Unit 10

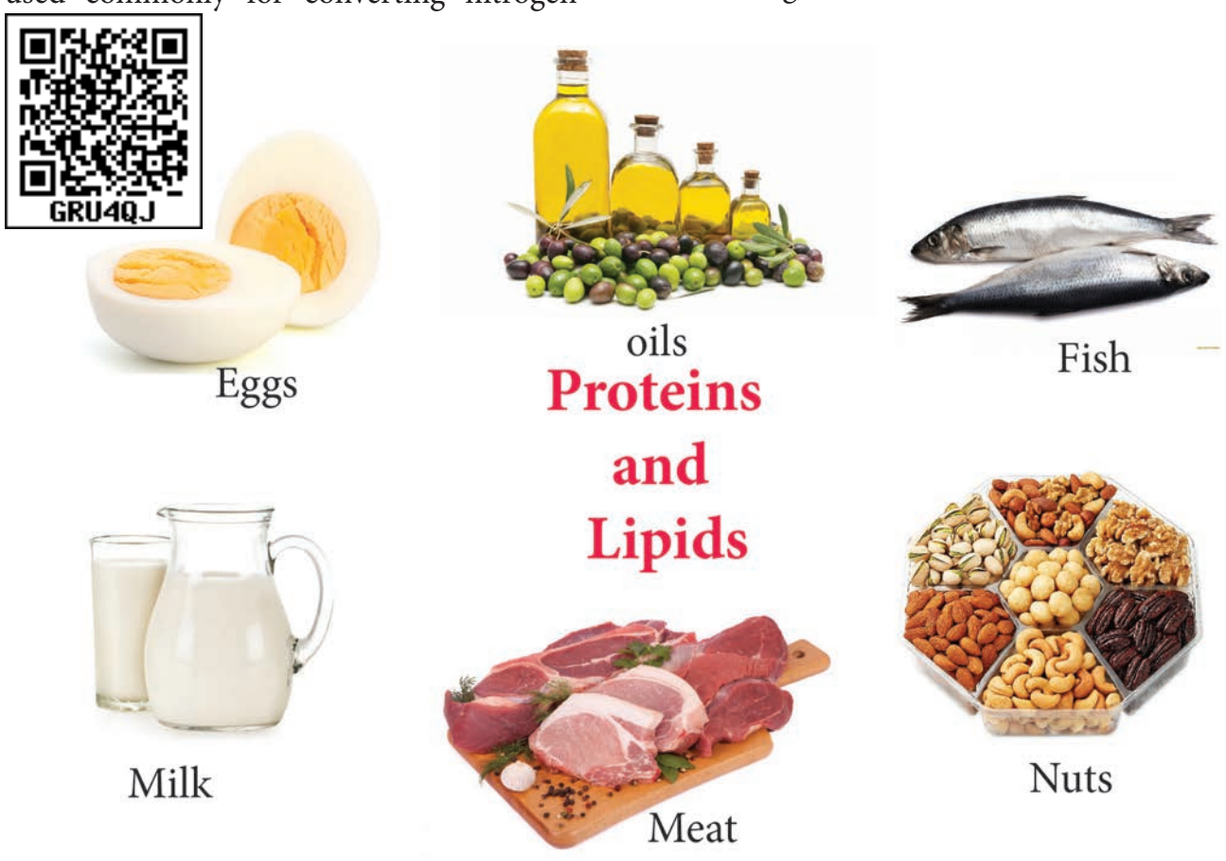
PROTEINS AND LIPIDS

The word '**Protein**' is derived from a Greek word 'protos' meaning 'primary or holding first place' which is appropriate name for an essential life forming and life sustaining substance of all organisms. Proteins contain nitrogen, but the nutritive value of protein-rich foods does not depend upon the total nitrogen content, but on the constituent of aminoacids. The nitrogen content of proteins varies from about 14 to 20 % and in most of the proteins, the value is about 16%.This average figure of 16% is used commonly for converting nitrogen content of foodstuffs or tissues into proteins (multiplied by the factor 6.25 [100/16].

Fat is a member of the class of compounds called '**Lipids**'. The lipids in foods and in the human body include triglycerides (fats and oils), phospholipids and sterols. Lipids perform many tasks in the body, but most importantly, they provide energy.

In this lesson, the students will be able to:

- understand the importance of protein for growth



Proteins and lipids

- know the effects of protein deficiency in children.
- gain an understanding of lipids as a concentrated source of energy.
- differentiate between healthy and unhealthy fats in the diet.

10.1 Origin and composition of proteins:

Origin

Amino acids are small units that combine to form a protein molecule. Plants synthesise amino acids with the help of bacteria and fungi from : (i) soil, which supplies the necessary nitrogen and sulphur; (ii) water, which provides oxygen and hydrogen; and (iii) atmospheric carbon dioxide, which supplies carbon and oxygen. Animals cannot synthesise amino acids from basic elements, but derive them from ingested plants. Thus, the primary source of all proteins is the vegetable kingdom.

Composition

Proteins are chemical compounds that contain the same atoms as carbohydrate and lipid – Carbon(C), Hydrogen (H) and Oxygen (O). Which is not present in CHO and lipibs. They also contain nitrogen (N) atoms. These Nitrogen atoms give the name 'amino' (nitrogen containing) to the amino acids that are the links in the chains referred to as proteins.

DO YOU KNOW...?

- Proteins are the building blocks of life
- Proteins are used for tissue repair and healing

10.2 Structure of proteins

About 20 different amino acids may appear in proteins. All amino acids share a common chemical 'backbone' and it is these backbones that are linked together to form proteins. Each amino acid also carries a side chain, which varies from one amino acid to another. The side chains make the amino acids differ in sizes, shape and electrical charge. The side chains on amino acids are what makes proteins so varied in comparison with either carbohydrate (or) lipids.

Each amino acid contains a carboxyl (COOH) or acidic group and an amino (NH_2) or basic group. The amino acids are mostly linked together in forming a protein molecule through NH_2 group of one amino acid condensing with COOH group of another amino acid with the elimination of one molecule of water, and a compound thus formed is called a peptide and the linkage is called '*peptide linkage*'.

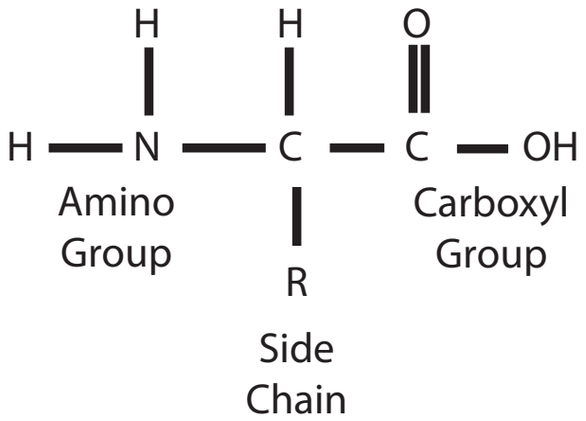


Fig 10.1: Amino acid structure

Protein chains

The 20 amino acids can be linked end-to-end in a virtually infinite variety of sequences to form proteins. When two amino acids bond together, the resulting

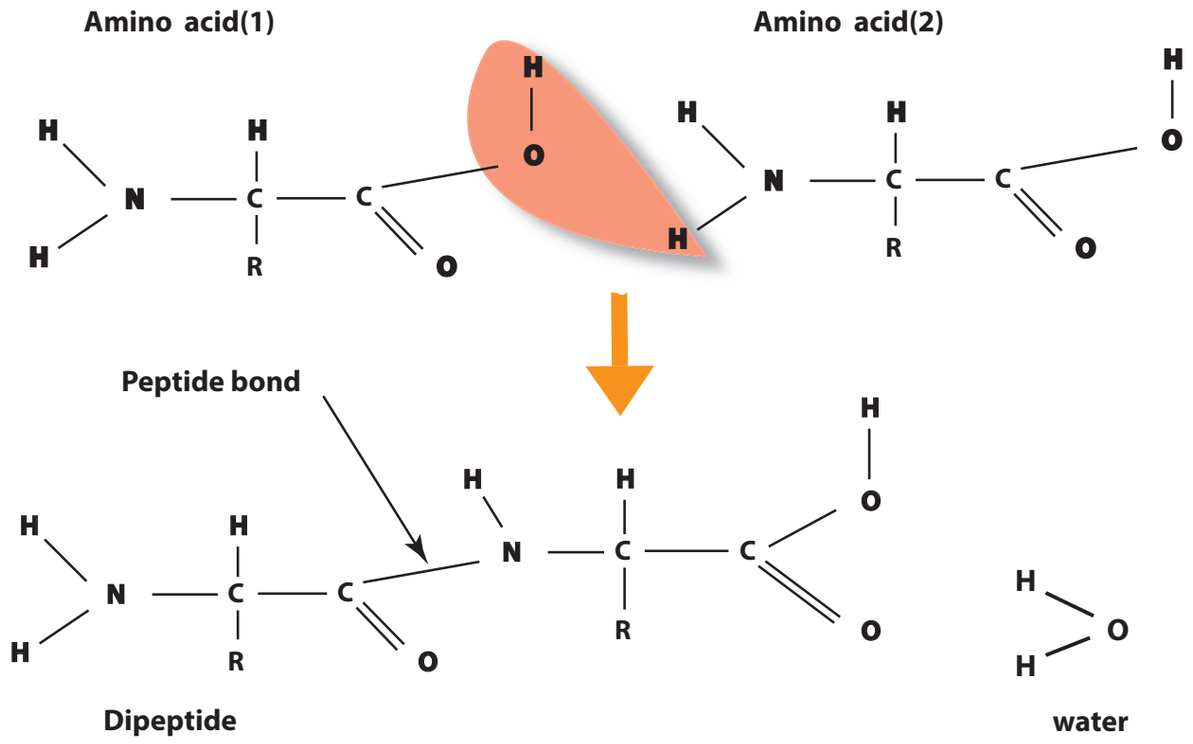


Fig 10.2: Structure of dipeptide

structure is known as dipeptide. Three amino acids bonded together to form a tripeptide. As additional amino acids join the chain, the structure becomes a polypeptide. Most proteins are polypeptides that are 100 to 300 amino acids long.

10.3 Classification of proteins

Proteins are large molecules formed by the combination of a number of aminoacids. About 20 amino acids have been found to occur in proteins and are important from the point of view of human nutrition. Amino acids can be classified as follows:

10.3.1 Nutritional Classification of Amino Acids

I. Essential Amino acids (Indispensable Amino acids)

An *essential* amino acid may be defined as one which is necessary for the growth and health of all living organisms and which cannot be synthesised in the body and must therefore be supplied through dietary intake. There are nine amino acids considered essential for the human infant, out of which Histidine is considered non-essential for the adult.

II. Semi-essential Amino acids (Conditionally Essential Amino acids)

Sometimes a non-essential amino acid can become essential. During illness or conditions of trauma, or in other special circumstances the need for an amino acid that is normally non-essential may become greater than the body's ability to produce it. In such circumstances, that amino acid becomes essential for the ill person. Amino acids that behave this way are referred to as **'Conditionally Essential'** amino acids for critically ill people.

Methionine can be converted to cystine, but cystine cannot be converted to

methionine. Similarly, phenylalanine can be converted to tyrosine, but not vice-versa. yet these spare the requirements of the corresponding essential amino acid. Hence, cystine and tyrosine are sub-classed as semi-essential amino acids.

III. Non-Essential Amino acids (Dispensable)

These amino acids can be synthesized in the body and not necessarily obtained through dietary intake.

The nutritional classification of amino acids is presented in **table 10.1**

10.3.2 Classification of Proteins (Based on chemical composition)

a) **Simple proteins**: It is composed entirely of amino acids only.

b) **Conjugated or Complex proteins:** It is made up of amino acids and other organic or inorganic compounds.

Table 10.1: Nutritional classification of amino acids

Essential	Semi-essential	Non-essential
Histidine	Arginine	Glutamic acid
Lysine	Tyrosine	Aspartic acid
Tryptophan	Cystine	Alanine
Phenylalanine	Glycine	Proline
Methionine	Serine	Hydroxyproline
Threonine		Cysteine
Leucine		
Isoleucine		
Valine		

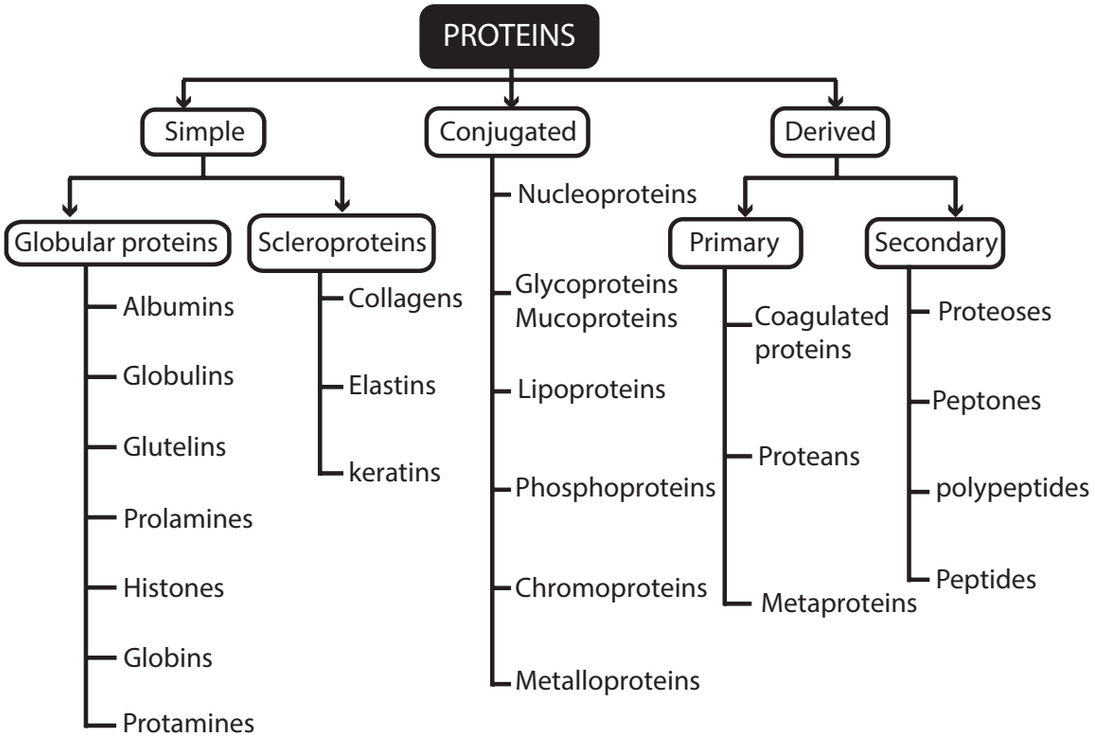


Fig 10.3: Classification of Proteins based on chemical composition

The non-amino acid group is termed as Prosthetic group (e.g.) Lipoproteins - Chylomicrons

c) **Derived proteins:** These are derivatives of proteins resulting from the action of heat, enzymes or chemical reagents. This group also includes the artificially-produced polypeptides(e.g.)Fibrin

10.3.3 Classification of proteins (Based on nutritional value)

Proteins are classified into two types based on nutritional values as follows:

1) **Complete proteins:** These contain all the essential amino acids in sufficient quantity to supply the needs of the body. They support life even if supplied as the sole source of protein. These proteins are of animal origin (e.g) milk, meat, poultry, egg and fish. The quality of these proteins is much superior to those of incomplete proteins.

2) **Incomplete proteins:** These proteins are deficient in one or more of the essential amino acids and therefore, they do not support life on their own. All plant sources of proteins (i.e) vegetables, fruits, cereals, pulses, nuts and oilseeds contain incomplete proteins to varying degrees.

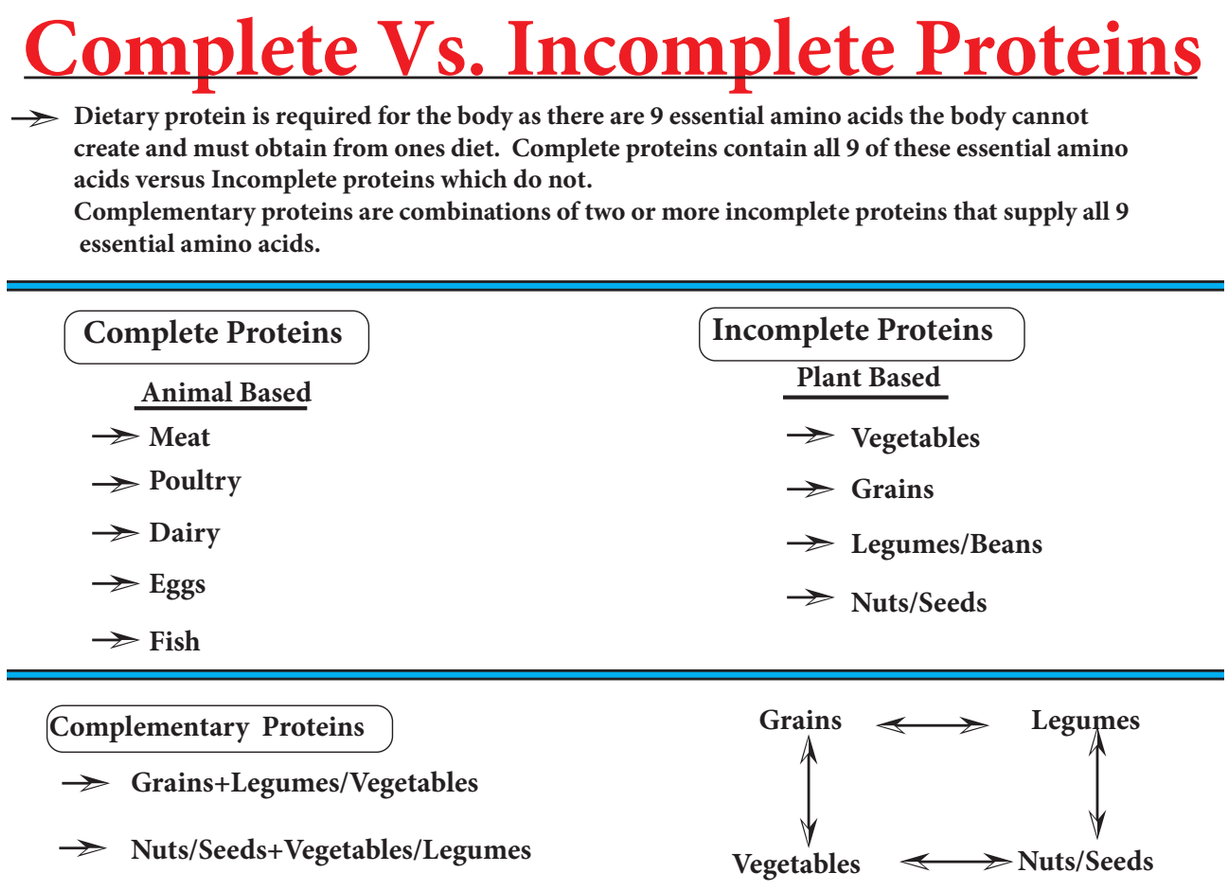


Fig 10.4: Complete Vs Incomplete protein

Pongal

Rice kheer

Fig 10.5: Complementary proteins

ACTIVITY - 1

Match the right answer

1) Polypeptides	-	Essential amino acid
2) Legumes	-	Complete protein
3) Proline	-	Conjugated protein
4) Arginine	-	Non-essential amino acid
5) Tryptophan	-	Derived protein
6) Meat	-	Simple protein
7) Nucleoproteins	-	Semi-essential amino acid
8) Albumin	-	Incomplete protein

Complementary proteins : If two sources of incomplete proteins are combined in the same meal, the resulting protein may be of better quality. These are called as ***Complementary proteins*** (e.g) Pongal prepared using moong dhal and rice is of better quality than rice or dhal cooked separately. Rice is deficient in aminoacid lysine, but rich in methionine. Pulses are rich in lysine, but deficient in methionine. So, rice and pulse combination will complement each other. Rice Kheer is another example, where animal and vegetable proteins –milk and rice are cooked together.

10.4 Food sources of proteins

Animal sources are complete proteins which includes meat, egg, fish and poultry and they are good protein foods in both quantity and quality. Milk is a valuable source of protein (casein) because although it does not contain a large quantity of protein, the quality is excellent.

Good sources of plant proteins are legumes, pulses, nuts and oil seeds, but their quality is poorer than that of animal foods. However, complementing two plant sources or combining an animal and a vegetable source in one meal increases the nutritional value of the meal tremendously. All vegetables and fruits are poor sources of proteins.

ACTIVITY - 2

- Display food sources of complete and incomplete proteins
- Prepare and display any dish which is an example of complementary proteins

DO YOU KNOW...?

One gram of protein on oxidation yields 4 Kcal

Protein content of foods

The protein contents (range) of various groups of foods are given in **table 10.2**

Table 10.2: Protein content (range) of different groups of foods

Food groups	Protein content g/kg
Cereals and millets	6 -14
Pulses (legumes) dry	18 – 24
Oilseeds and nuts	18 – 40
Meat, fish and liver	18 -20
Eggs	12 – 14
Milk(fresh)/100ml	3.5 – 4.0
Milk,(whole) powder	26 – 28
Milk,(skimmed)powder	33 - 38
Vegetables(fresh)	
Leafy	1 – 4
Roots and tubers	1 – 1.5
Other vegetables	1 - 7

10.5 Functions of proteins

Proteins form a major part of total body structures and they participate in many activities in our body. The major functions of protein in our body is presented in **table 10.3.**

10.6 Protein requirements

The important factors affecting the utilization of dietary proteins are the following:

1) **Calorie intake :** For the maximum utilization of dietary proteins, the calorie intake should be adequate. If the calorie intake is inadequate, a part of the dietary protein will be wasted in meeting the energy requirements and the protein need will not be satisfied.

2) **Digestibility co-efficient of proteins:** In the utilization of dietary proteins, a part of the proteins is lost in digestion and in metabolism.

3) **Biological or nutritive value:** The protein in the diet should be derived from different sources such as cereals, pulses, nuts and oilseeds, milk and flesh foods. Since animal proteins possess, in general, a higher nutritive value than vegetable proteins, the diets of children, expectant and nursing mothers should in particular, contain large amounts of proteins derived from milk, eggs and fleshy foods.

The protein requirements depend on age and physiological state of the individual. The ICMR recommended dietary allowance for Indians is shown in **table 10.4.**

10.7 Effects of protein deficiency

Diseases due to the deficiency of proteins and calories occur commonly among weaned infants and pre-school children in India and other developing countries.

10.7.1 Protein Energy Malnutrition

Protein Energy Malnutrition (PEM) is defined as a range of pathological conditions arising from coincident lack of varying proportions of protein and calorie,

Table 10.3: Functions of proteins			
1	Build and repair body tissues		Proteins form integral parts of most body structure such as skin, tendon, membranes, muscles, organs and bones. They support the growth and repair of body tissues.
2	**Regulation of body processes:** Proteins are required for highly specialized functions in our body. These proteins are as follows:		
	a.	Immune proteins	Antibodies, necessary for immunity reactions, are protein in nature. Resistance to disease is an immunological response.
	b.	Hormones	Regulates body processes. Hormones such as adrenocorticotrophic hormone (ACTH) and insulin, are protein in nature
	c.	Enzymes	All enzymes are protein in nature and are required at every step of digestion, absorption, and metabolism
	d.	Nucleoproteins	These govern the synthesis of all body proteins (e.g) Histones, protamine
	e.	Contractile proteins	Actin and myosin are responsible for the action of muscles.
	f.	Blood proteins	Haemoglobin is a protein which carries oxygen. Other proteins found in blood are lipoproteins, transferrin, serum albumin and immunoglobulins. Serum albumin is also responsible for regulating osmotic pressure and maintaining the fluid balance of the body
	g.	Specific functions	Some amino acids have specific and specialized functions in the body • Tryptophan is a precursor of niacin and serotonin. Methionine supplies labile methyl groups for synthesizing choline, which prevents accumulation of fat in the liver • Glycine is required for the formation of the porphyrin ring of haemoglobin and is an important constituent of nucleic acids
3	Supply of energy		Proteins provide fuel for the body's energy needs [4 Kcal/gm].
4	Storage		Proteins help to store iron and copper.
5	Acid-base balance		Proteins help maintain the acid-base balance of the body fluids by acting as buffers.
6	Pregnant and lactating women		Provides amino acids for the growth of foetus in pregnancy and for the production of milk during lactation.

Table 10.4: ICMR Recommended Dietary Allowances for Proteins

Group	Particulars	Protein requirement g/day
Man	Sedentary work	60
	Moderate work	
	Heavy work	
Woman	Sedentary work	55
	Moderate work	
	Heavy work	
	Pregnant woman	82.2
	Lactation (0- 6 months)	77.9
	Lactation (6-12 months)	70.2
Infants	0 – 6 months	1.16 g/kg/ day
	6 – 12 months	1.69g/kg/ day
Children	1 -3 years	16.7
	4 – 6 years	20.1
	7 – 9 years	29.5
Boys	10 -12 years	39.9
Girls	10 -12 years	40.4
Boys	13 – 15 years	54.3
Girls	13 – 15 years	51.9
Boys	16 -17 years	61.5
Girls	16 – 17 years	55.5

occurring most frequently in infants and young children and often associated with infection (WHO,1973)

PEM affects children under 5 years of age belonging to the poor underprivileged communities. Under nutrition is a complex condition with multiple deficiencies such as proteins, energy and micronutrient deficiencies often occurring together. According to WHO, malnutrition is an underlying factor in over 50 % of the 10 – 11 million yearly deaths of children under 5 years.

10.7.2 Classification of PEM

Protein energy malnutrition may be classified into three types as follows:

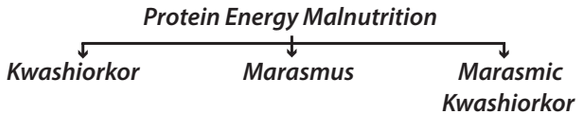


Fig 10.6: Classification of PEM

10.7.3 Causes of PEM

PEM is prevalent in all parts of the world and in all ages. It is primarily a disease that occurs in young children who live in poverty. In India, PEM is the most widespread form of malnutrition among pre-school children. A majority of them suffer from varying grades of malnutrition.

The paths leading from early weaning to Nutritional marasmus and from protracted breast feeding to kwashiorkor is schematically presented below:

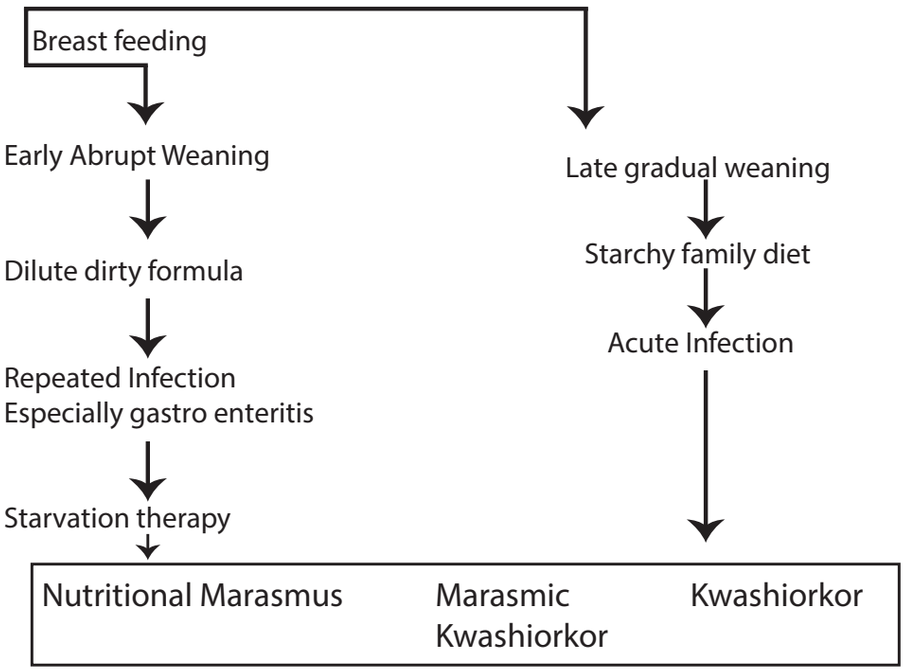


Fig 10.7: Causes of PEM

10.7.4 Clinical signs and symptoms of PEM

I. Kwashiorkor

This disease was first reported to occur in children in Africa by Dr.Cicely Williams in 1935.

It is caused by deficiency of proteins in the diet. The important symptoms of the disease are:

1) Growth failure
2) Oedema of the face and lower limbs
3) Muscle wasting
4) Fatty liver
5) Anorexia (loss of appetite)
6) Diarrhoea
7) Change in the colour, sparse, soft and thin hair.
8) Change in the colour of the skin (hypo and hyperpigmentation)
9) Anaemia
10) Vitamin A deficiency
11) Angular stomatitis (Cracks in the corners of mouth)
12) Cheilosis (inflammation and cracks in lips)
13) Moon face

II. Marasmus

This is caused by severe deficiency of proteins and calories in the diet. The important features are as follows:

1) Severe wasting of muscles
2) Loss of subcutaneous fat (Limbs appear as skin and bones)
3) Skin is dry and atrophic
4) Anaemia
5) Eye lesions due to Vitamin A deficiency
6) Irritability and fretfulness
7) Diarrhoea

Fig 10.8: Kwashiorkor

Fig 10.9: Marasmus

8) Dehydration
9) Body temperature is sub-normal
10) Failure to thrive
11) Wrinkled skin - Old man's face
12) Grossly underweight

III. Marasmic Kwashiorkor

Children suffering from this disease show signs of both kwashiorkor and marasmus.

10.7.5 Differences between Kwashiorkor and Marasmus

Table 10.5: Differences between Kwashiorkor and Marasmus

Kwashiorkor	Marasmus
It develops in children whose diets are deficient of protein.	It is due to deficiency of proteins and calories.
It occurs in children between 6 months and 3 years of age.	It is common in infants under 1 year of age.
Subcutaneous fat is preserved.	Subcutaneous fat is not preserved
Oedema is present.	Oedema is absent.
Enlarged fatty liver.	No fatty liver.
Ribs are not very prominent.	Ribs become very prominent.
Lethargic	Alert and irritable.
Mild or no Muscle wasting.	Severe muscle wasting
Poor appetite.	Voracious feeder.
The person suffering from kwashiorkor needs adequate amounts of proteins.	The person suffering from marasmus needs adequate amount of proteins, fats and carbohydrates.

10.7.6 Treatment of PEM

Children with severe PEM are often seriously ill when they first present for treatment. They should be admitted to a hospital for the treatment of life- threatening problems. Specific deficiencies should be corrected and metabolic abnormalities reversed. When the child's condition is stable and the appetite has returned,which is usually after 2- 7 days ,the treatment can be continued outside the hospital .

A. Hospital based management

1) **Dehydration:** Diarrhoea leading to dehydration is a serious and often fatal event in children with severe malnutrition. Skin elasticity is poor in children with marasmus and their eyes are normally sunken. Unlike Kwashiorkor, the altered skin elasticity is masked by oedema. Patients with mild to moderate dehydration can be treated by oral or nasogastric administration of fluids.

2) **Infection:** Infection is often the immediate cause of death in PEM. It is difficult to detect infections clinically as fever and rapid pulse rate may not be present in severely malnourished patients. Since infection is common, antibiotics should be given routinely to all malnourished patients. Children with complications should be treated with broad spectrum antibiotics like amoxicillin and ampicillin. Intestinal infections like ascariasis must be treated with appropriate de-worming agents.

3) **Hypoglycemia:** A child may become drowsy or develop convulsions due to hypoglycaemia. In mild cases, oral administration of 50 ml of 10% glucose may be sufficient. If a child develops convulsions or becomes unconscious, 10% glucose should be given intravenously (5ml/kg) followed by 50ml of 10% glucose by nasogastric tube.

4) **Hypothermia:** Marasmic children are prone to have low body temperature. If the room is cold, the child should be properly covered with a blanket. The state of shock should be treated with intravenous injection of glucose –saline or blood transfusion.

5) **Anaemia:** Severe anaemia is dangerous, as it can result in heart failure. If the haemoglobin falls below 5g/dl, blood transfusion should be given.

B. Dietary management

Although treatment of complications can reduce mortality, proper dietary management is important for complete recovery. The child should be given a diet providing sufficient quantities of calories and protein, in gradually increasing amounts, without provoking vomiting or diarrhoea. It is best to begin with liquid formula, as it is easy to feed and measure the intake. Initially the child may refuse the feeds due to lack of appetite. As the appetite improves and child starts taking food by mouth, solid supplements can be introduced. The diet should be given frequently and in small amounts.

High energy intakes (150Kcal/kg) and high protein intakes (3-4g/kg) are required for rapid recovery. Most hospitals use milk-based formulas for feeding

malnourished children. Either fresh milk or skimmed milk can be used for preparing the formula. Sugar and vegetable oil are added to increase the energy content. In older children, an entirely liquid diet is not necessary as they can accept solid foods. A mixed cereal-based diet can be given with added oil to increase energy density.

Fig 10.10: Dietary management for PEM

ACTIVITY - 3

(Think and answer)

1) Ramu has stunted growth, severe diarrhoea, moon face and oedema. What is he suffering from?

   _____

2) Sheela has dry wrinkled skin, severe muscle wasting and diarrhoea. What is she suffering from? _____

   _____

3) Suggest a calorie and protein rich breakfast for a child recovering from PEM.

Vitamin and Mineral supplements

Vitamin and mineral supplements should be given for all malnourished children. Daily supplements of iron (60mg/day) and folic acid (1 microgram/day) should be given to correct anaemia along with multivitamin preparation.

With this treatment, clinical improvement is seen within a week. The child becomes alert and the appetite improves; Oedema disappears in about 7 -10 days. During this period, there may be some weight loss, but thereafter, the child starts gaining weight . After the child is discharged form the hospital, he should be followed up in the out-patient clinic or at home till he reaches normal weight for height.

Low cost recipes for children recovering from PEM

1) Ragi, green gram, jaggery - puttu
2) Ragi, Bengal gram, wheat - puttu
3) Wheat rava, green gram dhal, vegetable - upma
4) Rice, green gram dhal - pongal / khichdi
5) Rice, bengalgram - porridge

LIPIDS

The term 'Lipids' is applied to a group of naturally occurring substances characterized by their insolubility in water, greasy feel and solubility in organic solvents. They occur in the plant and animal kingdom. Fats are a more concentrated form of storage of energy than carbohydrates. In the presence of adequate supply of carbohydrates, fat is stored in the adipose(fatty) tissue.

10.8 Chemical composition of lipids

Fat is a complex molecule constituting a mixture of fatty acids and an alcohol, generally glycerol. Like carbohydrates, it

contains carbon, hydrogen and oxygen, but it differs from a carbohydrate in that it contains more carbon and hydrogen and less oxygen. When oxidized, it gives nine kilocalories. A molecule of fat consists of three molecules of fatty acids and one molecule of glycerol. It is also known as *triglyceride*.

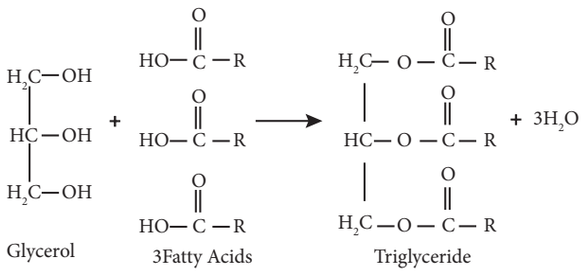


Fig 10.11: Formation of Triglyceride

10.9 Differences between fats and oils

Fats and oils have many types of triglycerides. Nature of fat or oil depends on the type of fatty acids attached to the glycerol molecule.

Table 10.6: Difference between Fats and Oils

S.no	Fats	Oils
1	Fat is solid at room temperature	Oil is liquid at room temperature
2	Fat is obtained from animals (i.e) butter, ghee, egg yolk ,meat	Oils are obtained from plant sources (i.e) mustard oil, groundnut oil, almond oil
3	Fats have only saturated fatty acids	Oils have saturated and unsaturated fatty acids

DO YOU KNOW...?

- Fats are a concentrated source of energy
- Good fats can promote health and bad fats can increase risk of chronic diseases

Fig 10.12: Fats and oils

10.10 Classification of fats

Fats are classified into 4 categories as follows:

I. On the basis of chemical composition
II. On the basis of fatty acids
III. On the basis of requirement
IV. On the basis of sources

10.10.1 On the basis of chemical composition

Fats can be classified into 3 main groups as follows:

1) Simple lipids

These are esters of fatty acids and glycerol. They are also called as neutral fats or triglycerides. These neutral fats make up 98 -99% of food and body fats. (e.g) fats and oils

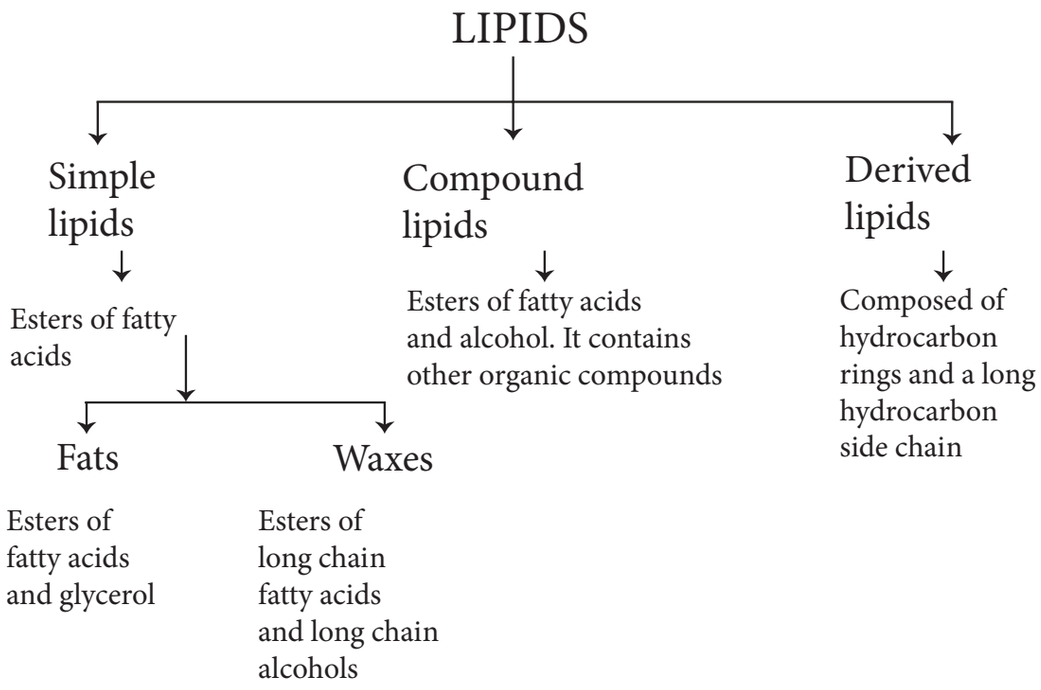


Fig 10.13: Classification of fats based on fatty acids

Waxes: A wax is a simple lipid which is an ester of fatty acids and long chain aliphatic alcohols. The alcohol may contain 12-32 carbon atoms. Waxes are found in nature as coatings on leaves and stems. The wax prevents the plant from losing excessive amounts of water.

2) Compound lipids

The compound lipids contain, in addition to fatty acids and glycerol,some other organic compounds.

(i) **Phospholipids:** These contain phosphoric acid and a nitrogenous base in addition to fatty acids and glycerol(e.g.)Lecithin and cephalin.

(ii) **Glycolipids:** Complex lipids containing carbohydrates in combination with fatty acids and glycerol(e.g) Cerebrosides.

(iii) **Lipoproteins:** Lipoproteins are the most important as they are the carriers of lipids in the blood and form cell membranes.

3) Derived lipids

These are substances liberated during hydrolysis of simple and compound lipids which still retain the properties of lipids. The important members of this group are sterols, fatty acids and alcohol.

(i) **Sterols :** Sterols are solid alcohols and form esters with fatty acids. In nature they occur in the free state in the form of esters. Based on their origin sterols are classified as cholesterol (animal origin) and phytosterol (in plants).

Cholesterol is a waxy, fat-like substance found in all cells of the body and has several important functions in the body. It is synthesized in the body by the liver independent of the dietary intake. The body normally synthesizes about 2 grams of cholesterol. The dietary sources of

cholesterol includes animal foods. It is used in the body for synthesizing hormones, Vitamin D and substances which help to digest foods. High blood cholesterol is a risk factor for heart disease. Rich sources of dietary cholesterol include meat, poultry (with skin), organ meats like brain, kidney, liver and full fat dairy products.

(ii) **Fatty acids:** They are the key refined fuel form of fat that the cell burns for energy. They are the basic structural unit of fats and they may be saturated or unsaturated. (e.g) oleic acid, linoleic acid, linolenic acid, palmitic acid and myristic acid.

10.10.2 On the basis of fatty acids

Fats can be classified based on the fatty acids present in them as follows:

1) Saturated fatty acids

A saturated fat is a type of fat in which the fatty acid chains have all or predominantly single bonds. Various fats contain different proportions of saturated fat. Saturated fatty acids, especially palmitic and stearic acids are found in animal products such as cream, cheese, butter, other whole milk dairy products and fatty meats which also contain dietary cholesterol. Certain vegetable products have high saturated fat content, such as coconut oil and palm kernel oil. Many prepared foods are high in saturated fat content, such as pizza, dairy desserts and sausage.

2) Unsaturated fatty acids

An unsaturated fat is a fat or fatty acid in which there is at least one double bond within the fatty acid chain.

(i) **Monounsaturated fatty acid (MUFA):** A fatty acid chain is monounsaturated if it contains one double bond. Monounsaturated fats are good fats. A diet high in MUFA can reduce blood cholesterol levels, lowers risk of heart disease, stroke and breast cancer, reduces pain in rheumatoid arthritis and helps in

Fig 10.14: Food sources of Saturated fats

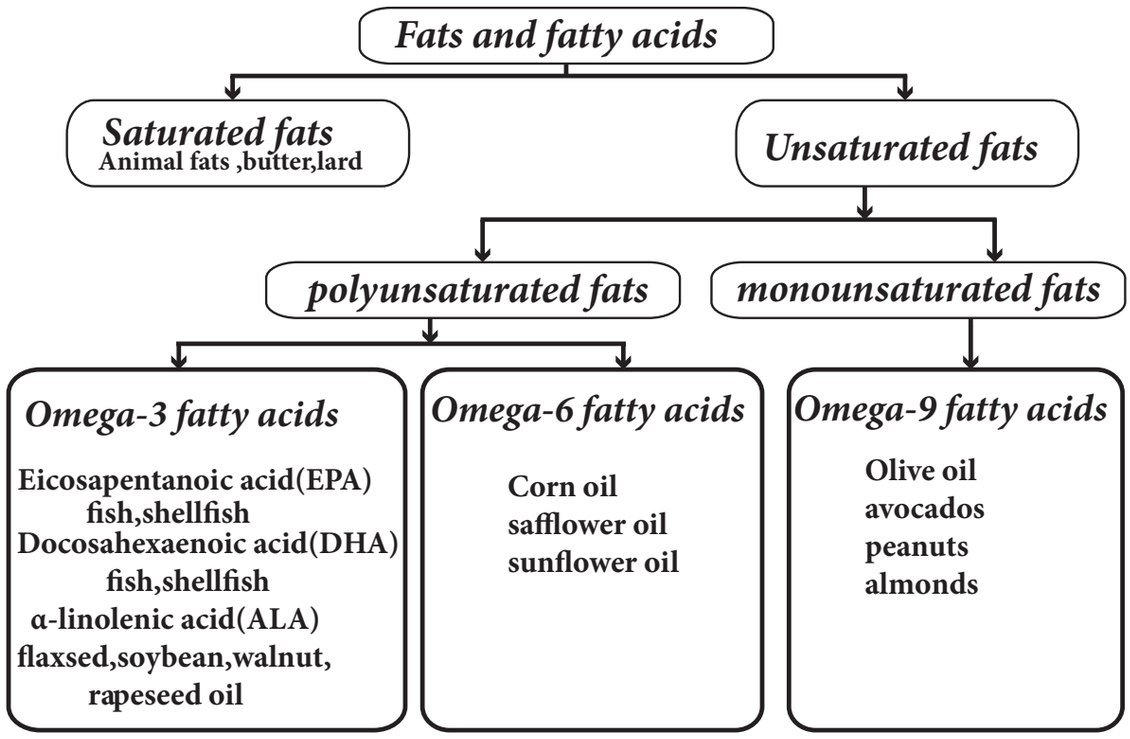


Fig 10.15: Classification of fats based on fatty acids

weight loss. Foods which contain MUFA (Oleic acid) are avocados, olives, olive oil, peanut butter and peanut oil. It is also known as omega-9 fatty acid.

(ii **Polyunsaturated fatty acid (PUFA):** A fatty acid is polyunsaturated if it contains more than one double bond. They are of two types, namely Omega-3 and Omega-6 fatty acids.

a) **Omega-3:** It is also called ω−3 fatty acids or n−3 fatty acids with a double bond (C=C) at the third carbon atom from the end of the carbon chain. The three types of omega−3 fatty acids involved in human physiology are α-linolenic acid (ALA) [found in plant oils], eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) [both commonly found in marine oils]. Common sources of plant oils containing the omega−3 ALA fatty acid include walnut, flaxseed, flaxseed oil,soybeans and chia seeds.The sources of animal omega−3 EPA and DHA fatty acids include fish and fish oils.

The health benefits of omega-3 fatty acids are immense and they have been proven effective in the treatment and prevention of hundreds of medical conditions which includes high cholesterol, depression, anxiety, cancer, diabetes mellitus, inflammatory diseases, arthritis and cardiovascular diseases.

b) **Omega-6:** Omega-6 fatty acids (also referred to as ω-6 fatty acids or n-6 fatty acids) are a family of pro-inflammatory and anti-inflammatory polyunsaturated fatty acids that have in common a final carbon-carbon double bond in the n-6 position, that is the sixth bond, counting from

Fig 10.16: Rich sources of omega-3 fatty acids

the methyl end. Omega-6 fats, also known as linoleic acid, are available only in food. The human body cannot make them, so they are considered as essential fats. They support brain function, bone health, reproductive health, hair growth and regulation of metabolism. Good sources of linoleic acid include vegetable oils.

10.10.3 On the basis of requirement

Fatty acids are of 2 types:

1) Essential Fatty Acids

Fatty acids which are essential to be taken in our diet because they cannot be synthesized in our body are known as Essential Fatty Acids. (eg.) Linoleic, linolenic and arachidonic acids.

2) Non-Essential Fatty Acids

Non-Essential Fatty Acids are those which can be synthesized by the body and which need not be supplied through the diet. Palmitic acid, oleic acid and butyric acid are examples of non– essential fatty acids.

10.10.4 On the basis of sources

Fats are divided into 2 types based on their source, namely visible and invisible fats. Some fats and oils added to food or used for

Fig 10.17: Rich sources of omega-6 fatty acids

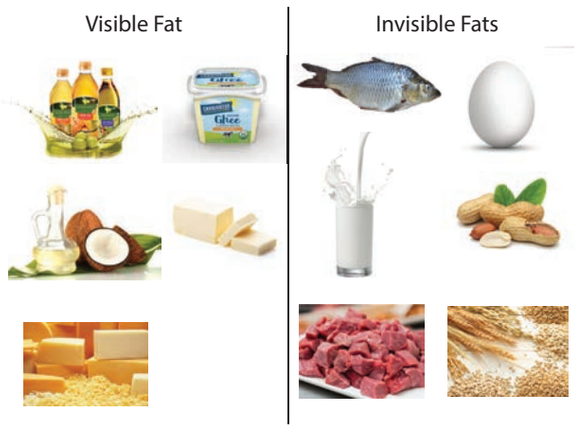


Fig 10.18: Sources of visible and invisible fats

ACTIVITY - 4

Match the right answer

1) Fish oil	-	MUFA
2) Olive oil	-	Saturated fat
3) Corn oil	-	Omega 3 fatty acid
4) Cholesterol	-	Pulses
5) Red meat	-	Omega 6 fatty acid
6) Invisible fat	-	Organ meats

frying are visible fats. These are also known as pure fats. Many foods like milk, cream, egg yolk, meat, fish and even cereals and legumes contribute substantial amount of invisible fats (not visible in the food) to the diet.

10.11 Hydrogenated fats

Hydrogenation (or, more accurately, "partial hydrogenation," as the process is incomplete) is the forced chemical addition of hydrogen into omega-6 polyunsaturated oils to make them hard at room temperatures, primarily as a cheaper and less perishable substitute for butter. The liquid fat becomes a solid fat and the unsaturated fatty acid contents decrease as a result of hydrogenation. Common hydrogenated fats include hydrogenated or partially hydrogenated cottonseed, palm, soy and corn oils, but theoretically almost any polyunsaturated oil can be hydrogenated. During the process of hydrogenation, hydrogen is added to the unsaturated linkage with nickel as catalyst.

A major health concern during the hydrogenation process is the production of trans fats. Trans fats are the result of a side reaction with the catalyst of the hydrogenation process. This is the result of an unsaturated fat which is normally found as a cis isomer converts to a trans isomer of the unsaturated fat. Isomers are molecules that have the same molecular formula but are bonded together differently. A cis isomer has the hydrogens on the same side, whereas a trans isomer has hydrogen atoms on the opposite side. Due to the added energy from the hydrogenation process, the activation energy is reached to convert the cis isomers of the unsaturated fat to a trans isomer of the unsaturated fat .

Although trans fats are edible, consumption of trans fats has been shown to increase the risk of coronary artery disease in part by raising levels of the lipoprotein LDL (often referred to as "bad cholesterol"), lowering levels of the lipoprotein HDL (often referred to as "good cholesterol"), increasing triglycerides in the bloodstream and promoting systemic inflammation. Trans fat are found in margarine, vanaspathi, baked goods such as doughnuts, pastries, cookies, deep fried foods like fried chicken and French-fried potatoes, microwave popcorn, snack chips, processed foods and confectionery fats.

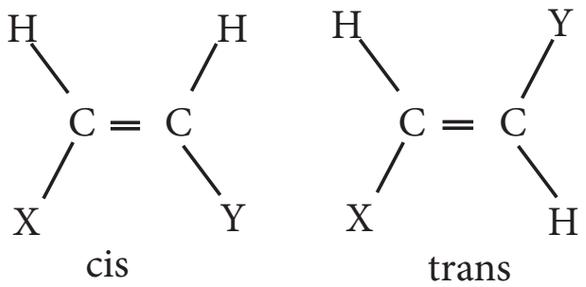


Fig 10.19: Cis and trans fats

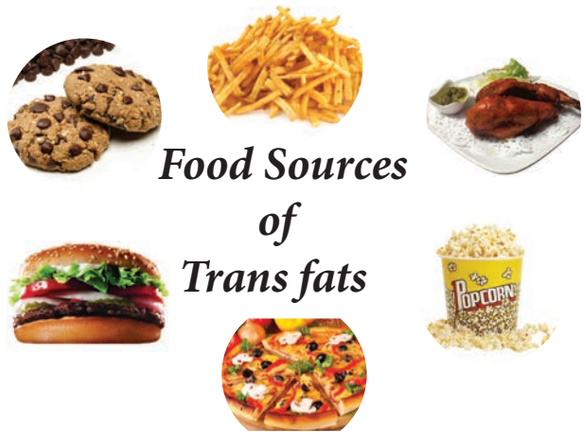


Fig 10.20: Food sources of trans fats

ACTIVITY - 5

1) Display food sources of GOOD and BAD fats.
2) What on the foods containing trans fats which you frequently consume and list their harmful effects.

DO YOU KNOW...?

when oxidized one gram of fat gives 9 kcal.

10.12 Functions of fats

Fats perform several important functions:

1) Fats are a concentrated source of energy. one gram of fat gives 9 kilocalories of energy. Fat is stored in the body in the adipose tissue and provides energy to the body when required.
2) Fats are the constituents of cell membrane structure and regulate the membrane permeability.
3) Subcutaneous fat acts as an insulator and helps in retaining body heat.
4) They are essential for the digestion, absorption and utilization of fat soluble vitamins like Vitamin A, D, E and K.
5) Fats are important as cellular metabolic regulators (Steroid hormones and prostaglandin).
6) Fats have a sparing action on vitamin B_1 (i.e) if fat consumption is adequate, not much vitamin B_1 is needed.
7) Fats improve the palatability of the diet and give satiety value.(ie.)feeling of fullness in the stomach.
8) The calories in fat spare proteins from being oxidized for energy.
9) Cholesterol is needed for synthesis of sex and adrenal hormones (steroid hormones).
10) Substituting a fat high in PUFA or MUFA for a fat high in saturated fatty acids can decrease the level of blood cholesterol levels and hence reduce risk of heart disease.

10.12.1 Functions of Essential Fatty Acids

1) Maintenance of the functioning and integrity of cellular and sub-cellular membrane.
2) Regulation of cholesterol metabolism by transporting it between the blood and body tissues.
3) Acts as precursors for important group of hormone like compounds-prostaglandins which aid in regulating vascular function and help relieving pain and inflammation.
4) Delays blood clotting time.

10.13 Fat requirements

The ICMR recommended allowances of fat for Indians is given in **table 10.7.**

10.14 Deficiency and excess of fat in the diet

a) Effects of EFA deficiency

Deficiency of fat in the diet causes the deficiency of essential fatty acids. Deficiency of essential fatty acids leads to cessation of growth. It also results in flaky skin, development of itchy sores on the scalp. The common disorder in adults and children in India is phrynoderma or toad skin. The condition is characterized by the presence of horny eruptions on the posterior and lateral aspects of the limbs on the back and buttocks.

Table 10.7: ICMR Recommended Dietary Allowances for Fats

Group	Particulars	Visible fat (g/day)
Man	Sedentary work	25
	Moderate work	30
	Heavy work	40
Woman	Sedentary work	20
	Moderate work	25
	Heavy work	30
	Pregnant woman	30
	Lactating woman (0-6 months)	30
	Lactating woman (6 -12 months)	30
Infants	0 – 6 months	-
	6 – 12 months	19
Children	1 – 3 years	27
	4 – 6 years	25
	7 - 9 years	30
Boys	10 – 12 years	35
Girls	10 – 12 years	35
Boys	13 – 15 years	45
Girls	13 – 15 years	40
Boys	16 – 17 years	50
Girls	16 – 17 years	35

Phrynoderma is cured rapidly by the administration of linseed or safflower seed oil rich in EFA. Infants fed on an EFA deficient diet develop irritation and changes in the skin within a few weeks. The skin appear as dryness and desquamation with oozing in the folds. Diarrhoea may also occur, supplementation of the diet with linoleic acid helps to restore the skin to normal condition.

b) Effects of Excess of fat

1) Leads to Obesity because more than required calories are consumed. In addition, the excess carbohydrates are also converted to fat for storage in the body resulting in obesity.
2) Slows down digestion and absorption of foods.
3) Interferes with the absorption of calcium by combining with calcium to form an insoluble calcium soap.
4) Cause ketosis unless adequate carbohydrate is present to complete the oxidation of fat.

Fig 10.21: Effects of EFA deficiency - Phrynoderma

DO YOU KNOW...?

Ketosis is a normal metabolic process. When the body does not have enough glucose for energy, it burns stored fats instead; this results in a build-up of acids

ACTIVITY - 6

1) How is excess fat or cholesterol in the body linked with heart disease?
2) What is known as Good cholesterol and Bad cholesterol?

SUMMARY

- Proteins are the building blocks of life.
- Proteins are used for tissue repair and maintenance.
- Amino acids are small units that combine to form a protein molecule.
- Aminoacids are classified as essential, semiessential and non essential aminoacids.
- Proteins are classified as simple proteins, conjugated or complex proteins and derived proteins.
- Proteins are also classified as complete proteins and incomplete proteins.
- If two sources of incomplete proteins are combined in the same meal, the resulting protein may be of better quality. These are called as Complementary proteins.
- Animal sources are complete proteins which includes meat, egg, fish and poultry and they are good protein foods in both quantity and quality. Milk is a valuable source of protein because although it does not contain a large quantity of protein, the quality is excellent.
- Good sources of plant proteins are legumes, pulses, nuts and oil seeds, but their quality is poorer than that of animal foods.
- All vegetables and fruits are a poor source of protein.
- The main functions of protein are building and repair of body tissues and regulation of body processes.
- Protein Energy Malnutrition (PEM) is defined as a range of pathological conditions arising from coincident lack of varying proportions of protein and calorie ,occurring most frequently in infants and young children and often associated with infection.
- The treatment of PEM include hospital based management and dietary management.

- The term 'Lipids' is applied to a group of naturally occurring substances characterized by their solubility in water, greasy feel and solubility in organic solvents.
- They occur in plant and animal kingdom. Fats are a more concentrated form of storage of energy than carbohydrates.

Glossary

Terms	Meaning
Arthritis	It is a term often used to mean any disorder that affects joints. Symptoms generally include joint pain and stiffness.
Coronary heart disease (CHD)	It is a disease in which a waxy substance called plaque builds up inside the coronary arteries. These arteries supply oxygen-rich blood to the heart muscle.
Fatty liver	Fatty liver, or hepatic steatosis, is a term that describes the build-up of fat in the liver.
Hypoglycemia	A lower than normal level of glucose in blood (<70 mg/dl).
Hypothermia	The body loses heat faster than it can produce heat, causing a dangerously low body temperature.

Questions

GS3ZS7

Part - A

Choose the correct answer (1 mark)

1) Three amino acids bonded together form a _____

a) Peptide b) Dipeptide

c) Tripeptide d) monopeptide

2) _____ is considered as a non-essential amino acid for adults.

a) Histidine b) Tryptophan

c) Methionine d) Peptide

3) The protein requirement for a 12 year old girl is _____ per day.

a) 39.9 g b) 40.4 g

c) 42 g d) 41 g

4) 1 gram of proteins gives _____ Kcal.

a) 4 b) 9

c) 7 d) 5

5) One gram of fat gives _____ kilo calories.

a) 9 b) 4

c)7 d)3

6) _____ is a concentrated source of energy.

a) Protein b) Carbohydrate

c) Fat d) Lipids

7) _____ is also known as Good cholesterol.

a) HDL b) LDL

c) VLDL d) MDL

8) Deficiency of EFA causes _____.

a)Anaemia b)Phrynoderma

c)PEM d) Fever

9) Trans fats are formed during _____ of vegetable oils.

a)Hydrogenation b)Extraction

c) Refining d) oxidation

10) _____ are rich in trans fats.
a)Processed foods b) Cereals
c) Pulses d) Vitamines

11) _____ is an example of essential fatty acid.
a) Oleic acid b) Linoleic acid
c) Palmitic acid d) Acid

12) A pregnant woman requires _____ grams of fat per day.
a) 20 b) 25
c) 30 d) 35

Part - B

Write short answer (2 marks)

1) What is an incomplete protein?
2) What are derived proteins?
3) List any 2 food sources of complete proteins.
4) What is Kwashiorkor? Give any 2 clinical signs of kwashiorkor.
5) What are simple proteins? Give examples.
6) What are simple lipids?
7) Give any 2 differences between fats and oils.
8) What is the chemical composition of lipids?
9) Give any 2 food sources of Omega-3 fatty acids.
10) What are the health benefits of MUFA?
11) What is cholesterol? Give examples of foods rich in cholesterol.

Part - C

Answer in brief (3 marks)

1) What are complementary proteins? Give examples.
2) What are Essential amino acids? List the essential amino acids.
3) Define PEM. Give the classification of PEM
4) List the causes of PEM
5) List any 3 low cost recipes for children recovering from PEM
6) What are polyunsaturated fatty acids? Classify them with examples.
7) What are EFAs ?Give examples
8) Differentiate between visible and invisible fats
9) Give the fat requirement for a 12 year old, 5 year old and 17 year old boy.
10) What are the effects of excess fat in the body?

Part - D

Answer in detailed (5 marks)

1) What is PEM? Give the classification of PEM and highlight on the clinical signs and symptoms of PEM.
2) What are the functions of proteins?
3) List the differences between Kwashiorkor and Marasmus.
4) How will you treat a child suffering from PEM?
5) Explain the nutritional classification of amino acids with examples.
6) Explain the following terms with examples:
a) Complete protein
b) Incomplete protein
c) Complementary proteins
7) What are lipids? Classify fats on the basis of their chemical composition.
8) What are essential fatty acids? Give their functions and effects of deficiency.
9) List the functions of fat in the body.
10) What are trans fats? List the food sources and harmful effects of trans fats.
11) What are unsaturated fatty acids ? Classify them and give their food sources and benefits.