of the diet. Phytates are present in whole-grain cereals and legumes and in smaller amounts in other vegetables. They have a strong potential for binding divalent cations and their depressive effect on zinc absorption has been demonstrated in humans. After absorption, zinc is bound to albumin and transported to the liver. In liver, it is concentrated and then transported to different tissues by various plasma proteins. Zinc is taken up by various tissues and is incorporated in different enzymes. Zinc is found in most organs, concentration being higher in liver, kidney, muscle, skin and bone. Zinc content of muscle, brain, lungs and heart is relatively stable and does not respond to changes in dietary zinc intake. Similarly, release of zinc from bones is very slow and does not contribute zinc to other tissues during deprivation. Zinc is excreted primarily through the following three routes:

i) *Gastrointestinal tract:* Majority of zinc is lost from the body in feces.
ii) *Kidney:* Very small amount of zinc is excreted in the urine (0.3-0.7 mg/day), as most of the zinc filtered by the kidney is reabsorbed. Starvation and muscle catabolism increase zinc losses in urine.
iii) *Body surface:* Loss of zinc occurs due to the exfoliation of skin and sweating (0.7 -1.0 mg/day). Another route of zinc loss is hair, which contains 0.1-0.2 mg Zdg hair. Strenuous exercise and elevated ambient temperatures can lead to high losses through perspiration.

- **Nutritional requirement and RDA for Zinc:**

The requirement for adult males is 11 mg/day and adult females are 8 mg/day. It is increased to 11 mg during pregnancy and 12 mg during lactation. A tolerable upper limit of 40 mg/day for adults has been advised by the US Food and Nutrition Board. Intakes in excess of 40 mg are undesirable.

- **Health aspects**
  Deficiency:

The clinical features of severe zinc deficiency in humans are growth retardation, delayed sexual and bone maturation, skin lesions, diarrhea, alopecia (loss of hair or baldness), impaired appetite, increased susceptibility to infections mediated via defects in the immune system, and the appearance of behavioral changes. The central role of zinc in cell division, protein synthesis and growth is especially important for infants, children, adolescents and pregnant women; these groups suffer most from an inadequate zinc intake. Zinc-responsive stunting has also been identified in several studies. Even though zinc is an essential requirement for a healthy body, too much zinc can be harmful.

Toxicity:

Gross acute zinc toxicity has been reported after consuming water stored in galvanized containers. Symptoms include nausea, vomiting and fever. These symptoms are observed after ingestion of 2g or more of zinc. Long-term zinc intakes

higher than requirements could, however, interact with the metabolism of other trace elements. Copper seems to be especially sensitive to high zinc doses. Intakes between 25 -50 mg zinc per day have been reported to interfere with metabolism of both iron and copper. FAO/NHO 2004 therefore recommended the upper level of zinc intake for an adult man at 45 mg/day.

3.3.5.3 COPPER

From very early times, copper compounds were used to treat various diseases. It is now known that copper is a constituent of several enzymes and proteins, most of which catalyze oxidation reduction reactions. In the body, copper occurs in two oxidation states- Cu" (Cuprous) or Cu2+ (Cupric). The body of a healthy adult contains a little over 0.1 g of copper with concentration being high in liver, brain, heart, bone, hair and nails. About 25 % of body copper is present in muscle, and 42% in the skeleton.

- **Food sources of Copper:**

Green leafy vegetables, nuts, legumes, dried fruits, muscle meats and shellfish especially oysters are foods containing more than 1 mg copper per 1000 kilocalories. Copper though present in small amounts in the food needs to be absorbed, transported, stored and excreted efficiently so as to be able to perform its host of functions some of which are critical for other metabolic functions in our body.

- **Functions of copper**:

Copper serves as a co-factor, as well as, an allosteric component of enzymes. In many enzymes copper functions as an intermediate in electron transfer. Copper appears to influence gene expression through binding to specific transcription factors. In some cases, copper has been shown to influence transcription by binding to transcription factor, which in turn binds to promoter sequence of DNA.

Absorption, storage and excretion:

In food, most copper is present as Cu2+ and some as Cu+. This copper is bound to organic compounds especially protein. pepsin and some proteolytic enzymes aid in the release of copper. Released copper forms soluble complexes with amino acids, organic acids and other chelators which are readily absorbed mainly in the upper intestinal tract. Some copper is also absorbed from the stomach; Once copper is within the intestinal cell, it may be used by the cell, may be stored in the cell or may be transported across the basolateral membrane. Most absorbed copper is secreted by the liver into the bile to be excreted jn the feces. This process is the major regulator of copper elimination. Only small amount of copper (10-50 mcg) is excreted through kidney. Thus, the absorption and excretion process of copper helps in maintaining optimum levels of this element in our body so that it can help in performing a number of metabolic reactions in the body.

- **Nutritional requirements:**

Safe and adequate range for copper intake is 1.5-3 mg/day.

- **Health aspects:**

Deficiency:

The predisposing factors of copper deficiency are prematurity, low birth weight and malnutrition, especially when combined with feeding practices such as cow's milk or total parenteral nutrition. The most frequent symptoms are anemia, neutropenia (abnormally high levels of a type of WBC's in blood) and bone fractures. Other less frequent symptoms include hypo-pigmentation, impaired growth, and an increased incidence of infections and abnormalities of glucose and cholesterol metabolism.

Toxicity

Acute copper toxicity in humans is rare and occurs due to inadvertent consumption of copper salts. Symptoms include vomiting, diarrhea, hemolytic anemia, renal and liver damage. Clinical symptoms of chronic copper toxicity appear when the capacity for protective copper binding in the liver is exceeded which include jaundice, hepatitis and liver cirrhosis.

Apart from an abnormally high or low intake, copper imbalance in various tissues may also develop as a consequence of genetic disturbances in the metabolism of copper. The most important one's being the ***Menke's*** and the ***Wilson's disease.***

3.3.5.4 SELENIUM

Selenium is a non metallic element and exists in several oxidation states which include Se2+,S e4+and Se6+.T he chemistry of selenium is similar to that of sulphur. Total selenium content of the body varies from 3-15 mg depending on the dietary intake. Approximately 30% of tissue selenium is contained in the liver,

15% in kidney, 30% in muscle and 10% in blood plasma.

- **Food Sources of selenium:**

Environmental conditions and agricultural practices have a profound influence on the selenium content of many foods. Selenium enters the food chain through plants. The concentration of selenium in plants is directly related to the concentration of the mineral in the soil on which plants were grown. Among the different trace elements, selenium varies greatly in its soil concentration. The absorption of selenium by plants is not only dependent on the concentration of selenium in the soil but also on pH, microbial activity, rainfall and the chemical form of selenium. Owing to all above factors, the selenium content in food varies greatly. Overall, animal products, especially organ meats, are thought to contain more selenium than plant sources

Until recently, the only known metabolic role of selenium in humans was as a component of glutathione peroxidase which along with vitamin E and superoxide dismutase forms a part of the antioxidant defense system. Selenoproteins in animals and humans are involved in protection from oxidative damage, maintaining adequate thyroid hormone status and protection from injury by a heavy metal like mercury.

Selenium compounds' are generally very efficiently absorbed by humans and selenium absorption does not appear to be' under homeostatic control. Selenium is mainly absorbed from the duodenum. Less absorption occurs in the jejunum and ileum. In addition, some dietary factors appear to influence the absorption of the element. Phytates and heavy metals, such as mercury through chelation and precipitation, hinder selenium absorption. Vitamins C, A and E, as well as, glutathione enhance the absorption. Selenium is excreted from the body almost equally in the urine (as methyl selenium) and feces (unabsorbed selenium, biliary, pancreatic and intestinal secretion). Unlike copper, selenium is rapidly excreted in urine. Selenium losses through lungs and skin also contribute to daily selenium excretion.

- **Nutritional requirements:**

In the U.S., recommended nutrient intake is 70 mcg/day for men and 55 mcg/day for women.

- **Health aspects:**

Deficiency

Selenium deficiency has been linked to two regional human diseases: *Keshan disease* and *Kashin Beck's disease.*

Keshan disease: It is a cardiomyopathy (disease of the myocardium, involving heart muscle) that was identified to affect children and women of child bearing age in China.

Kashin Beck disease: Kashin Beck disease was identified to affect growing children in parts of Siberian Russia and China. It is characterized by osteoarthritis involving degeneration and necrosis of the joints and epiphyseal-plate cartilages of legs and arms.

Toxicity

There is a narrow margin between the beneficial and harmful intakes of selenium. The level at which selenosis occurs is not well-defined but threshold for toxicity appears to be 850-900 microgram per day. Symptoms of chronic toxicity include brittle hair and nails, skin lesions with secondary infections and garlic odor in the breath.

3.3.5.5 CHROMIUM

Chromium is present in small amounts in human body wherein the kidneys, followed by spleen, liver, lungs, heart and skeletal muscle are the tissues with greatest chromium concentration. Chromium supplementation is known to improve impaired glucose tolerance. Like other elements, Chromium also exists in several oxidation states from Cr2- to Cr6+ however Cr3+ or the trivalent form is the biologically important one.

- **Food Sources**

Like we know, chromium occurs in trivalent form in foods. Good sources of chromium include whole grains, spices and condiments, meats especially organ meats, mushrooms, cheese, prunes and tea. Brewer's yeast has a high content of biologically active organically complexed form known as the ***Glucose Tolerance Factor (GTF).*** Chromium forms complexes with nicotinic acid and amino acids to form GTF.

- **Functions**

Active chromium as GTF potentiates the action of insulin and thus influences carbohydrate, lipid and insulin metabolism.

1. *Role in Insulin Formation:* chromium activates the 'insulin receptor tyrosine kinase' and inhibits the 'insulin receptor tyrosine phosphatase which leads to an increased phosphorylation of the insulin receptor, which is associated with increased insulin sensitivity. Since chromium improves insulin function, it is suggested that chromium may play a role in glucose and lipid metabolism.
2. *Role in Glucose, Lipid and Nucleic Acid Metabolism:* Chromium leads to a decrease in blood glucose concentration in people with elevated glucose levels and an increase in those with low blood glucose levels. It shows no effect in the subjects with normal blood glucose levels.
   Overall, chromium appears to reduce levels of total cholesterol, LDL cholesterol and triglycerides in blood and increase level of HDL cholesterol.

   Another proposed role for chromium is in relation to nucleic acid metabolism. It is postulated that Cr3+ is involved in maintaining the structural integrity of nuclear strands and in the regulation of gene expression.

- **Absorption, storage and excretion:**

Chromium appears to be absorbed throughout the small intestine, with absorption being higher in jejunum. The mechanism of absorption involves simple diffusion and other processes. As compared to healthy individuals, insulin-dependent diabetic patients absorb 2-4 times more chromium. It appears that these patients have an impaired ability to convert inorganic form to usable form and therefore require higher chromium.

After absorption, chromium binds to plasma proteins for transportation. Both transferring and albumin are capable of binding absorbed Cr. Although transferrin and albumin play the major roles in transportation, other plasma proteins such as alpha and beta globulins and lipoproteins are also involved. It appears that absorbed inorganic chromium is transported to the liver, which is postulated to be the possible site for synthesis of metabolically active molecule. This molecule is held in a body pool and released as needed.

Most ingested chromium is excreted in feces. Inorganic chromium is excreted primarily by the kidney, with small amounts being excreted through hair, sweat and bile. Organically bound chromium is excreted through bile.

- **Nutritional requirements:**

There is no Recommended Dietary Allowance (RDA) for chromium but adequate intakes that can be used as a goal for individual intakes has been proposed by the Food Nutrition Board of the National Academy of Services, USA. An adult male and female require up to 30 and 20 microgram per day. During pregnancy and lactation chromium needs increase to 30 and 45 micrograms per day respectively.

- **Health aspects:**

Deficiency:

Marginal chromium deficiency leads to *impaired glucose tolerance.* Individuals receiving TPN without chromium have been shown to develop symptoms of deficiency such as impaired glucose tolerance with high blood glucose level and glucose excretion in urine. Peripheral neuropathy has also been reported which was reversed with chromium supplementation. Chromium deficiency results in insulin resistance characterized by hyperinsulinemia. Hyperinsulinemia is implicated as a risk factor for coronary heart disease.

Toxicity

Trivalent chromium, the form of chromium found in foods and supplements, is least toxic. Oral supplements up to 800 to 1000 mcg per day appear to be safe. Cr6+ on the other hand can be highly toxic. Inhalation of Cf" may result in respiratory disease while direct contact results in dermatitis and skin ulceration and sometimes liver damage.

3.3.5.6 MANGANESE

In living tissues, manganese is found in the + 2, **+3** and +4 oxidation states. An adult man is estimated to contain 10-20 mg of the metal, with *25%* of the total body stores in the skeleton. In addition, the rest is present in liver, pancreas and intestine.

- **Food Sources**

The food sources of manganese are whole cereals, nuts; leafy vegetables and tea. Diets high in foods of plant origin provide an average 8.3 mg of manganese per day.

- **Functions**

Like other microminerals, Mn also functions in mammalian enzyme systems. It can function both as an integral part of metalloenzymes and as an enzyme activator.

1. *Antioxidant activity:* As Mn is a component of mitochondria (Superoxide Dismutase (SOD), it can protect against oxidative damage.
2. *Carbohydrate metabolism:* Mn is required for carbohydrate metabolism.
3. *Integrity of cartilage:* Mn plays an important role in proteoglycan biosynthesis, which is essential for the integrity of cartilage.

- **Absorption, storage and excretion:**

Intestinal absorption of Mn occurs throughout the length of the small intestine. Ingested manganese is thought to be converted into Mn3+ in the duodenum. Studies show that the mucosal uptake could be a rapidly saturable process, which appears to be mediated by a high-affinity, low-capacity active transport system. Absorption of Mn from the diet is very low. On the basis of Mn retention, it has been estimated that adult humans absorb 4.8% of ingested manganese.

After absorption, Mn is complexed with albumin and transported to the liver, which is the key organ in its metabolism. Mn is found in most organs and tissues and preferentially accumulates in the mitochondria. There is no storage form for Mn. Bone contains substantial amount of mineral but there is no mechanism to release it and thus bone Mn is considered as passive storage.

Mn is almost totally excreted in the feces (92%). Excess absorbed MI is quickly excreted by the liver into the bile to maintain homeostasis. Only trace amounts are excreted in urine.

- **Nutritional requirements:**

  There is no Recommended Dietary Allowance (RDA) for manganese Instead there is an average intake (AI) value established by US Food and Nutrition. An adult male and female require up to 2.3 and 1.8 mg per day. During pregnancy and lactation manganese needs increase to 2.0 and 2.6 mg per day respectively.

- **Health aspects:**
  Deficiency

  Humans, there is a little evidence of Mn deficiency as this mineral is widely distributed in a variety of foods. However, limited studies have reported symptoms of its deficiency after consuming experimental diets deficient in Mn. These included dermatitis, depressed growth of hair and nail, hypocholesterolemia and weight loss. Mn deprivation has been associated with osteoporosis, diabetes, epilepsy, and atherosclerosis and impaired wound healing.

  Toxicity

  Manganese is considered least toxic of the trace minerals through oral intake. Majority of Mn toxicity cases have been reported from individuals exposed to airborne Mn in industrial areas in excess of *5* mg per cubic meter. Mn toxicity is a serious health hazard; in its severe form it results in serious psychiatric symptoms such as hyperirritability, violent acts, hallucinations and poor coordination. Several abnormalities occur in the central nervous system, the morphological lesions being similar to Parkinson's disease.

3.3.5.7 IODINE

Iodine is of nutritional importance as a constituent of thyroid hormones which are indispensable for normal growth and development in humans. Synthesis of the iodine containing thyroid hormones occurs exclusively in the thyroid gland. The relation between iodine deficiency and enlargement of the thyroid gland or goiter was found when it was seen that the thyroid gland became hyperplastic or there was an increase in number of normal cells in an organ and therefore an increase in volume or size of the organ with low level of iodine in the body. Iodine is a non-metallic element of the halogen group and it is typically found and functions in its ionic form, iodide (I-'). About 15 -20 mg iodine is found in human body, of which 70 -80% is present in the thyroid gland. The thyroid gland weighs 15-25 grams and has a remarkable ability to concentrate iodine. In the iodine deficient individual, enlarged thyroid gland may contain only 1 mg iodine.

- **Food Sources**

  The iodine concentration in foods is highly variable and also depends on the concentration of iodine content of soil in that region. The amount of iodide in drinking water is an indicator of the iodide content of the rocks and soils of a region and it parallels the incidence of iodine deficiency among the inhabitants of that region. The iodine present in the upper crust of the earth is leached by glaciation and repeated flooding, and is carried to the sea. Seawater is, therefore, a rich source of iodine.

- **Functions of Iodine:**

  Iodine is an essential constituent of the thyroid hormones: thyroxin (T4) and triiodothyronine (T3), which have a key role in growth and development.

  Thyroid hormone performs multiple functions as regulator of cell activity and growth. The hormone has crucial metabolic roles in the fetus and in the infant (post-natal).It promotes growth and maturation of peripheral tissues in the human embryo, the most visible effect seen in the skeletal growth. Delayed bone development has been seen in hormone deficient human embryos. Thyroid hormone influences neuronal cell growth and dendrite development in the embryo. **A** major effect of fetal iodine deficiency is *cretinism,* characterized by mental deficiency and deaf mutism (defects of hearing and speech), squint, disorders of stance and gait and stunted growth. Linear growth, i.e. stature and bone maturation are critically dependent on thyroid hormone. Both are retarded when there is a deficiency of the hormone due to low iodide intakes. The hormone plays an important role in the provision of energy to most cells in the body; the best indicator of this is the energy available for utilization in the basal state, i.e. the basal metabolic rate. In endemic iodine deficient regions school children have been shown to have general IQs 10 points lower than children in non-iodine deficient areas. Reduced

mental function is widely prevalent in thyroid hormone deficiency in the iodine deficient endemic areas which shows the key role of this hormone in brain development and function.

The thyroid hormones:

Overall, thyroid hormones stimulate synthesis of enzymes, oxygen consumption and basal metabolic rate (BMR) and thereby affect heart rate; respiratory rate, mobilization and metabolism of carbohydrates, lipogenesis and a wide variety of other physiological activities. They are necessary for the normal nervous system development and linear growth. Directly or indirectly, most organs are under the influence of these substances.

It is probable that iodine has additional roles to that of thyroid hormones activity, e.g.in antibiotic and anticancer activity, but these have not yet been researched well.

- **Absorption, storage and excretion**:

Like other nutrients, dietary iodide is either found free or bound to amino acids. It is primarily found as *iodide* or *iodate.* The latter form is reduced to iodide by glutathione in the gut. Iodide is rapidly 'and completely absorbed throughout the gastrointestinal tract and very little iodine appears in feces. After absorption, free iodide appears in the blood and circulates to all tissues. Thyroid gland traps most of the ingested iodide (80%).

Unutilized iodide is excreted via kidneys, which forms the major route of iodide excretion (80-90 %). The urinary output of iodide correlates closely with the plasma iodide concentration and has been used to monitor iodide status. Some iodide is also lost in sweat, especially in the hot tropical regions.

- **Nutritional requirements of Iodine:**

The minimum amount of iodide to prevent goitre is estimated between 50 and 75 mcg/day or 1 mcg/kg body weight. The 1989 ICMR recommended RDA is 150 mcg/day for adults of both sexes. Although the recommendations are the same for both males and females, iodide needs are higher during pregnancy and lactation and recommended intakes are 175-200 mcg iodine per day.

- **Health aspects:**

Deficiency

Iodine deficiency affects all populations at all stages of life, from the intrauterine stage to old age. However, pregnant women, lactating women, women of reproductive age, and children younger than 3 years of age are considered the most important groups because iodine deficiency occurring during fetal and neonatal growth and development leads to irreversible damage of the brain and central nervous system and, consequently, to irreversible mental retardation. *Mild goitre, endemic cretinism, hypothyroidism are c*ollective manifestations of iodine deficiency and are termed as *'Iodine Deficiency Disorders'* (IDD).

Apart from cretinism, hypothyroidism and goitre, other features linked to IDD are the decreased fertility rates, increased stillbirths and spontaneous abortion rates and increased perinatal and infant mortality. Epidemiological studies have indicated that an ingestion of 100-200 mg of iodine daily is sufficient to prevent deficiency except among individuals suffering from a genetic disorder.

Toxicity

Over 2 mg iodine per day for long periods is regarded as excessive or potentially harmful that are very high in seafood and/or seaweed or comprising foods contaminated with iodine. Iodine-induced *thyrotoxicosis* (hyperthyroidism) and toxic modular goiter may result from excess iodine exposure. *Hyperthyroidism* is largely confined to those over 40 years of age and symptoms are rapid heart rate, trembling, excessive sweating, lack of sleep, and loss of weight and strength. Individuals who are sensitive to iodine usually have mild skin symptoms.

Refer to table no.3.3.5.7 for ICMR RDIs of Iodine for Indians

3.3.5.8 FLUORINE

Fluorine is potentially a toxic element though the role of fluoride in providing protection from dental caries in human has been demonstrated. Fluorine (F) is a gaseous chemical element, while its ion, fluoride **(F)** is composed of fluorine bound to a metal, non-metal, or an organic compound. Fluoride predominates in nature and in body, it is deposited in bones and teeth. Its incorporation into tooth enamel markedly increases the hardness and resistance to decay.

- **Food Sources**

The major source of fluoride in most diets is water, with foods providing only about 25% of total intake. These include tea and marine fish, ready-to-use infant formulas made with fluoridated water.

- **Functions of Fluorine:**

The only beneficial role demonstrated for fluoride is in reducing the prevalence and severity of dental caries in children and adults. There are three ways in which fluoride may act to prevent tooth decay.

When fluoride is incorporated into the tooth early in life at the time of tooth eruption, the enamel containing fluoroapatite becomes more resistant to dissolution by acids. Secondly, as the enamel gets demineralized by contact with food acids and presence of fluorine ensures that enamel structure is maintained. Lastly, fluoride inhibits glycolysis and reduces acid formation from sugars on the teeth helping to prevent enamel demineralization and tooth decay.

- **Absorption, storage and excretion**:

Soluble fluorides, even at high intake levels are almost completely absorbed from gastrointestinal tract. These include aqueous solutions of fluorides, sodium fluoride used in toothpastes, and sodium fluorosilicate used in water fluoridation. Once absorbed, the fluoride passes into the blood for distribution chiefly to the calcified tissues. Most of the ionic fluoride enters the bone and developing teeth. About half of the fluoride absorbed each day is deposited in the skeleton or teeth within 24 hours. Nearly 99% of the fluoride in the body is in the calcified tissues.

- **Health aspects:**

Deficiency:

For the above reasons, fluoride is considered as a beneficial element for humans, but it is not an essential element so a deficiency does not have much effect. Drinking water fluoride levels of 0.7 to1.2 mg/L is considered safe.

Toxicity

Fluoride is a cumulative toxin. Ingestion of fluoride 1.0-1.5 mg/L for several years may produce *dental fluorosis,* i.e. browning and pitting of teeth known as *mottling,* Chronic high level of fluoride in the range of 2-5 mgL can cause *skeletal fluorosis.* The severe forms of skeletal deformity in toxic fluorosis include kyphosis (abnormal curvature of the spine), fixed spine and other joint deformities. Hyper parathyroidism secondary to high fluoride intake has been reported, which induces calcification of soft tissues. A form of severe skeletal flourosis known as "Genuvalgium" (knocked knees) has been reported from part of India, China and African countries. The condition is characterized by severe skeletal fluorosis and osteoporosis of the limbs.

3.4 Other constituents of Food

Apart from major nutrients like carbohydrates, proteins, fats and minor nutrients like vitamins and minerals, there are some more constituents of food which help in the digestion, absorption, assimilation of food and nutrients and excretion of wastes from the body. They are water and dietary fibre.

3.4.1 WATER

Water comprises about two thirds of the body's weight, and is the medium or solvent in which almost everybody process takes place both inside and outside the cells. The need of the body for water is second only to to its need for air. One can survive for weeks without food but only a few days without water. Water comes from solid foods as well as from drinks and is lost by evaporation in the breath, sweat and urine. The balance of water retained in the body is carefully regulated by the kidneys but excessive is lost during vomiting, diarrhea, strenuous activity or hot climate. In such conditions, water must be immediately replenished or dehydration may result. In temperate climates, at least 1 liter of water or fluid should be drunk and more if heavy work is done.

You may already know that the total body water (TBW) constitutes 50-60% of the body weight. The body of a 70 kg adult male contains 42-liter water - 60% of his body weight while the body of an adult female contains 55% water. This difference in both sexes is due to a higher fat content found in females. Similarly muscular people have a higher proportion of water than the less muscular or obese people. This is because the striated muscle contains more water than any other body tissue (except blood). As we, age we notice that there is a steady fall in the proportion of water which is due to an increased deposition of fat in the body, as well as, loss of muscle mass with age.

- **Functions of Water**

1. *Water as **a medium** and solvent:* Water is the medium of all cell fluids, including digestive juices, lymph, blood, urine, and perspiration. All the physiochemical reactions that occur in the cells of the body take place in the precisely regulated environment of the body fluids. Water enters into many essential reactions, such as hydrolysis, that occurs in digestion. Water is an end product in the oxidation of energy-yielding nutrients.
2. *Water as a lubricant:* All fluids have lubricating as they can make it easier for the solid materials to slip over one another. Water-based fluids act as lubricants in various parts of the body, most notably within joints where synovial fluid makes movements easier and minimizes wear and tear in cartilage and bone.
3. *Water as a temperature regulator:* Water plays an important role in the distribution of heat throughout the body and the regulation of body temperature. Heat is generated in the body due to hard work, exposure to heat, fever or merely by the metabolism of energy-yielding nutrients. The most effective route of heat loss from the body is via the evaporation of water as perspiration from the surface of the skin.
4. *Water as a source of dietary minerals: T*hough water is composed of only oxygen and hydrogen, the water we drink or use in food preparation can contain significant amounts of minerals, such as calcium, magnesium, zinc, copper and fluoride; the amount will vary based on the source of water and any treatment the water has been put through. While hard water will contain magnesium and calcium, the soft water may contain sodium.

Water distribution in the body:

Within the body, water is found in two major compartments. These are: .

- The intracellular compartment (inside the cell)
- The extracellular compartment (outside the cell).

The intracellular puid or the water within the cells makes up about 40-45% of the total body weight. Because the body cells are the sites of vast metabolic activity, it is of no surprise that the total water inside the body cells is about twice the amount outside the cells. These are high in potassium and magnesium and low in sodium and chloride ions.

The *extracellular fluid* compartment is further subdivided into several smaller compartments as you may have noticed in Figure 6.2. These include:

- Plasma
- The intravascular fluid compartment, and
- The intercellular [interstitial or extra vascular fluid (ISF)] compartment.
- The transcellular fluid compartment

The movement of water is controlled mainly by osmotic pressure generated by the inorganic ions in solution in the body. *Osmotic pressure refers to the pressure exerted by water or solvents flowing into a solution at the cell membrane.* The osmotic pressure of the intracellular fluid is the function of its content of potassium, the predominant cation in the

intracellular fluid. By contrast, the osmotic pressure of extracellular fluid may be considered relative to its content of sodium, the major cation present in extracellular fluid. Variations in the distribution of sodium and potassium ions are the principal causes of water shifts between the various compartments,

WATER BALANCE

The amount of fluid in the body is tightly controlled because imbalance can be

devastating. In a normal individual, the maintenance of water balance is achieved by adjusting both water intake and excretion as needed.

Water Intake

The, major sources of water are:

1. The preformed water that we consume as water or as beverage. This will include both preformed water in fluids and in food. *Foods* (other than water and beverages) are the second most important sources of water for the body. Most foods contain 50% water, but **milk** has the highest amount of water. Fruits and vegetables rank next to milk, while fats and oils do not contain any water, The water contained in cookies, cakes and chocolates are relatively low. This entire group contributes to 25-30% of daily water intake. This may also be referred to as *preformed water* in *foods.*
2. Water that arises from oxidation of foods within the body, which is referred to as *water of oxidation* or *metabolic water.* Water which comes from the oxidation of food is the last source of water. 1 g of starch yields 0.6 g of water; 1 g of protein 0.41g; and 1 g of fat gives 1.07 g of water. This source contributes only about 10% of the total water input. This is also known as *water of oxidation or metabolic waste.*

Water Output (Losses of body water)

Water is lost from the body by the four routes, namely kidneys (renal system), skin, lungs and intestine.

1. *Renal loss:* Normal adult kidneys excrete about 1-2 liters of urine daily. The

   water in this total volume is made up of two portions: *obligatory* and *facultative.*

2. Skin: The water loss from the skin is through perspiration, which could be

   insensible and /or visible.

3. *Intestine:* A small quantity of water (about 100-200 ml) is normally lost in feces, but this can exceed 5 L in diarrhoea1 episodes.
4. *Lungs:* The air expired from the lungs also contains water. Any condition that would increase the rate of respiration.

- **Nutritional requirements for water**

The body has no provision for water storage; therefore, the amount of water lost every 24 hours must be replaced to maintain health and body efficiency. The precise need for water depends on a person's body weight and lifestyle. a reasonable allowance based on recommended energy intake is 1.0**ml** / Kcal for adults and 1.5 ml / Iccal for infants. This translates into:

- 35 ml/ kg in adults

- 50 - 60 ml/ kg in children

- 150 ml / kg in infants

Infants have an increased need for water because of the limited capacity of their kidneys to handle the renal solute load, their higher percentage of body water and large surface area per unit of body weight. Exercise, high temperature, low humidity, high altitude and a high fibre diet increase fluid needs. Alcoholic beverages and those containing caffeine such as coffee, tea and sodas, however, are not good substitutes for water; both alcohol and caffeine act as diuretics, causing the body to lose fluids.

- **Health aspects**

The correct functioning of cells and tissues depends on appropriate concentrations of nutrients; so any *abnormal loss* or *accumulation of fluid* can cause a variety of problems.

Dehydration:

Dehydration is defined *as the excessive loss of body water.* It may occur because of inadequate intake, or abnormal loss of body water or a combination of both. The symptoms of dehydration are :

- Thirst
- Loss of appetite
- Decreased urination
- Impaired physical performance
- Nausea
- Impaired temperature regulation
- Muscle spasms
- Increased pulse rate
- Increased respiration rate
- General debilitation

With water loss in excess of 10% of body weight, there is a possibility of cardiovascular failure caused by a reduction in blood pressure and a compensating increase in the heart rate. People for whom water losses may be accompanied by significant losses of sodium include those engaged in strenuous physical activity of any sort, those exposed to high environmental temperatures at work, and visitors to tropical regions who are unaccustomed to heat. Such people, and in general anyone loosing in excess may need small amounts of salt along with the fluid they drink to intake up their sodium loss. One other situation that demands extra fluid for the body is a long airplane flighl; a traveler can lose approximalely 1.5 litres of water during a 3-hour flight chiefly due to increased in sensible perspiration. The dehumidified air in the airplane is so dry that excessive 'insensible' perspiration and evaporation occur. Athletes in good physical condition experience a reduction in athletic performance if they lose 3% of body water. Reduction of as little as 2% of total body water causes a decline of 20 to 30% in efficiency at work. Fluid loss secondary to diarrhea has been responsible for thousands of deaths of children in developing countries. Oral rehydration therapy (ORT).with a simple mixture of water, salts and sugar has been highly effective in reducing the number of deaths.

Oedema

In some pathological conditions, the body is in a positive water balance; that is the intake of fluids is greater than the excretion, and the patient is said to have edema. *Oedema results when the body* ***water is*** *increased to the levels of 10% or* ***more*** *above normal.* Kwashiorkor, a dietary protein deficiency in PEM, Nephrotic syndrome, Congestive cardiac failure (CCF) and cirrhosis of the liver are conditions when oedema is seen. Low or loss of plasma proteins, disturbance in sodium excretion are causes of water retention or oedema in the body.

3.4.2 DIETARY FIBRE:

Some foods particularly cereals and some fruits and vegetables, contain substantial amounts of dietary fibre or roughage. In contrast to other nutrients, this mixture of indigestible materials is not absorbed into the body; instead it adds bulk to the feces. This property is beneficial to health. In other words *"Dietary fibre* is the edible part of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fibre includes polysaccharides, oligosaccharides, lignin and associated plant substances. Metabolic diseases such as diabetes, cardiovascular diseases, as well as, the diseases which were a result of straining at stool such as diverticular disease, hiatus hernia and hemorrhoids are a result of low fiber in the diet.

Dietary fibre (DF) includes many components which can be categorized on the basis of solubility or 'their location in the plant.

Dietary fibre (DF) includes many components which can be categorized on the basis of solubility or 'their location in the plant.

- Insoluble DF:
  - Cellulose
  - Some hemi-celluloses.
  - Lignin
- Soluble DF:
  - Pectin,
  - Gums,
  - Mucilages
  - Some hemi-celluloses

Pectin is a complex polysaccharide found in apples and many other fruits and roots. It forms a stiff jelly when cooked. It is not fibrous and is completely digested and has little effect on feces (unlike dietary fibre), yet it is often considered as a part of dietary fibre.

- **Functions:**

Dietary fibre has major effects on:

a) ***Satiety***: Ingestion of a high fibre food induces a feeling of satiety, reduces meal size and food intake.
b) ***Nutrient Absorption***: Inclusion of fibre has been shown to retard the absorption of some nutrients. The inclusion of viscous polysaccharides reduces the postprandial glucose level concentration.
c) ***Integrity of gut/colon:*** Dietary fibre especially fermentable fibres, play an important role in maintaining the integrity of gut.
d) ***Stool weight and laxation:*** The amount of stool excreted varies markedly from individual to individual and in an individual over a period of time.

- **Recommended Intake of Fibre:**

An intake of 10-13 g dietary fibre intake per 1000 Kcal also has been suggested by American dietary association and an upper limit of 35 g/day.

- **Health aspects:**

Dietary fibre plays a protective role against chronic degenerative diseases like colon cancer and cardiovascular diseases. Further, fiber has been shown to lower serum estrogen concentrations, and therefore may have a protective effect against hormone-related cancers. Recent studies have shown a decreased risk of endometrial cancer, ovarian cancer, and prostate cancer with high fiber intakes.

Thus, dietary fibre is now .recognized as important component of diet and plays an important role in gastrointestinal physiology and has a number of potential health benefits.

3.5 Let us sum up:

- We learnt that vitamins and minerals are vital to the body functions even if they are needed in very small amounts. Vitamins are categorized into fat soluble and water soluble vitamins. Fat-soluble vitamins i.e, Vita A, D, E, and K. can be obtained from dairy products and also inexpensive, readily available plant foods and sunlight. A table below summarizes the important functions and sources of fat-soluble vitamins. We learnt that the deficiencies of these vitamins are of public health significance and should be addressed to immediately.
- Water-soluble vitamins comprise of vitamins of the B complex group and vitamin C. In this unit, we learnt about the important functions and sources of water-soluble vitamins that are summarized below. We also learnt about the recommended dietary intake and problems that arise due to deficiency and toxicity (high intake) for each of these vitamins.

- We learnt about calcium, phosphorous, magnesium, sodium, potassium and chloride which are the major macro minerals required by our body. All these macro minerals constitute an important part of our daily diet and perform both structural and metabolic functions in the body. Most minerals support the activity of specific enzymes and are thus involved in catalytic function. However, Na and K majorly function by changing their location i.e., from one side of plasma membrane to other. Regulation occurs either at the level of absorption or excretion or storage. In addition, these minerals interact with each other and other nutrients thereby influencing their bioavailability. Therefore, there is a need to consume diets containing appropriate amounts of all the nutrients.
- We studied about 8 physiologically important micro minerals namely, iron, zinc, copper, selenium, chromium, manganese, iodine and fluorine. We learnt about their history, food sources along with content, their physiology of metabolism inside our body. We also focused on their vital functions, the deficiency and toxicity levels. In addition, we learnt about their recommended level of intake of requirements that are essential to carryout various physiological roles.
- We learnt that water is an essential nutrient required for life. Though the content of total body water varies from individual to individual, it plays a key role in the body. It involves carrying several nutrients and waste products throughout the body, serving as the solvent for minerals, vitamins, amino acids, glucose and a multitude of other small molecules, and acting as lubricant and cushion around joints. It aids in body's temperature regulation, serves as a shock absorber inside the eyes, spinal cord and in pregnancy, the amniotic sac surrounding the fetus in the womb and actively participates in many chemical reactions.
- We learnt that dietary fiber is now .recognized as important component of diet, plays an important role in gastrointestinal physiology, and has a number of potential health benefits.

3.5 GLOSSARY

Angular stomatitis:	inflammation of the mucous membrane of the mouth.
Antacids	medicines used to reduce or prevent acid collecting in the stomach.
Apoenzyme	a protein that combines with a coenzyme to form an active enzyme.
Coenzymes	a small molecule associated with an enzyme that participates in enzymatic catalysis
Cyanosis	bluish colour of the skin due to the insufficient oxygen in the blood.
Delirium	a state in which the thoughts, expressions, and actions are wild, irregular.
Dysnpoea	difficult respiration.
Dyspepsia	a kind of indigestion or a state of the stomach in which its functions are distributed.
Enzyme	proteins produced by living organisms and functioning biochemical catalysts
Erythema:	a disease of the skin, in which diffused inflammation forms rose-coloured patches of variable size.
Erythroid	red coloured tissue.
Glossitis	inflammation of the tongue.
Haptocorrin	a cobalamin- binding protein.

Hyperaesthesia	an abnormal increase in sensitivity to sensory stimuli, as of the skin to touch or the ear to sound.
Immunoglobulins	group of large glycoproteins that are secreted by plasma cells which function as antibodies in the immune response by binding with antigens incoherent as a consequence of fever or some other disease.
Lesions	inflammations
Ligand	a molecule that binds to a receptor protein to form a larger complex.
Megaloblastic anaemia	deficiency of RBCs characterized by inany large immature and dysfunctional RBCs in the bone marrow associated with pernicious anemia.
Metabolic trapping	phosphorylation and retention of each fonn of vitamin after the process of absorption.
Neural lbbe Defect	malformations of the neural tube, during embryogenesis (i.e., formation of embryo).
Neural tube	a tube of extradermal tissue in the embryo from which the brain and spinal cord develop.
Niacin equivalents	1 mg of niacin or 60 mg of tryptophan.
Opriguria	a lower than normal volume of urine.
Ossification	the process of forming new bone by which inorganic material is deposited in cartilage or membrane, forming bony tissue.

3.6 Check your progress:

1. Define vitamins and minerals. (refer to point no.3.1)
2. Differentiate between fat soluble and water soluble vitamins.
3. What are the sources and functions of Vitamin A? (refer to point no.3.2.1)
4. What is the recommended dietary allowance for vitamin A ?
5. What happens when a person is deficient or has an overdose of vitamin A?
6. What is vitamin B complex? Describe it? 3.2.2
7. List the different sources of B vitamins. 3.2.3-3.2.10
8. List the different functions of B vitamins.3.2.3-3.2.10
9. Which vitamin is known as ascorbic acid? Describe its sources.3.2.11
10. What are the functions of vitamin C? 3.2.11
11. What are the symptoms of deficiency and toxicity of vitamin C? 3.2.11
12. Which vitamin is known as sunlight vitamin? Describe its sources.3.2.12
13. What are the functions of vitamin D? 3.2.12
14. What are the symptoms of deficiency and toxicity of vitamin D? 3.2.12

15. Describe the sources of vitamin E. (3.2.13)
16. What are the functions of vitamin E? 3.2.13
17. What are the symptoms of deficiency and toxicity of vitamin E? 3.2.13
18. Describe the sources of vitamin K. (3.2.14)
19. What are the functions of vitamin K? 3.2.14
20. What are the symptoms of deficiency and toxicity of vitamin K? 3.2.14)
21. What are the functions of minerals? 3.3)
22. What are the sources and functions of Calcium? (3.3.1)
23. What is the nutritional requirement of calcium per day?(3.3.1)
24. What are the symptoms of deficiency and toxicity of calcium?(3.3.1)
25. What are the sources and functions of phosphorus? (3.3.2)
26. What is the nutritional requirement of phosphorus per day?(3.3.2)
27. What are the symptoms of deficiency and toxicity of phosphorus?(3.3.2)
28. What are the sources and functions of magnesium? (3.3.3)
29. What is the nutritional requirement of magnesium per day?(3.3.3)
30. What are the symptoms of deficiency and toxicity of magnesium ?(3.3.3)
31. Which three minerals are known as electrolytes? What are their sources and functions?(3.3.4)
32. What is the nutritional requirement of sodium, potassium and chloride per day?(3.3.4)
33. What are the symptoms of deficiency and toxicity of sodium, potassium and chloride?(3.3.4)
34. Differentiate between macro minerals and micro minerals.
35. What are the sources and functions of iron? (3.3.5.1)
36. What is the nutritional requirement of iron per day?(3.3.5.1)
37. What are the symptoms of deficiency and toxicity of iron?(3.3.5.1)
38. What are the sources and functions of zinc? (3.3.5.2)
39. What is the nutritional requirement of zinc per day?(3.3.5.2)
40. What are the symptoms of deficiency and toxicity of zinc?(3.3.5.2)
41. What are the sources and functions of iodine? (3.3.5.2)
42. What is the nutritional requirement of iodine per day?(3.3.5.2)
43. What are the symptoms of deficiency and toxicity of iodine?(3.3.5.2)
44. What is the importance of water in our diet? (3.4.1)
45. How is water distributed in our body? (3.4.1)
46. What is water balance? Explain. (3.4.1)
47. Describe dehydration and oedema.
48. What is the importance of fibre in our diet? (3.4.2)
49. What is soluble and insoluble fibre?(3.4.2)
50. What is the RDA of fibre and its health aspect? (3.4.2)

Table no. 3.2.1 Recommended dietary allowances for vitamin A

GROUP		Vitamin A (mcg/day)	
		Retinol	**b-carotene**
Man		600	2400
Woman		600	2400
Pregnancy		950	3800
Lactation			
Infancy	0-6 months	350	1200
	6-12 months	350	1200
Children	1 -3 years	400	
	4-6 years	400	1600
	7-9 years	600	2400
Boys	10- 12 years	600	2400
Girls	10-12 years		
Boys	13-15 years	600	2400
Girls	13-15 years		
Boys	16- 18 years	600	2400
Girls	16- 1 8 years		

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Table no. 3.2.10 Recommended dietary allowances for vitamin D

Age group	FAO/WHO 2004 Mcg/day	ICMR (IU/day)
Infants		
0-6 months	5 (200 IU)	
7-12 months	5 (200 IU)	
Children		
1-3 yrs	5 (200 IU)	
4-6 yrs	5 (200 IU)	200-400
7-9 yrs	5 (200 IU)	
Adolescents 10-18 yrs	5 (200 IU)	
Adults		
19-50 yrs	5 (200 IU)	
Older adults 51-65 yrs	10(400 IU)	
Elderly adults 65 +yrs	15 (600 IU)	
Pregnant/ lactating women	5 (200 IU)	

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Table no. 3.2.11 Recommended dietary allowances for vitamin K

Age group	RDA mcg/day
Infants and children	5+
0 - 6 months	10
7 - 12 months	15
1 - 3 years	20
4 - 6 years	25
7 - 9 years	
Adolescents, 10 - 18 years	35-55
Females	35-55
Males	
Adults	55
Females, 19 - 65 yeus	55
65+ years	65
Males, 19 - 65 years	65
65+ years	65
Pregnancy/ Lactation	55

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Table no. 3.2.3 Recommended dietary allowances for Thiamin

Group		ICMR (mg/day)
Male	Sedentary work	1.2
	Moderate work	1.4
	Heavy work	1.6
Women	Sedentary work	0.9
	Moderate work	1.1
	Heavy work	1.2
Pregnancy		+0.2
Lactation		
	0 - 6 months	+0.3
	7 - 12 months	+0.2
Infants	0 - 6 months	55 mcg/kg
	6 - 12 months	50 mcg/kg
Children	1 - 3 years	0.6
	4 - 6 years	0.9
	7 - 9 yeas	1.0
Adolescent		
	Boys 10 - 12 years	1.1
	Girls 10 - 12 years	1.0
	Boys 13 - 15 years	1.2
	Girls 13 - 15 years	1.0
	Boys 16 - 18 years	1.3
	Girls 16 - 18 years	1.0

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Table no. 3.2.4 Recommended dietary allowances for Riboflavin

Group		ICMR (mg/day)
Male	Sedentary work	1.4
	Moderate work	1.6
	Heavy work	1.9
Women	Sedentary work	1.1
	Moderate work	1.3
	Heavy work	1.5
Pregnancy		+0.2
Lactation		
	0 - 6 months	+0.3
	7 - 12 months	+0.2
Infants	0 - 6 months	60mcg/kg
	6 - 12 months	66mcg/kg
Children	1 - 3 years	0.7
	4 - 6 years	1.0
	7 - 9 yeas	1.2
Adolescent		
	Boys 10 - 12 years	1.2
	Girls 10 - 12 years	1.3
	Boys 13 - 15 years	1.5
	Girls 13 - 15 years	1.2
	Boys 16 - 18 years	1.6
	Girls 16 - 18 years	1.2

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Table no. 3.2.5 Recommended dietary allowances for Niacin

Group		ICMR (mg/day)
Male	Sedentary work	16
	Moderate work	18
	Heavy work	21
Women	Sedentary work	12
	Moderate work	14
	Heavy work	15
Pregnancy		+2
Lactation		
	0 - 6 months	+4
	7 - 12 months	+3
Infants	0 - 6 months	710mcg/kg
	6 - 12 months	650mcg/kg
Children	1 - 3 years	8
	4 - 6 years	11
	7 - 9 yeas	13
Adolescent		
	Boys 10 - 12 years	15
	Girls 10 - 12 years	13
	Boys 13 - 15 years	16
	Girls 13 - 15 years	14
	Boys 16 - 18 years	17
	Girls 16 - 18 years	14

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Table no. 3.2.6 Recommended dietary allowances for pyridoxine

Group	ICMR (mg/day)
Male Sedentary work	2.0
Moderate work	
Heavy work	
Women Sedentary work	2.0
Moderate work	
Heavy work	
Pregnancy	2.5
Lactation	2.5
Infants 0 - 6 months	0.1
6 - 12 months	0.4
Children 1 - 3 years	0.9
4 - 6 years	0.9
7 - 9 yeas	1.6
Adolescent	
Boys 10 - 12 years	1.6
Girls 10 - 12 years	
Boys 13 - 15 years	2.0
Girls 13 - 15 years	
Boys 16 - 18 years	2.0
Girls 16 - 18 years	

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Table no. 3.2.7 Recommended dietary allowances for folic acid

Group	ICMR (mg/day)
Male Sedentary work	100
Moderate work	
Heavy work	
Women Sedentary work	100
Moderate work	
Heavy work	
Pregnancy	400
Lactation	150
Infants 0 - 6 months	25
6 - 12 months	
Children 1 - 3 years	30
4 - 6 years	40
7 - 9 yeas	60
Adolescent	
Boys 10 - 12 years	70
Girls 10 - 12 years	
Boys 13 - 15 years	100
Girls 13 - 15 years	
Boys 16 - 18 years	100
Girls 16 - 18 years	

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Table no. 3.2.8 Recommended dietary allowances for Vit. B12

Group		ICMR (mcg/day)
Male	Sedentary work	1
	Moderate work	
	Heavy work	
Women	Sedentary work	1
	Moderate work	
	Heavy work	
Pregnancy		1
Lactation		1.5
Infants	0 - 6 months	0.2
	6 - 12 months	
Children	1 - 3 years	0.2-1.0
	4 - 6 years	
	7 - 9 yeas	
Adolescent		
	Boys 10 - 12 years	0.2-1.0
	Girls 10 - 12 years	
	Boys 13 - 15 years	0.2-1.0
	Girls 13 - 15 years	
	Boys 16 - 18 years	0.2-1.0
	Girls 16 - 18 years	

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Table no. 3.2.9 Recommended dietary allowances for Vitamin C

Group		ICMR (mg/day)
Male	Sedentary work	40
	Moderate work	
	Heavy work	
Women	Sedentary work	40
	Moderate work	
	Heavy work	
Pregnancy		40
Lactation		80
Infants	0 - 6 months	25
	6 - 12 months	
Children	1 - 3 years	40
	4 - 6 years	
	7 - 9 yeas	
Adolescent		
	Boys 10 - 12 years	40
	Girls 10 - 12 years	
	Boys 13 - 15 years	40
	Girls 13 - 15 years	
	Boys 16 - 18 years	40
	Girls 16 - 18 years	

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Summary of Fat Soluble Vitamins

Vitamins	Sources	Functions
• Vitamin A	• Retinol: liver, egg yolk, cream, butter, ghee, milk p-carotene: yellow and orange vegetables, green leafy vegetables	• Maintenance of health of epithelial tissues Vision in dim light Growth of skeletal and soft tissues • Resistance to infections
• Vitamin D	• Action of sunlight on the skin Animal foods like eggs, butter, fish liver oil	Absorption of calcium and phosphorous Deposition of calcium and phosphorous in bones
		• Protection of unsaturated fatty acids, vitamin A and C from destruction in the body/ food.
• Vitamin E	• Vegetable oils, whole grains, deep green leafy vegetables, pulses, nuts and oilseeds,	• Clotting of blood.
• Vitamin K	• Dark green leafy vegetables, egg yolk, liver. Bacterial synthesis	

Summary of Water Soluble Vitamins

Vitamin	Food Sources	Function
• Thiamin or **B1**	• Whole grain cereals, pulses, nuts, egg yolk, meat	• Role in carbohydrate metabolism
• Riboflavin or B2	• Green leafy vegetables, milk, eggs, organ meats like liver, kidney	• Role in the metabolism of carbohydrates, fats and proteins.
• Niacin	• Cereals, pulses, milk, nuts & oil seeds, organ meats, fish	• Role in the metabolism of carbohydrates, fats and proteins.
• Folic acid	• Whole grain cereals, leafy vegetables, milk and eggs, organs meats like liver and kidney	• Role in the formation of normal red blood cells in the bone marrow.
• Vitamin B12	• Animal foods like milk, egg, organ meats	• Role in the formation of normal red blood cells in the bone marrow and proper functioning of the digestive tract and nervous system.
• Vitamin C	• Citrus fruits, amla, guava, capsicum, green leafy vegetables, green chilies	• Role in collagen formation and hence in wound healing. Role in absorption of iron and prevention of destruction of other substances.

Table 3.3.1: ICMR recommendation for daily intake of Ca and P

Group	ICMR (mcg/day)
Adult man	400
Adult woman	400
Pregnancy	1000
Lactation	
Infants 0 - 6 months	500
6 - 12 months	
Children 1 - 3 years	400
4 - 6 years	
7 - 9 yeas	
Adolescent	
Boys 10 - 12 years	600
Girls 10 - 12 years	600
Boys 13 - 15 years	600
Girls 13 - 15 years	600
Boys 16 - 18 years	500
Girls 16 - 18 years	500

Based on human milk intake of 0.75 l/day.

Source: Recommended Dietary Allowances for Vitamins, NIN, ICMR, Hyderabad, India (2002) and Vitamin and Mineral Requirements in Human Nutrition, FAO/WHO (2004).

Table 3.3.5.1: ICMR recommendation for daily intake of iron

Group	ICMR (mg/day)
Adult man	28
Adult woman	30
Pregnancy	38
Lactation	30
Children 1 - 3 years	12
4 - 6 years	18
7 - 9 yeas	26
Adolescent	
Boys 10 - 12 years	34
Girls 10 - 12 years	19
Boys 13 - 15 years	41
Girls 13 - 15 years	28
Boys 16 - 18 years	50
Girls 16 - 18 years	30

Source: Recommended Dietary Allowances for Macronutrients and Minerals, Dietary Guidelines for Indians, NIN, ICMR, India (1998).

Table 3.3.5.7: ICMR recommendation for daily intake of iodine

Group	ICMR (mcg/day)
Pregnancy	200
Lactation	200
Infants 0 - 59 months	90
Children 6-12 years	120
Adolescent 13 through adulthood	150

Source: Assessment of *the iodine deficiency disorders and monitoring their elimination.*

Geneva, World Health Organization, 2001 (WHO/NHD/01.1). '

UNIT-4 RDI (recommended dietary intake), Balanced diet (concept and components), Food groups (importance, nutritive value and types) and Meal planning (principles, objectives and factors)

Structure

4.0 Objectives

After studying this unit, we will able to:

1. Understand the importance of RDI and set diets according to recommended dietary intakes
2. Plan balanced diets according to RDI with the help of food guide
3. Identify food groups and their nutritional contribution
4. Learn to calculate nutritive value of menus
5. Design cost effective and healthy menus for various conditions

4.1 Introduction

In the last units, we learnt about nutrients and the vital role they play in maintaining and sustaining our body. In this unit, we shall learn as to how much of each nutrient we would need to maintain optimum health. This is known as recommended dietary Intake (RDI) and is laid down by the Indian Council of Medical Research (ICMR).

Recommended dietary intake of individuals varies according to age, sex and physical and medical conditions. Therefore, diets have to be designed to provide for optimum nutrition. Such diets are called balanced diets. A balanced diet provides for the energy necessary for the body to function and all nutrients in right proportions for bodybuilding, repair and protection against diseases.

In order to plan a balanced diet, it is not possible for us to count the calories and weight of each nutrient every day. Hence, with lot of research, experts have found out the kinds of food and their nutritional values which we need to take in our daily diet. They have translated the calories and amount of nutrients into portions so that it is easy for us to plan a balanced meal. This is also known as the food guide wherein foods are grouped according to the nutrients they provide.

This guide helps in food selection and ensures good nutrition on a daily basis.

Menu planning is a creative activity and generally requires some intelligent thinking and manipulation. This is because apart from the influence of age and sex of an individual, his/her physique, physiological condition, level of physical activity also effects the requirements of nutrients to the body. Climatic conditions, growth and pathological stress play an important role in nutritional demands of the body. All these factors have to be taken into consideration while planning a menu for an individual.

Unlike balanced diet where foods are grouped for easy usage, meal planning involves the application of dietary knowledge of nutrients as exchange list; interaction of nutrients with each other and other technical know how to plan a meal for an individual. This is especially beneficial for people with any medical disorder or pathological stress.

4.2 The Indian RDI

There were several reasons for setting up the RDIs. Long back in 1936 it was found that the effects of deficient diets were drastic, so countries in the League of Nations set up a committee to recommend daily dietary allowances for each of the known nutrients. Later during the Second World War, many recruits were rejected from the army, as they were underweight. The governments in various countries were shocked with the rate of rejection and anxious to change this situation. They formed an Expert Committees to set up Recommended Dietary Allowances (RDAs) to guide people to meet their nutritional needs and their daily requirements of food. Thus, the RDAs were set up in various countries between 1940 and 1944.

Over the years, these recommendations had to be revised based on newer research findings. In India, major revisions were made in 1958, 1968 and 1981. The 1981 revision is entitled Recommended Dietary Intakes (RDIs) for Indians. The name has been revised to emphasize intake. These values are not final and will be revised as and when there are new research findings.

When RDIs were laid down for India and provision for adequate amounts of nutrients to the body was thought of then it was necessary to express the age and body dimension of the person. This was to ensure that all persons would meet their nutrient needs. Therefore, one representative person was chosen whose age and body size was defined. Therefore, the thought of a reference man and a reference woman came into being.

A reference man is of age 20-39 years, weighs approximately 55 kgs whereas a reference woman is of age 20-39 years, and weighs 45 kgs.

Refer to table no.4.2 for RDIs for Indian adults

The Recommended dietary intakes are given for:-

1. Energy
2. Proteins
3. Minerals--Calcium and iron
4. Vitamins-Water soluble- (vitamin C and vitamin B- thiamine, riboflavin and niacin)
5. Vitamins-Fat soluble-(vitamins A and D)

Our body needs only two nutrients in large amounts –Energy in kilocalories and proteins in grams.

1. ***Energy***: RDIs for energy are with reference to average or reference weights. Although there is normally no need for adjustment for groups of different weights, there is evidence that average energy intakes are now lower perhaps in relation to our reduced energy expenditure.
2. ***Protein:*** The RDIs for protein represent 10 per cent of the energy requirement (ex. For a pregnant woman, 60g of protein provides 240 kcal, which is 10 percent of her total requirement of 2400 kcal.)Our need for protein is about 1

gm per kg body weight. Therefore, the protein RDI for the reference man is 55 gm and the reference woman is 45 gm. It should however be noted that if energy requirements are not fully met at the same time, that protein which is eaten will be utilized more to provide the needed energy than for growth and tissue repair.

3. ***Fat and carbohydrate:*** There appears to be no absolute dietary requirement for either fat or carbohydrate except for a small amount (1-2 per cent of energy requirement) of essential fatty acids and some carbohydrates (50-100 g/day) are necessary to prevent the undesirable effects that result from extremely high fat diets.

However in contrast to the recommendations for protein, minerals and vitamins which are designed to ensure that the intakes by different groups of the population are high enough for health, a number of bodies in developed countries have suggested dietary guidelines to restrict intakes of fat, sugars and alcohol. This is because there is growing concern that some individuals are obtaining too much of these nutrients (and not enough dietary fibre).

1. ***Calcium and Iron***: Both recommendations allow for the limited absorption of these nutrients from the diet.
2. ***Niacin and Vitamin A***: The intakes recommended allow for the likely contributions made by tryptophan and carotenes to the pre-formed nicotinic acid and retinol intakes respectively.
3. ***Vitamin C***: There are differing opinions as to the quantity of vitamin C required for health. It is generally agreed that 10 mg daily will not only prevent but also cure scurvy. The recommended intake of 30 mg is thought to provide a reasonable safety margin; there is no nutritional advantage from enormously higher intakes although there may be some pharmacological action.
4. ***Vitamin D:*** It is not possible to make firm estimates of dietary needs because most of our requirements are met by vitamin D formed from the action of sunlight on a substance present in the skin. The amounts recommended may be considered as a safety measure for those who are little exposed to sunlight.

Excessive intakes of many of the minerals can be harmful, as can excessive intakes of some of the vitamins especially vitamin A and D which accumulate in the liver. Such intakes are unlikely to arise from food but may result from excess use of mineral and vitamin supplements. Thus, when RDIs are expressed in daily terms, it is not necessary for the diet to contain these quantities every day. It is sufficient if the requirements are met over a period of, let us say, a week.

Besides these, there are other nutrients, which our body needs. No specific recommendations were made about any of these because when we plan a meal (a good mixed diet), not only our need for the above nutrients from natural foods are provided for but they will also provide enough of all other nutrients also. To ensure that the recommended intakes cover differences in needs of healthy persons, a liberal margin of safety is provided.

Energy requirements are different from other nutrients as appetite normally controls the intake and keeps it close to its requirements and intakes in excess of requirements are undesirable and may lead to obesity. The recommendation for each group of people is therefore set at its estimated average requirement.

4.2.1 Changes in RDI with age and activity

It is natural that nutrient needs vary with age. Table 2.2 gives the RDIs for two major nutrients-energy and protein, for various stages of life. We notice that there is a progressive increase in need for nutrients with age from birth to adolescence. Babies grow very fast in the first year. That is why the recommendations for the first year are given per kilo of body weight. When children become adolescents, there is rapid growth between 10-15 years, then the growth spurt.

Girls grow faster than boys do during this period. Therefore, the recommendations of energy for girls of 10-12 years are higher than in later years. Once they reach the adult stage, the growth, development of the body is nearly complete, and nutrients are needed only for maintenance and repair. Thus, the requirement of adults is lower than that of adolescents.

Besides age, requirements vary with the kind of physical work or activity we are engaged in .As there are innumerable human activities with varying energy needs, the experts have broadly divided these into three groups:

1. ***Sedentary worker***- a sedentary person is someone who does most of the work sitting in one place and uses only hands and head. An executive, writer, typist, clerk, teacher, or a homemaker who has household help is examples of sedentary workers.
2. ***Moderate worker*** - a moderately active person is someone who uses the muscles of hands and feet fast and continuously. Postal workers, house cleaners, gardeners, factory workers, waiters in hotels, farmers and homemakers who do housework themselves are examples of moderate workers.

3. ***Heavy worker***- a very active person is involved in heavy work if he uses most of the body muscle and moves quite fast for several hours each day. Rickshaw pullers, loaders, coolies, miners, workers in heavy construction work belong to this group and it includes sportsmen who practice active sports.

Refer to table no.4.2.1a for changes in RDIs with age.

Refer to table no.4.2.1b for changes in RDIs with activity.

4.2.2 RDIs for pregnancy and lactation

Besides age and activity, there is an increase in need for nutrients in conditions like pregnancy and lactation. We can see that in the RDIs for these categories in Table. As we are aware, more than three-fourth of the growth of the fetus occurs in the second half of pregnancy. Therefore, the recommendations for the additional needs are given for the second half of pregnancy. Allowances for pregnancy or lactation are in addition to the normal needs of a woman as discussed earlier.

The RDIs are highest in the first six months of lactation, because the mother feeds the infant with her milk. By the time, the infant reaches six months of age, the mother's milk supply decreases. We notice that the recommendations for this stage and after this are eventually reduced.

Refer to table no.4.2.2 for RDIs for pregnancy and lactation.

4.2.3 Uses of RDI

Recommended dietary intakes were set to meet a particular need. They have several important uses like:

1. They can enable the government to predict food needs of the population,
2. They help plan supplementary feeding programs for mothers and children.
3. They guide agricultural planning,
4. They decide policy of import and export of food,
5. They help large catering establishments such as hostels, hospitals to calculate foods to be ordered for their inmates,
6. They help organize food supply for defense personnel etc.

4.3 Balanced Diet

The provision of palatable and acceptable meals must be the first consideration; only within this framework can planning for good nutrition be effective.

A balanced meal is one that provides adequate amounts of protein and of all the minerals and vitamins as well as energy. It should also provide dietary fibre, and should be limited in its fat, sugar and salt contents- particularly if these are likely to be amply supplied from other sources during the day. At least one balanced mal should be eaten every day.

Most foods contain a wide variety of common foods. Thus, the simplest way to meet nutritional standards is to eat a varied diet containing a wide selection of different types of food.

4.3.1 Concept and components

Experience and custom have influenced food choice in such a way that traditional meals are generally nutritionally satisfactory as well as good to eat; nevertheless to be sure that this is maintained, now that we rely to a greater extent on snacks and convenience foods, certain general rules can be followed:

1. Each meal should contain some foods rich in protein, such as meat, poultry, fish, cheese, eggs, milk, bread or other cereal product, nuts, peas or beans.

2. Each main meal should contain plenty of fruit and vegetables, which are good sources of vitamins and minerals not commonly found in other foods.

3. Foods rich in energy should be eaten only in amounts, which will satisfy appetite and maintain correct body weight. Such foods include butter and margarine (which also vitamins A and D), bread and other cereals (which also provide protein, minerals, vitamins and dietary fibre) and only then jam, cakes, biscuits and other foods rich in sugar and fat.

The total daily intake of each of the major nutrients that is recommended for groups of people of different ages and occupations. The total amount of fat should not provide more than 35 per cent of the energy in the diet, nor saturated plus trans fatty acids more than 15 per cent of energy except for small children. By implication, the total carbohydrate in the diet should provide about 55 per cent of the dietary energy.

In practice it will be found that certain meals such as traditional Sunday lunch are likely to be rich in many nutrients where as others including breakfasts for many people will proof a counter balance. It is the total nutrient intake over at least one day and preferably a week, that should be assessed and even then, it is the adequacy of the diet in the longer term that is important for health.

4.4 Food groups

All these foods, which form a part of our food pattern, are divided into five food groups in the daily food guide for India. As we may observe, the first column in the table indicates the food group, the second column gives the foods included in the group, the third column specific the amount, which gives the size of the serving of each food, and the last column indicates the minimum number of servings to be taken to meet one's nutritional needs. If sufficient amounts of food from each of the five groups are included in the day's diet, the nutrient needs of the body will be met. Such a diet is a balanced diet, as it meets the nutritional needs of the body.

Let us study each of the food groups in detail and understand how it is used in practice.

Refer to table no.4.4 for the food group guide.

4.4.1 The cereals-millets group-1

This group includes preparations of rice, wheat, jowar, bajra, maize, ragi and their products such as rawa (suji or semolina), rice flakes (poha), sevian (vermicelli), daliya (broken cereals) etc.. The foods from this group provide more than half the day's needs of our body for energy and proteins. In addition, these foods can be a valuable source of one of the B vitamins-thiamine and the mineral iron, especially if the preparation is made from unrefined wheat flour. Chapattis made from whole wheat flour contain six times as much thiamine as bread made from the same amount of maida (refined wheat flour). Parboiled rice contains more thiamine than milled, polished rice.

1. **Size of one serving** Any preparation made from 25 gm of any cereal is counted as unit for serving of foods from this group. This is equal to half a katori of cooked rice, one medium chapati, two to three puries, half of a medium bhakari, two slices of bread, two tablespoons of rice flakes (dry, not soaked) or ready-to-eat cereals.
2. **Suggested number of servings: A** sedentary person it is suggested to include at least six servings from this group. Those who are moderately active, or are involved in heavy physical work such as load-lifting, will need more servings from this group. If we If we pursue any hobbies or sports which involve intense physical work play any games like badminton, tennis, squash etc., regularly, we will need more servings from this group.

   Teenagers need more servings from this group to meet their need for growth. Expectant mothers in the later half of pregnancy need two servings more than their normal intake; while nursing mothers may need four additional servings.

4.4.2 The dal, milk, egg, fish, meat group-2

All preparations made from dals, whole pulses, milk, eggs, fish, poultry and meat are included in this group.The foods in this group are generally used in preparations which are served with cereals. Some preparations, such as idli, dosa are made by combining cereals such as rice or rawa (suji) with urad dal; while curd or butter milk are served with rice; egg with toast,and chicken with rice.

One third or more of our protein requirement is provided by these foods. The foods in this group are good sources of protein, which is needed for growth and repair of body tissues, e.g. muscles, blood, skin, hair, etc. In addition we meet part of our requirement for minerals and vitamins through these foods. These foods supply part of our B-vitamins requirement also. Milk, eggs and liver are good sources of vitamin A. Dals, eggs and meat are good sources of iron. Milk is a very good source of calcium.

Size of one serving: The foods in this group vary in their composition. Therefore, the serving size of each of these varies:

1. Dals and whole pulses 25 gm
2. Milk or milk preparations 150 gm
3. Egg (no.) 1
4. Fish, meat and poultry 25-30 gm

One serving of each of these foods provide 5 to 6 grams of protein.

Suggested number of servings: The number varies with age and body size. For example, a child may need only 3 servings, whereas a teenager may need upto 5 servings.

1. Dals include all types of dals such as chana, moong, urad, masur dal, etc. As we know dal is obtained by removing the seed coat of whole pulse. The whole pulse of legumes such as whole chana, moong, rajma, peas, masur (lentils), matki (moth beans), Kulthi (horsegram), etc. are all included in this group. We know that oil seeds such as groundnuts and sesame belong to the legume family and are included in this group. As mentioned earlier any preparation in which 25 gm of any of these foods is used is taken as a serving unit.
2. Milk is used as such and in a number of preparations like tea, coffee, buttermilk, curds, basundi, etc. When we drink milk or use curd the amount used is easy to note. However, the amount of milk used in preparations varies. We may use 15 gm to 25 gm in tea; 30 gm in coffee, a cup of buttermilk may contain 40to 50 gm milk, while a cup of basundi may be made from two to two and half cups of milk by concentrating it. Thus, our intake of these needs is to be noted to get an estimate of total milk intake. An average teacup or 150 ml of milk or a preparation in which 150 ml of milk is used is counted as one serving.
3. We use egg as boiled egg, omelet, in curry, pudding or custard. One medium egg weighs 50 to 52 gm and is counted as one serving. If egg is used in preparation such as pudding, we can estimate the amount we eat by observing the portion we eat.
4. When we think of a serving of fish, poultry and meat, include the lean parts (without fat) of the variety that is eaten. Even organs such as liver, heart and kidney are classified as meat. 20 to 30 gm of fish, poultry or meat can be counted as a serving. We normally buy these by weight. If we note the amount of fatty tissue and bone, we can estimate the amount of lean part per kilogram. When these are served as chops, it is easy to estimate the weight of each chop and the number of chops eaten to estimate the intake. If we make a curry, it is necessary to record total amount of curry made and the amount served per person to estimate the intake. Please remember that the protein content of lean meat is less in fatty parts of meat.

4.4.3 Vegetables and fruits group-3

The vegetables and fruits we use are divided into two broad groups 3 & 4, according to their nutritional contribution. This makes it easy to choose the vegetables and fruits which meet the nutritional needs. The third food group is made up of protective vegetables and fruits.

A) Green and Yellow Vegetables and Fruits

1. **Dark Green leafy vegetables:** All dark green leafy vegetables, such as moth (amaranth), palak (spinach), methi (fenugreek), radish leaves, colocasia (alu, arbi) leaves, etc.
2. **Light green vegetables:** Cabbage (gobi), onion tops, etc.
3. **Yellow vegetables and fruits:** Carrot, pumpkin, mango, papaya, orange, apricots etc.

All these vegetables and fruits have one common component, which brings them together in one group-the yellow plant pigment beta carotene. This pigment is converted to vitamin A in our body. These vegetables and fruits are a rich source of this pigment. One serving of this group provides half or more of our day's need for vitamin A. In addition the dark green leafy vegetables contain some vitamin C, minerals and fibre.

Size of one serving: Half a katori or *50* gm of cut vegetable or a fruit can be counted as one serving. We need at least one serving every other day (once in two days) from this group. Normally the leafy vegetables are sold as a bunch or in a bundle. The weight of the bunch varies from 200 to 300 gm. After purchase, the vegetable is sorted to remove damaged leaves and tough stems, thus the edible part is reduced. The amount thus lost varies with the quality and variety of the leafy vegetable selected. A good quality spinach bunch has a high edible portion, being *90-95* per cent. Thus, we can get 4 to *5* servings from such a bunch. In other leafy vegetables it may be only *70* per cent. Thus our selection can affect the cost per serving.

We buy cabbage, carrots, pumpkin by weight. Therefore it is possible to estimate the servings, if we know the amount purchased. When we buy yellow-orange fruits, we need to estimate the edible portion after deducting the weight of skin and seeds.

The edible portion varies between *70* to *75* per cent in these fruits.

B) Vitamin C Rich Vegetables and Fruits

In a tropical country like India, we have a variety of vitamin C rich vegetables and fruits. That is not the case in the temperate region. For example, the richest source of vitamin C in the tropics is amla (also known as Indian gooseberry). It contains ten times as much vitamin C as any citrus fruit. Guavas are another rich source, especially the newer varieties. Apples, cabbage and drumsticks, both leaves and pods are excellent sources of vitamin C. Besides these there are citrus fruits such as oranges, mosambis, and grape fruits. In addition, papaya, mango, pineapple and tomato are also good sources of vitamin C.

Size of one serving: We can take a 50 gm portion, which may fill half a katori, as one serving. It provides half or more of our day's needs for vitamin C. There are some exceptions to this serving size. This happens when we choose a very concentrated source. For example, we need only one amla or 15 gm of guava to supply half of our vitamin C requirement for the day. As .for other fruits, a quarter of a medium orange or musumbi, two segments of grape fruit or a slice of papaya, pineapple or mango, or one medium tomato can be counted as one serving. Please remember, a vegetable or fruit, which is a good source of both beta-carotene and vitamin C, will take care of both Group 3 (a) and 3 (b) servings. Some examples of these are orange and papaya, cabbage, drumstick leaves and amaranth.

4.4.4 Other vegetables and fruits group-4

1. Vegetables - cucumber, capsicum, pumpkin, lady finger, brinjal
2. All gourds like ash gourd, bottle gourd, snake gourd, bitter gourd, ridge gourd, sponge gourd, etc. come under this category.
3. All immature beans - french beans, cluster beans, red gram (tender), etc. and peas ,
4. Fruits like melons, grapes, apples, pears, chikkus, bananas and berries.

These vegetables and fruits supplement the minerals, vitamins and fibre provided by group 3 in our diet. The fibrous tissues present in these fruits and vegetables are not digested and help to move the food-through the digestive tract. Thus they help to regulate elimination of waste products from the digestive tract.

Size of one serving: We can count as one serving 50 gm portion or half a katori of any vegetable or fruit from this group. It is suggested that we include at least two or more servings from this group daily. Most of the vegetables and fruits in this group are purchased by weight. Some of the fruits bought by weight are grapes, apples, pears, etc. Bananas and melons are sold by numbers. The edible portion in some of the vegetables, such as capsicum, lady finger, brinjal, french beans, papadi, cluster beans (gawar), beetroot, radish, etc., is as high as 95 to 98 per cent; while in peas it is only 50 per cent.In bananas the edible portion varies from 65 to 75 per cent. The same is true of melons. Grapes, apples. pears, chikkus (sapota) and berries are generally eaten with the skin. Thus the edible portion of these fruits is more than 95 per cent.

4.4.5 Sugar, jaggery, oil and fats group-5

Foods in this group add taste and make our food palatable. The morning cup of tea or sherbat we enjoy on a hot summer day have sugar as an essential ingredient. The bread or toast we have at tea time tastes better with butter.The taste of dal, vegetable and salad is enhanced by the seasoning with oil, which is customarily a part of the Indian diet. So we see the foods in this group have an important role of improving the palatability of our meals. There are basically two major classes of foods included in this group. They are:

a) Sugar, jaggery and their preparations such as jams, jellies, syrups, squashes etc. and

b) Oils, ghee, butter and vanaspati.

All these foods are mainly a source of energy. Sugars are a readily available source of energy, while oils and fats are a concentrated source of energy. We may recall that sugars belong to the carbohydrate family and a gram of carbohydrate provides four kilocalories of energy.One gram of fat or oil gives nine kilocalories and that is why it is a concentrated source of energy.

These will be needed so as to make the food palatable. We can arrive at a good estimate by thinking of how we use it. A cup of tea may require 5-10 gm sugar depending on how sweet we make it. A glass of sherbat may need 15-20 gm sugar.

Size of serving for sugar: So, on an average, 20-25 gm of sugar per day will be enough for a person. It is good to remember that there is no recommended amount for sugar, as it is not an essential component in nutritional planning. Since we know that sugar is only a sweetening agent, it is good to take it in reasonably moderate amounts.

Oils and fats improve the taste and acceptability of foods to which these are added as a seasoning or dressing. In addition, these are necessary in the transport and utilisation of fat soluble vitamins in the body. Vegetable oils contain essential fatty acids, which are necessary for growth in the weng and to maintain the health of our skin. It is necessary to include at least 15 gm of vegetable oil, such as groundnut, sesame, safflower, cotton seed, maize or soyabean oil in the diet daily. That will meet the need for essential fatty acids, the remaining amount can be taken as ghee, butter or vanaspati.

Size of serving for oils and fats: A teaspoon or 5 gm is a good unit of serving for this group. Since we use a teaspoon to add sugar to beverages and to serve oillfat, it is easy to use it as a measure in serving.The total amount of oils and fats in the diet will vary with our total energy needs and the energy intake from foods of the first two food groups. We may know that high fat diets are harmful to our health. Therefore the ICMR Advisory Committee (RDI 1981) suggested that the adult intake of dietary fat be 20 per cent or less of the total calorie intake.

4.4.6 Uses of food groups in menu planning

Please note the following important points in the use of the daily food guide in planning a meal:

1. Select foods from the five broad food groups.
2. Choose at least the minimum number of servings from each of the food groups.
3. Make choices within each group. The foods included in each group are given in detail earlier in this unit. Please remember that foods in each group are similar, but not identical in food value.
4. Try to include at least one food from group 2 in each meal.
5. Use vegetables and fruits, which are in season to ensure high quality at reasonable cost.

Please remember, we can add more foods from all groups to the minimum servings suggested, to make the meals satisfying. As we may have noticed, there are a large number of foods in each group. So we can choose foods which we like from each group and meet our nutritional needs. In a tropical country like India, we have a large variety of vegetables and fruits available in each season. We can choose any leafy vegetable, for they are all good sources of the pigment beta-carotene. We must include sufficient amount of food from each group. The particular food we choose and the way we season it, is a matter of our choice.

One of the questions that may worry we is, will nutritious food be more costly that what we eat at present? Or can we afford nutritious food? The answer is an emphatic No for the first question and Yes for the second. Cost is not related to nutritive value of foods. It is dependent on a availability and season; not on its nutrient content.

The foods, which have a great variation in prices, are vegetables and fruits. We know that those, which are in season, cost the least. What we should know is that at the peak of the season, each vegetable and fruit has the highest nutrient content, flavour and taste. There has been extensive research in this aspect and it has been proved that the nutrient content and yield of any plant food, whether it is spinach, beans, oranges or mangoes, is highest at the peak of the season. When we buy seasonal foods, we buy the best in terms of quality and nutrients at a reasonable price. Another point to note is that inexpensive fruits such as amla and guava are excellent sources of vitamin C, but apples-and grapes, which are costly, are poor sources of this vitamin.

We can meet the needs of different members of our family by using the food guide. For example, the teenagers in our family can take more servings of foods from Group 2 to meet the protein requirements for growth and more servings from groups 1 and 5 to meet the high energy requirements of body building. One must be cautious about the affinity to a group

and should be moderate for food one takes from any group. Even if we like it very much, we may not be able to include exact amounts of food from all food groups if we choose a lot more from a single group.

4.5 Meal and menu planning

Any individual who carries the responsibility of providiilg meals has to take decisions regarding what to serve, how nluch to serve, how much to spend, where to shop, how much to buy, how to prepare food, how to serve meals, at what hour to serve meal and so on. All such decisions are a part of planning meals. Extending this concept further, one could define meal planning as *a simple practical exercise which irzilolves applying the knowledge of food, nutrient requirement and individual preferences to plan adequate arzd acceptable nzeals.* In other terms, meal planning means *planning for adequate rzutritio~z.* Remember meal planning is just not an exercise of selecting the right kind of foods to help meet the nutrient needs. It also concerns with preparing/planning attractive and enjoyable meals for all persons. Meals must taste good and smell good. Because food is seen before it is tasted, the eyes have a role as well, in food acceptance. Meals must 'look good' to be tasted to be enjoyed. To do this, the planner does not have to be knowledgeable only, but also imaginative and creative. The art of skillful blending of foods in terms of colour, texture and flavour must be known. In this context, therefore, it is said that meal planning is an art. It is an **art** which develops through thought and inspiration. Meal planning, in fact, is a skill which improves with practice.

4.5.1 Principles and objectives

'Menu', as we all know, is nothing but *a list of dishes planned for preparation,* and forms the very core of all activities in the food service establishment. Although it may seem a simple exercise of providing something to eat and drink, in practice, good menu planning requires a lot of skill. It involves planning of balanced meals that are colourful, appetizing, palatable and within the economic means of the individuals concerned. When a food has to be bought, prepared and served in large quantities to people of varying tastes and requirements, for example in hospital food service, lot of attention has to be paid for this activity. It is essential to provide appetizing, nourishing and attractive meals to the people at a reasonable price. This is possible only if the meals are planned in advance.

1. Planning in advance helps to determine *quantities of different foods* accurately. Food buying can be controlled through advance buying because the quantities need to be calculated beforehand. Time and effort spent on haphazard ordering, shopping and receiving of food materials is saved .
2. Planning in advance helps to *avoid monotony* in the menus; *variety in terms of colour, flavour* and *texture* and different methods of cooking could be given due consideration if the menu is planned in time. If the meal fit the budget, it cannot be put into practice. Bulk purchasing, including seasonal foods help in this; this means that menu planning has to be done in advance.
3. The dietitian is responsible for giving clear instructions to the kitchen staff to ensure harmony among the staff involved in preparation. This is possible only if the menus are planned in advance.
4. In hospitals, the quantity of nutrients for the day for patients with various diseases and its distribution between the various meals of the day all need due consideration so that the patients are satisfied with the service provided. This is possible only with planning menus. Having understood the rationale for menu planning, we will learn the factors that affect the food choice.

4.5.2 Factors affecting food choice

Various factors influence our food choices. They are:

1. Nutritional Factors

Food choices made based on sound principles of nutrition will be conducive to good health while carelessness about nutrition can contribute towards chronic degenerative diseases like diabetes and heart diseases. We do not consume nutrients as such, but as meals/dishes made up of foodstuffs containing the nutrients in various amounts, knowledge of food groups will help one to formulate a healthy diet. The various foods in a food group are similar in a general chemical (nutrient) composition, and hence contribute almost similar types of nutrients to the diet, although not always in the same proportion.

At this point, it is worthwhile to learn about the evolution of the concept of *Food groups.* In the 1940s, nutritionists began translating RDA into terms that are more practical so that people with no special training in nutrition could still estimate whether their nutritional needs were being met.

A seven-food-group plan was one of the early formats. Daily food choices had to include food from each food group. This plan was simplified into five food- groups. By the mid-1950s, a four-food-group plan was established that included milk group, meat group, fruit-vegetable group and bread and cereal group. In 1979, the names of the groups were revised, and a fifth group containing fats, sweets and alcoholic beverages was added. We need to be cautious while consuming this last group, though it can supply essential fatty acids and vitamin E.

The following discussion briefly summarizes the nutritive value of each of these food groups. Let us begin with cereals.

1) *Cereals and Bread Group*

Cereals form the staple of the Indian diet. These grains are the main source of energy in the Indian diets contributing as they do 60-70% of daily energy intake of majority of Indians. This is because they are rich sources of carbohydrates. Proteins in cereal grains are partially complete as grains are low in one or two essential amino acids - lysine and threonine.

However, cereals when eaten with pulses, as is the common practice in India, the protein quality improves due to mutual supplementation between the cereal and pulse proteins, the former being deficient while the latter (pulse) being rich in lysine. Cereals are low in fat, but contain 1-3% omega-3 fatty acids.

Cereals in general, cannot be considered rich sources of minerals. However, ragi is rich in calcium (i.e. 344 mg1100 gm); bajra, and whole-wheat flour are high in iron content. The non-nutrient factors such as phytates, oxalates and fibers, which are present in them, interfere with the absorption of calcium and iron. Cereals, particularly the whole grains, are important sources of B-vitamins. Since most of these vitamins reside in the outermost layer of the grains, they are lost during polishing and refining. Parboiling, which involves soaking in water and subsequent steaming of paddy, results in seeping of vitamins present in outer layer into the grain; thus, parboiled milled rice retains much of the vitamins. Cereals are neither rich in vitamin A nor C; they do not contain any vitamin B12 either; however, whole grain cereals are rich in the other B-vitamins.

2) Pulse/Meat, Poultry/Sea Food Group

They are excellent sources of protein, containing 25% protein, but varying from each other in other respects. Let us discuss each of these groups and find out what these differences are:

1. Pulse group

Pulses are rich sources of proteins (20-25 g1100 g), the *limiting amino acid* being *methionine.* However, protein quality can be improved by mutual supplementation with cereals. Soybean though has exceptionally high protein content (43 g/100 g). Pulses have carbohydrates in fair amounts. Pulses are rich in iron, with soybean, cowpea, black gram and horse gram being exceptionally rich.

Sprouting or germination of legumes, a practice common in indian households, brings about beneficial effects. Vitamin C, which is practically absent in dry pulses, increases in significant amounts upon sprouting; folic acid also increases threefold. Interestingly sprouting brings about a decrease in flatus-forming compounds originally present in non-germinated pulses. Sprouted pulses require a much shorter time to get cooked. The anti nutritional factors such as trypsin inhibitors, are inactivated by sprouting, thus rendering them more easily digestible.

2. Fish and Seafood group

They are rich sources of proteins (20-25%) of a high biological value. Dry fishes contain more (60%) proteins since most of the moisture is lost. Dried fishes have exceptionally high amounts of calcium since it is consumed with the bones. Some varieties of fish such as hilsa, seer, katla, pomfret and mackerel are rich in omega-3 fatty acids, which are known to protect against cardiovascular diseases.

3. Meat and Poultry group

Meat and poultry are rich sources of proteins of high biological value.

They do not contain carbohydrates.

All the meats except egg yolk contain haem iron; therefore, the iron is well absorbed. However, egg yolk contains non-haem iron; the phosvitin, which is present in egg yolks, interferes with iron absorption but consuming vitamin C in the same meal helps lo overcome this problem.

1. Egg yolk is rich in vitamin A and p-carotene, while liver is rich in vitamin A.
2. Red meats are rich in saturated fats, while fish and poultry contain very small amounts of fats. Lean meats contain less fat.
3. Organ meats such as liver, kidney and brain and egg yolks are rich in cholesterol. Including large amounts of such foods in the diet, especially along with saturated fats in the diet has been shown to result in high serum cholesterol, which is a risk factor for coronary heart diseases.
4. Flesh foods are rich in iron, zinc and vitamin B12, but are devoid of fibre and vitamin C.

1. Dairy/Milk group

This first food of mammals is rich in body-building proteins and bone-forming calcium, besides being the only source of vitamin BIZ for the vegetarians. However, milk does not contain vitamin C, besides being deficient in iron. Dairy milk of varying fat contents is available in the market, the highest fat milk is known as full fat milk, the next known as standard milk and the lowest is skim milk. Low fat dairy milk is better suited for adults, especially the ones who want to watch their weights and have a check on their cholesterol levels. Curds are an ideal substitute for people who have problems in digesting milk due to the deficiency of the enzyme lactase.

2. Vegetable-Fruit Group

Vegetables and fruits add colour and variety to our diets in addition to providing a host of essential nutrients and phyto nutrients that help to prevent chronic degenerative diseases. Fruits are also high in potassium and help to establish a proper balance between the sodium and potassium content of our diets.

An often-neglected group, this group provides for the water-soluble vitamins and minerals, so vital for the proper functioning of the body's various mechanisms. These delicious natural capsules of vitamins and minerals offer protection against many diseases, especially, heart diseases and certain types of cancer. Most important is the fact that it offers a variety in terms of texture, colour and flavour and thus helps to avoid monotony in the meal.

Green leafy vegetables are rich sources of various nutrients such as iron, calcium, p-carotene, folic acid and vitamin C. Their contribution to energy intake is very low, usually less than 2-3%. Yellow-orange coloured vegetables are rich in b-carotene they must therefore be included at least four to five times in our diets. The citrus fruits such as oranges, sweet-lime (mosasmbi) and also, papaya and guavas are rich in vitamin C and the yellow-orange ones such as mango and papaya are rich in p-carotene. Fruits with high water content such as melons have low energy content, while dry fruits such as dates and raisins are high in energy.

3. Fats, Oils and Sugar Group

This group imparts flavour to the items and thereby improves the palatability. Items incorporating them have a “melt in the mouth” feeling. The fats and oils are generally the most expensive among the dietary items and therefore intakes are determined by the economic affordability. A deficit in the intake of fats and oils is rare in the affluent population while an apparent surfeit in this group is often responsible for obesity, heart ailments and certain types of cancers. Hence, one needs to use caution in the amounts used.

Each of these groups provides some but not all of the nutrients. No single natural food supplies all the essential nutrients and the phytonutrients in proper proportions to maintain health, nor is a food group more important than the other does. A meal plan that includes adequate amounts of foods from the different groups provides the foundation for good health that needs to be supported by food hygiene, clean drinking water and a clean environment. Besides nutritional factors there are some other factors too which affect food choices.

4. Other Factors

Although people are aware and realize that their food choices affect their health, they often choose food for other reasons. Let us review these factors.

1. ***Personal Preferences:*** Often people choose foods because they like certain flavours. While we Indians enjoy strong curry spices, the Western cuisine does not include them. Similarly, asafoetida (hing) features in the South Indian preparations while garam masala features in the North Indian cuisine.
2. ***Habit:*** We often select food just out of habit. While *idli* and d*osa* feature in South Indian breakfast, *parathas* feature more commonly in the North Indian cuisine.
3. ***Social Interaction****:* Food signifies friendliness. Meals are social events, and the sharing of food is a part of hospitality, Social customs almost compel people to accept food or drink offered by a host or shared by a group.
4. ***Availability, Convenience and Economy:*** People eat foods that are accessible, quick and easy to prepare, and within their financial means. Many people frequently eat out or have food delivered, which limits food choices to the selections on the restaurant's menu. Seasonal availability of food is particularly important aspect, which influences the food choices, particularly for lower income group families.
5. ***Positive and Negative Associations****:* People tend to associate foods with occasions like sweets during celebrations and happy occasions (birthdays and festivals) whereas we often develop a dislike to foods that we have to eat when we are sick or when forced to eat when not hungry.
6. ***Emotional Comfort:*** Some people eat in response to an emotional stimulus for e.g. to relieve boredom or depression or to calm anxiety. A lonely person may choose to eat rather than to invite a friend and risk rejection. Eating **in** response to emotions can easily lead to over-eating and obesity.
7. ***Body Image****:* Sometimes, people select foods which they believe will improve their physical appearance and avoid those that may be detrimental. Such decisions can be beneficial when based on sound nutrition and fitness knowledge but undermine good health when based on food fads or are carried to extremes.

4.5.3 Exchange list vs. food composition table

A dietitian is expected to make quick and reasonably accurate estimation of the nutritive value of diets or calculate diets that must be controlled for one or more nutrients. The nutritive value can be calculated from the Food Composition Tables (given in the Nutritive Value of Indian Foods by Gopalan et. **al.,** NIN, Hyderabad). Initially, dietitians and physicians were aware that Food Composition Tables used for calculating therapeutic diets were cumbersome, time-consuming and needlessly precise and dietitians did not have the time to calculate for each day the energy and nutrient composition of the food required to fulfill the dietary prescription. Thus, an *Exchange List* was evolved. The exchange list is *a grouping of foods in which specified amounts of all the foods provide approximately equal amount of (the same amount) carbohydrate, protein and fat and hence, energy content.* Specific foods within the group may vary slightly in nutritive value from the averages stated in the group. These differences in composition tend to cancel out because of the variety of foods selected from day to day. Thus, any food within a given list can be substituted or exchanged for any other food in that list in the given quantities.

Food exchange system allows one to choose a variety of foods with adequate nutrients. The food exchange system is important in planning a nutritious diet. Essentially, the *Food Exchange System* allows variety in the diets without altering the energy or the macronutrient contents. The exchange lists are especially useful in planning diets for metabolic diseases and are very useful in the management of obesity.

1. Steps in the Development of Exchange List

As mentioned above, when we group together similar food items so that each supplies a constant amount of a particular nutrient, we call the group *a food exchange.* Given herewith are the steps which when followed, will guide we in developing the exchange list. It is a difficult task to develop an exchange list for Indian foods as our dishes defy any attempt at standardization. But anyways we can try.

1. The first step in developing an exchange list is the standardization of serving or portion sizes. The portion sizes vary considerably in India. *Idlis, dosas, chapattis* and *puris* of different sizes in different states and in different households. Despite this, portion sizes have been defined.

2. The second step is to calculate the energy, carbohydrate, protein and fat content of one serving or portion size of the different dishes. This can be done by converting the cooked weight of one serving of a dish into raw weight of the ingredients that have gone into it. Although allowances should be made for cooking losses, this has not been done. Future exchange lists may take care of this. From the raw weights of the ingredients in one serving and using the Indian Food Composition tables, the energy, carbohydrate, protein and fat content of one serving can be calculated.
3. The third step is to create an exchange list of different dishes in terms of standard portion sizes that would provide approximately the same energy or carbohydrate or fat. Since foods contain widely varying amount of the macronutrients, serving or portion sizes are defined for a group of more or less homogeneous foods. For example, all cereals provide approximately the same number of calories, approximately 350 per 100 g raw weight and about the same amount of carbohydrates, about 70 g per 100 g raw weight Therefore, cereal exchanges are grouped together. Similarly, there are vegetable, fruits, and milk and meat exchanges. Within each of these food groups, the composition of the different items in terms of carbohydrate, protein and fats remain similar.
4. An example is provided in Table 12.2 from a comprehensive exchange list developed by the Lady Irwin College. Another list, originally developed by the Dietary Department of CMC, Vellore and subsequently added to by many other institutions; consists of six exchange groups. These are cereals, pulses, milk, meat, fruits and vegetables A and B. A brief review of these exchanges follows:

1. Cereal exchange per serving, provides 85 kcal, 20 g carbohydrate and 1.6 g protein
2. Milk exchange provides per serving 65 kcal, 4 g carbohydrate, **3** g protein and 4 g fat.
3. Meat exchange provides per serving 85 Kcal and varying amounts of CHO, protein and fat.
4. Fruit exchanges provide per serving 40 Kcal and 10 g carbohydrate.
5. The vegetable A group exchange provides 30 Kcal while the B group provides 30-50 Kcal.

Using the steps elaborated above, we hope we will be in a position to use the exchange system to calculate a diet pattern, which calculates the diet order in kinds and number of servings of food exchanges to be consumed by any individual or a patient each day. Although the exchange system reflects average and not specific energy and nutrient values, the therapeutic success that results when the values are used to calculate the diet pattern demonstrate that the method is accurate enough to serve this purpose. An adequate diet, providing all nutrients is needed throughout our lives.

An adequate and balanced diet is one that meets all the nutrient needs of an individual for maintenance, repair, growth and development. A balanced diet provides all the nutrients in required amounts and proper proportions. It can be achieved through maintaining variety in foods and including foods from the different food groups discussed above. The quantity of food needed to meet the nutrient requirements vary with age, gender, physical activity etc.

Refer to table no.4.5.3a for nutritive values used in dev. of exchange list of cereals.

Refer to table no.4.5.3b for food exchanges.

4.5.4 Planning a menu

Generally menu planning is done for adults. The term 'adult' refers to *any individual in the age group of twenty years and above.* The period beginning from twenty years and extending through old age until the time of death is considered the period of *adulthood.* Adulthood represents the stage in life when an individual has completed higher growth in terms of body size. The nutritional need is for maintenance of body functions rather than for growth.

As an individual ages, there is a gradual and progressive change in body functioning. This is because there is an increased breakdown of tissues while the renewal process is slow. These changes associated with ageing are common to all individuals, but there is a variation from person to person. In some individuals, the changes become significant relatively early, whereas, in other cases these changes appear much later in adulthood. All these factors influence the nutrient needs of adults.

1. Recommended Dietary Allowances (RDA)

We already know that recommended dietary allowances, are *estimates of nutrients to be consumed daily to ensure the requirements of all individuals are met in a given population.* Growth is no longer an energy-demanding factor in adulthood and BMR is relatively constant among population groups of a given age and gender. Rather habitual physical activity and

body weight are the main determinants for the diversity in energy requirements, in particular for adult populations with different lifestyles. Table no.4.5.4a presents the ICMR recommended dietary intakes of adults.

The nutrient requirements for adults are given under the three categories based on activity level - sedentary, moderate and heavy work, and

1. The nutrient requirements for men and women are given separately. For computing RDA, the ICMR has taken body weight of 'reference man' as 60 kg and that of 'woman' as 50 kg.
2. The requirements for proteins are based on body weight. The requirements are expressed as 1g protein per kg body weight.
3. RDIs for thiamin, riboflavin and niacin are dependent on RDAs for energy.

Refer to table no.4.5.4a for RDIs for adult man (60-65 kg)
Refer to table no.4.5.4a for RDIs for adult man (60-65 kg)

4. Some menus and dietary guidelines:

Now that we have a thorough and complete understanding about food exchange lists and the nutrient requirements for adults, we shall review a few regional menus and critically analyze them from nutritional point of view. But first, we would like we to study the dietary guidelines for Indians developed by National Institute of Nutrition (NIN), ICMR. These guidelines presented in Tables 12.5, 12.6 and Table 12,7 provide information as to the number of portions and actual diets that need to be consumed in order to ensure optimal health for Indian adult man and women. These diets, we would notice, are based on locally available foods within the reach of the people and generally are in conformity with our tradition and custom. Using these guidelines, we can plan diets for adults.

MENU (SOUTH INDIAN)

Menu	
Breakfast	**Ragi Kanji** **Ragi** ***Milk*** **Sugar**
Mid morning	**Rice flakes (roasted and sweetened)** **Guava**
Lunch	**Rice** **Roti** **Dal** **Aloo Palak, (Palak, Potato and Tomato)** **Dry fish chutney**
Snacks	**Lemon rice (with groundnuts)**
Dinner	**Pongal Rice** **Mung dal** **Drumstick leaves Bhaji**

Nutritional analysis:

1. Ragi Kanji is given forms a good source of calcium in diet.
2. Rice flakes forms one of fairly good sources of iron and to aid for good absorption of iron, Guava is given, which is one of the cheapest sources of vitamin C.
3. Lunch has normal staple diet like rice, dal and roti which is accompanied by a 100g palak - one of the sources of green leafy vegetable in diet and dry fish chutney, which forms a good source of protein.

4. Lemon rice is given, which is typical to South Indian inenu and forms one of the sources of vitamin C. Lemon should be squeezed just before consumption to avoid oxidation of vitamin C. It also contains peanuts, which adds protein and calories to the diet.
5. Pongal forms a good supplementation of protein through vegetarian sources due to mutual supplementation of rice and pulse, which completes the inadequacies of each other.
6. Dinner also contains drumstick leaves chutney, which forms one of sources of calcium. Curds form good source of protein.

MENU (NORTH INDIAN)

This north Indian menu is planned for a pregnant lady, who is anemic, doing household chores and belongs to a low socio-economic groups, So let us proceed and find out what nutrients considered and which food items have been selected to fulfill the above listed criteria.

MENU (NORTH INDIAN)

Menu	Items
Breakfast	Moong sprouts Potato Parantha - Groundnuts, wheat four, fat Tea - Milk, sugar Fruit – Sugar
Lunch	Bajra Roti (Bajra flour, fat) Dal (Masoor dal,, onion, tomato, fat) Diy fish chutney Vegetables (Yam, onion, tomato, french beans, fat) Plain curds
Snacks	Tea - Milk, sugar Masala roti (Wheat flour, groundnuts)
Dinner	Plain rice Dal (masoor dal, tomato, fat) Vegetable (amaranth, potato, onion, tomato, fat) Butter milk

Nutritional analysis:

The plan is for a anaemic pregnant lady, from a lower socio-economic level and doing moderate level of work, hence selection of foods is made accordingly.

- Among cereals, along with rice, whole-wheat flour, some amount of Bajra is also incorporated to fulfill the iron requirements.

- Among pulses, as already to her low economic level, rationale for pulses is a big restrictive. Hence, it has been made a point to incorporate sprouts to provide for some additional vitamins and minerals.

- There is also an accommodation made for nuts (groundnuts, being cheap) to meet her energy requirements along with calcium, iron, and protein.

- Milk is very important for her condition as milk is a very good source of calcium which is required in highest quantities.

- In flesh, dry fish has been incorporated, which is a cheaper than other fish foods and at the same time, the best source of iron and calcium, which are the basic requirements of a pregnant woman.

- There is a need to give good amount of fruits and vegetables in the diet (increased need for vitamins, minerals, antioxidants, fibre). But as her socio-economic status is low, care has been taken to give her fruits/vegetables which are cheaper yet an good source of many nutrients.

7. Planning a Low Cost Menu

Here are some examples of a few low cost menus. We can analyze this menu from the nutritional point of view.

Menu I

Menu	Items
Breakfast	1. Poha (with potato and moong sprouts) 2. Tea 3. Guava
Lunch	1. Chapati 2. Rice 3. Masoor dal 4. Yam Bhaji 5. Dry fish chutney 6. Cucumber raita
Snacks	7. Ragi Porridge 8. Puffed rice and groundnut laddu 9. Papaya
Dinner	1. Bajra Bhakri 2. Dry fish chutney 3. Palak dal gravy 4. Buttermilk

Nutritional analysis:

1. Guava is served at breakfast containing rice flakes; vitamin C in guava will help in the absorption of iron (in rice flakes).
2. Ragi is given, which will supply calcium.
3. There is a combination of all the food groups at both lunch and dinner.
4. Dry fish is a cheap source of good quality protein, calcium and iron.
5. Raw foods in the form of raita and fruits are incorporated in the menu.

Menu II

Low cost menu for a woman from a low socio-economic group:

Menu	**items**
Breakfast	1. Bajra Bhakri, Colocasia leaves and potato bhaji 2. Papaya 3. Tea
Mid- morning	1. Sukha Bhel
Lunch	1. Roti 2. Khichadi

	3. Dry fish chutney 4. Aloo methi bhaji 5. Pumpkin raita
Snacks	1. Rajgira Laddu 2. Tea
Dinner	1. Roti 2. Rice 3. Dry fish chutney 4. Aloo methi bhaji 5. Cucumber raita

Nutritional analysis:

1. Bajra used in the breakfast is a cheap and rich source of iron.
2. Colocasia leaves are rich in iron, calcium, p-carotene and vitamin C.
3. Papaya is an exceptionally rich source of b-carotene, besides being rich in vitamin C.
4. We already know the advantage of dry fish in a menu.
5. The menu for both lunch and dinner are almost same, and hence are ideally suited in the menu of the woman from the low socio-economic group.

Refer to table no.4.5.5a for balanced diet for adults (according to activity)
Refer to table no. 4.5.5.b for sample meal for adult man (sedentary)
Refer to table no. 4.5.5.b for sample meal for adult woman (sedentary)

4.6 Let us sum up

1. We have learnt what the recommended dietary intakes are and why these were set up. The recommendations are given for energy, proteins, calcium, iron, vitamin C. thiamine, riboflavin, niacin, vitamin A and vitamin D. There are variations in RDIs for various age groups, activity patterns and physiological conditions. RDIs are useful in planning food needs of catering organizations, detecting deficiencies in food consumption surveys, predicting deficiencies in food consumption surveys, and organizing food trade. Foods can be classified based on the predominant nutrients contributed by them.
2. A daily food guide has been developed for use in India, taking into account foods available and normally used in the Indian diet; the normal meal pattern of Indians and the nutritional needs as indicated by the Recommended Dietary Intakes (RDI). We learnt about the foods included in each group, the size of serving of each and the minimum number of servings from each group needed to meet the nutritional needs of an individual. We can use the guide to meet the needs of an individual whose need is higher due to strenuous activities. We have learnt to use the food guide as a tool in planning adequate diets and to evaluate diets for nutritional adequacy.
3. We learnt about the meaning of the term 'menu' and the concept of menu planning. We saw the various benefits of menu planning and the nutritional and non-nutritional factors affecting people's food choices. Further, to facilitate the process of menu planning, we learnt about food exchange lists and food composition tables. We also learnt the steps involved in the development of food exchange list and planned a few low cost menus along with their nutritional analysis, where we saw how meals must be planned based on the important nutrients, physical activity, and gender and income level. In addition, we got to have a look at a few sample menu plans along with their nutritional justification.

4.7 Glossary

Words	Meanings
Beta-carotene :	A fat soluble plant pigment, which is the precursor of vitamin A.
ICMR :	Indian Council of Medical Research.
International Unit (IU):	Unit used internationally to express requirement of Vitamin D.One IU of vit. D = **0.025** mcg of the vitamin.
Margin of safety :	The amount of nutrient required by a normal healthy person is increased by a certain amount to obtain the recommended amount. This increase is intended to ensure that almost all the individuals in that age group meet their need for that nutrient. This increase is known as margin of safety.
Menstruation :	The monthly discharge of blood from the outer layer of uterus, resulting in increased need for blood-forming nutrients.
Microgram :.	There are 1000 micrograms in one milligram
Milligram :	There are 1000 milligrams in one gram.
Precursor :	A compound that can be used by the body to form an essential nutrient.
RDA	Recommended Dietary Allowances.
RDI	Recommended Dietary Intakes
Reference man	A 20-39 years old man who weighs 55 kg.
Reference woman	A 20-39 years old woman who weighs 45 kg.
Retinol	The chemical name of one of the forms of vitamin A, retinaldehyde is the other form.
Sedentary	(A person) accustomed to sitting most of the time.
Bhaji-Vegetable	When used in a menu it refers to cooked vegetable preparation.Sukhi bhaji has no water added, rasbhaji has some water added.
Balanced Diet	A diet which meets the nutritional needs of the body.
Chapati	Unleavened bread made from whole wheat flour.
Dal-bhaat	Dal and cooked rice.
Food group	A grouping of foods on the basis of the predominant nutrients,which they supply.
Food Guide	A guide to help food selection and to evaluate it to ensure good nutrition.
Balanced meal :	A meal including different types of foods in such quantities and proportions that the need for calories, vitamins, minerals and other nutrients is adequately met.
	Amino acids that cannot be synthesized by our body and hence need to be supplied through diet.
	A grouping of foods in which specified amount of all foods provide

	approximately equal amount of energy content.
Essential Amino Acids :	A number of food items sharing commoil Characteristics
Exchange list	A list of dishes planned for preparation.
Food group	Planning of balanced meals that are colourful, appetizing, palatable and within the economic means.
Menu :	A nutritional strategy in which vegetable foods with low contents of amino acids are eaten together with a food that is high in that sane amino acid.
Menu planning	Any food preparation carried to the place of work which is consumed in the afternoon
Mutual supplementation :	To cook partially by boiling for a short period of time A feeling of satisfaction **and** fullness after consuming meals. Foods used frequently or daily, for example, rice (in the South) or wheat (in the North).
Packed lunch	the structure, appearance, consistency of foods or food items. Crisp, smooth, soft, hard or chewy are some of the textures of the food.
Parboiling	
Satiety	
Staple food	
Texture	

4.8 Check your progress:

1. Why were RDIs set up? (4.2)
2. Why do energy requirements vary with age? (4.2.1)
3. Explain the basis of dividing activities into groups. (4.2.1)
4. Which group do these people belong to: lecturer, post man, porter? (4.2.1)
5. Which nutrients will we need in grams, milligrams, micrograms and calories? (4.2)
6. What are the five basic food groups? Illustrate. (4.4)
7. What is the importance of group 1 cereals-millets in the diet? (4.4.1)
8. What is the importance of group 2 pulses, fish, egg, meat in the diet? (4.4.2)
9. What is the importance of group 3 vegetables and fruits in the diet? (4.4.3)
10. What are the functions of fats and oils in our diet? Who should restrict their intake of foods from this group? (4.4.5)
11. List the advantages of buying seasonal vegetables and fruits. (4.4.4)
12. What do we understand by the terms 'menu' and 'menu planning'? Why is menu planning considered an important activity in a food service organization? (4.5.1)
13. Discuss the nutritional significance of: a) Fruits and vegetables b) pulses. (4.4.3 and 4.4.2)
14. Enumerate the various factors affecting choice of food items. (4.5.2)
15. Define an exchange list. (4.5.3)
16. What are the advantages of using exchange list in planning and calculating the nutritive value of a menu? (4.5.3)
17. What are the two major aspects that must be kept in mind while planning meals for: a) A rickshaw puller b) A teacher? (4.5.4)
18. Plan a diet for adult male who leads a sedentary life-style. (4.5.4)

Table 4.2 RDIs for Indian adults

Nutrient	units	Adult Man	Adult Woman
Energy	kcal	2400	1900
Protein	gm	55	45
Calcium	mg	400-500	400-500
Iron	mg	24	32
Water soluble vitamins			
Vitamin C	mg	40	40
Thiamine	mg	1.2	1.0
Riboflavin	mg	1.4	1.1
Niacin	mg	16	13
Fat soluble vitamins			
Vitamin A (retinol)	mcg	750	750
Vitamin A (beta carotene)	mcg	3000	3000
Vitamin D	IU	200	200

Table 4.2.1a Changes in RDIs with Age

Age (months/years)		Energy (kcal)		Protein (gm)
• Infants				
0-6 months 7-1 2 months		118/ kg body wt. 108/kg body wt.		2.01 kg body wt. 1.7/kg body wt.
• Children				
1-3 years *4-6* years 7-9 years		1220 1720 2050		17-20 22 33
	Boys	Girls	Boys	Girls
10-12years 13-15 years 16-18years	2420 2500 2820	2620 2200 2000	41 55 60	43 50 50

Table 4.2.1b Changes in Energy RDIs with Activity Level

Adult	RDI for energy (kcnl)
Man	
• Sedentary • Moderately Active • Heavy work	2400 2800 3900
Woman	
• Sedentary • Moderately Active • Heavy work	1900 2200 3000

Table 4.2.2 RDIs for Pregnancy and lactation

Stages	Energy (kcal)	Protein (gm)
Pregnancy-I1 half	+300	+14
Lactation 0-4 months	+550	+25
7-12 months	+400	

Table 4.4 The Daily Food Guide

Food gp.	Foods included	Size of serving	No.of servings
1.	**Cereals and Breads**		
	Rice, wheat, bajra, jowar. Maize, ragi and their preparations	25 gms.	6-12
2.	**Protein foods**		3-6
	Dals, legumes, nuts, and oil seeds	25 gms	
	Milk and milk products	150 gms	
	Eggs (nos.)	1	
	Fish, poultry, meat	30 gms	
3.	**a) Green and yellow vegetables**	50-75gms	1
	All green leafy vegetables		
	Orange-yellow vegetable and fruits		
	b) Vit.C rich vegetable and fruits	50-75 gms	1
	Amla, guava, drumstick, orange, papaya, mausambi etc.		
4.	**Other vegetables and fruits**	50-75 gms	2 or more
	All fruits, vegetables, gourds, immature beans and peas. Fruits like bananas, melons, chikoo, grapes, apples etc.		
5.	**Oils, fats, sugars**	5gms	5
	Oils, vanaspati, ghee, butter, sugar, jaggery, syrups, murabbas		

Table 4.5.3a Nutritive values used in the development of exchange list of cereals

Food group	Energy (kcal)	CHO (g)	Protein(g)	Fat (g)
Bajra	361	67.5	11.6	5.0
Jowar	349	72.6	10.9	1.9
Maize, dry	342	66.2	11.1	3.6
Ragi	328	72.0	7.3	1.3
Rice, raw	345	78.2	6.8	0.5
Parboiled	346	79.0	6.4	0.4
Flakes	346	77.3	6.6	1.2
Puffed	325	73.6	7.5	0.1
WWF	341	69.4	12.1	1.7
Maida	348	73.9	11.0	0.9
Semolina	348	74.8	10.4	0.8
Vermicelli	352	78.3	8.7	0.4
Mean	344	73.5	9.1	1.5
Bread, *White*	245	51.9	7.8	0.7
Brown	244	49.0	8.8	1.4

Table 4.5.3b Food exchanges

Exchange (Food Group)	No. of exchanges	Amount* (g)	Energy Content (kcal)	Protein Content (g)
(Energy Giving group)				
Cereals	1	20	70	2
Roots and tubers	1	60	70	2
Sugar and Jaggery	1	5	20	-
Fats and oils	1	5	45	-
(Body-building group)				
Milk	1	250 ml	170	8
Pulses	1	30	100	7
Meat/fish/poultry/egg	1	40-50	70	7
(Protective/regulatory group)				
Green leafy veg.	1	100	Negligible	Negligible
Vegetables	2	200	40	2
Other vegetables	1	100-150	40	2
Fruits	1	80-100	40	Negligible

Source: Adapted from Comprehensive Exchange List developed by Lady Irwin College, Delhi.

Table no. 4.4.1 ;Courtesy: Fundamentals of Foods & Nutrition 2nd ed., p. 13 by Mudambi, S.R. & M.V. Rajgopal, WileyEasterin Ltd., New Delhi, 1987.

Table 4.5.4a Recommended dietary intakes for adult man (60-65 kg)

Nutrient	Sedentary Work	Moderate Work	Heavy Work
Energy (Kcal)	2425	2875	3800
Proteins (g)	60	60	60
Calcium (mg)	400	400	400
Iron (mg)	28	28	28
Vitamin A (mcg)			
Retinol *0* r b -carotene 2400	600 2400	600 2400	600 2400
Thiamine (mg)	1.2	1.4	1.6
Riboflavin (mg)	1.4	1.6	1.9
Niacin (mg)	16	18	21
Ascorbic acid (mg)	40	40	40
Folic acid (mcg)	100	100	100
Vitamin B,, (rncg)	1	1	1

Table 4.5.4b Recommended dietary intakes for adult woman (50-55 kg)

Nutrient	Sedentary Work	Moderate Work	Heavy Work
Energy (Kcal)	1875	2275	2925
Proteins (g)	50	50	50
Calcium (mg)	400	400	400
Iron (mg)	30	30	30
Vitamin A (mcg)			
Retinol *0* r b -carotene	600 2400	600 2400	600 2400
Thiamine (mg)	0.9	1.1	1.2
Riboflavin (mg)	1.1	1.3	1.5
Niacin (mg)	12	14	21
Ascorbic acid (mg)	40	40	40
Folic acid (mcg)	100	100	100
Vitamin B,, (rncg)	1	1	1

Source: Nutrient Requirements and Recommended Dietary Intakes for Indians. ICMR, 1990.

Table 4.5.4 a Balanced diet for adults (sedentary/moderate/heavy activity): No. of portions

Food groups	Portion/ gms.	Type of work					
		sedentary		Moderate		Heavy	
		Man	Woman	Man	Woman	Man	Woman
Cereals & millets	30	14	10	16	12	**23**	16
Pulses	30	2	2	3	2.5	3	3
Milk	lOO ml	3	3	3	**3**	3	**3**
Roots & tubers	100	2	1	2	1	2	2
Green Leafy veg.	100	1	1	1	1	1	1
Other vegetables	100	I	1	1	1	I	1
Fruits	100	1	1	1	1	I	I
Sugar	*5*	*5*	4	8	5	1 1	9
Fats and Oils (visible)	*5*	4	4	7	6	11	8

Source: Dietary Guidelines for Indians - A Manual. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad (1998).

Table 4.5.4 b Sample meal plan for adult man (sedentary lifestyle)

Meal time	Food group	Raw amounts	Cooked recipe	servings
Breakfast	Milk Sugar Cereals Pulses	100 ml 15g 70g 20g	Milk/tea/coffee Breakfast (idli/ dosa/ upma/ bread/ cornflakes)	½ cup 2 cups 1 cup
Lunch	Cereals Pulses Vegetables Vegetables Milk (curd)	150g 20g 150g 50g 100ml	Rice Chapatti Dal Veg curry Veg salad curd	2 cups 2 nos. ½ cup ¾ cup 7-8 slices ½ cup
Tea	Milk Sugar Cereals	50ml 10g 50g	Snacks (poha, toast, samosa, sandwich, biscuits) Tea	2 nos. or 1 cup 1 cup

Dinner	Cereals Pulses Vegetables Vegetables Milk (curd) Fruit	150g 20g 150g 50g 50ml 100g	Rice, Phulkas, Dal Veg curry Veg raita Seasonal	2 cups 2 nos. ½ cup ¾ cup ½ cup 1 med.

Source: Dietary Guidelines for Indians - A Manual. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad (1998).

Note: For non-vegetarians - substitute one pulse portion with one portion of egg/meat/ chicken/ fish .Use 20 g visible fat per day. 1 cup= 200ml.

Table 4.5.4c Sample meal plan for adult woman (sedentary lifestyle)

Meal time	Food group	Raw amounts	Cooked recipe	servings
Breakfast	Milk Sugar Cereals Pulses	100 ml 10g 50g 20g	Milk/tea/coffee Breakfast (idli/ dosa/ upma/ bread/ cornflakes)	½ cup 2 cups 1 cup
Lunch	Cereals Pulses Vegetables Vegetables Milk (curd)	100g 20g 100g 50g 100ml	Rice Chapatti Dal Veg curry Veg salad curd	1 cup 2 nos. ½ cup ½ cup 7-8 slices ½ cup
Tea	Milk Sugar Cereals	50ml 10g 50g	Snacks (poha, toast, samosa, sandwich, biscuits) Tea	2 nos. or 1 cup 1 cup
Dinner	Cereals Pulses Vegetables Vegetables Milk (curd) Fruit	100g 20g 100g 50ml 50g 100g	Rice, Phulkas, Dal Veg curry Veg raita Seasonal	1 cup 2 nos. ½ cup ½ cup ½ cup 1 med.

Source: Dietary Guidelines for Indians - A Manual. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad (1998).

Note: For non-vegetarians - substitute one pulse portion with one portion of egg/meat/ chicken/ fish .Use 20 g visible fat per day. 1 cup= 200ml.

UNIT 5 NUTRITION & DIET FOR SPECIAL CONDITIONS (infancy, childhood, adolescence, pregnancy and lactation, and old age)

Structure

5.0 Objective

After studying this unit, we will be able to:

- describe the normal growth pattern through the lifecycle, from infancy to old age
- identify the nutritional requirements during the various stages
- list the problems faced during these stages and
- list the diets and feeding patterns.

5.1 Introduction

In this unit, we shall learn about nutrition through the life cycle i.e. nutrition in infancy, childhood, adolescence, pregnancy, lactation and old age. We shall study about the typical characteristics of each period and how they affect the growth and development of an individual. We shall also learn to apply basic principles of meal planning while keeping in mind the various considerations and guidelines specific to the life stage. Other factors which would influence diets and meal planning apart from the nutritional needs of the individual at that stage are the psychological state of the individual, socio economic factors, other physical conditions, the environment around them etc.

Through this unit we shall realize how important nutrition is from conception to old age and an individual's total life (both physical and mental) depend on it.

5.2 Infancy

Infancy is a period of rapid growth. From the safe protected world in the mother's womb, where it was nourished, the baby now comes into an environment that places a lot of stress on it. The baby has to make an effort to get the food it needs and has to cope up with the infections. Breast-feeding is unique because it nourishes the baby and protects it from many infectious diseases. As the baby grows, mother's milk alone is not sufficient and it will need other baby foods.

5.2.1 Growth and development

During the first year of life, the infant grows and develops far more rapidly than at any other stage in life. A number of important changes accompany this stage.

- **Physiological Changes**

These changes bear important relationship to the care and development of infants. They are:

1. Changes in physical development
2. Changes in mental development
3. Changes in gastrointestinal system
4. Development of excretory system
5. Changes in body composition
6. Changes in feeding behavior

- **Growth Monitoring**

Growth monitoring is a tool that helps to identify growth [altering at an early stage and helps to institute corrective measures so that malnutrition can he avoided. In growth monitoring, weight is plotted against age accurately on the growth chart. Growth charts are available with all pediatricians, health workers, anganwadi worker and health centers. The growth chart depicts vaccination schedule, birth history, general guidelines, disease history and one-year weight record with guidelines of infant feeding. Interpretation of growth charts is very important for any health and nutrition professional. The *upward curve* indicates *weight gain* while *flat curve* indicates *no weight gain.* The *downward curve* indicates *weight loss* and is not desirable.

Besides identifying growth faltering, growth charts also provide the following information:

1. The growth is considered normal or satisfactory if the curve falls above the topmost line indicating- 80% of the ideal weight for age.
2. The growth curve falling between lines indicating 1 and 2 shows that body weight is 71 to 80% of the ideal, This indicates 1^{st} degree malnutrition.
3. The curve falling between second and third line shows 61-70% of the ideal body weight. This indicates 2^{nd} degree malnutrition.
4. The curve falling between third and fourth line shows 50-60% of the ideal body weight. This indicates 3^{rd} degree malnutrition.
5. The curve falling below fourth line shows body weight to be below 50% of the ideal indicates 4^{th} degree malnutrition.

Refer to table no. 5.2.1 for the growth chart of infants

The weight and height is compared with those of well-to-do Indian children as given in Table 5.2.1. It takes 1-3 years for an infant to establish his own genetic growth pattern. When this figure is established (such as height-for-age or weight-for-age), the child's measurements should then move along the curve. The first three years are crucial, as malnutrition is most common and severe during this stage. Height-for-age is a measure of achieved linear growth that can be used as an index of past nutritional status.

- **Health Monitoring**

Infections are a major cause of malnutrition in children. For many of the preventable early childhood diseases, vaccines are now available so that these diseases of early childhood can be prevented providing a better opportunity for normal growth. Also known as childhood immunizations schedule these schedules must be adhered to strictly. Malnutrition, high infection rate, incomplete immunization and poor diarrhea management are major cause of high infant mortality rate (IMR) and under five mortality rates. Use of ORS and ensuring complete immunization schedule has been able to reduce mortality rate considerably.

5.2.2 Nutrient needs and RDA

The nutritional requirements of infants are met by exclusive breast-feeding until 6 months, after which it is imperative to introduce complementary feeding.

- **Energy:**

Energy requirements of infants are based on the energy intake through breast milk by infants of well-nourished mothers.

The energy demand for growth constitutes up to 35% of Total energy expenditure (TEE) at 0-3 months and 17.5% at 3-6 months. The growth requirement should be added to TEE to give total energy requirement.

Refer to table 5.2.2a for energy requirements of infants

- **Protein:**

Protein allowances of infants should meet both growth and maintenance requirements. Protein allowances are computed from the protein content of breast milk and the volume of milk consumed by healthy infants growing normally. In case of infants beyond six months, breast milk alone cannot satisfy protein needs. Supplementary food has to be introduced, consisting of a source of good quality protein like milk and milk products, cereal and pulse combinations, non-vegetarian foods like fish, chicken etc. Hence, protein allowances for infants between 6-12 months are in terms of both milk protein and vegetable protein, each contributing almost equally to the total protein intake.

Refer to table 5.2.2 b for protein requirements of infants.

- **Fats:** Adequately breast-fed infants receive nearly 30 *g* fat per day, of which 10% is linoleic acid and 1% is linolenic acid. Breast milk thus suffices the needs of EFA for infants, which is about 6-en%, Human breast milk is superior to other milk for its long chain n-6 and n-3 PUFA content that are biologically more potent.
- **Calcium**: The calcium requirements of young infants are computed from the calcium content of breast milk and volume of breast milk intake. Up to 6 months of life, 300 mg calcium intake is adequate. ICMR (1990) recommends 500 mg of calcium daily during the entire period of infancy.
- **Phosphorus:** Phosphorus requirements are linked to the calcium intake and the requirements of both these minerals is .almost equal. However, in all age groups, Ca: P ratio should be 1:1 except infancy when 1:1.5 is recommended.
- **Iron:** In first two weeks of life, the hemoglobin falls to a normal level of 11-12 g/d as against 17-23 g/dl at birth. The iron is redistributed in the first month of infancy hence breast milk alone meets iron needs of infants. Although iron in breast milk is low, it is very well absorbed. Iron fortified complementary foods are important in maintaining the iron status of infants especially in situations where additional iron rich foods are not offered to the infant after 6 months of age.
- **Vitamins**: The requirements of both classes of vitamins - fat-soluble and water soluble are given in **table 5.2.2.c.**
- **Trace elements**: Most elements, such as zinc and iodine, hold a major significance in infant nutrition. Zinc is associated with growth while iodine with the brain growth and development. Their significance starts since conception in the mother and should be adequately provided.

Refer to table no. 5.2.2 c for RDAs of various nutrients for infants

Compared to adults an infant's requirements are considerably very high. The RDA table shows the energy requirement of a sedentary man to be 2400 kcal. If we express energy in terms of per kg of body weight, we find that the energy requirements of an infant (per kg of body weight) are much higher. The need for other nutrients like proteins, vitamins and minerals (per kg of body weight) is also several times more in infants than adults.

Refer to table 5.2.2.d for comparison of nutrient needs of an infant & adult

5.2.3 Diet and feeding patterns

Diet and feeding patterns of infants has been sub-divided into 0-6 months and 6-12 months. Breast milk is best food for an infant. It is nature's provision to satisfy the needs of the infant for growth and development including emotional development. Even a poorest mother is able to nurse her child satisfactorily at least during the first few months. WHO recommends a normal mother to exclusively breast feed until 6 months of age.

- **0 to 6 months:** The term exclusive breast-feeding is used when all fluids, energy and nutrients are provided by breast milk, with the possible exception of small amount of medicinal supplements. Exclusive breast-feeding means that not even water is given. Breast milk provides enough water even for the hot summer months.

Sometimes exclusive breast-feeding cannot be sustained. Working mothers join their duty in the fourth month and exclusively breast-feeding stops. Although infant needs of almost all nutrients are met from breast milk alone but in absence of breast milk, other milk can be given. Giving undiluted homogenized, pasteurized, toned milk that has been boiled at home is a relatively inexpensive option. Buffalo's milk can be given by initially diluting in the ratio of 2: I. The

alternate caregivers may over dilute the milk, which can cause under nutrition. The usual challenge in alternate milk is water quality, hygiene, handling, and milk allergies. Cow milk is known to cause allergies worldwide. Heat-treated milk formulae have shown better tolerance but are expensive and their over-dilution is a major cause of malnutrition.

Refer to table 5.2.3a Nutrient composition of different milks/100 g

- **6 to 12 months:** As the infant grows older, mother's milk alone is not sufficient to meet his increasing needs. This is seen in some infants between 4-6 months by the downward slope in the growth curve. Especially if for some reason, mother's milk is insufficient, the infant is then weaned. Weaning is a process of gradually introducing foods other than breast milk. Weaning foods are those foods, which are used during the gradual transition of the infant from breast-feeding to a normal diet. It may start with the introduction of other milk but the best option is to continue breast milk and give other solid foods in liquid and semi solid consistency. The introduction of complementary foods/weaning foods ensures fulfillment of nutritional requirements and gradually introduces the child to family eating pattern. By the time the child is one year old, he should get used to eating the normal family diet.

Balanced Diet for Infants

The infants aged 6-12 months can eat in a day's diet:

- 30-45 of cereal,
- 15 g pulse,
- 200-500 ml of animal milk (if breast-fed then 200 ml top milk is recommended),
- 50 g roots and tubers,
- 25 g green leafy vegetables,
- 25 g other vegetables,
- 100 g fruit,
- 25 g sugar,
- 10 g fat.

Adding extra fat in dal khichri is a recommended practice to ensure 40 en % of fat for infant's growth and decreasing bulk in diet.

Refer to table no. 5.2.3.b for complementary foods for 4 to 12 months infants.

Feeding Schedule in Infancy

1) Milk feeding 5 - 6 times/day.
   Continue breast-feeding.
   Exclusive breast-feeding up to 6 months even during illness.
   Follow demand feeding.
2) 6 months: Start complementary feeding;
   Feed 3-4 times/day, example, porridge: twice/day,
   Vegetable – once/day,
   Fruit – once/day.
3) 6-9 months: Continue breast-feeding,

   Feed 4-5times/day e.g. family diet – twice/day,

   Commercial premixes or homemade multi grain mixes including amylase rich foods (ARF) – twice/day,

   Vegetable/fruits - once a day.
4) 9-12 months: Continue breast-feeding, feed family food;
   Feed 5-6 times/day
   Family food twice/day,
   Instant mix – twice/day,
   Fruits/vegetables - once a day.

***Source: WCD.* Govt. of India.**

5.3 Childhood

Also known as school age, the school age period can be termed as 'Middle Childhood'. School age children are those who are between 6 and 12 years. After 13 years, children enter their adolescent years. You may call them teenagers. The school age is a serene or calm period because the child has fewer problems than the preschool period or-during adolescence. The physical ability of the child improves and makes the child more skilful. Thus, the child may take more active part in sports.

He/she is more independent than before. There is a steady increase in the height and weight. One important thing in the child's life is the daily routine of school and many extracurricular activities

5.3.1 Growth and development

Children between 6 years and the onset of the adolescence grow relatively slowly. One characteristic that we notice is that there is individuality in growth rate of children in these years. There is little growth in head size, but the trunk and legs grow (remember brain growth is completed during the preschool years.) Skeletal maturation occurs during these years. Annually the increment in height may be approximately 5 to 6cm, with girls gaining a little more than boys do. Weight increases are usually between two and three kilograms per year.

5.3.2 Nutrient needs and RDA

Children in this age group have no special nutritional needs. Since children are growing at this age, they require all the nutrients and hence a well-balanced diet. Children who play a lot, and are very active, will need more energy than children of the same age who are less active i.e., one who spends a lot of time in reading, or watching television or painting or drawing. If the child is getting an adequate diet, he/she will have a low risk of having nutritional problems. However, any inadequacy in a child's diet will affect him/her more quickly and more severely than it would affect an adult. Blood formation keeps pace with the need for increased blood supply for the child's growing body. Children from this age group have more resistance to disease than the preschoolers. Another important point to bear in mind is that girls should have an adequate iron intake so that they have sufficient iron stores before they reach menarche. Under nutrition may have serious consequences. If the child is undernourished, he/she will become easily tired and will not be able to perform well in school or be able to do the physical activities well or fully. Such a child may be susceptible to infection as well.

Refer to table no. 5.3.2 for RDAs of various nutrients for schoolchildren

ICMR (1990) gives requirements of 4-6 years and 7-9 years categories. After 10 years of age, boys' and girls' are categorized into three categories i.e. 10-12 years, 13-15 years and 16-18 years. Boys, as compared to girls, have higher lean body mass (LBM), skeletal mass and lower fat as a ratio of total body mass. This difference in body composition leads to differences in their nutrient needs as LBM has more metabolic activity than adipose tissue.

- ***Energy****:* Occupational and recreational activities variably affect energy requirements. The energy requirements are calculated for children over five years of age and for adolescents with lifestyles involving three levels of habitual physical activity. They are:

1. ***Light*** physical lifestyles: Children and adolescents who spend several hours at school or in sedentary occupations; do not practice physical sports regularly; generally use motor vehicles for transportation; and spend most leisure time in activities that require little physical effort, such as watching television, reading, using computers or playing without much body displacement.
2. ***Vigorous*** lifestyles : Children and adolescents who walk long distances or use bicycles for transportation; engage in high energy-demanding occupations, or perform high energy-demanding chores for several hours each day; and/or practise sports or exercise that demand a high level of physical effort for several hours, several days of the week.
3. ***Moderate*** lifestyles: Children and adolescents with habitual physical activity that is more strenuous than the activities for a light lifestyle, but not as demanding as the activities for vigorous lifestyle have a moderate lifestyle.

As the lifestyles suggest, the intake of calories shall depend accordingly.

- **Protein*:*** FAO/WHO/UIW (1985) recommends factorial method to compute their protein requirements. The factorial value is increased by 50% to obtain the physiological requirements for growth and further 25% has been added to give safe level of intake.
- **Fats**: The linoleic acid requirements for schoolchildren and adolescents have been set at 3-en%. In terms of visible fats, ICMR (1990) has recommended an intake of 5-en%. Since their energy requirements are almost equal to adults, the minimum amount of visible fat works out to be 12 g/d.
- **Calcium** Calcium requirements in children and adolescents can be calculated based on calcium accretion during growth. In absence of definite data on Indian children and the rate of absorption, ICMR recommended 400 mg for the age group1-9 yrs. Good physical activity, adequate calcium intake and Ca:P ratio of 1:l is recommended for adequate bone mass.
- **Iron:** The maintenance requirements are computed same as adults i.e. 14 (g/kg BW). For children up to 12 years of age, the growth and blood expansion requirements are 15 mcg/kg of BW. Thus, 29 mcg/kg BW is recommended until 12 years of age. Talking into account an absorption figure of 3%, the daily dietary iron requirements are computed for different body weights at different ages of growing child.

- **Vitamin *A:*** The vitamin A requirement of children is 300-400 mg retinal/d. In view of high vitamin A deficiency in India and low serum levels, ICMR 1990 recommends 600 mg of retinol to schoolchildren and adolescents.
- **Other fat-soluble vitamins**: ICMR (1990) does not give recommendations for vitamin D, E and K. Vitamin D is very important for skeletal growth and optional utilization or calcium and phosphorus. School children and adolescents, who spend plenty of time in outdoor games in school or home, get vitamin D by bioconversions
- **Water-soluble vitamins**: Thiamin is computed as 0.5 mg/1000 Kcal, riboflavin as 0.6 mg/1000 Kcal and niacin as 6.6 mg niacin equivalents/1000 Kcal, as is done for adults. Folate requirements are computed on per kg body weight basis .Vitamin B12 requirement ranges between 0.2-1.0 mcg/d and needs to be ascertained age wise, if any. In absence of precise data on vitamin C requirements of Indian children and adolescents, a value of 40 mg/d is sufficient for all ages 1-18 years and adults. Vitamin C is heat labile and destroyed on storage. Its adequacy is important everyday for enhancing availability of iron from diets.

5.3.3 Diet and feeding patterns

Starting school (especially full-time) can bring a number of changes in a child's eating habits. A large part of the child's time will be spent in school. Therefore, the meal timings should be adjusted according to the child's schedule. One must see that the child has a good breakfast. A hungry child cannot concentrate and participate fully in the learning experience. Not only cereal but also a protein-rich food and a fruit which supplies some vitamin C should be included at breakfast time. Good breakfast helps in attention span, good social behavior, sense of security and contentment and prevent snacking and bingeing. Yet most schoolchildren and adolescents rush through their breakfast or completely skip it. One common reason for skipping breakfast is sleeping late and rising-late. Pressure of school routine puts them into a rushed morning routine. They are not able to regain adequate appetite in this rushed routine in the morning. Adequacy of children's food and nutrient intake depends on:

1. Sibling company
2. Peer pressure
3. Model set by parents and other adults in the family their personal attitudes and practices. Sometime they have knowledge but cannot translate into practice.
4. Harmony at home and stress of school
5. Mass media
6. Convenience foods and fast food outlets.

We often find that a child becomes so involved with other activities that it is difficult to get him/her to sit down and eat. In addition, when we force them they may eat a little and rush back to whatever they were doing. Later they may feel hungry, and want a snack. If we do give snacks, we should encourage the child to eat nutritious ones instead of chocolates or chips.

In the daily diet we must include 2 to 3 servings of fruits or vegetables, green leafy or yellow vegetables about 3 to 4 times a week. We must make sure that we include a citrus fruit or some other good source of ascorbic acid. Many children may dislike vegetables. However, we must try to get them to eat these foods. One way of doing so is by preparing colorful, attractive, tasty dishes. Another important aspect is that at this age, they may need to eat four or five times a day. Permanent teeth start erupting at about 6 years. One must guard against caries formation in children at any age but especially in schoolchildren because they have permanent teeth. Caries formation occurs because of poor dental hygiene especially after consumption of sweet foods. One can prevent this by ensuring that the child brushes and cleans his teeth well in the morning and night. Also, we must not give too many sweet foods. For most children, lunchtime is during school hours. We already know that the lunch provides the child with one-third of his/her daily nutrient needs. So most of the time mothers will have to provide a packed lunch for the child.

Let us discuss a few points to keep in mind while planning a packed lunch.

1) It should be easy to eat and not spill over or leak. Avoid any oily or liquid preparations (unless it is separately packedin a bottle). Oil and liquid will leak out of the box and spill over children's books. Chutneys, etc. should be as dry as possible.

2) Let the food be as dry as possible (the child may/may not have a place to sit down and eat and wash hands as he can at home).

3) Many things that taste good when they are hot are not so tasty when they are cold. A packed lunch will always be cold. Hence, it should be prepared accordingly.

Refer to table 5.3.3 for balanced diet for schoolchildren

A sample menu for a school-going child (8-10 yr old).

- Breakfast : Paratha/ upma/ bread 2 slices
  Milk/Egg
  Banana/Guava/Orange
- Lunch : Chapati-2
  Leafy vegetable and dal preparation -½ cup
  Carrot (Salad)
  Dahi/Lassi-1 cup
- Tea : Tea
  Biscuits/Chikki/Bread and butter-2
- Dinner : Rice- ¾ cup
  Chapati-1
  Vegetable- ½ cup
  Dal ½ cup
  Milk/ dahi -½ cup
  Salad

In the day, a child should get the following foods in addition to an adequate intake of cereals:

2 -Servings of Milk

2 -Servings of dal

3 -Servings of vegetables

(including 1 of green leafy/yellow orange vegetable)

1 -Serving of fruit

Sugar - according to taste

Oil, fat - added while cooking

5.4 Adolescence

Adolescence is a unique period of dynamic change, which we may refer to as "growing up". In this period, not only will a boy or girl attain physiological maturity, but the adolescent also becomes increasingly independent and tries to be an adult. This period in lasts nearly a decade. It is a critical period since development of the individual occurs at the physiological, psychological and social levels. Adolescence is the time that begins with the onset of puberty. At the end of adolescence, the individual has functional reproductive organs and has attained final physical growth i.e., will not grow any further. Puberty or pubescence begins with the appearance of secondary sex characteristics. In girls, this shows development of the breast, beginning of the menstrual period etc. In boys, there is development of the genitals, appearance of the facial hair etc. In both sexes, hair begins to grow in the under arms. At the end of puberty, sexual reproduction becomes possible. Adolescence follows puberty and ends with the completion of physical growth at maturity. Thus, at adolescence, a girl is capable of bearing a child.

5.4.1 Growth and development

WHO defines 10- 18 years children as adolescents. *Adolescence is* a *period of second growth spurt after infancy.* Growth spurt refers to a *sudden increase in the rate of growth.* The rate of growth is not constant in both sexes. In both sexes, it occurs in spurts.

Growth and development in children can be studied under the following heads:

- Changes in physical development and body composition
- Sexual maturity
- Psychosocial changes

Changes in physical development and body composition

Adolescence is one of the most challenging periods in human development. Adolescence is a period of second growth spurt after infancy. Most girls begin the adolescent growth spurt between the age of 10 and 13 years, and boys between the age of 12 and 15 years. Nearly every organ in the body grows during this period of rapid growth. Most noticeable are increases in height and weight and development of secondary sexual characteristics. During the growth spurt, girls gain about 25 cm height and boys 30 cm height. From age 10 years, girls tend to accumulate both lean body mass (LBM) and fat, whereas, boys tend to gain mostly lean tissue. The growth in LBM corresponds to increase in spontaneous physical activity in boys and increase in work capacity and heart volume.

Boys double their LBM while girls increase by 1.5 fold. Height gain is essentially complete by 19 years. Head size in proportion to total height shrinks from 114" to 118" between infancy to adulthood. Growth ceases in girls and boys when skeleton reaches its final size. Once the growth spurt ceases in girls, which is 2 years after menarche, an adequate nutrient intake will help maintain health and lead to increased weight by allowing normal cellular hypertrophy.

Sexual Maturity

Sexual maturity develops along with growth spurt in adolescence. In girls, growth stops on attaining menarche (puberty). The other changes seen in sexual maturity of girls is development of breasts, axillary hair and pubic hair. Menarche occurs only after this growth. In boys, changes in sexual maturity and growth go together. The secondary sexual changes are deepening of the voice, broadening of shoulders, developing axillary, body and' pubic hair. There are distinct changes in the hormones. Sex hormones determine thermo genesis, moods, food intake and body composition.

Psychosocial Changes

Adolescence is a period of maturation for both mind and body. Along with thephysic4 growth, emotional and intellectual developments are rapid. The child develops gradually the ability to reason, develop problem-solving skills, and attain emotional maturity. Adolescence marks a major shift from protected parental care to move into adult life pattern. During this transition, they try to build self-identity. Adolescents often feel uncomfortable with their rapidly changing bodies. Developing an image of the physical self is intertwined with nutritional issues. There is tremendous peer pressure. Peer pressure and some adult idol determine their food habits, dressing and group conduct. There is a tremendous impact of mass media on this age group.

5.4.2 Nutrient needs and RDA

This period of growth is less predictable than at other ages, i.e., some teenagers may have their growth spurt at 11-12 years of age and others at 14 years. Their requirements are determined by sex and sometimes even within the same sex, age, stage of puberty and growth rate are important factors, which determine the nutritional requirements. Recommended allowances of the Indian Council of Medical Research are based on chronological age. Adolescence is divided into 2 age groups: 13 to15 years and 16 to 18 years.

Refer to Table 5.4.2 for Recommended dietary allowances of nutrients in adolescents

In adolescence, maintenance and growth requirements can be computed separately for energy and protein. We know that food and nutrient needs are going to be proportionately higher during the growth spurt. Enough cereals and protein containing foods like dals or milk, meat/fish/egg and also leafy vegetables and other fruits and vegetables are very important. They provide minerals like calcium, which is important for development of bones and iron for blood formation along with vitamins A and C. During the adolescent growth spurt (for about 18 to 24 months), when the growth rate is at its maximum, the nutritional requirements of the teenager may be twice as much as during the rest of the adolescent period. Nutrient requirements of course will parallel their growth. However, energy requirements as we already know will depend upon the amount of activity the teenager is involved in. During this period the need for all minerals increases but three of them are particularly important. They are--calcium (for increased skeletal mass), iron (for the expansion of blood volume) and zinc (for the development of sexual organs and generation of new skeletal and muscular tissue). Girls need more iron than boys do because of iron losses in blood during menstruation. The best way we can determine whether the teenager is receiving sufficient nutrition is to see whether he/she is growing well, see whether he/she is eating a well balanced diet and whether he/she feels healthy and has stamina. If a teenager is constantly falling ill or feels tired continuously, there is reason to worry.

5.4.3 Diet and feeding patterns

Just like schoolchildren, adolescents' adequacy of food and nutrient intake depends on:

- Sibling company
- Peer pressure
- Model set by parents and other adults in the family

- Harmony at home and stress of school
- Mass media
- Convenience foods and fast food.

For adolescents, other than points covered above, there are two more important points to be considered. They are:

- Inanition
- Fad diets

Inanition actually refers to *exhaustion from lack of nourishment; starvation.* Many teenagers rarely relate today's food habits to tomorrow's health. They have a notion of 'desirable' body shape and 'ideal' body weight. They purposefully starve to maintain such a weight. Very often they might miss meals at home, often skipping breakfast and lunch altogether, whereas during this time of peak growth velocity, adolescents usually need to eat often and in large amounts.

On the other hand, fad diets are common especially among boys. Girls resort to fad diets in order to lose weight and adolescent boys for muscle building, broadening shoulders, waist narrowing etc.

Problems that effect feeding patterns and nutrition are:

1. **Obesity**: One problem is that a diet which consists of high calorie foods only may lead to obesity. If a teenager is overweight, he/she is made fun of. This may affect the psychological and social maturation of the adolescent. Eventually obesity will alter metabolic function and lead to elevation of blood pressure and raise levels of triglycerides, glucose etc. leading to high risk of heart disease, when he becomes an adult.
2. **Acne**: Adolescents of both sexes dread pimples and the problems of a bad complexion. There are many fads and fallacies regarding their causes and treatment. The real cause is that the sebaceous glands which produce oil and lubricate the skin, are under hormonal control. In puberty, hormone production increases greatly thus, leading to acne. The best thing is to have a well balanced diet and combine it with good skin care.
3. **Alcohol**: Teenagers may drink alcohol for fun in the company of friends. What they must take care of is that it should not become an addiction. Alcohol is not a food. Moreover, it adversely affects appetite and nutritional status of an individual.
4. **Diabetes**: A diabetic adolescent (juvenile diabetes) must be given insulin and it is important that he/she is provided with a normal and nutritionally adequate diet. The diet should be satisfying and flexible enough or else the teenager will find it very hard to adhere to it.
5. **Teenage pregnancy**: Families: who are not financially well off, get their teenage daughters married off at a very early. As a result, many adolescent girls become pregnant. Nutritional needs during this time should be taken care of so that the pregnant teenager has enough food for her and her baby's growth.

We may encounter adolescents who suffer from other health problems like asthma, atherosclerosis and bone disorders etc. For each of the conditions we must take adequate and appropriate care under a doctor's guidance so that there will be no detrimental effects on his/her health in the future.

Simple nutritious diet, rich in iron, plenty of fruits and vegetables, low fat and low sucrose diet with plenty of exercise and sports can in fact ensure good physique and long term good health.

Refer to table no.5.4.3 for balanced diet for adolescents

Sample items on a menu for an adolescent:

1) Paneer parantha with fruit.
2) Sprout upma/poha with fruit/sprout chat.
3) Missi parantha with vegetable (as carrot, peas, pumpkin, aloo methi).
4) Palak/bathua/methi/missi parantha with oil-free lemon-ginger pickle.
5) Vegetable and peanut idli with chutney.
6) Paneer and vegetable pulao.
7) Vegetable and nugget noodles (avoid plain noodles),
8) Rajma/paneer low fat patties

Sample diet for a 13-15 yr old boy

Breakfast :	Milk 1 glass/Tea/1cup
Egg	Paratha **2** or Bread slices 3 with butter
	Fruit
Lunch :	Chapati **4** stuffed with channa **dal**
	Potato curry 1 cup
	Salad
	Chikki
Tea :	Sandwich of **4** slices bread
	Milk
Dinner :	Rice 2 cups
	Dal 1 cup
	Green leafy vegetable 1 cup
	Dahi

5.5 Pregnancy

Pregnancy and lactation are unique periods in the life cycle. They occupy a critical place in the life cycle and have health and social importance for individuals, families and society. This intergenerational significance has led all societies lo recognize these as special periods and to make provisions for their care. We shall first discuss about pregnancy and the impact of nutrition on it.

A normal pregnancy, as you know, lasts for 9 months or 270 days, approximately. During this time, the baby grows from being as tiny as a pinhead to a weight of almost 2.5 to 3 kg. During the period of fetal growth in the mother's womb, the fetus is nourished directly by the mother herself, through a spongy structure called the Placenta. Since the baby relies totally upon its mother for nourishment, you realise how vital it is to provide a pregnant woman with an adequate well balanced diet.

5.5.1 Growth and development

A completely new life begins at conception. Organ systems develop rapidly and nutrition plays many supportive roles. Pregnancy from conception to birth usually lasts 40weeks (10 lunar months/menstrual cycles) in humans. During this period, the unborn child grows from a single cell to an infant that is ready for life outside the womb. Many physical changes also take place in the mother to support her developing offspring, regulate her own (maternal) metabolism and prepare her for labor, birth and lactation. Changes in the mother are anatomical, physiological and complex, affecting almost every function of the body. They are an integral part of the maternal - fetal system, which creates the most favorable environment possible for the developing child. Many of these changes are apparent in the very early weeks.

It is necessary to conduct biochemical tests at suitable intervals such as in the first, second and third trimesters, to follow these changes and determine if there is a deviation that calls for an intervention. The most common measurement of nutritional importance done routinely in India is hemoglobin in the second and third trimesters. Measurement of blood pressure and fundal height are other two measurements done routinely to determine high-risk pregnancies and development of the fetus.

Lot of hormonal changes happen during pregnancy like:

- **Human chorionic gonadotropin (HCG)** begins to increase immediately on implantation of the ovum and reaches a peak at around 8 weeks of gestalion. HCG maintains the corpus luteum which is the main source of oestrogens and progesterone in the early weeks of pregnancy.
- **Human placental lactogen**, with a structure similar to the growth hormone, increases throughout pregnancy. Placental lactogen stimulates lipolysis and is important in maintaining a flow of substrates to the foetus. Placental lactogen along with prolactin also promotes the development of mammary glands.
- **Oestrogens and progesterone** are secreted by the placenta from 8-10 weeks of gestation. It stimulates maternal respiration ensuring an adequate supply of oxygen to the foetus. 1n addition, it relaxes smooth muscle in the uterus to accommodate the growing foetus and allow for childbirth. Progesterone, while stimulating lobular development in the breast, inhibits milk secretion during pregnancy.

- Another hormone that increases in maternal plasma during pregnancy is ***cortisol.*** Cortisol enhances production of glucose from amino acids (gluconeogenesis) and also antagonizes the action of insulin. This way it increases the availability of glucose to the foetus which relies solely on glucose for its energy needs.

Placental Transfer of Nutrients

Also called the lifeline for the foetus, the placenta is a *transitory structure which develops during pregnancy and lies implanted on the uterine wall.* It is connected with the foetus through the *umbilical cord.* The foetus derives all its nutrition from the mother across the placental barrier. If the consumption, absorption and utilization of the nutrients by the mother and the transport of nutrients across the placental barrier are inadequate, then foetal malnutrition develops. Dietary inadequacies are a major cause of fetal under nutrition in developing countries. Maternal diseases such as diabetes and hypertension compromise the delivery of nutrients across the placenta to the fetus.

Role of the placenta in fetal nutrition

Nourishes the fetus	Facilitates transfer of oxygen and nutrients from mother to foetus.
Removes wastes	picks up fetal waste products such as CO2, urea, bilirubin.
Fetal lung	performs the respiratory, absorptive and excretory functions that the fetus lungs, digestive system and kidneys will provide after birth.
Protective barrier	protects the fetus from harmful agents, which are of high molecular weight including proteins except maternal immuo globulin G conferring immunity to the fetus.
Endocrine gland	produces several hormones that maintain pregnancy and prepare the mother's breasts for lactation.

Maternal Weight Gain: A pregnant woman must gain about 7 to 10 kg during the entire pregnancy. Ideally, a mother should begin her pregnancy at the appropriate weight for her height. It is advisable that during the first three months, a pregnant woman should put on approximately 1 to 2 kg. Thereafter, her weight gain should be at the rate of about 2 kg per month. Maternal weight gain represents two major components.

1) The products of conception i.e. the fetus, amniotic fluid and the placenta
2) Maternal tissues gained, expansion of blood and extracellular fluid, enlargement of uterus and mammary glands and maternal stores (adipose tissue).

These physiological changes contribute towards the increased nutrient demands on the nutritional status of the expectant mother.

In India, the weight gain during pregnancy *for the upper economic group is 11kg and, the lower economic group women is only 6-7 kg.* Lower weight gain is associated with increased risk of intrauterine growth retardation and perinatal mortality. It is useful to define certain terms here. When a baby is born full term, i.e. 39-40 weeks of gestation but has a weight less than 2.5 kg, the baby is referred to as a *low birth weight* ***(LBW)*** baby but if a baby is born prior to full term and weighs less than 2.5 kg, it is not to be classified as low birth weight or small for date. Such babies are pre maturely born.

Refer to Table no.5.5.1 for Distribution of weight gained during pregnancy

5.5.2 Nutrient needs and RDA

- **Energy:** During pregnancy, a woman needs more amount of almost every nutrient. The calorie requirement increases by 15% or more. The ICMR has recommended that a pregnant woman's intake should be 300 Kcal more than her normal intake in the second half of pregnancy. This is because the baby grows very rapidly, in the second half of pregnancy. The composition of the diet during pregnancy should be the same as for a non-pregnant woman; hence, the contribution to calories from carbohydrate, protein and fat does not change. However, carbohydrate intake should not be <100 g per day. Pregnant adolescent girls, underweight women and women who are exceptionally active (heavy physical activity) may require more energy.

Refer to table no.5.5.2a for comparison of nutritional requirements of pregnant (2nd & 3rd trimester) and non-pregnant woman

- **Proteins**: Proteins are needed for the growth of the fetus and maternal tissues. A mother should take about 14 gm of protein more than a normal woman during the second half of pregnancy.. This increase could be either through vegetarian sources such as pulses (soybean), milk and milk products (cheese) or through meat/fish and eggs in the diet. This is based on the needs of the non-pregnant woman plus the extra amounts needed for growth. Maternal and foetal growth accelerates in the second month and the rate progressively increases until just before term. Therefore, the need for protein follows this growth rate. It is important to ensure protein quality, as well as, quantity. The physically active pregnant women and adolescent girls would however require more as compared to sedentary pregnant woman.
- **Micronutrients**: Minerals and vitamins are necessary for growth, for formation of red blood cells, formation of bones and teeth and development of the nervous system. Since energy intake increases, the requirements for few micronutrients needed for energy utilization i.e. thiamin, niacin, riboflavin and magnesium also increase. Since protein needs are higher, the requirements for vitamin B6 and zinc also increase. Micronutrients involved in the growth and development of bone and connective tissue and the synthesis of new cells are needed in greater amounts.

Refer to table no.5.5.2b for RDIs during pregnancy

Refer to table no.5.5.2c for iron requirement during pregnancy

Common concerns during pregnancy:

High Risk Pregnancies:- these happen due to pregnancy related problems such as:

- Anemia in Pregnancy
- Hypertensive Disorders of Pregnancy
- Pregnancy and Diabetes Mellitus
- Pregnancy and Obesity and
- Adolescent Pregnancy

5.5.3 Diet and feeding patterns

An adequate diet is very important so that the placenta grows well in order that the baby will receive all the nourishment it needs. If a woman has gained more than the expected amount of weight early in pregnancy, she should be advised not to put on too much weight. However, she should not drastically curtail her diet. It is important to know why weight gain is so important during pregnancy. She may give birth to an underweight baby. This may not be a serious problem if the baby is small, alert and healthy. However, a low birth weight baby is usually also malnourished and weak. Such a baby may not be strong enough to get all the nourishment it needs by suckling. It may not be able to cry loudly and vigorously to attract its mother's attention. If a pregnant woman does not consume enough food early in pregnancy, growth of the placenta and therefore the baby's growth may be less than normal. A weak baby girl, when she becomes an adult (presuming that she is well-nourished throughout her childhood) grows to be smaller in stature and so may in turn bear an undersized or poorly developed infant. Such an infant will not be able to achieve its full potential. Thus, the food that a woman eats and her nutritional status affect the health of her children and the future of her family.

Refer to table no. 5.5.3 Prediction of low birth weight on the basis of BMI of mother

Daily Food Guide for the Pregnant Woman

Foods	No. of extra servings to be taken by a pregnant woman
• Cereals and Millets	+2
• Dals/Egg/Milk/Meat/Fish	+2
• Protective Vegetables and Fruits (vitamin C rich)	+1
• Dark green leafy Vegetables	+1
• Other Vegetables and Fruits	+1

During pregnancy, some women may develop a craving for certain foods. As long as these cravings do not interfere with good eating habits and are not health hazards, we need not worry about it. Some women crave for amla, raw tamarind, etc. These foods are nutritious (good sources of vitamin C) and should be eaten.

Some women have nausea (feel sick) or morning sickness in early pregnancy. Eating snacks often helps to prevent and overcome this problem.

5.6 Lactation

Lactation is a physiological process, which has profound relevance for both the mother and the newborn. It is the period following pregnancy when the woman nourishes a fully developed and a rapidly growing baby with breast milk. A lactating woman secretes about 500 ml milk/day in the first month, which increases to about 850 ml/day by the fifth month. On an average, a well-nourished lactating woman secretes about 850 ml/day. During pregnancy, changes occur in the mother's breasts to prepare for milk production and body fat is deposited to ensure that energy is available for lactation.

***Lactogenesis* i**s the onset of copious milk secretion around parturition, triggered by a fall in plasma progesterone levels. Although some colostrums is secreted after delivery (2-3 days), full lactation begins later. The first 2-3 days after delivery is a period of rapid lactation initiation, followed by the longer period of maintenance of lactation. This complex neuroendocrine process is facilitated by interplay of various hormones. *Oxytocin* and *prolactin* instigate the lactation process. Prolactin is responsible for milk production and oxytocin is involved in milk ejection from the breast.

5.6.1 Human milk composition

Human milk contains several nutrients and that it is tailor made to meet the requirements of the growing infant. Nature has designed milk to be species-specific. Thus, human milk is unique to the needs of the young homosapiens. The value of human milk for the health and growth of the baby is undisputed and rarely does breastfeeding need to be discouraged. Human milk is a solution of proteins, sugar and inorganic compounds in which a variety of fatty acids are suspended.

Refer to table no. 5.6.1 for the nutritional composition of human milk.

Milk composition varies between mothers (inter-individual variation) from one period of lactation to the next (intra-individual variation) and even within a single 24-hourperiod (diurnal variation) and the time during the feed, as well as, the breast. The composition of milk is also related to the amount secreted, timing of withdrawal and individual variations, which includes maternal age, parity, health and socio-economic status. Gestational age of the infant also affects, since milk from in others of premature infants has higher concentrations of some nutrients as compared to milk from mothers of term infants. Similarly, diet and use of oral contraceptives may also influence composition.

Special characteristics of colostrum, beneficial to the infant are summarized herein:

1. Volume of colostrum :2 -10 ml/feeding/day - related in part to the parity of the mother
2. Typically yellow, due to a relatively high carotene content
3. Transparent, contains more protein, less sugar and much less fat
4. Lower in calories than mature milk (58kcal vs. 70 kcal/100 ml)
5. Concentration of sodium, potassium, and chloride greater than in mature milk
6. Facilitates establishment of 'bifidobacteria' in the gastrointestinal tract of newborn
7. Facilitates passage of meconium in the newborn's intestines
8. Contains abundant antibodies which provides passive immunity for infant.

Some characteristics that make breastfeeding beneficial to the infant are :

- Mature human milk contains about 1/3rd the protein found in cow's milk - more than 25% of its nitrogen is non-protein nitrogen. The concentration of casein to whey protein is lower; 1.5 for breast milk and 0.2 for cow's milk. Thus, human milk with its low casein content forms a flocculent suspension with a curd tension of 0. These curds are easily digested and hence better tolerated by the infant.
- Lactoferrin in human milk inhibits the growth of certain iron-dependent bacteria in the GI tract and therefore affords protection against gastrointestinal infections.
- Protection from respiratory tract allergy and eczema.
- Immunoglobulins provide passive immunity and protect against infection by retarding viral and bacterial invasion of the mucosa.
- Relatively low in amino acids that are detrimental at high levels.
- It has a threefold higher fat content. Higher content of linoleic and oleic acid, cholesterol, the latter being needed for myelin synthesis.
- Contains lipase which helps in digestion of milk triglycerides and partly accounts for a greater ease in fat digestion of breastfed infants.

- Minerals: As compared to cow's milk, 6-times more phosphorus, 4 times more calcium - lower renal solute load - better availability.
- Lower iron content but nearly 50% of iron in human milk is absorbed.
- Levels of water-soluble vitamins likely to reflect maternal dietary or supplementary intake.
- Several hormone-like substances and growth factors in human milk.

5.6.2 Nutrient needs during lactation

Milk is the only source of nourishment for many infants for up to 6 months to a year or even more. Therefore, the relationship between .maternal nutritional status and lactation performance is important. Successful breastfeeding requires adequate nutrition and rest. For adequate lactation, substrates must be available in sufficient quantities from the mother's diet or body stores laid down during pregnancy. If these are insufficient, some degree of subsidy from maternal body tissue can be expected. We know that the simplest evidence of tissue depletion is weight loss. In a sense, pregnancy and lactation need to be considered as a continuum. However, the longer the duration of lactation, the greater would be the impact on the mother's nutritional status.

Studies indicate that there are major physiological alterations in calcium and bone metabolism during lactation, independent of maternal calcium intake. Bone resorption and bone formations are high, particularly in the 1st 3-6 months of lactation.

Among well-nourished women, weight loss can occur after childbirth, although this depends on their caloric intake and their physical activity. In poorer communities, dietary intakes of breastfeeding mothers are not very different from non-lactating women. The RDIs for all major nutrients are given for the first 6 months of lactation, as well as, the second 6 months of lactation, when the volume of milk produced has decreased. However, women who have a low pre pregnancy weight gain, who have decreased weight for height and who breastfeed more than one infant, need additional kilocalories during lactation. FAO/WHO 2004 recommends that well-nourished women with adequate gestational weight gain should increase their food intake by 505 Kcal/day for the first six months of lactation, while undernourished women and those with insufficient gestational weight gain should add to their personal energy demands 675 Kcal/day *d*uring the first six months of lactation. Energy requirements for milk production in the second six months are dependent on rate of milk production, which are highly variable among women and populations.

The nutrient needs of a lactating mother.

Energy and Protein Needs*:* Remember that during pregnancy, well-nourished women will have laid down approximately 2-4 kg of fat. This can be mobilized to supply a portion of the additional energy for lactation. It is estimated that this amount of storage fat will provide 200-300 Kcal/day for a period of three months. However, this amount represents only a part of the energy cost of milk production.

The additional protein intake suggested in Table 13.9 not only takes into account the additional protein needs but also the net protein utilization of Indian diets,

The requirement of several micronutrients also increases and is summarized herewith.

Micronutrient*:* Vitamin and mineral deficiencies can have profound influence on the composition of milk. Calcium is a nutrient of special concern, since there are some reports in the literature that if the mother's diet is not adequate, it will be mobilized from her bones. This is especially of concern in case of prolonged lactation. Hence, the RDI for calcium is high for lactating mothers.

The requirements for other nutrients are all increased, reflecting the need for milk production and the need to replenish maternal stores. Folate needs are increased above non-pregnant levels but are not as high as during pregnancy. Iron needs are not increased during lactation because little iron is lost in milk, and in most women, losses are decreased because menstruation is absent. However, if the mother's iron status is poor, supplements of 30 mg of elemental iron per day may be recommended for the first 2 to 3 months of lactation to replete iron stores.

Refer to table no.5.6.2 for RDIs for lactating mothers

Besides these, water needs during lactation should be paid attention to. An increase in fluid intake does not increase milk volume, however, additional fluid is needed to maintain a normal maternal fluid balance. When fluid intake is low, the mother's urine becomes more concentrated to conserve water for milk production. To avoid dehydration and ensure adequate milk production, fluid intake should be increased by about 1lt per day.

5.6.3 Diet and feeding patterns

Generally, a well-'balanced diet meets nutrient needs of the mother. Whenever feasible, food should be the source of nutrients and self-initiated vitamin and mineral supplements should be avoided. The dietary intake of caffeine, artificial sweeteners and alcohol must be totally avoided. This is because most chemicals ingested by the lactating mother cross into the milk**.** Therefore, the mother should seek the advice of her physician before taking any dietary supplement, medication or drugs. Excess caffeine may make the infant irritable and wakeful, but the research indicates that moderate amounts of caffeine (1-2 cups of coffee per day) will not harm or upset the infant. Further, infants metabolize alcohol inefficiently. Smoking also reduces milk volume. Infant exposure to passive smoke negates the protective effect of breastfeeding and offers against sudden infant death syndrome.

Foods with a strong flavour may alter the flavour of milk. A few infants may be sensitive to particular foods like cow's milk protein. Hence, when the mother's diet includes such foods, the infant may experience discomfort. In general, the mother can eat whatever she likes. However, if she suspects that a particular food is causing the infant discomfort, she should consult the physician. If the food is eliminated for an extended time, appropriate foods should be substituted to ensure nutrient adequacy. During the period of nursing or breastfeeding one can notice that a mother needs to consume one-and-a-half times her normal food intake.

Sample menu for a nursing mother

Foods	Amount
Chapati or	One
Rice	One cup
Dal or	One cup
Egg or	One
Milk/curd or	One cup
Fish or	One piece
Nuts	25 gm
Any dark green leafy vegetable	One serving
Ghee/butter/oil/fat	4-5tsps
Sugar/jaggery	4-5tsps

We are familiar with the traditions of feeding special preparations to a nursing mother. Many communities give a nursing mother kheer or laddus made from dry fruits, methi, lobia, leafy vegetable soups, etc. All these foods provide energy, proteins, minerals and vitamins that the mother needs.

It is not always necessary to prepare such foods. We can meet the additional requirements of the mother by increasing some common food items in the normal diet which provide the same nutrients.

5.6 Old age

Ageing is a continuous process. It starts at birth and continues throughout our life. This process though is hastened in later years of life.

Here we will focus on the vital relationship between nutrition and ageing discuss the current nutritional recommendations for healthy ageing. One of the fundamental and unavoidable facts of life is that our body composition changes with age. It changes from the way it looks to the way it functions. Externally, the hair greys, skin wrinkles, eyes and ears also go through their own degeneration. Internally, many physiological changes occur and practically all the tissues and organs decline in their functional efficiency over time. Also no two persons of sixty or sixty-five years look alike. Some may look ten years younger, others a few years older than they are. In other words, their actual age, which is also known as chronological age, does not coincide with their biological age. However, the chronological age is most often used by gerontologists to define the aged. In India, a cut-off age of 60 years is taken for classifying people as 'old' and is used for census purposes.

Many nations follow the cuts off age at 60 years while many developed countries and United Nations take the cut-off age at 65 years to designate the elderly. In India, socio-economic development along with better health facilities and medical care including primary health services has raised the life expectancy. At present, the elderly constitute 7.7% of the total population i.e. approximately 76 million and are projected to reach about 150 million (12 percent) by the year 2025. The

elderly population is a very heterogeneous group, which has varying problems and needs. We can classify the elderly into two groups, the 'young old' (i.e. 60 to 74 years) and 'old old' (i.e. 75 years plus), Men outnumber women in young old age groups and women outnumber men in the higher old ages. The Indian population projections reveal an impending burden of elderly care in the near future. Our health planners will have to give more attention to the preventive and health promotion for the elderly. This would help to improve their quality of life and reduce morbidity levels so that they live purposefully and independently within the community.

5.6.2 Changes in ageing

As we grow older, our body is the sum total of the care, use, misuse or neglect it has undergone. The illnesses or diseases that we may have suffered also leave their mark. If we had accidents, the cumulative effect of these on the body is also felt in old age. Infections like diarrhea, dysentery, fevers etc. that we may have suffered due to environmental factors also leave their mark on certain systems of the body. How well the need of the body was met by foods we ate throughout the years affects not only the ageing process, but also our resistance to disease.

- **Physiological changes:** Many changes occur in our body, mind, social and economic status with age. The digestive system undergoes considerable change with age. The amount of acid and digestive enzymes secreted by gastric glands decreases. Thus, the digestion and absorption of nutrients is decreased. About 10 per cent of the elderly suffer from reduced secretion of hydrochloric acid or gastric acid. This takes away the first line of defense of the body, since gastric acid acts as an antiseptic also. As a result, they suffer from frequent diarrhea and stomach upsets due to increased infections. The movement of the alimentary tract becomes sluggish with age. Food stagnates, bowels do not move regularly and constipation is a common problem. It may have been treated with drugs over a period, further reducing its activity. Proper mastication helps the process of digestion of food but with teeth fallen, decayed or functionless, food is often swallowed than chewed by the elderly. If they have poorly fitted dentures, they do not use them due to discomfort. The ability to smell and note differences in taste reduces with age, which leads to decreased enjoyment of food. The progressive accumulation of plaques leads to narrowing of the lumen of blood vessels and loss of elasticity. There is a decline in the cardiac output, an increased resistance to the flow of blood and resultant reduced capacity to respond to extra work. As the rate of blood flow is reduced, the digestion, absorption and distribution of nutrients is retarded. Skeletal bone loss occurs with ageing and may have serious consequences among the elderly. With ageing, there is thinning of bone tissues due to the loss of these minerals. In some elderly, there is an abnormal thinning of bone tissue and as a result, osteoporosis develops.

From age 25 years, the basal metabolism decreases by about *2* percent for each decade due to the increasing proportion of body fat and lesser muscle tension. The ability to maintain normal body temperature is also lessened and hypothermia in the elderly can be especially dangerous.

Carbohydrate metabolism*:* Glucose tolerance may be impaired to some extent.

Usually, the fasting blood sugar is normal. The absorption of carbohydrate is not impaired, however, when a carbohydrate load is presented, as in the glucose tolerance test, the blood sugar remains elevated for a longer period of time as compared to the younger persons.

Fat metabolism*:* With increasing age, the blood cholesterol and blood triglyceride levels gradually increase. Certain factors like the kind and amount of fat and carbohydrate in the diet, the degree of overweight, the stresses of life may be responsible for the elevated levels.

Changing body composition: By 80 years, it is estimated that only half of the muscle cells remain. Connective tissue, which is so abundant in the human body, sees many changes, which are of special significance. Collagen is one of the fibrous materials found in tendons, ligaments, skin and blood vessels. With ageing, the amount of collagen increases and becomes rigid, the skin loses its flexibility, the joints creak and the back becomes bent. Both longitudinal and cross-sectional studies throughout the world indicate that height decreases with age. The average reduction in height during the total life span is about 2.9 cms in men and 4.9 cms in women, with approximately half the decrease being in sitting height. The reduction in sitting height is a result of vertebral compression, change in shape and height of vertebral discs, loss of muscle tone and postural changes. Weight loss in elderly is generally caused by a reduced lean body mass (LBM) and body fat due to metabolic and physical changes associated with ageing or presence of disease conditions. The body water content reduces with advancing age and this has been implicated as an important cause of decline in weight after 65 years. Studies also show a slow, progressive redistribution of fat in the elderly. The body fat relocates centrally and intra abdominally, while the subcutaneous fat on the limbs tend to decrease. An increase in abdominal circumference with age may also reflect shortening of trunk due to osteoporosis or other spinal deformities. As the length of the trunk decreases, the abdomen increases in girth.

5.6.3 Nutrient needs and RDA

There is evidence that diet and nutrition are directly linked to many of the chronic diseases afflicting older adults. A consideration of recommended dietary allowances (RDAs) for older adults must recognize each of these aspects of the relationship between nutrition and ageing. The Basal Metabolic Rate (BMR) gradually decreases after the attainment of maturity due to a decrease in muscle mass tissues and physical activity. With an increase in age, the percentage reduction in the total energy requirement as recommended by

ICMR is 20 percent for 60 to 69 years of age and 30 percent for 70 to 79 years of age and above, although there can be wide individual variations. The elderly need the same nutrients that they needed earlier. One change that definitely accompanies the ageing process is a decreased energy need. With age the basal metabolism and activities slow down. On an average, men and women in the 55-75 years age group need 400 to 500 calories less per day than they did before this stage. The need for other nutrients is not altered. Therefore we do not find changes in recommendations for nutrients except energy.

Refer to table no.5.6.2a for recommended dietary allowances of nutrients for the elderly

The metabolic demand for vitamin B, to maintain glucose tolerance and

normal cognitive function in older adults is higher than the earlier consumption. Vitamin B6 and vitamin E supplementation help to enhance the vigor of immune reactions which slow down with age. The efficiency in absorption of vitamin B12 and folic acid in the gut may be reduced with age owing to the decrease in secretion of hydrochloric acid in the stomach of many elderly people. The capacity of the skin to synthesize vitamin D from sunlight and also kidney's ability to convert vitamin D to its biologically active form, declines with ageing process.

The potential benefits of micro nutrients should also be taken into account when the nutrient allowances are defined for older adults. The increase in the status of vitaminB6, BI2 and/or folate gives protection against elevations in homocysteine – an independent risk factor for cardiovascular disease, depression and certain deficits of neuro-cognitive function. A good nutritional status of vitamin C, E and b-carotene (antioxidants) among healthy elderly have shown a reduced risk for cancer, cataract and heart disease.

Nutrients act as modulators of chronic disease risk. Therefore, it is more important for .the elderly to consume a diet rich in antioxidant nutrients (vitamin A, C and E and selenium), B vitamins (folate, vitamin B6 and B12) and minerals like calcium, to prevent chronic disease, rather than consuming just the amount of nutrients that are needed to prevent a deficiency state from occurring. Strong links which have been made between specific nutrients and particular chronic illnesses.

Refer to table no.5.6.2 b for interactions between specific nutrients and chronic illness

5.6.4 Diet and feeding patterns

Balanced diets for elderly

The key element in planning diets for the elderly should be nutrient-based dietary guidelines, in order to reduce the burden of chronic disease afflicting this group by nutritional means. The adults over 70 years generally consume less food than younger people primarily because of decrease in energy expenditure and distinctly different metabolic processes. It is important to note the following:

1. Foods that are nutrient dense in vitamins and minerals should be included. For example, whole grain and enriched or possibly fortified bread should be preferred to refined grain products for provision of adequate amounts of B vitamins. This is especially important since cereals and bread comprise the bulk of the diet of elderly people, many of whom are at risk for malnutrition.
2. In the fruit and vegetable category, deeply colored ones should be chosen for provision of folate and antioxidant nutrients.
3. In the milk and milk products group (curd, paneer, cheese) emphasis should be placed on low fat dairy products for the provision of adequate amounts of calcium and vitamin D.
4. From the protein rich group of meat, poultry, fish, beans, eggs and nuts groups, variety should be the key principle to follow with individual choices being made according to availability, affordability, chew ability, individual and ease of preparation.
5. Foods high in dietary fiber should be given and fluid intakes of elderly people should be emphasized since thirst sensation is decreased in older people.
6. For non-vegetarians, pulses can be exchanged for eggs or a portion of chicken or fish.

Refer to table no. 5.6.3a for balanced diet for elderly (man)

Refer to table no. 5.6.3b for balanced diet for elderly (woman)

Food guide pyramid for the elderly:

Food groups	Amount
Fats, oils and sweets	Use sparingly
Meat, poultry and egg	1-2 servings
Fruits	2 or more servings
Milk, curd and paneer	3 servings
Vegetables	3 or more servings
Bread, cereal,rice or pasta	6 or more servings
water	8 servings

Consistency of food and recommended food items for elderly with chewing difficulty.

Elders, without teeth cannot chew their foods, hence they have semi-solid or liquid food. This could reduce the quantity and quality of nutrition in them. It is better to provide elderly people without teeth with artificial dentures. Some of the following suggestions may help the elderly who have chewing difficulty.

- Chop, grind or mechanically blend foods that are hard to chew
- Serve milk as a beverage
- Paneer (cottage cheese)
- Eggs - soft cooked or scrambled
- Tender meat or poultry, finely minced or ground, soft-cooked fish
- Soft raw fruits like banana, papaya, mango, cooked apples or peas, fruit juices or pineapple, lime or orange
- Soft cooked vegetables, chopped or mashed
- Raw vegetables such as tomatoes can be eaten if finely chopped and the skin removed, soups can be given
- Cooked rice, suji, kheer, upma, poha or vermicelli
- Plain bread or toast with hot or cold milk
- Desserts: ice-creams, puddings, jellies, halwas

The varjous considerations to be kept in mind for providing nutritious meals to the elderly are highlighted herewith. Due to restriction in calories, nutrient dense foods should be included in them to meet the nutrient requirements.

- Small frequent meals, which are easy to prepare and digest, should be given.
- The taste acquisition and sensation of smell decline in later years, so some pleasure derived from food is lost. It is, therefore, advisable that the meals should be made more attractive and appealing by including a variety of foods and color to encourage or motivate them to eat. Every effort should be made to make food palatable, without using spices in excess. ,
- Overuse and sprinkling of table salt over preparations while eating should be avoided by the elderly.
- Loss of teeth due to increased decay of teeth and gums is common in aged person. Ill fitting dentures may also make chewing difficult. A change in the texture and method of food preparation is recommended. Consequently, well cooked and soft meals must be included in the diet. Care must be taken to avoid too much of soft carbohydrate-rich foods and include foods that provide nutrients such as vitamins, proteins and minerals like calcium.
- There is decreased secretion of saliva, which makes swallowing difficult.

  Therefore, soups, vegetables with gravies, curds or raitas, dals etc.should be included in the meals and very dry meals should be avoided.

  Gastric acidity decreases with age. Peptic, tryptic, amylolytic and lipolytic activities of the digestive secretions are decreased. Reduced acid secretion and muscle weakness leads to delayed esophageal emptying, poor tolerance to fat, distention, flatulence and constipation. A liberal intake of fibre and fluid (at least 8 glasses of water or non alcoholic caffeine free beverages) should be consumed by an elderly .person to facilitate the digestion process. Roughage in the form of tender vegetables and fruits is beneficial against the problem of constipation.

- Protective foods (fruits/vegetables) must be included in the daily diet of elderly.
- Impaired absorption of iron and calcium may occur because of hypochlorhydria (decreased stomach acidity). This may lead to anemia and may contribute to osteoporosis. Iron and calcium-rich food should be included in the daily dietary intake. Elderly people also have to make a conscious effort of drinking water in order to remain well hydrated especially in warm climates. This is because their thirst mechanism is reduced with an increase in age. This also helps to overcome the problem of constipation, which is a very common complaint during this age.
- Energy intake should be sufficient to maintain normal weight without leading to obesity or weight loss. Under nutrition is undesirable and on the other hand obesity may lead to diabetes, coronary heart disease, gout and other degenerative disorders.
- Small meals at frequent intervals should be consumed. Fats, oils, refined cereals and sweets should be consumed by the elderly. Dietary fat, if poorly tolerated may be reduced.
- Elderly need more calcium, iron, zinc, antioxidant nutrients like b-carotene, vitamin E and C to prevent age-related diseases. Inadequate diets of the elderly may need to be supplemented with pharmaceutical nutritional supplements.
- The likes, dislikes and food preferences of the elderly should be considered while meal planning. Among elderly who suffer from chronic diseases like diabetes, hypertensions or heart disease, further dietary modifications may be required.
- Alcohol consumption and cigarette smoking should be completely avoided.

5.7 Summary

- We learnt that infancy is one of the most rapid periods of growth in life. Human milk is ideally suited to the needs of the human infant. It is important to feed colostrum to the infant. In order to nurse her baby successfully, a mother should consume atleast one-and-a-half times her normal diet. After 5 to 6 months of age, milk alone is not sufficient for the baby's needs. Other foods, like semi-solids should be introduced into the infant's diet at this age. By one year the child should be able to eat most of the foods that are eaten by adults. When it is not possible to feed a baby with mother's milk, cow's or buffalo's milk, can be used after suitable modification.
- Growth in the school years occurs at a slow but steady pace. Except in the early school years, appetite of the schoolchild is quite healthy. Nutrient requirements are in proportion to their growth rate and energy requirements and will vary according to their physical activity. If the schoolchild is malnourished, he/she will not be able to perform well in school. Providing adequate nutrition is important so that the child will be able to build up adequate nutrient reserves, which will be needed during the adolescent growth spurt.
- Adolescence is a period of rapid growth at the end of which the individual reaches physiological maturity and is also sexually mature. Differences in body composition, weight and height between sexes and between individuals of the same sex will become apparent. Nutrient needs in this period are in accordance with the needs for growth. Psychological and emotional factors may affect food intake in this age group. Peer pressure and lack of awareness regarding nutritional needs may lead to consumption of nutritionally inadequate diet. Problems related to teenage obesity, sports activity, marriage and diseases like diabetes may affect growth and nutritional status of the adolescents.
- During pregnancy, changes in both the mother and the fetus necessitate increased intakes of nutrients needed for growth. A pregnant woman should gain about 7 to 10 kg during the entire nine months. She should eat foods which are rich in vitamins, minerals and proteins in addition to lots of carbohydrates and good fat. Malnutrition during pregnancy affects the developing baby. It may lead to a woman delivering prematurely or a low birth weight. Curtailing dietary intake or unbalanced diets during pregnancy should be avoided. Fluid intake and consumption of vegetables and fruits should be ample and normally salt should not be restricted.
- We learnt about the nutritional needs of the elderly, and in doing so we have also focused on many other aspects such as the definition of elderly, what is an ageing process and the impact of nutritional status on the health of older adults. We studied about physiological changes in the body systems and based on these nutritional requirements of the older adults. The guidelines for planning balanced nutrient dense diets for them were also outlined.

  There are special considerations to be kept in mind while planning menus for them and these have been pointed out.

5.8 Glossary

INFANCY :

ARF : amylase rich flour, prepared by germinating, drying and powdering wheat grains.

Bifidus Factor : a component of breast milk that promotes the growth of *lactobacillus bifidus,* a harmless bacteria in baby gut.

Bioavailability: the relative ability of nutrients in foods to be properly digested and absorbed.

Development . : the process associated with &e growth of tissues and organs to take on complex functions.

Exclusive breast-feeding : entails not even giving honey or water supplements and other animal milk.

Extrusion reflex : before 4-5 months, the baby is not able to suck. If a solid food is placed on tongue, these movements push the food out. By 6 months, the infant overcomes this and can transfer food inside the mouth.

Growth: biological growth occurs by cell multiplication.

Infant: a child in the first year.

Low birth weight infant: infants born on term but have weight <2.5kg .

Premature infants: infants born before full term of gestation i.e. less than 38 weeks.

Stunting: those children whose height-for-age is -2 SD. It indicates long term malnutrition.

Wasting: those children whose welight-for-height is - 2SD.It indicates acute under-nutrition.

Under weight: those children who have low (-2SD) weight for age. It indicates both chronic and acute under nutrition.

Weaning foods: foods, which are used during the gradual transition of the infant from breast-feeding to a normal diet.

CHILDHOOD AND ADOLESCENCE :

Anorexia nervosa: an eating disorder characterized by refusal to maintain a minimally normal weight for height and age.

Axillary: region of the armpits.

Bulimia: an eating disorder characterized by binge eating followed by forced purging by means of self induced vomiting or use of laxatives.

Circulatory system: the system of blood vessels in the body which carry blood from the heart to the tissues and then return it from the tissues to the heart.

Fad diets: a weight loss plan or aid that promises dramatic results.

Growth spurt: a sudden increase in the rate of growth in terms of height or weight.

Hormones: chemical substances secreted by certain glands which exert their effects elsewhere in the body e.g. the sex hormones are produced by the sex glands and cause effects in the sex organs and are responsible for the appearance of secondary sex characteristics.

Inanition: exhaustion resulting from a lack of food, either from partial or complete starvation.

Menarche: the time when menstruation i.e. monthly loss of blood in the girl, begins. In other words, the time when the first menstrual cycle occurs.

Net protein utilization : the ratio of amino acid converted to proteins to the ratio of proteins supplied.

Processed foods: foods which have been subjected to certain procedures such as drying, exposure to heat/cold and then packaged for sale. Processed foods usually require further cooking after unpacking.

Pubic: middle part of the lower abdominal region; pubic hair refers to the hair appearing in this region.

Ready-to-eat foods: foods already cooked by roasting or frying or baking which can be consumed as such.

Respiratory system: the system consisting of the body parts necessary for breathing i.e. nasal cavity (entry for air through the nose) which leads into a tube called the (ii) trachea. The trachea branches into the (iii) bronchi, which enter the (iv) lungs.

PREGNANCY AND LACTATION :

Basal Metabolic Index: a relationship between weight and height that is associated with body fat and health risk.

Basal Metabolic Rate: a measurement of energy required to keep the body functioning at rest.

Cretinism : a condition of endemic or inherited idiocy, accompanied by physical degeneracy and deformity.

Enternal feeding : a method of providing food through a tube placed in nose, stomach or small intestine.

Oesophageal regurgitation: flow of the stomach's contents back up into the esophagus.

Heartburn : a burning sensation experienced in the lower area of the heart.

Homeostasis : metabolic equilibrium actively maintained by several complex biological mechanisms that operate via autonomic nervous system.

Neural tube defect : a congenital defect of the central nervous system, including spinal cord, skill and brain, resulting from failure of the neural and brain.

Parenteral feeding : a method of providing a liquid food mixture through a special tube in the chest.

Parity : the number of children borne by one woman

Pre eclampsia: abnormal state of pregnancy characterized by hypertension and fluid retention and buminuria.

Pregnancy induced hypertension: a complication of pregnancy inslrked by high blood pressure especially in the last three months of pregnancy.

Stroke volume : the amount of blood pushed into the aorta with each beat of the heart.

Teratogenic : substances such as chemicals of radiation that cause abnormal development of an embryo.

Toxemia : an abnormal condition of pregnancy characterized by hypertension, edema and proteinuria

ELDERLY :

Ageing: the process of gradual and progressing changes which take place over the entire adult life span.

Chronological age : a person's age stated in hours, days, weeks, months, or years and months since birth.

Collagen: a protein that forms white fibers of the bones cartilage, connective tissues and tendons.

Constipation: a condition characterized by difficulty in passing stools,

Dementia: chronic loss of mental capacity; involve progressive deterioration of thinking, melancholy, 131ehavior, personality and motor function.

Gerontologist: a person who studies old age.

Hypochlorhydria : decreased secretion of hydrochloric acid in the stomach.

Osteoporosis: spotty clarifying of bones that fracture spontaneously.

Psychosis: a disease of the mind especially a functional; mental disorder affecting the ability to function normally.

Roughage: dietary fibre present in coarse food stuffs like whole cereals, pulses, raw fruits and vegetables.

Senescence: the stage of growing old.

Taste buds: small organs of taste on the tongue, which help to detect different tastes or flavors.

Texture: refers to structure; appearance, consistency of foods or food items.

5.9 Related questions

Infancy :

1. What is infancy and what are its features?
2. What do we understand by growth monitoring and how do we interpret a growth chart?
3. Discuss the advantages of breast milk.
4. Which nutrients are vital for an infant?
5. Why are the nutrient needs of an infant higher than that of an adult?
6. What precautions should be taken when foods other than mother's milk are introduced in the infant's diet.
7. What is weaning and what foods are generally given to infants to wean them?
8. Prepare a balanced diet for a 6-12 months old infant.
9. What is the feeding schedule of an infant (0 to 6 and 6-12 months)?
10. What do you understand by complementary feeding? List any five nutritionally adequate supplementary weaning foods.

Schoolchildren and adolescents:

1. Who are schoolchildren and how is their growth different from infants?
2. What factors influence the nutrient needs of schoolchildren?
3. Plan a menu for a 10 yr old child.
4. What special considerations must be kept in mind while planning a packed lunchbox for a school going child?
5. What are the specific features of adolescence? Explain them.
6. What is the dietary pattern followed by most adolescents and how can we bring some positive change in them?
7. Why should we pay more attention to diets of adolescent girls? Explain.

Pregnancy and Lactation:

1. What are the types of foods and the number of servings of each food a pregnant woman should have to meet her daily nutritional needs.
2. Why are nutritional needs increased during pregnancy?
3. How is mother's weight related to pregnancy outcome?
4. Discuss the importance of human milk for infants.
5. How is breast milk beneficial to the infant.
6. Which nutrients' needs increase during lactation and why?
7. What nutritional precaution should a lactating mother take during the period of breastfeeding?
8. Plan a diet for a pregnant

Elderly :

1. Whom do you designate as the elderly in India?
2. What are the nutritional deficiencies commonly found in elderly?
3. Which factors could be responsible for loss of appetite in older persons?
4. What are the changes, which occur with ageing that, may modify the digestion of food?
5. Why do the energy requirements decrease with an increase in age?
6. What role do antioxidant nutrients play in maintaining the health of the elderly?
7. Why do elderly people have to make an effort of drinking water?
8. List the guidelines for planning a balanced diet for the elderly.
9. Plan a day's sample menu for an elderly man with chewing difficulty.
10. Why should fats and sweets, be restricted in the diets of elderly people?
11. Why should an elderly person consume 'whole wheat chapati' instead of 'bread'?
12. What are the special nutritional needs of elderly people?
13. What is osteoporosis?
14. How do nutritional needs of the elderly vary from those of adults?

Table 5.2.1 The growth chart

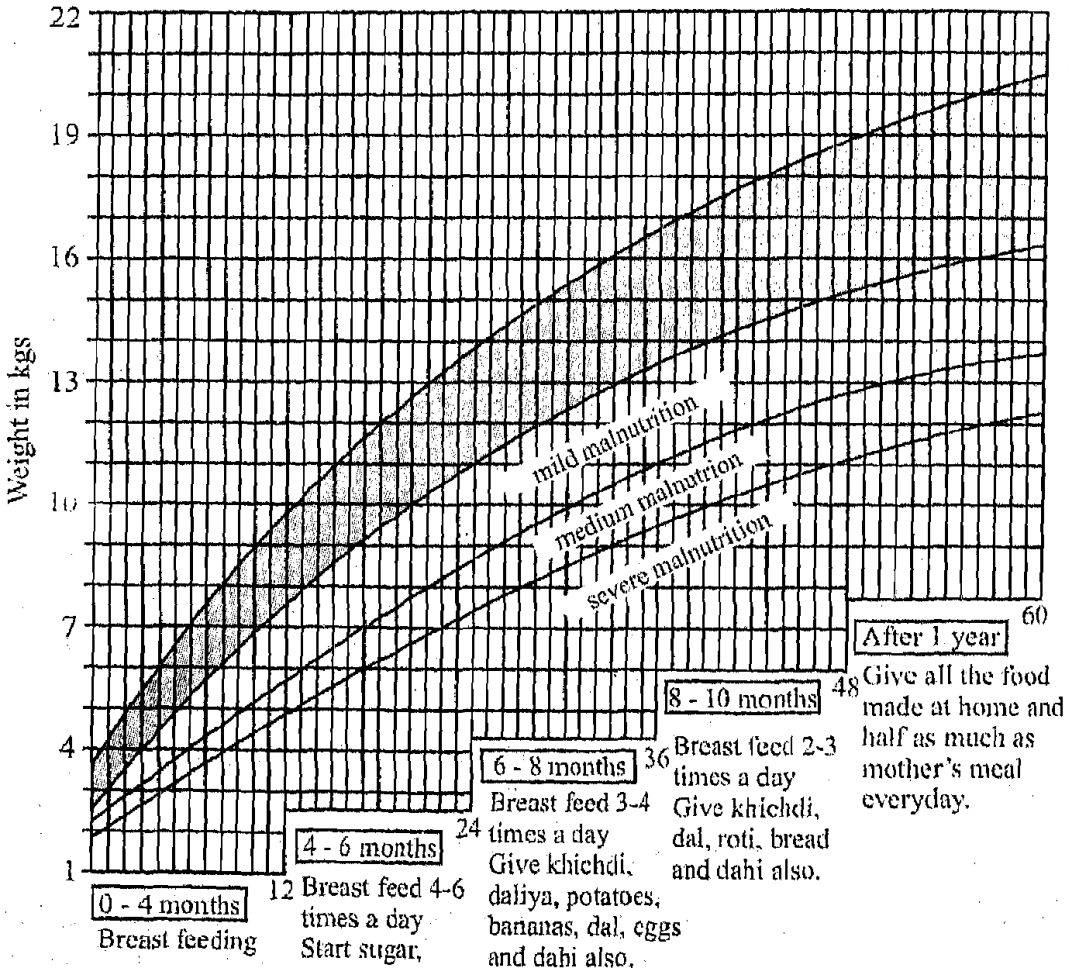


Table 5.2.2a Energy requirements of Infants

Age (months)	Kcal/kg body wt.	mean
0-3	116	108
3-6	99	
6-9	95	98
Avg. energy needs during the first year		103

Table 5.2.2b Protein requirements of infants

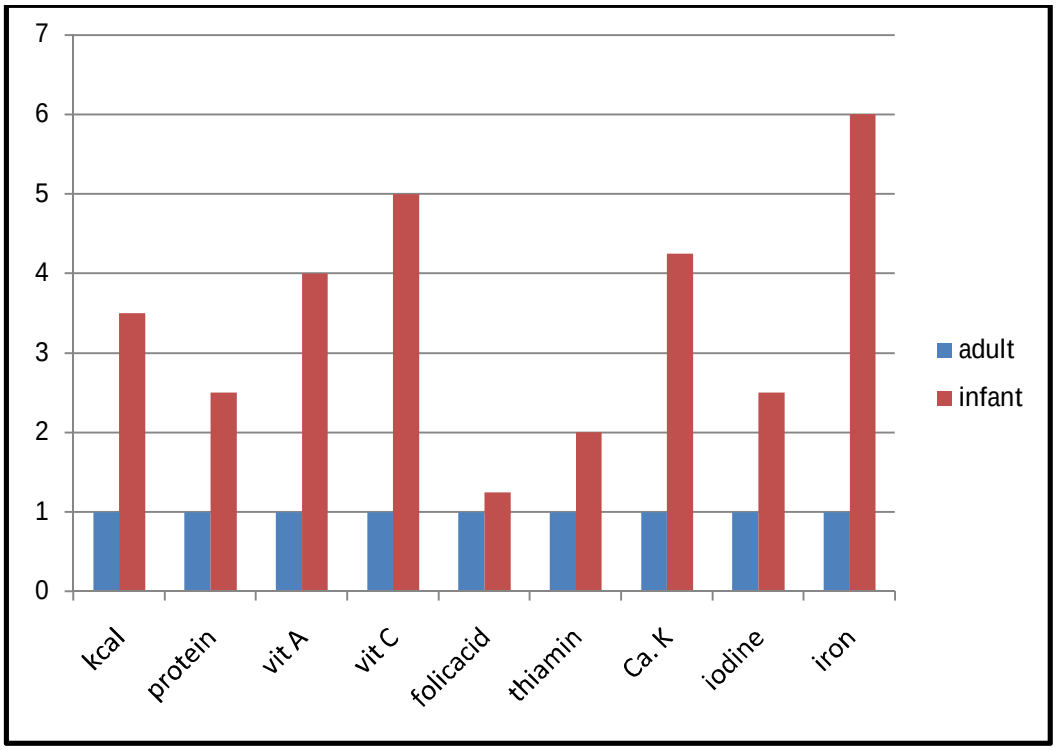
Age (years)	Protein Allowances (g/kg/d)	RDA (g/kg/d)
0 -3	2.3"	1.85 *
3 -6	1.85"'	
6 - 9	1.65"	1.65
9 - 12	I.5*"	

Table 5.2.2c RDA of various nutrients for infants

Nutrients	Age (0-6 months)	Age (6-12 months)
Energy (kcal/d)	108/kg	98/kg
Protein	2.05/kg	1.65/kg
Calcium (mg/d)	300	500
Phosphorus	450	500
Retinol (mcg/d)	350	350
Beta carotene (mg/d)	1400	
Thiamin (mcg/d)	55/kg	
Riboflavin (mg/d)	65/kg	
Niacin (mg/d)	710/kg	
Vitamin C (mg/d)	25	25
Folic acid (mcg/d)	25	25
Vitamin B12 (mcg/d)	0.2	0.2

***Source*: ICMR (1990)**

Table 5.2.2 d Nutrient needs of an infant compared to an adult



COURTESY: Whitney,E.N. and C.B. Cataldo. Chapter 16, page 573

In: Understanding Normal And Clinical Nutrition, West Publishing Company, 1983

Table no.5.2.3 a Nutrient composition of different milks/100 g

Milk	Energy (kcal)	Protein(g)	Carbohydrate (g)	Fat (g)	Calcium (mg)	Vit. C (mg)
Breast milk	65	1.1	7.4	3.4	28	3.0
Cow's milk	67	3.2	4.4	4.1	120	2.0
Buffalo's milk	117	4.3	5.0	6.5	210	1.0
Toned milk	58	3.2	4.7	3.0	118	

Source: **ICMR, 1989.**

Table 5.2.3b Complementary foods for 4 to 12 months infants

Infant's age	Food stuff	Forms	Amount	Consistency	Child's milestones
4-6 Months	Fruit Juices	Juice mixed with a little sugar (avoid sour)	Start with 1 to 2 tsp and increase to about 30 to 50 rnl	Liquid	Rooting reflex Sucking reflex Swallowing Extrusion reflex
	Green Leafy Vegetables	Soups in milk (Avoid fibre)	Start with 1 to 2 tsp and increase toabout 50 ml	Liquid	
5-6 Months	Cereals	Cooked in water or **milk**	Cook about 2 tsps of cereal in a cup of milk or water, like sujikheer, rice **kheer,** phirni	Semi-solid	Extrusion reflex disappears Learns to reach mouth with hand Sits with balance
6-7 Months	Egg yolk	Half boiled egg yolk	Start with ½ tsp and increase to 1 yolk.	Semi-solid	Moves food from
	Starchy vegetables and fruits Pulses	Boiled and Mashed potato with butter or ***milk*** Mashed banana with **milk**	Start with a small amount and increase to ½-3/4 cup.	Semi-solid	the front of tongue to back
7-8 Months	Vegetables and pulses	Well cooked vegetables, thin khichri (small particle stew)	Starting with small amounts, Increase quan tity gradually 2-3 cups.	Semi-solid	Learns rotary chewing Tooth eruption Coordinates hand to mouth
10-12 Months	Whole egg Including the egg white. Meat, vegetables, fruits	Soft boiled egg, scrambled egg, custard, Well cooked raw or cooked (chopped) meat, Vegetable or fruit	One egg, Biscuits, Banana, Chopped fruit, Starting with small quantities increase the amount .	Semi-solid Solid like to bite and chew (soothe gums)	Able to bite and chew Holds cup without help Feeds self

Table 5.3.2 Recommended dietary allowances of nutrients in schoolchildren

Age (yrs)	7-9	10-12 boys	10-12 girls	13-15 boys	13-15 girls
Energy (kcal/d)	1950	2190	1970	2450	2460
Protein (g/d)	41	54	57	70	65
Calcium(mg/d)	400	600	600	600	600
Iron (mg/d)	26	34	19	41	28
Retinol (microg/d)	600	600	600	600	600
Betacarotene	2400	2400	2400	2400	2400
Thiamin (mg/d)	1.0	1.1	1.0	1.2	1.0
Riboflavin(mg/d)	1.2	1.3	1.2	1.5	1.2
Niacin(mg/d)	13	15	13	16	14
Vitamin C (mg/d)	40	40	40	40	40
Folic acid (microg/d)	60	70	70	100	100
Vit B12(microg/d)	0.2-1.0	0.2-1.0	0.2-1.0	0.2-1.0	0.2-1.0

Table 5.3.3: Balanced diet for schoolchildren

Food groups	7-9 yrs	10-12 yrs boys	10-12 girls
Cereal and Millets (g)	270	330	270
Pulses (g)	60	60	60
Milk (ml)	500	500	500
Roots and Tubers (g)	100	100	100
Green leafy vegetables (g)	100	100	100
Other vegetables (g)	100	100	100
Fruits (g)	100	100	100
Sugar (g)	30	35	30
Visible Fats and Oils (g)	25	25	25

Source: ICMR, 1998

Table 5.4.2: Recommended dietary allowances of nutrients in adolescents

Age (yrs)	13-15 boys	13-15 girls	16-18 boys	16-18 girls
Energy (kcal/d)	2450	2460	2460	2060
Protein (g/d)	70	65	78	63
Calcium(mg/d)	600	600	500	500
Iron (mg/d)	41	28	50	30
Retinol (mcg/d)	600	600	600	600
Betacarotene(mcg/d)	2400	2400	2400	2400
Thiamin (mg/d)	1.2	1.0	1.3	1..0
Riboflavin(mg/d)	1.5	1.2	1.6	1.2
Niacin(mg/d)	16	14	17	14
Vitamin C (mg/d)	40	40	40	40
Folic acid (mcg/d)	100	100	100	100
Vit B12(mcg/d)	0.2-1.0	0.2-1.0	0.2-1.0	0.2-1.0

Table 5.4.3 Balanced diet for adolescents

Food groups	13-18 yrs boys	13-18 girls
Cereal and Millets (g)	420	300
Pulses (g)	60	60
Milk (ml)	500	500
Roots and Tubers (g)	200	100
Green leafy vegetables (g)	100	100
Other vegetables (g)	100	100
Fruits (g)	100	100
Sugar (g)	35	30
Visible Fats and Oils (g)	25	25

Source: ICMR,1998

Table no. 5.5.1 Distribution of weight gained during pregnancy

	Development	Total Weight Gained	
o	Infant (baby) at birth	23	2.3
o	Mother's fat stores	21	2.1
o	Increase in mother's womb m support baby and placenta	18	1.8
o	In- in mother's blood volume to nourish baby	16	1.6
o	Increase in size of mother's breasts	10	1.0
o	Fluid to surround baby and cushion it	8	0.8
o	Placenta	4	0.4
o	Total weight gained	7 to 10 kg.	

Table no. 5.5.2a Comparison of nutritional requirements of pregnant (2nd & 3rd trimester) and non-pregnant woman

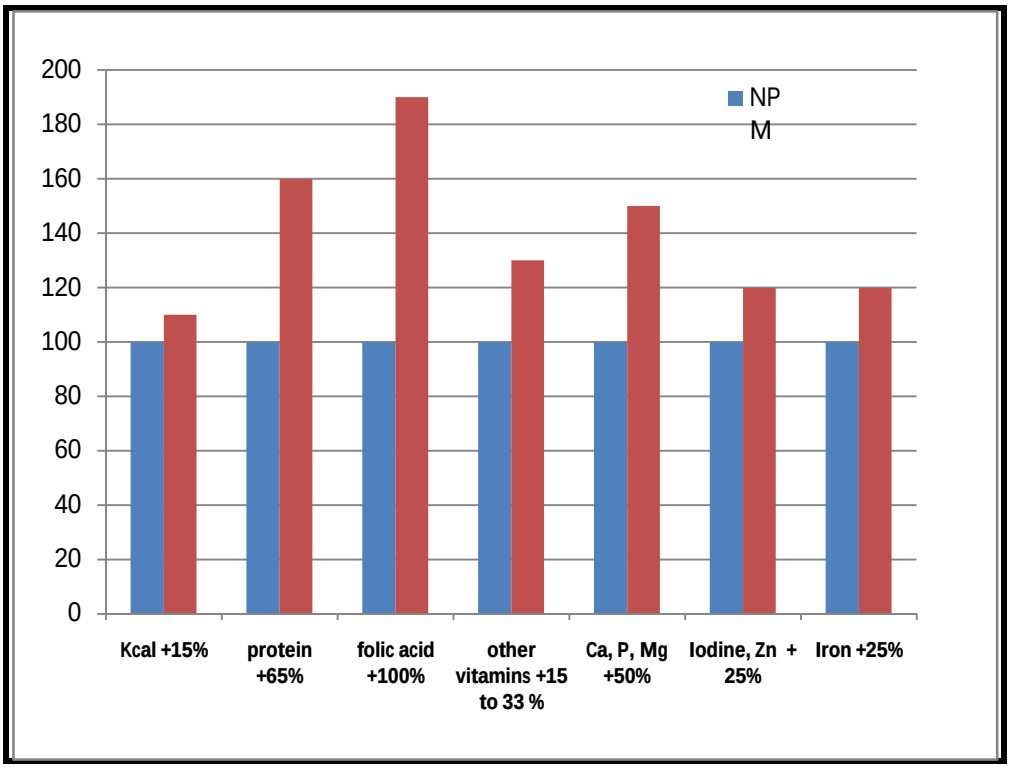


Table no. 5.5.2 b RDIs during pregnancy

Nutrient	Pregnant Woman
o Energy (Kcal/day)	o +300
o Protein (g/day)	o +25 '
o Fat (g/day)	o 30
o Calcium (mg/day)	o 1000
o Iron (mg/day)	o 38
o Vitamin **A** (RE) (mcg/day)	o 60
o p-carotene	o 2400
o Thiamin (mg/day)	o 4.2
o Riboflavin (mg/day)	o 4.2
o Nicotinic acid (mg/day)	o +2
o Pyridoxine (mg/day)	o 2.5
o Ascorbic acid (mg/day)	o 40
o Folic acid (mcg/day)	o 400
o Vitamin B (mcg/day)	o 1

Table No.5.5.2 c Iron requirement for pregnancy

Requirement	Iron (mg)
• Foetus at term	*280*
• Expansion of red call mass	450
• Placenta and umbilical cord	90
• Maternal blood loss during delivery	150
• Obligatory loss in the mother - day to day	*230*
• Total iron cost of a pregnancy	12a3

Table no.5.5.3 Prediction of low birth weight on the basis of BMI of mother

BMI	LBW %
< 16	53
16 - 17	41
17 - 18.5	36
18.5 - 25	27
25 - 30	15
> 30	20

Table no. 5.6.1 Nutrient composition of human milk

Nutrients	Amount (per 100 ml)
Energy (Kcal)	65
Protein (g)	1.1
Carbohydrates (g)	7.4
Fats (g)	3.4
Calcium (mg)	28
Iron (mg)	-
b-carotene (mcg)	137
Thiamine (mg)	2
Riboflavin (mg)	2
Niacin(mg)	-
Vitamin C(mg)	3

Source: Nutritive Value of Indian Foods, NIN (1989).

Table no. 5.6.2 RDIs for the lactating mother

Nutrients	RDIs	
	0-6 months lactation	6-12 months lactation
Energy (Kcal)	+550	+450
Proteins (g)	+25	+18
Calcium (mg)	1000	1000
Iron (mg)	30	30
Vitamin A(mcg)	-	-
Retinol or	950	950
p-carotene	3800	3800
Thiamine (mg)	+0.3	+0.2
Riboflavin (mg)	+0.3	+0.2
Niacin (mng)	+4.0	+3.0
Ascorbic acid (mg)	80	80
Folic acid(mcg)	150	150
Vitamin B (rncg)	1.5	1.5

Source: Nutrient Requirements and Recommended Dietary Intakes for Indian, ICMR (1990).

Table no. 5.6.2a RDAs of nutrients for elderly

Nutrients	Males		Females	
	60-69 yrs	70 & above yrs	60-69 yrs	70 & above yrs
Energy (kcal)	1940	1697	1500	1312
Protein (g)	60	60	50	50
Calcium (mg)	400	400	400	400
Iron (mg)	28	28	30	30
Tot. vitamin (mcg)	600	600	600	600
Thiamin (mg)	0.9	0.8	0.7	0.6
Riboflavin (mg)	1.1	0.9	0.8	0.7
Nicotinic acid (mg)	16	16	12	12
Pyridoxine (mg)	2.0	2.0	2.0	2.0
Ascorbic acid (mg)	40	40	40	40
Folic acid (mcg)	100	100	100	100
Vitamin B1(mcg)	1	1	1	1

Table no. 5.6.2b Interactions between nutrients and chronic illness

Deficient nutrients	Chronic illness
• **B** vitamins (folate, vitamin B6 and vitamin B1,	• Prevention of atherosclerotic cardiovascular disease and stroke
• Calcium and vitamin D	• Amelioration of bone demineralization or osteoporosis
• Antioxidant nutrients like vitamin C, E and selenium	• Prevention of atherosclerotic cardiovascular disease, cerlairi site specific cancers • Prevention of age-related muscular degeneration
• Carotenoids, zeaxanthin and lulein	

Table no. 5.6.3a Balanced diet for elderly man

Food groups	Years			
	60-69 yrs.		70 and above yrs.	
	Amount (gms)	Approx. measurement	Amount (gms)	Approx. measurement
Cereals	265	8 chapatis	225	7 chapatis
Pulses*	60	2 cups (medium)	40	2 cups (med.)
Milk (ml)	400	2 cups	400	2 cups
Roots and tubers	100	1 cup (medium)	100	1 cup (medium)
Green leafy veg.	100	1 cup (medium)	100	1 cup (medium)
Other vegetables	200	2 cup (medium)	150	1 ½ cup (med.)
Fruits	200	2 medium	200	2 medium
Sugar	20	4tsp	20	4tsp
Fats1 oils (visible)	20	4tsp	20	4tsp

Table no. 5.6.3b Balanced diet for elderly woman

Food groups	Years			
	60-69 yrs.		70 and above yrs.	
	Amount (gms)	Approx. measurement	Amount (gms)	Approx. measurement
Cereals	180	6 chapatis	150	5 chapatis
Pulses*	40	1 ½ cups (med)	30	2 cups (med.)
Milk (ml)	500	2 cups+ 1cup curd	450	2 ¼ cups
Roots and tubers	100	1 cup (medium)	50	½ cup (medium)
Green leafy veg.	100	1 cup (medium)	100	½ cup (medium)
Other vegetables	100	2 cup (medium)	100	1 cup (medium)
Fruits	200	2 medium	200	2 medium
Sugar	20	4tsp	20	4tsp
Fats1 oils (visible)	20	4tsp	20	4tsp