33

FATS AND LIPIDS

33.1 INTRODUCTION

Fats and their derivatives are collectively known as lipids. These are oily, fatty or waxy substances present in living organisms The main functions of lipids are to form part of structure of biological membrane and to store energy for the cell

In this lesson you will learn about various aspects of fats and lipids and how they are useful to us

33.2 OBJECTIVES

After reading this lesson ou will be able to:

- define lipids and ·ıte their composition
- differentiate betw ·n oils and fats.
- list the natural sources of lipids and fats.
- classify lipids
- give reasons for the fats being a rich source of energy
- list the biological functions of fats and lipids

33.3 WHAT ARE LIPIDS ?

Lipids are organic compounds of biological nature, insoluble in water but soluble in non-polar solvent like chloroform, ether or benzene.

The term lipid originated from a greek word 'Lipos" meaning fat. The lipids include fats oils, waxes and related compounds. The major component of storage fats in plant and animals are acylglycerols or neutral fats One fat molecule is formed if three molecules of fatty acids combine with one molecule of glycerol Glycerol is a three carbon alcohol

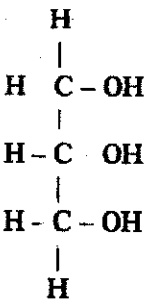
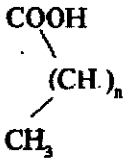


Fig 33 1 **Chemical formula of glycerol.**

Fatty acids have an even number of carbon atoms in straight hydrocarbon chains The chain may be saturated (carrying no double bonds) or unsaturated (containing one or more double bonds -C=C-). One end of the chain carries a carboxyl group (-COOH) which gives acidic properties to fatty acids. Fatty acid have the general formula



OR $C_nH_{2n+1}COOH$

Where n is the number of CH_2 units

Examples of saturated fatty acids are palmitic acid, stearic acid. myristic acid etc Their chemical formulae are given below.

Palmitic acid: $CH_3(CH_2)_{14}COOH$

Stearic acid : $CH_3(CH_2)_{16}COOH$

Myristic acid: $CH_3(CH_2)_{12}COOH$

Examples of unsaturated fatty acids are linoleic acid, oleic acid etc. Their chemical formula are given below.

Oleic acid $C_{17}H_{33}COOH$ (contains one double bond)

Linoleic acid. $C_{17}H_{31}COOH$ (contains two double bonds)

When all the three hydroxyl groups of glycerol are esterified with fatty acid, the structure is called triacylglycerols or triglycerides. Figure 33.2 shows how a triglyceride is formed

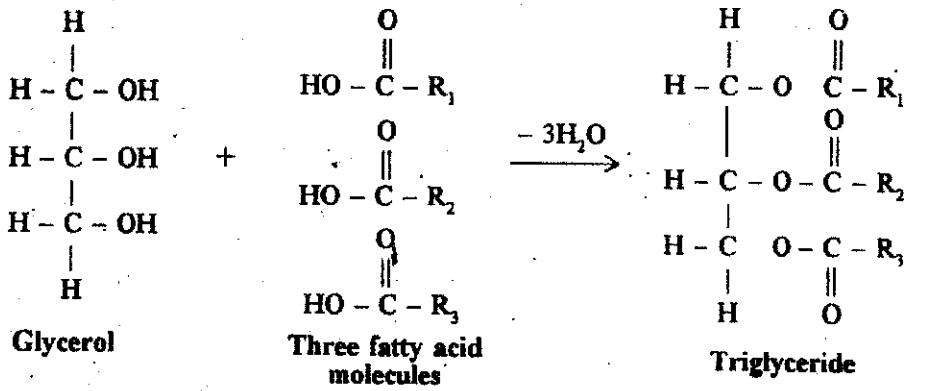


Fig. 33.2: **Formation of triglyceride.**

In fig. 33.2 R1, R2 and R3 represent straight chains of three different fatty acid molecules generally represented by C_nH_{2n}

33.4 NATURAL SOURCES OF LIPIDS AND FATS

Milk, cheese, butter, eggs, meat, bacon, fishes (especially cod and herring), nuts and oil seeds are very rich sources of lipids Depending upon the source the fats are divided into two groups: animal fat and vegetable fats Commonly used mustard oil, sunflower oil, groundnut oil, cotton seed oil and hydrogenated oils are good examples of vegetable fat.

INTEXT QUESTIONS 33.1

1. Define lipids

   .....

2. What are fatty acids? Write the general formula of fatty acids.

   .....

3. How is a triglyceride formed?

   .....

4. Name two natural sources of lipids

   .....

33.5 TYPES OF LIPIDS

Lipids have been divided into three main classes: (i) simple (ii) compound and (iii) derived

33.5.1 Simple lipids

Simple lipids. Oils, Fats and waxes are simple lipids They are als called triglycerides

Oils and Fats: These are most abundent lipids and are also called triglycerides as all the three hydroxyl groups of glyeerol are esterified. For example, tripalmitin is a simple triglyceride where three molecules of palmitic acid are esterified with three hydroxyl residues of gycerol (Fig. 33.3).

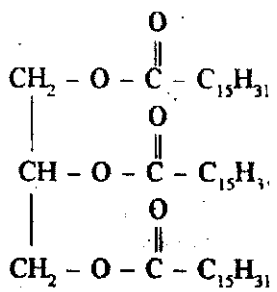


Fig 33 3 **A simple glyceride-tripalmitin.**

A mixed glyce i ' is where three different fatty acids are esterified with the hydroxyl residues of gly For example: palmito-oleo-stearate (Fig. 32.4) in which the three fatty acids esterifi d with -OH groups of glycerol are palmitic acid, oleic acid and stearic acid.

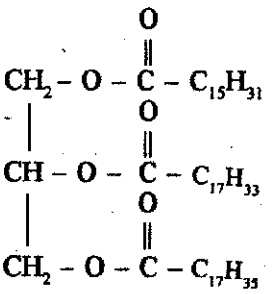


Fig. 33.4: **A mixed glyceride: Palmito-oleo-stearate.**

The main difference between oils and fats in that oils are liquid at room temperature (as they contain unsturated fatty acids) where as fats are solids at room temperature (as they contain saturated fatty acids)

Triglycerides are very important and are used in soaps paints, varnishes, printing ink, ointments, creams etc

Waxes: Waxes are also esters and simple lipids Waxes are fatty acid esters of long chain monohydric alcohols and may be represented by the general formula RCOOR' where R and R' are long hydrocarbon chains Fo example myricyl palmitate found in bees wax is $C_{15}H_{31}COOC_{30}H_6$. myric l cerotate found in Carnauba wax is $C_{25}H_5 COOC_{50}H_{61}$

In nature they exist as mix ures The waxes are widely spread and play an imporinat role as protective coatings on fruits, leaves and animals This is due to their properties of water insolubility, flexibility and non-reactivity. Thi makes them an excellent coating

Importance:

1 waxes are used in cosmetics, ointments, and as polishes f floors and furnitu e

2. Wax exist as thin coating on fruits, leaves, skin naturally to protect the surface from loss of water and attack from microorganisms

3. Waxes are used in making candles.

33.5.2 Compound lipids

Compound lipids are esters of fatty acids and alcohol with additional compounds like phosphoric acids, sugars, proteins etc. Compound lipids are classified into following groups:

i) **Phospholipids**: Lipids containing phosphorus are phospholipids, eg. phosphatidic acid, lecithin (phosphatidyl choline), plasmalogen (phosphatidyl ethanolamine).

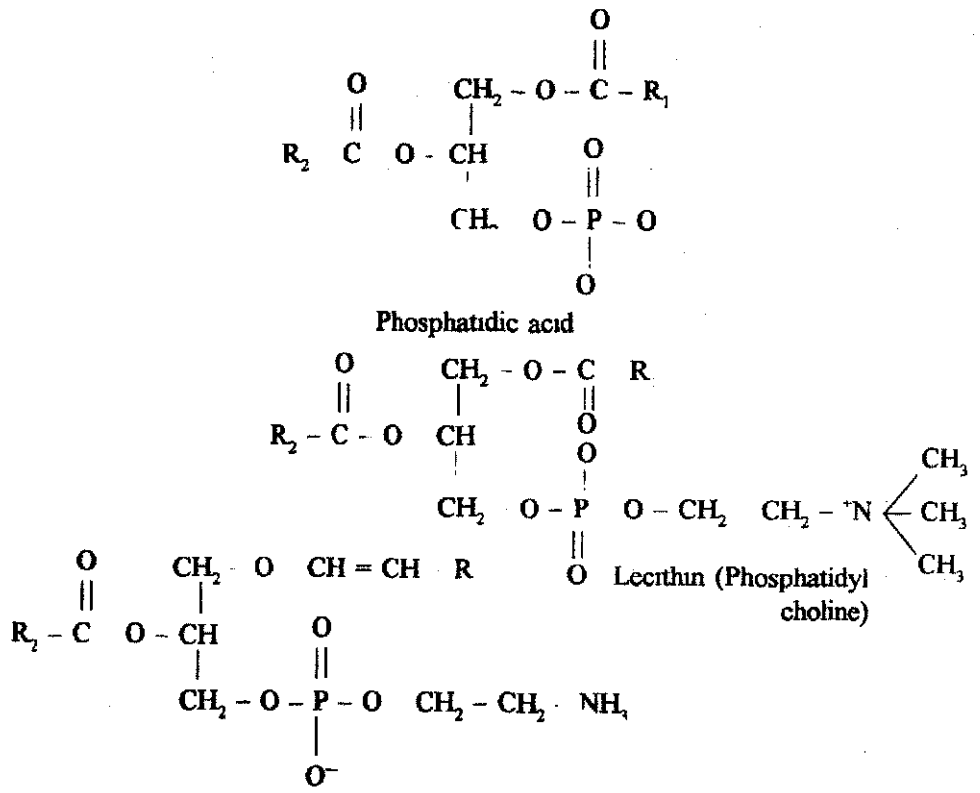


Fig. 33.5: **Chemical Structures of Phosphatidic acid, lecithin and plasmalogen.**

(ii) **Glycolipids:** Simple glycolipids contain only galactose a high molecular weight fatty acid and sphingosine (an amino alcohol with two asymmetric carbon atoms C-2 and C-3; structure of sphingosine is given below) They are known as cerebrosides.

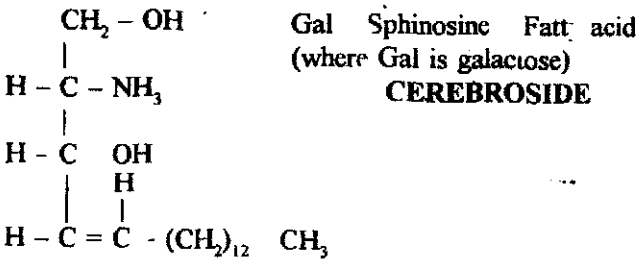
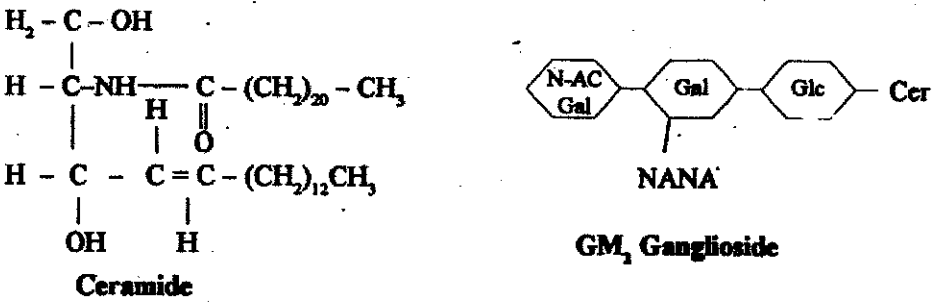


Fig 33 6 **Structure of sphingosine and a cerebroside.**

iii) **Gangliosides:** They are more complex glycolipids found in the brain They contain sialic acid, ceramide (ceramide formed by linkage of a fatty acid to the NH_2 group of sphingosine via an amide linkage) and three molecules of hexose (glucose and galactose) eg GM_2 ganglioside



Ceramide

GM_1 Ganglioside

Fig. 33.7: **Strucutre of ceramide and GM_1 ganglioside.**

In fig. 33.7 cer=ceramide, Glc=glucose, Gal=galactose and N-AcGal=N-acetyl galatosamine, NANA= N-acetylneuraminic acid (sialic acid)

(iv) **Lipoproteins:** When proteins are complexed with lipids without forming any covalent bond, they are called lipoproteins. There are a number of lipoproteins present in the cell, the most important being the lipoproteins present in the plasma. The lipoproteins of the plasma function as major transporters of lipids.

33.5.3. Derived lipids

Steroids like cholesterol, fat soluble vitamins like vitamin A, D, E and K are a few examples of derived lipids. Cholestrol is an essential lipid which is manily obtained from our diet but are also synthesised within our body. It has a complex chemical structure which is shown in fig.33.8. Various steroid hormones (e.g testosterome, estrogen) are derived from cholesterol.

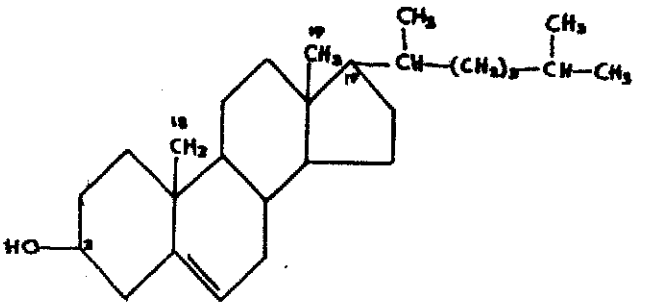


Fig. 33.8: **Chemical structure of cholestrol.**

In the next section, we will discuss about phospholipids in detail as they are the major component of all membranes in the cell.

INTEXT QUESTIONS 33.2

1 Classify lipids according to their structures

.....

2 What are simple lipids?

.....

3. What do you understand by compound lipids.

.....

4. Name two types of compound lipid.

.....

33.6 PHOSPHOLIPIDS

Lipids containing phosphorous are included in the general class of phospholipids Phospholipids have only two fatty acids attached to the glycerol molecule The third hydroxy group of glycerol is esterified to phosphoric acid and is bound to a secon alcohol molecul

Phospholipids are the lipids that con ain phosphorus a.d have the backbone of glycerol (eg. phosphoglycerides) or sphingosine (eg. sphingomyelin).

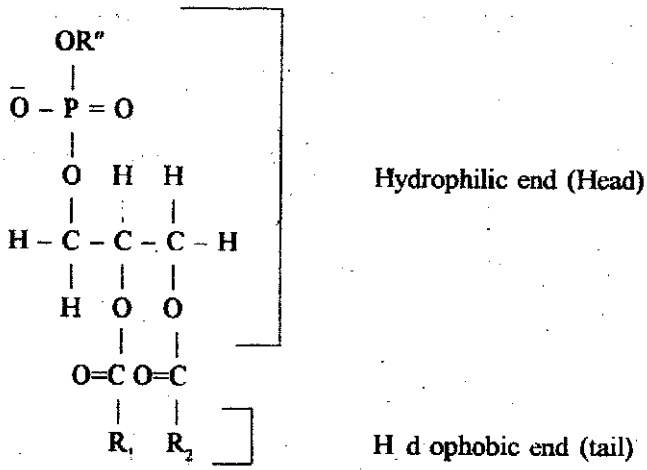


Fig. 33.9: **A phospholipid showing hydrophobic and hydrophilic region of the molecule.**

In fig. 33.9 R_1 and R_2 are two fatty acid molecules and R″ is a derivative of phosphoric acid.

The phospholipids have long hydrophobic fatty acid tails and a hydrophilic (polar) phosphate containing "head". Thus, phospholipids are amphipathic molecules (meaning one molecule containing both hydrophilic and hydrophobic region). Phospholipids are predominant part of biological membrane. Examples of important phospholipids are phosphotidylcholine, phosphotidylethanolamine, phoshphotidylserine and phosphotidylinositol. The differences between lipids and phospholipids is given in the Table 33.1.

Table 33.1 : Differences between lipids and phospholipids:

Lipids	Phospholipids
Simple lipids include neutral fats and waxes.	Compound lipids contain non-lipid component like phosphoric acids, sugar, proteins etc.
Neutral in nature. They are triglycerides commonly found in the cytoplasm of adipose (fat) cells.	Biological membranes are made up of bilayers of phospholipids.
Oils, fats and waxes are hydrophobic in nature and are immisible with water.	All the phospholipids have both hydrophobic and hydrophilic regions and are partially missible in water.

33.7 CALORIFIC VALUE OF FATS

Fats are the best source of energy. Energy is released by the oxidation of molecules. Fats are the richest source of energy because the energy released by the oxidation of one molecule of fatty acid is far more higher (at least twice) than that released by oxidation of glucose, which is another major source of energy in our bodies. The oxidation of palmitic acid (a fatty acid containing 16 carbon atom) to CO_2 and H_2O gives rise to 129 ATP molecules (129 ATP molecules are equivalent to 942 kilo calories of free energy) whereas only 36 ATP molecules are formed by the oxidation of glucose, a molecule with 6 carbon atom. If we compare the molecules of ATP released per carbon atom, even then ATP molecules yielded by the oxidation of palmitate are 129/16=8 and are more than that yielded by the oxidation of glucose i.e. 36/6=6 30-40% of the calories taken in everyday in average human diet are provided by the fatty acid components of the complex lipids present in the diet.

33.8 BIOLOGICAL FUNCTIONS OF LIPIDS AND FATS

1. Lipids are important structural components of cell membranes. They are mostly phospholipid, cholesterol and its esters.
2. Fats are cheif food storage compound and serves as a reservoir of energy.
3. Because of their high calorific value, they are rich source of respiratory energy.
4. They also transport cations across the lipid bilayer of biomembranes. Dietary lipids and fats are also essential for the efficient absorption of fat soluble vitamins A, D, E and K from the gastrointestinal tract.
5. Lipid and subcutaneous (layer just underneath the skin) fats serve as biological insulator against excessive heat loss (whales and animals living in cold region).
6. Adrenal corticoids (steroidal compounds secreted by adrenal gland) sex hormones and vitamin D_3 are synthesized from lipid derivatives.
7. They also protect internal organs from eventual damage on exposure to mechanical action
8. Many enzymes require lipid molecules for maximum activation.

INTEXT QUESTIONS 33.3

1. Define phospholipids.

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2. Write general strucutre of phospholipid.

.....

33.9 WHAT YOU HAVE LEARNT

- Fats and lipids are esters of glycerol and fatty acids.
- They are classified on the basis of their chemical structure.
- They are the main component of biological membranes.
- They also serve as storage of energy in cell.
- Phospholipids are amphipathic in nature.
- They have very high calorific value.

33.10 TERMINAL EXERCISE

1. W is a triglyceride? Write the general structure of a triglyceride.

.....

2. How is a triglyceride formed?

.....

3. Match the class of lipid given in column A with the group they are bonded with in column B.

A	B
1) Phospholipid	a) Sugar
2) Lipoproteins	b) Phosphorus
3) Glycoprot ins	c) Proteins

4. What is lecithin?

.....

5. Explain how fats are better source of energy than glucose.

.....

6. List the main differences between lipids and phospholipids.

.....

7 List the biological functions of lipids and fats.

.....

8. What the basic diffrence between fats and oils?

.....

CHECK YOUR ANSWERS

Intext Questions 33.1

1. Refer to Section 33.3
2 Refer to Figure 33.1.
3. Refer to Section 33.3.
4. Refer to Figure 33.2.
5. Refer to Section 3 4

Intext Questions 33.2

1. Three: Simple, compound and derived.
2. Refer to Section 33.5.
3. Refer to Section 33.5.
4. Phospholipids, glycolipids.

Intext Questions 33.3

1. Refer to Section 33.6.
2. Refer to Section 33.6, Figure 33.8.

TERMINAL EXERCISE

1. Refer to Section 33.1, Figure 32.2 and the paragraph above that.
2. Refer to Figure 33.2.
3.

A	B
1)	b)
2)	c)
3)	a)

Lecithin is a phospholipid. Write its structure refering to Figure 33.5.

5. Refer to Section 33.7.
6. Refer to Table 33.1.
7. Refer to Section 33.8.
Refer to Section 33.5.