Biochemical Engineering

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Lecture No. # 06

Lipids

In my earlier classes, I have already mentioned you about some of the macromolecules molecules present in the cell. Those macromolecules are either protein or carbohydrates or nucleic acids. Most of these macromolecules were soluble in nature. Today, I will be taking about a new molecule which are there in the cell but, it has got little different behavioral or different properties. Those types of macromolecules are called lipid.

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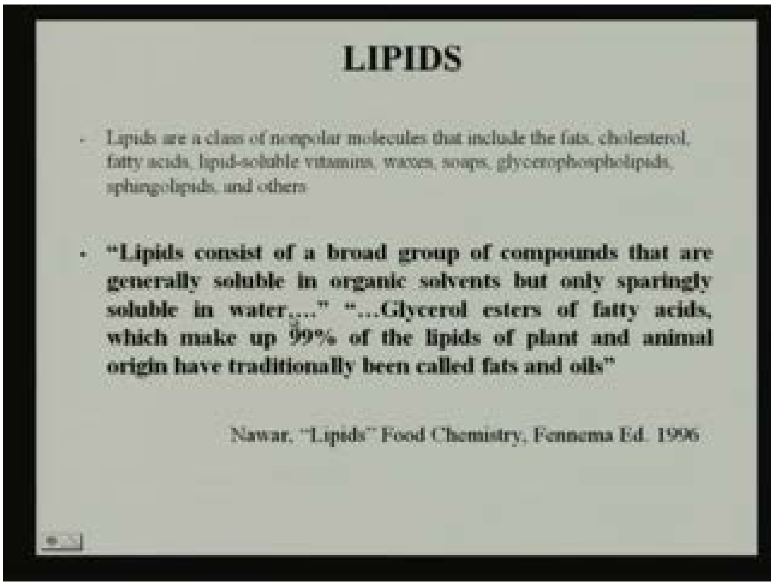

Now, if you see the lipids, then lipids are the nonpolar molecules that include fats, cholesterol, fatty acids, lipid-soluble vitamins, waxes, soaps and so on. Lipids consist of a broad group of compounds that are generally soluble in organic solvents and only sparingly soluble in water. Now, when we are taking about this lipid, this lipid molecule is present in every cell irrespective of microbial plants and animals. So, if you want to extract this lipid molecule, being nonpolar in nature, we have to use some solvent like chloroform benzene and so on, to extract this lipid molecule from the cell.

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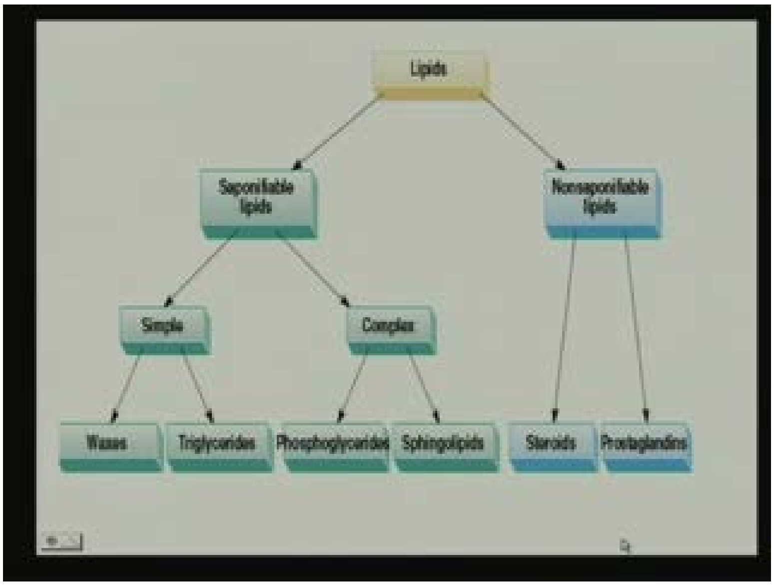

Now obviously, when I am taking about this particular macromolecule, so if we classify this lipid, entire lipid molecules, then we will find that the entire lipid molecule can be divided into two broad pairs like saponifiable lipid and nonsaponifiable lipid. That means, one type of lipid has some characteristics of soap formation and this type of lipids are further divided into simple lipid and complex lipid.

So, these particular classifications have been done based on the structural or this structural behavior of this lipid contain of the lipid molecule. Now, another group is the nonsaponifiable lipid steroid and prostaglandins are some of the example of that. Now, as I have mentioned that the classification is done based on the backbone structure of these lipid moieties.

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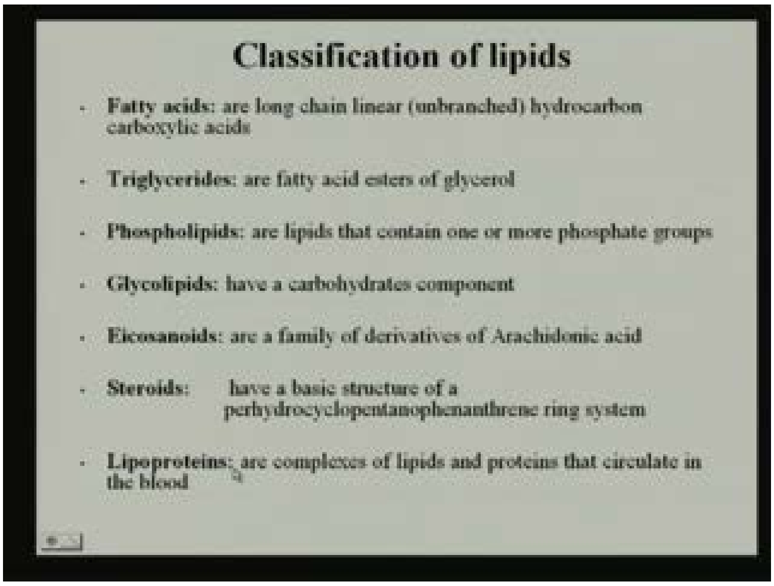

So, obviously the structure of these lipid molecules is coming to the picture. Now, when we are doing this classification, fatty acid is one of such long chain linear unbranched hydrocarbon, which is present in the lipid moieties. It has got a carboxylic acid group present attached to its core moieties. Triglycerides, phospholipids, glycolipids, eicosanoids lipids, steroids, lipoproteins are the different types of lipids which are there present in the lipid family.

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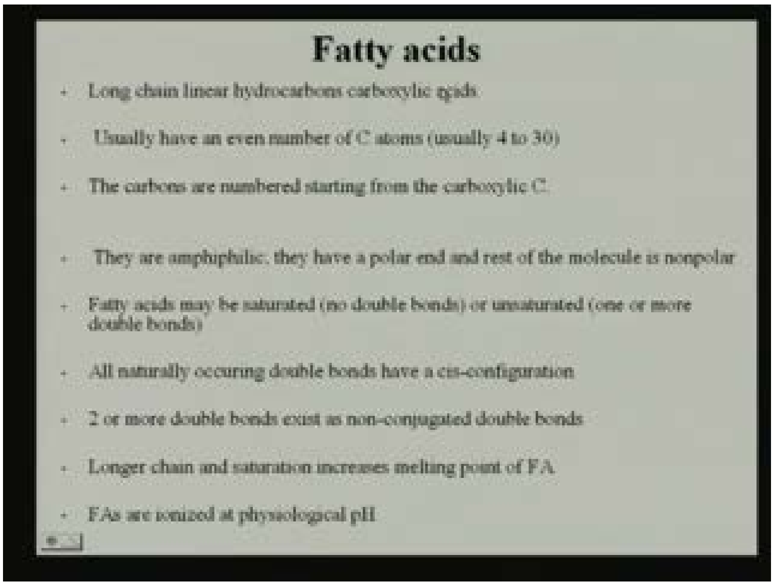

Now, let us come one by one. When we are taking about this fatty acid, it is the long chain linear hydrocarbon having that carboxylic acid end. Now, that means, it has got a carboxylic acid end.

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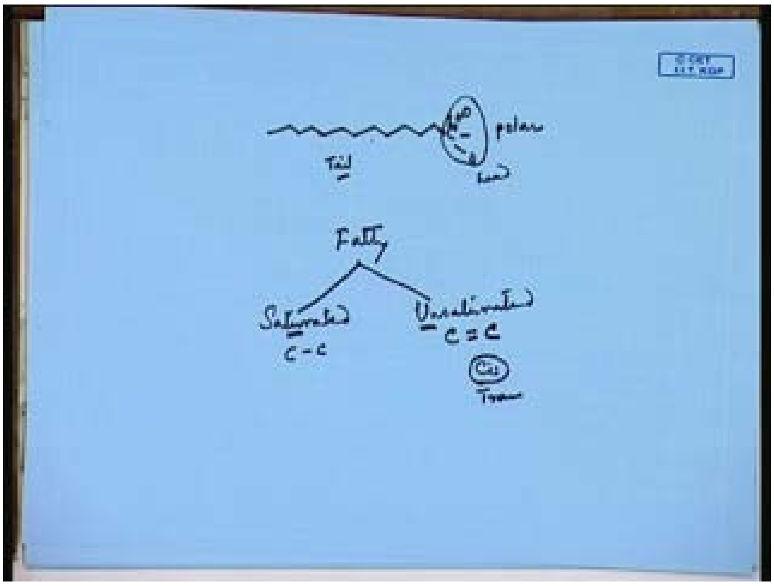

Now, if we are talking about this particular acid, then this carboxylic group which is there and if we considered about this chain then, we can find that this fatty acid has got one carboxylic end group, which is polar in nature and nonpolar chain like structure. That is, the tail part, one is the head and another is the tail. This hydrocarbon chain is the long chain, which is attached to this carboxylic end of this fatty acid. The chain length can be varied from four to thirty. The carbon, a number starting from this carboxylic end, that means, this is the carbon atom number 1 when it is 2 3 4 5 6 7 8 9. That way the numbering is done.

Now, it is amphipathic in nature. That means, it has got one polar end and one nonpolar end. Fatty acids may be saturated or unsaturated. That means, when we can tell that fatty acid is saturated, that means entire fatty acid can be divided into two parts. One is called the saturated fatty acid and another is the unsaturated fatty acid. Now, when this is saturated fatty acid? When there is no double bond present in this fatty acid. There is only the linear chain along with a carboxyl end. This chain length may get very different depending upon the nature of that fatty acid. But, when the double bond is present in between the nonpolar tail group, then we are calling, we call that type of fatty acid as the unsaturated fatty acid. All naturally occurring double bonds had a cis-configuration. So, most of this double bonds are, either it can be found either in the cis form or in the trans form. So, in most of the cases, this fatty acids are found in the cis form. I will be coming to this, the positional, this, what is cis and trans gradually. Now, two or more double bonds exist as non-conjugated double bonds and longer fatty acid and saturation increases the melting point of the fatty acid. Fatty acid gets ionized at physiological pH. That means, at pH around 7.4.

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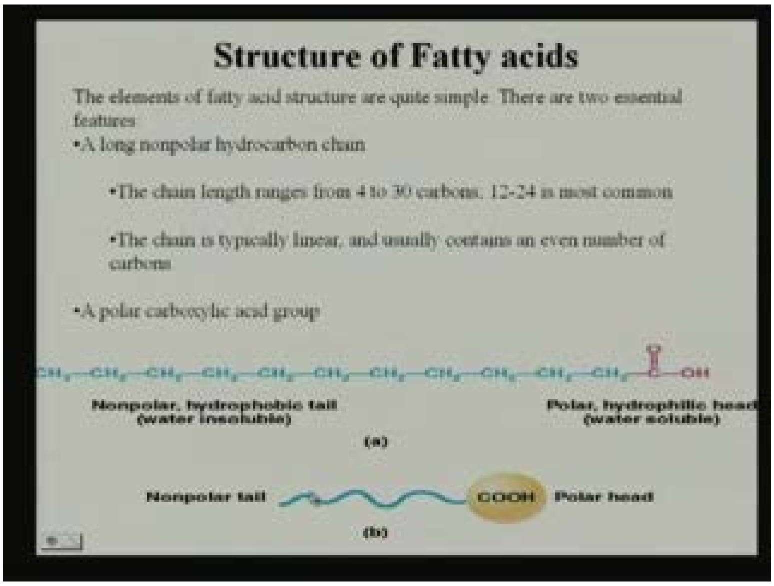

Now, as I have already discussed the structure, you see, here is a long chain which is the tail group. Nonpolar hydrophobic tail, which is water insoluble and here, the polar end which is hydrophilic in nature and this is the head group. So, we will present this COOH as the polar and the tail, which is attached as the nonpolar.

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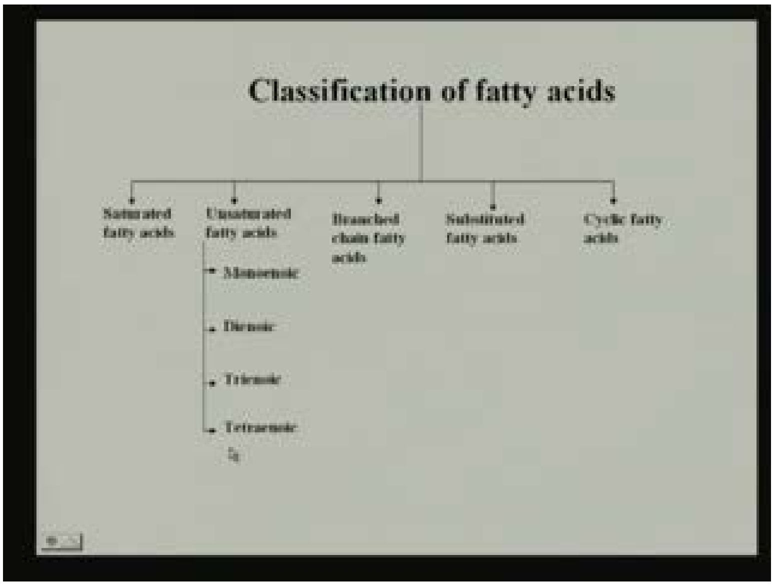

This fatty acid is once again classified into saturated and unsaturated. Sometimes, it is the branched fatty acid, substituted fatty acid and cyclic fatty acid. That means, besides this saturated and unsaturated, we can also get this fatty acid in a much more complex form. That means, sometimes we are getting it in the branched condition, substituted condition and sometimes we are getting in a cyclic form. When we are taking about the unsaturated fatty acid, it may be monoenoic acid, dienoic acid, trienoic acid, tetraenoic acid and so on.

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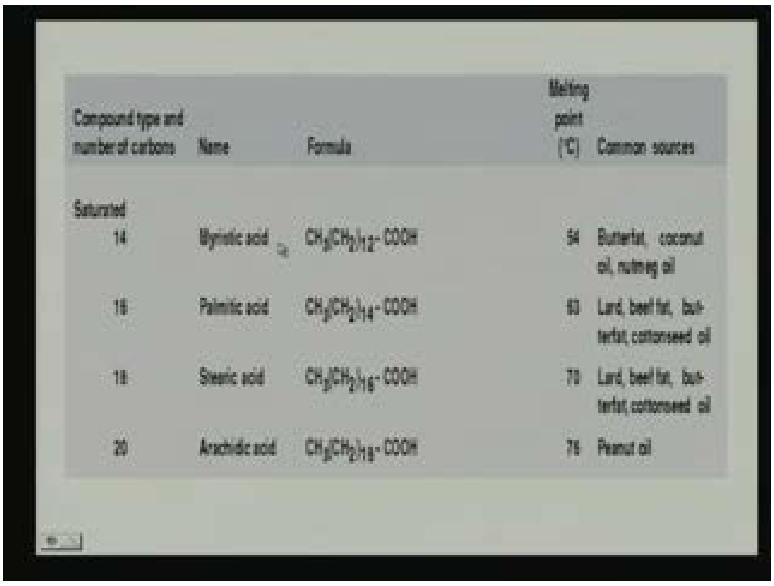

Compound type and number of carbons	Name	Formula	Melting point (°C)	Common sources
Saturated				
14	Myristic acid	$CH_3(CH_2)_{12}$- COOH	54	Butterfat, coconut oil, nutmeg oil
16	Palmitic acid	$CH_3(CH_2)_{14}$- COOH	63	Lard, beef fat, butterfat, cottonseed oil
18	Stearic acid	$CH_3(CH_2)_{16}$- COOH	70	Lard, beef fat, butterfat, cottonseed oil
20	Arachidic acid	$CH_3(CH_2)_{18}$- COOH	76	Peanut oil

Now, coming to the saturated fatty acid. As I have mentioned already, that saturated fatty acid has no double bond within it. If we are considering the total number of carbon present is 14, then myristic acid is one of the example. Now here, you see, total C carbon, the number of carbon atom present in this fatty acid is 14. We can get this type of fatty acid in butter fat, coconut oil and so on. When we are considering the 16 carbon molecule, then it is the palmitic acid. Here also, no double bonds are there. So here, 18 carbon is the stearic acid and so on. This way, the number is getting increased and the property and the characteristics are also getting changed. Now, this palmitic acid is found in lard, beef fat, coconut seed oil and so on. So, these are the common examples of saturated fatty acid.

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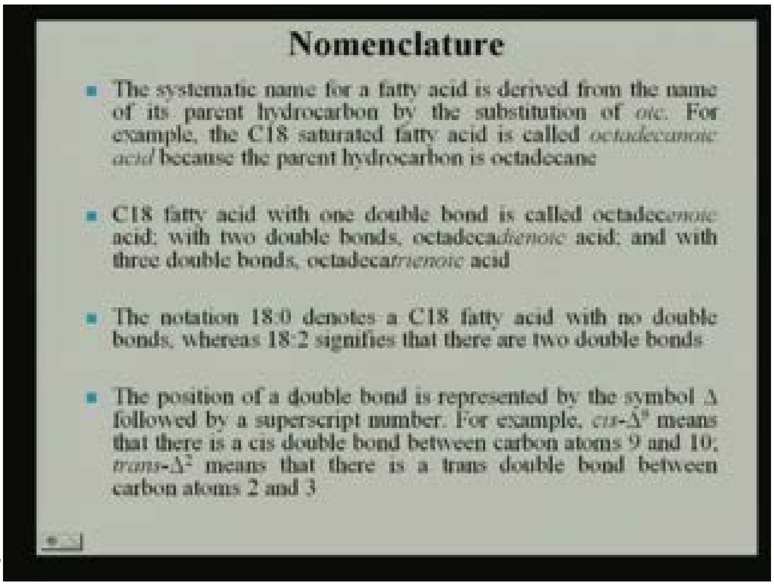

Now, coming to the nomenclature. The systematic name of the fatty acid is derived from the name of the parent hydrocarbon by the substitution of oic. For example, the C18 saturated fatty acid is called C18. That means, 18 carbon containing chain, that is octadecanoic acid. So, because the parent hydrocarbon is the octadecane, C18 fatty acid if it is having double bond then it is called octadecanoic acid. If two double bonds are there, then octadecadienoic acid and with three double bonds, then octadecatrienoic acid. Depending upon, as I have mentioned that, monoenoic, dienoic, trienoic, tetraenoic in that way, the naming has been done.

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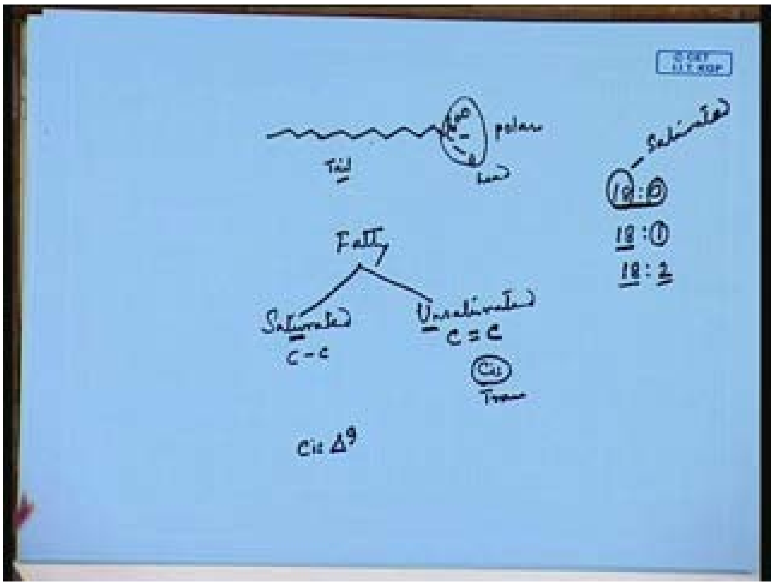

Now, sometimes we are getting some symbol like 18 is to 0. Sometimes, we are getting 18 is to 1. Sometimes, it is 18 is to 2. What is it mean? It means that, fatty acid is having 18 carbon atom and it has no double bond. That means, it is a saturated fatty acid. When we are getting 18 is to 1, that indicates that, 18 carbon atom containing fatty acid, the chain and one double bond is present in this. 18 is to 2, that means, 18 carbon fatty acid and two numbers of double bonds are present in this particular molecule. So, how it will be? This is the meaning of this particular 18 is to 1, 18 is to 2, 18 is to 0 and so on. The position of double bond is represented by the symbol delta followed by a superscript number. That means, if suppose the bond is cis type of bond and if it is written delta to the power 9, what does it mean. That means that, this fatty acid is arranged in a cis-configuration and this double bond is present in carbon atom 9 and 10. So and if it is suppose, trans delta 2, it means that there is a trans double bond between carbon atom 2 and 3. In this way, the numbering is done.

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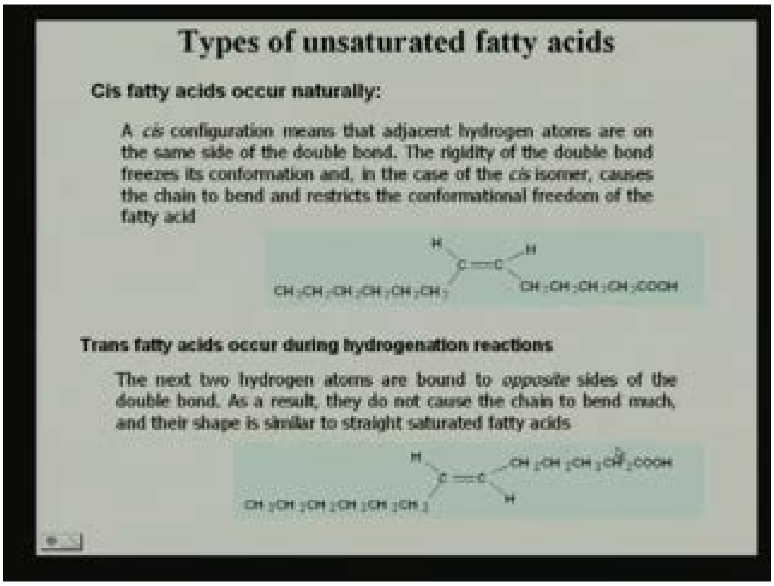

Now, if suppose, we are taking about the cis and trans configuration, then we can find that a cis-configuration means that the adjacent hydrocarbon atom is on the same side. See here. It is on the same side of the double bond. The rigidity of the double bond freezes the conformation and in the case of Cis isomer, causes a chain to bend and restricts the conformational freedom of the fatty acid. That means, in this type of configuration, we can find a kink in this fatty acid chain where this double bond is present. In case of this trans fatty acid, the next two hydrogen atoms are bonded in the opposite side of the double bond. As a result, they do not cause the change to bend much and their shape is similar to straight saturated fatty acid. So, this is the trans form of this fatty acid; transformed arrangement. Here, as their positions are like this, they do not get, we do not get a much kink or bend in this double bond side.

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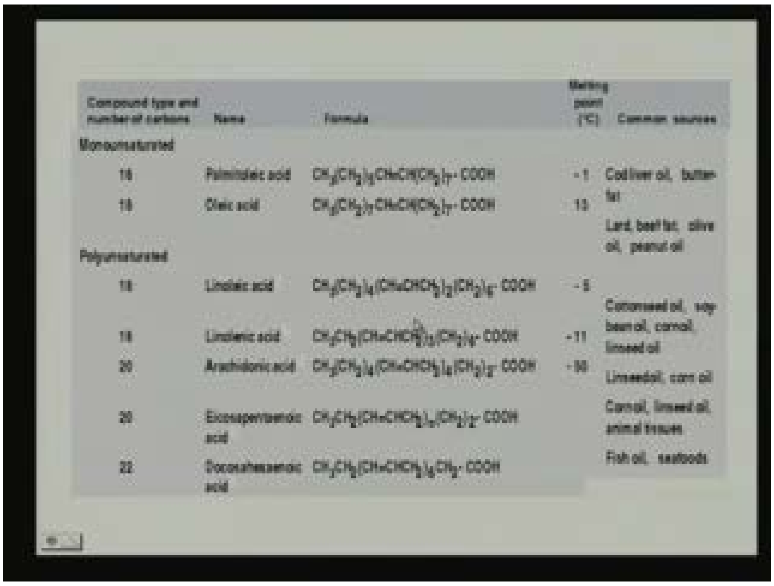

Now, if we see some of this example of the monounsaturated fatty acid and poly unsaturated fatty acid, then we can find that palmitic acid, oleic acid, linoleic acid, linolenic acid and so on, this is depending upon the carbon chain. Number of fatty acids, the naming has been done. So here, in case of palmitoleic acid, here you see, here only one double bond is there. When we are considering oleic acid, then here you can find that here also, single bond is there. In case of polyunsaturated fatty acid and linoleic acid, we are getting two double bond. Linolenic acid, we are getting three double bond and so on.

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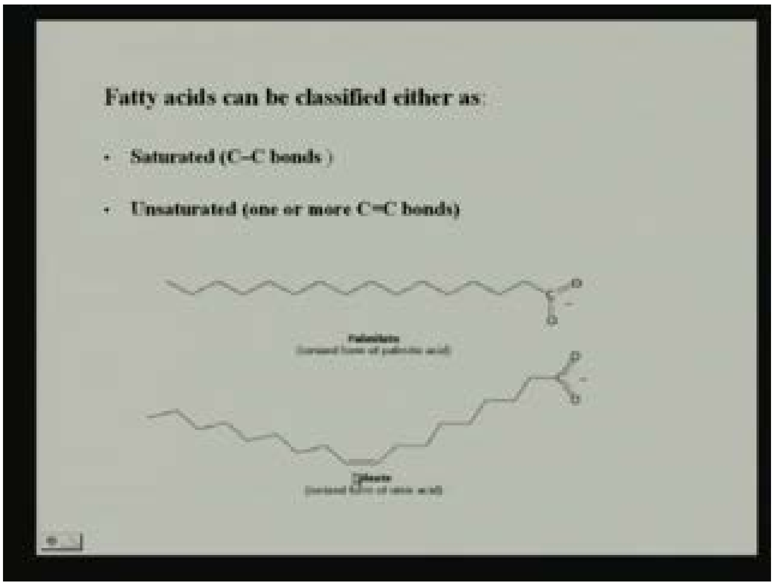

So, this way the chain is getting increased. So here, you see this is the saturated fatty acid and this is the unsaturated fatty acid. See, 1 2 3 4 5 6 7 8 9 and 10 carbon atom. So, when I am talking about cis delta 9, that means in between 9th and 10th carbon atom, the double bond is present and it is the oleic acid.

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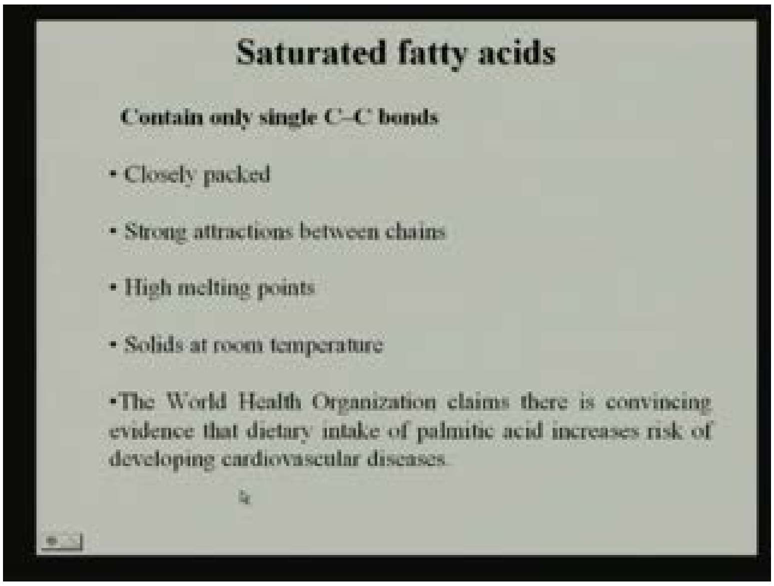

Now, coming to this saturated fatty acid. As I have already mentioned that, it is, it does not have any double bond closely packed, strong attraction between chains, high melting points, and solids at room temperature. It is a well established fact and world health organization also claims that, if a person is continuously taking a saturated fat or a saturated fatty acid, then he or she will have definitely the cardiac diseases. in with the continues taking of the this saturated fats.

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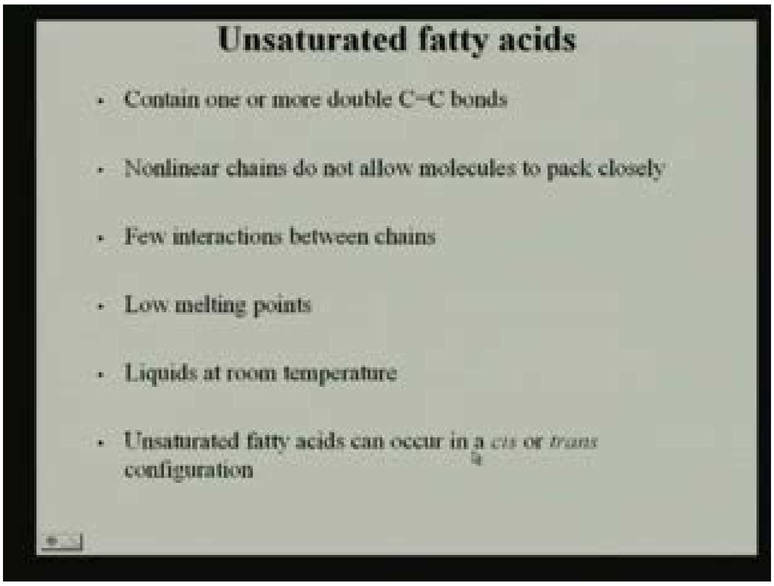

So, what is the unsaturated fatty acid? It contains one or more double bond. If one double is there, it is mono. If it has more than 1, 2 and 3, that is the polyunsaturated fatty acid. That is, pufa. Non-linear chains do not allow molecules to pack closely. Few interactions are there between the chains and that is reason, it has got a low melting point and liquid at room temperature and unsaturated fatty acid can occur in a cis or the trans configuration.

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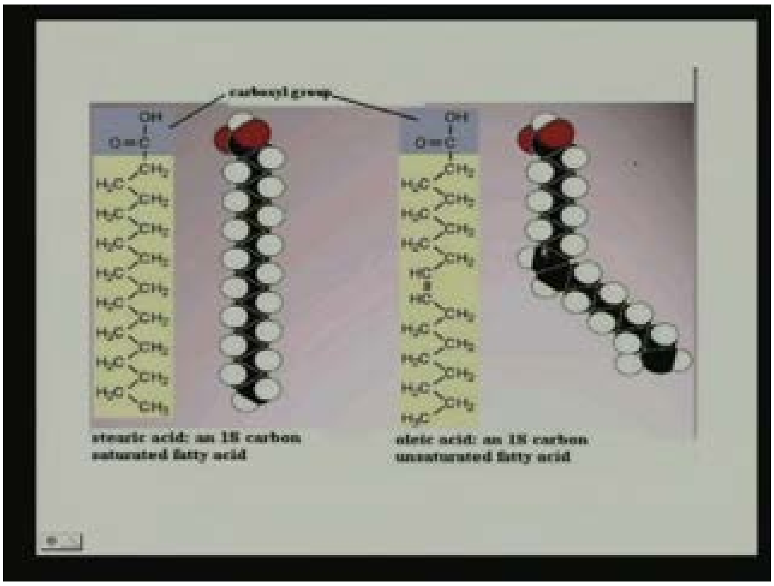

Now, if you see the structure of stearic acid; see here, the carboxylate and straight chain fatty acid. Whereas, in oleic acid, you see, here also it is 18 carbon molecule and here the double bond is present. It is also ending with the carboxylate. So, it starts with the carboxylate and when it is coming 1 2 3 4 5 6 7 8 9 and 10, this double bond is there. See, there is a kink. There is bent to this. That is making the inter property or inter characteristics of the molecule different.

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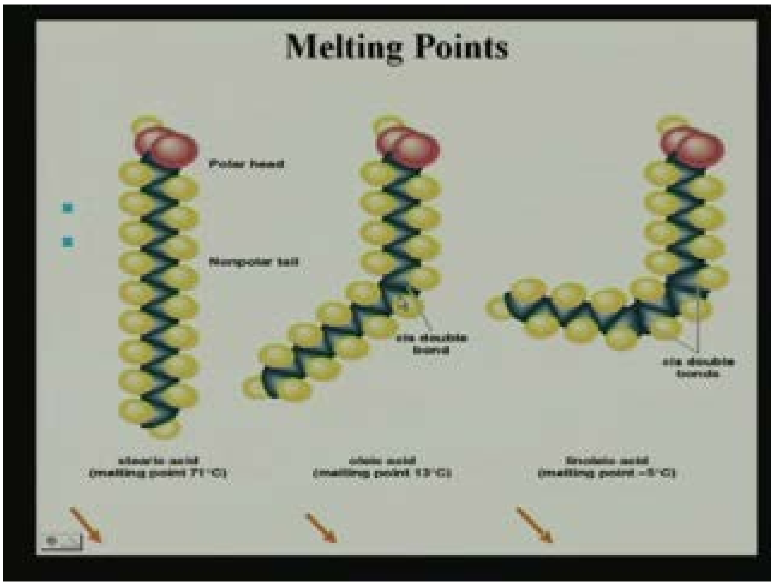

Now how? If the stearic acid has got melting point of 71 degree centigrade because, it is closely packed molecule. See here, melting point is 71 degree centigrade. In case of oleic acid, it is 13 degree centigrade and in case of linoleic acid, you see here, two double bonds are there and you see the melting point is minus 5 degree centigrade. So, with the number of double bonds, the characteristics and the behavior of the entire molecule is getting changed.

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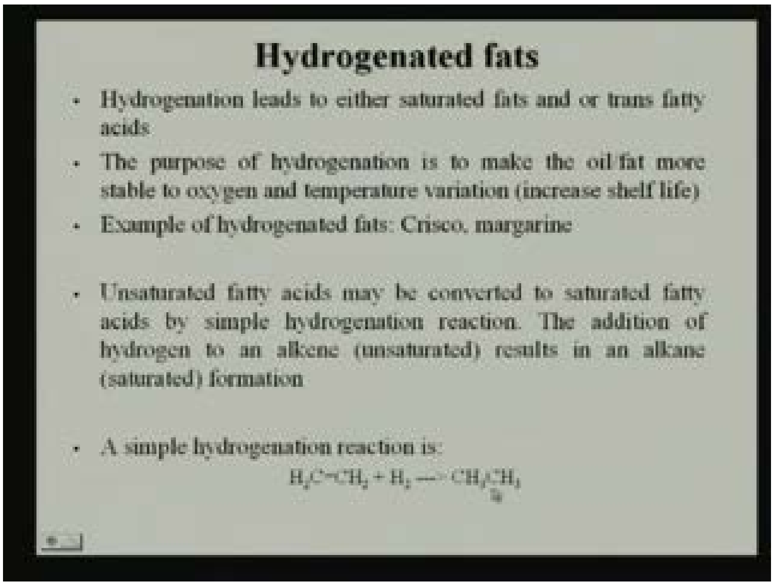

If we come to this hydrogenated fat, hydrogenation leads to either saturated fat and or trans fatty acid. The purpose of hydrogenation is to make the oil and fat more stable to oxygen and temperature variation. It also increases the shelf life of product. Now, one of the example of this is, the Crisco or margarine etcetera. Unsaturated fatty acid may be converted to saturated fatty acid by simple hydrogenation reaction. By the addition of the hydrogen, we know that that, alkene can be converted to alkane. If we say the hydrogenation reaction, so this type of reaction is taking place resulting in the hydrogenated fat. Dalda is one of the examples of this hydrogenated product.

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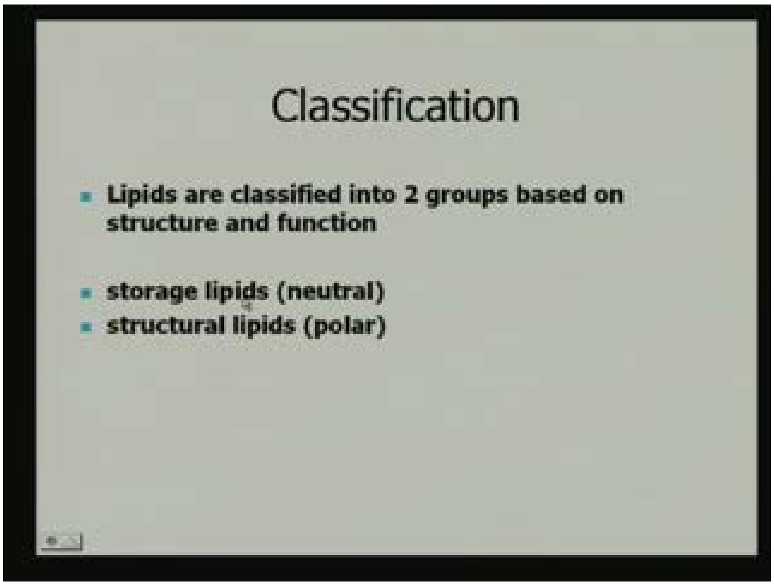

Now, this is, as I have already mentioned about this classification, it is based on the backbone structure of the fatty acid. This fatty acid, this lipid molecule can also be classified based on its biological structure and function. It can be divided into two parts. One is the storage lipid and another is the structural lipid.

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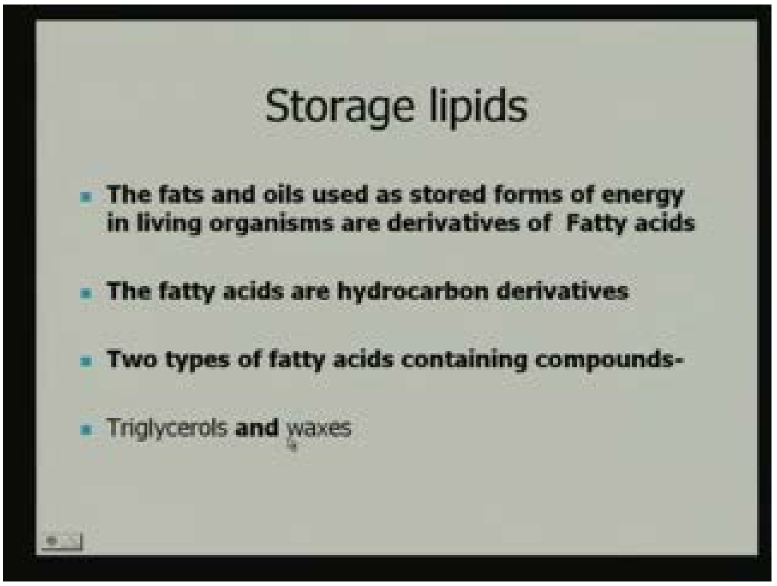

Now, when we are coming to the storage lipid, the fats and oils used in stored forms of energy in living organisms are derivatives of the fatty acids. The fatty acids are hydrocarbon derivatives. Two types of fatty acids containing compounds are there. Triglycerols and waxes are the example of the storage lipid molecule.

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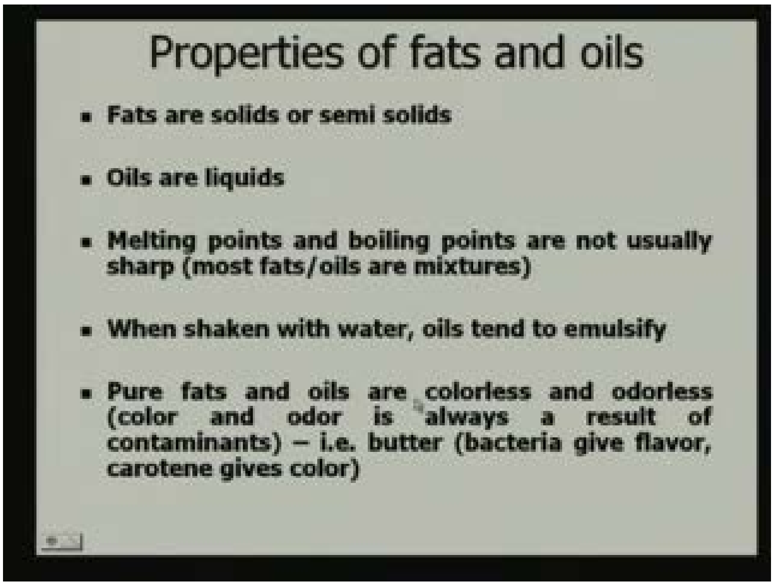

Now, when we are talking about properties of the fats and oils, fats are solid or semi solids in nature and oils are liquid. Melting point and boiling point are not usually sharp in case of this fats and oils. When shaken, it forms the emulsified product and pure fat and oils are colorless and odorless. Once we are getting some odor or color, we can easily detect that this particular product is contaminated.

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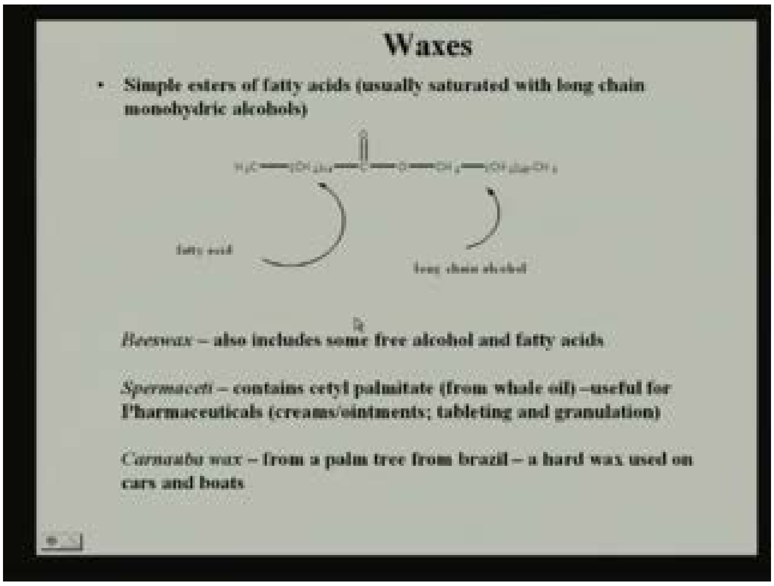

Now, coming to the wax. Wax is the example of simple lipid. Now, it is the simple ester of fatty acid and it has got a very long chain of monohydric alcohol, which is attached to this, its structure. Now, when it is warm, we are getting a soft form of wax. But, when it is at room temperature, then we are getting a solid mass of wax.

Now, when we see the different forms of these, the wax is present in different biological molecules. Then, we can find that, it is acting as a coating material of many biological molecules. Say for example, it is present in the skin, fur, feather etcetera. In some animals, waxes are also present on the exhaust skeleton. In case of some insects, it is present on exhaust skeleton. This particular molecule has got fatty acid, long chain fatty acid and long chain alcohol within its core moieties. It is also present in higher plants and animals too. Now, some of these examples, this beeswax is one of the example of the wax. Now, it is also, this bee wax also contains the fatty acid and some free alcohol within it.

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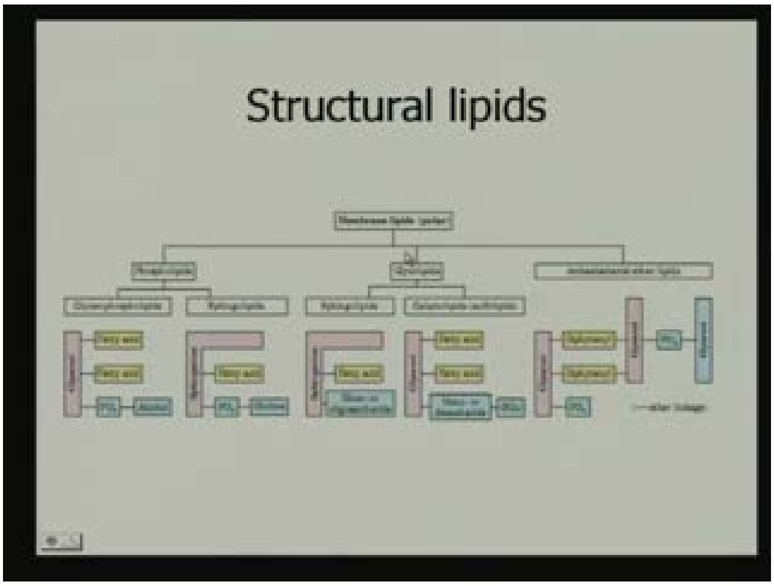

Now, coming to the structural lipid. If we see the structural lipid, that indicates, the name itself is telling that it is giving the structural support or strength to the membrane of the cell wall of the cell. If we see the membrane lipid, membrane lipid is one of the very important example of where the structural, this lipids are playing a very important and significant role. It can be divided into different parts. Say for example, phospholipid, glycolipid and archaebacteria ether lipid. So, these are the different composition of this structural lipids, which are mainly present in the cell wall or cell membrane of the cell, of any animal or plant cell. Now, glycerol phospholipid, sphingolipids are the example, and galactolipid are the example of such type of lipid molecule, where either the glycerol are sphingosine are present as the core moieties.

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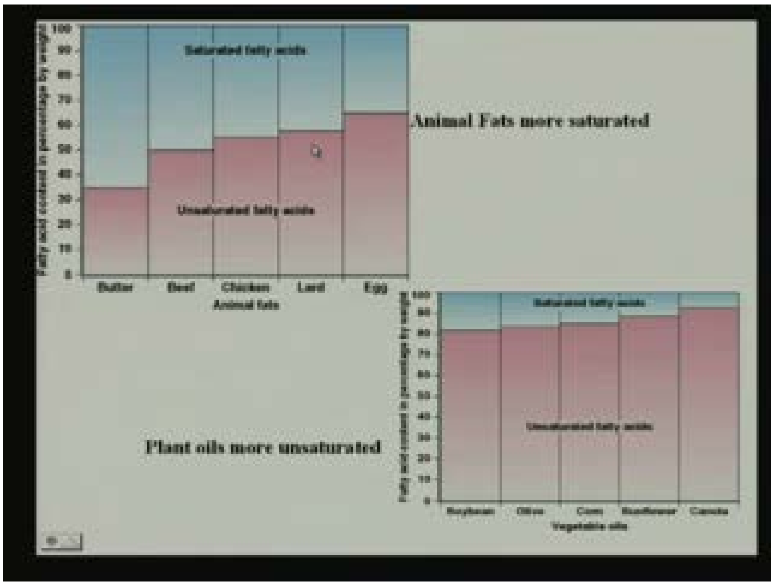

Now, I will be coming in details about structure gradually. Now, if we see the sources of different lipid molecules in animals as well as plants, we can find that, in animal system, whatever is the lipid molecule present is mostly the saturated form of lipid molecule. Here, the proportion of saturated versus unsaturated, you see, starting from butter, beef, chicken and animal fat, lard, eggs etcetera, you see, here the proportion of unsaturated fatty acid is much smaller compared to the plant sources. Here, the amount of unsaturated lipids or unsaturated fatty acids is more compared to the animal fat. Here, you see the difference between plant lipid and the animal lipid.

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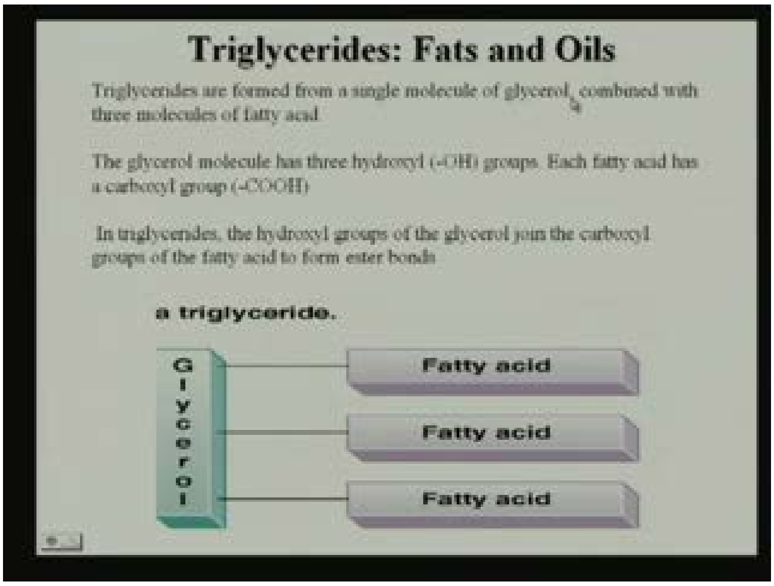

Now, coming to the triglycerides. Triglycerides are formed from a single molecule of glycerol. Now, if we see the structure of glycerol, then what we can see, glycerol is the three carbon molecule, CH 2 OH CHOH and CH 2 OH. This is the glycerol moieties.

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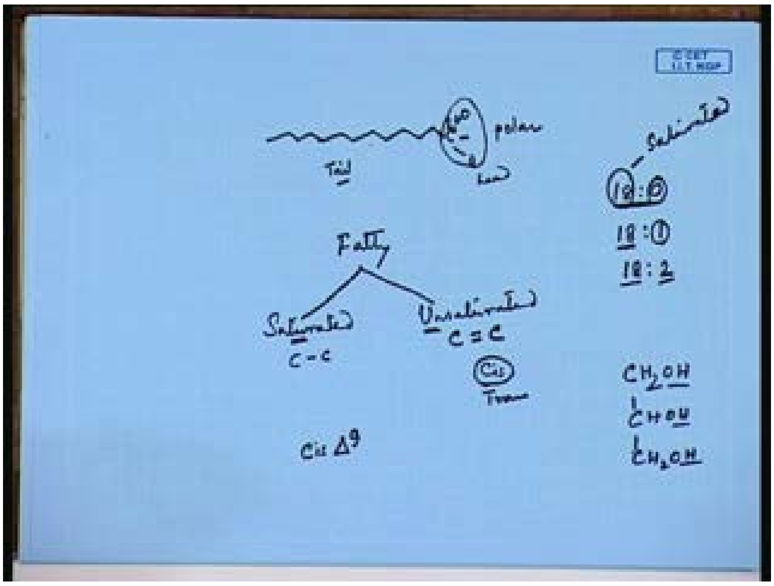

So, here in triglycerides, a single molecule glycerol is there combined with the three molecules of fatty acid. The glycerol molecules have three hydroxyl OH group within it. Each fatty acid has a carboxyl end. That I have already mentioned that, any fatty acid has got a carboxyl or the polar end within it. So, in triglycerides, the hydroxyl group of glycerol joins the carboxyl group of the fatty acid to form the ester bond. That means, this hydroxyl group and carboxylic group is getting linked with each other with the ester linkages and they form the triglycerides.

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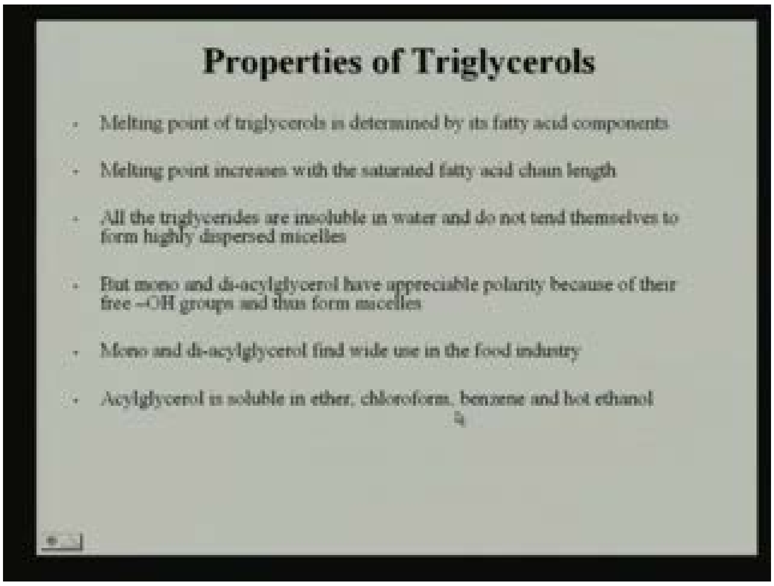

Now, if we see the properties of the triglycerols, then we can find that the melting point of triglycerols is determined by its fatty acid component. Melting point increases with the saturated fatty acid and its chain length. All the triglycerides are insoluble in water and do not tend themselves to from highly dispersed micelles. But, mono and diacylglycerol have appreciable polarity because of their free hydroxyl group. Thus, they can form micelles structure. Mono and diacylglycerol find wide use in the food industry. Acylglycerol is soluble in ether, chloroform, benzene and also in hot ethanol.

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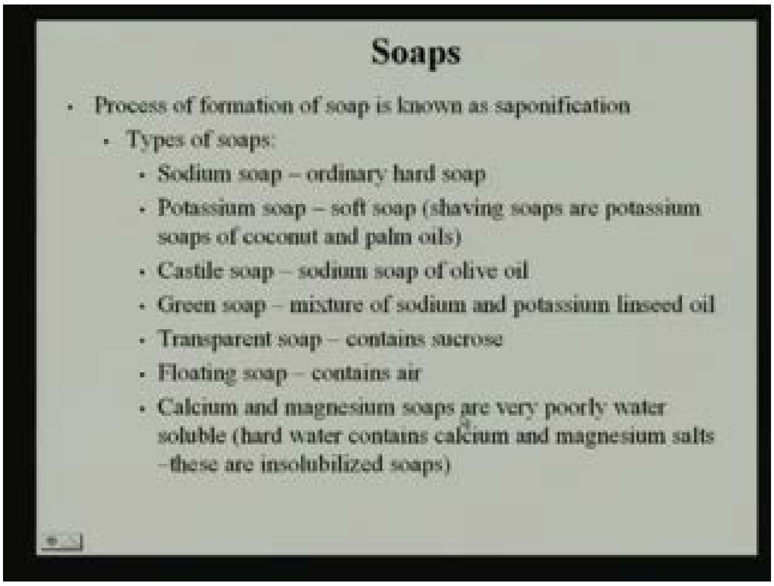

Now, when I was talking to you about the saponifiable lipid, now soap is one of the example of saponification process. Now, here if we see the types of soap, we can classify that sodium soap, which is an ordinary hard soap. Potassium soap, it is the soft soap, which is used for the shaving purposes. Castile soap, that is the sodium soap with olive oil and green soap, it is the mixture of sodium and potassium linseed oil. Transparent soap, it contains sucrose along with its structure and floating soap, it contains air. Calcium and magnesium soaps are very poorly water soluble in nature. These are the different types of soap molecules.

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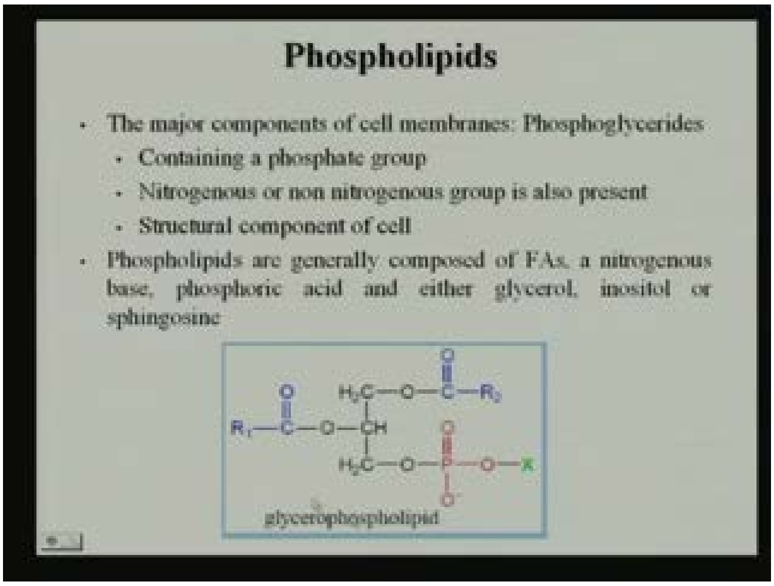

When we are coming to this phospholipid, we can find that the major component, it is one of the major constituent of the cell membrane. Phosphoglycerides contain a phosphate group and nitrogenous or non-nitrogenous group is also present in it. It is the structural component of any cell. Phospholipids are generally composed of fatty acids, nitrogenous base and phosphoric acid and either glycerol, inositol or sphingosine within it. See, I have already talked to you about the glycerol molecule CH 2 OH CHOH and CH 2 OH. See, here this, in this core moieties here, this core moieties, say first group is attached with the fatty acid. Second group is also attached with the fatty acid and third group, you see, one phosphate is attached and one x is there.

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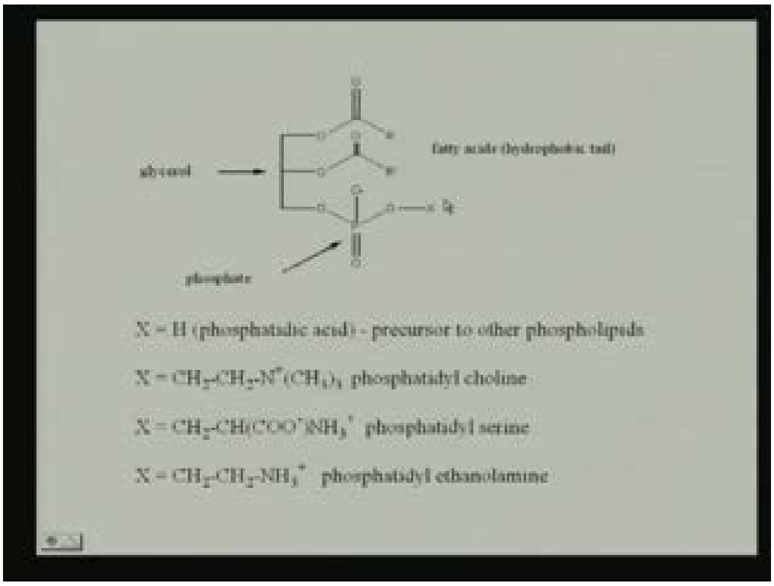

This x may be the precursor for the phospholipids and it may be phosphatidic acid. It may also be phosphatidyl choline or it may be phosphatidyl serine, phosphatidyl ethanolamine and so on. So, this is the core structure and this is the glycerol structure along with this fatty acid hydrophobic tails which are there and to this, this phosphate moieties are attached and to this x group, where this precursor of the phospholipids, phosphatidyl choline, phosphatidyl serine, phosphatidyl ethanolamine any moieties can come and join and form the molecule.

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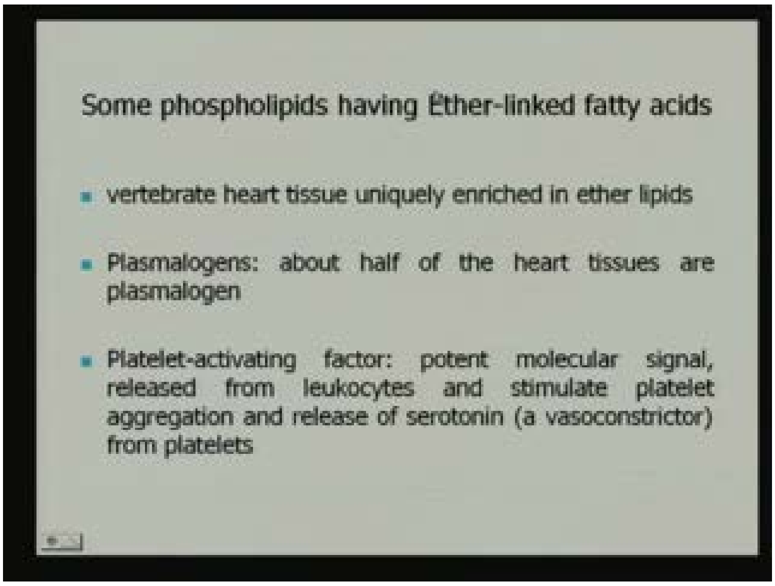

Some phospholipid, which has the ether-linked fatty acids are there in a living system. Some of the examples are, vertebrate heart tissue is uniquely enriched with this type of ether lipids. Plasmalogens, that is, half of the heart tissues are the plasmalogens. Platelet activating factors are also the example of the ether-linked fatty acid.

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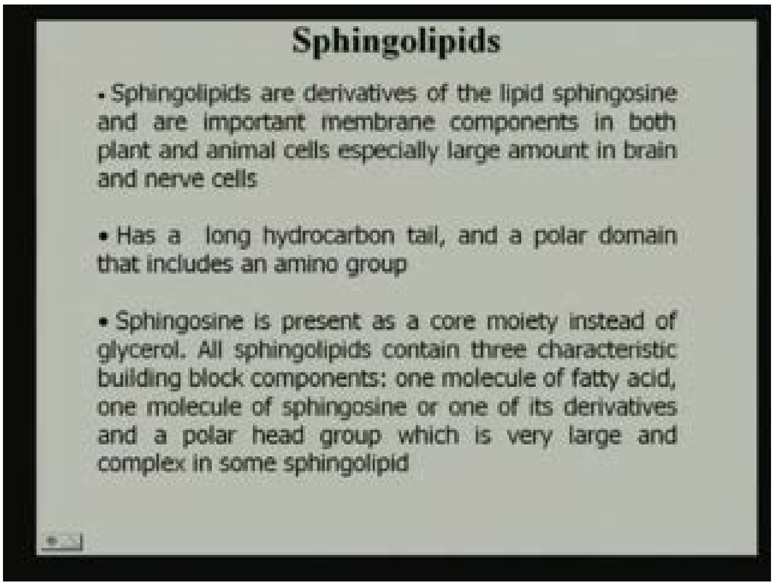

Now, coming to the sphingolipid. Sphingolipids are derivatives of the lipid sphingosine and are important membrane component in both plant and animal cells, especially large amount of brain and nerve cells. So, this particular lipid moieties are mainly present in the brain and nerve cells and play a very significant role. It has a long hydrocarbon tail and polar domain that includes an amino group. Sphingosine is present as a core moiety instead of glycerol. Now, in case of this phosphoglycerol, what I have told? Here, if you see, this main, it is the glycerophospholipid. Here, the main moieties are the glycerol moieties.

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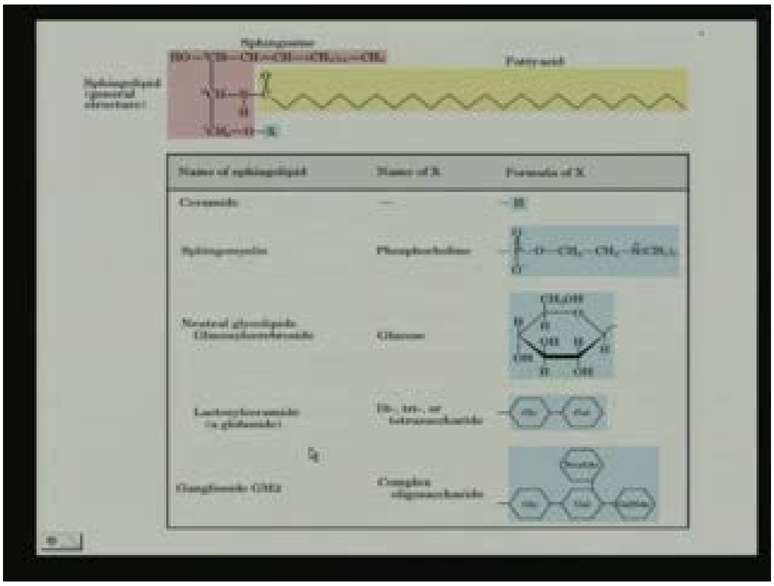

But, in this case, in case of sphingolipid, if we see the structure, here we can find, this is the sphingosine molecule along with this (( )) fatty acid is attached and this x group may be phosphocholine, glucose, oligosaccharide, which can be di, tri or tetrasaccharide. Thus, the oligosaccharide can be a simple sugar to a complete sugar molecule, which are attached to the sphingosine group. Lactosylceramide and ganglioside are the examples of oligosaccharide containing sphingolipid. Other examples of sphingolipids are sphingomyelin, neutral glycolipid etcetera. Sphingosine, that means sphingolipid.

If we see, then sphingosine has got a lipid sphingosine molecule moieties within this and which is replacing the glycerol of the other type of fatty acid. All sphingolipids contain three characteristics of building block components; one molecule of fatty acid, one molecule of sphingosine or one of the derivates of the polar head group, which is very large and complex in some sphingolipid. So, these are some of the example of the sphingolipid.

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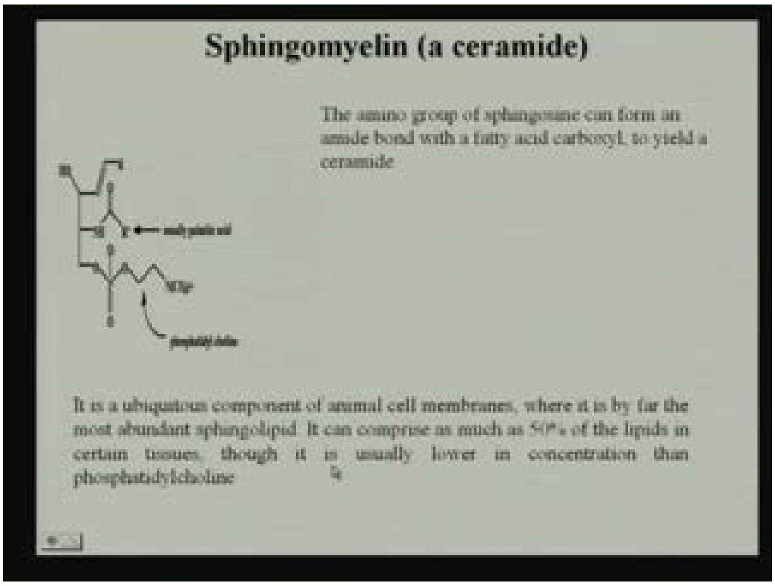

Now, coming to this spingomyelin. It is a ceramide. The amino group of sphingosine can form an amide bond with the fatty acid carboxyl group to yield a ceramide. So here, this is the bonding, which is this ceramide. This is the amino group, which is getting bonded. It is ubiquitous component in the animal cell membrane, where it is, by far the most abundant sphingolipid. It can comprise as much as 50 percent of the lipid in certain tissues, though it is usually found in lower concentration than the concentration of phosphatidylcholine, which is present in the cell.

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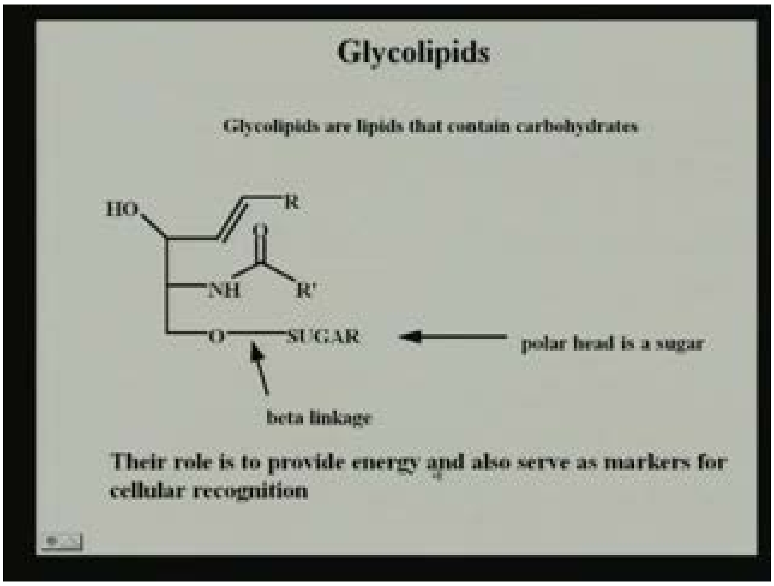

Similar to that is another type of lipid, which is called as glycolipid. As name itself indicating that, in glycolipid, they contain the carbohydrates moieties within it. That means, sugar moieties are there, which has got linked with the beta linkages. As I have already told you, alpha linkages and beta linkages. So here, it is attached with the beta linkages and polar head group is there for this sugar. Their role is to provide energy and also to act as a marker for cellular recognition. So, this is the major activities of the different types of lipid molecules.

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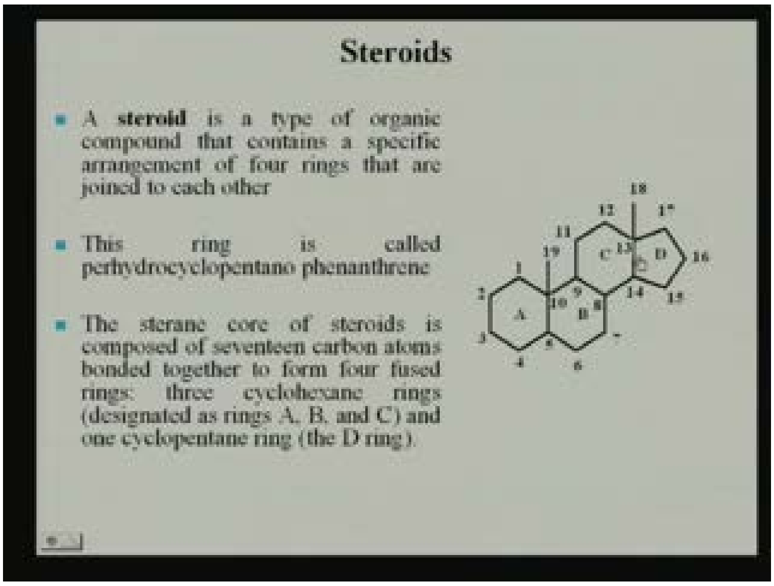

Now, I will be coming to another type of lipid moieties, which is called as the steroids. Now, the steroid is a typical, a type of organic compound that contains a specific arrangement of four rings, that is joined with each other. That means, if we see the structure of steroid, we can find that, you see, it has been denoted as A ring, B ring, C ring and D ring. Now, if we see A, B and C, then we can find that, this A, B and C ring are cyclohexane ring. Along with this cyclohexane, the D ring, which is attached, is the cyclopentane ring. Now, this ring is also called as perhydrocyclopentano phenanthrene ring. Now, this sterane core of steroid is composed of seventeen carbon atoms bounded together to form a four fused rings. That is, three are cyclohexane, and one is cyclopentane. So that means, this is a very complex water insoluble lipid moieties.

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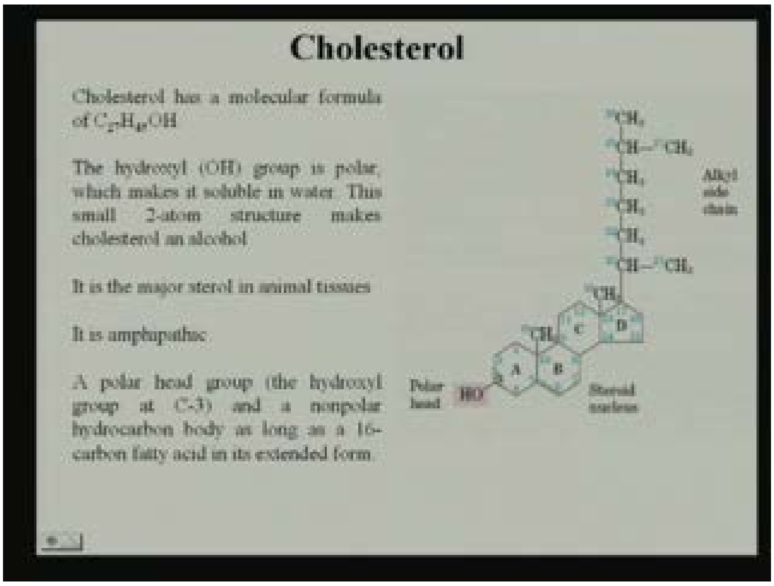

Cholesterol is one of such example of this steroid. Cholesterol has a molecular formula of C 27 H 45 OH. That means, it has got one hydroxyl group which is polar in nature, which makes it soluble in water. This small two atom hydroxyl group structure makes the cholesterol an alcohol. It is the major sterol in the animal tissues. It is amphipathic in nature. That means, on the third carbon of this, first A ring, that hydroxyl group is attached. A polar head, the hydroxyl group at carbon atom number three and a nonpolar hydrocarbon body as long as 16 carbon fatty acid in its extended form. So total, it has got 27 carbon atom and 16 carbon fatty acid is also attached as a alkyl side chain molecule. This is the steroid nucleus. Here, one hydroxyl group is attached on the carbon atom number three.

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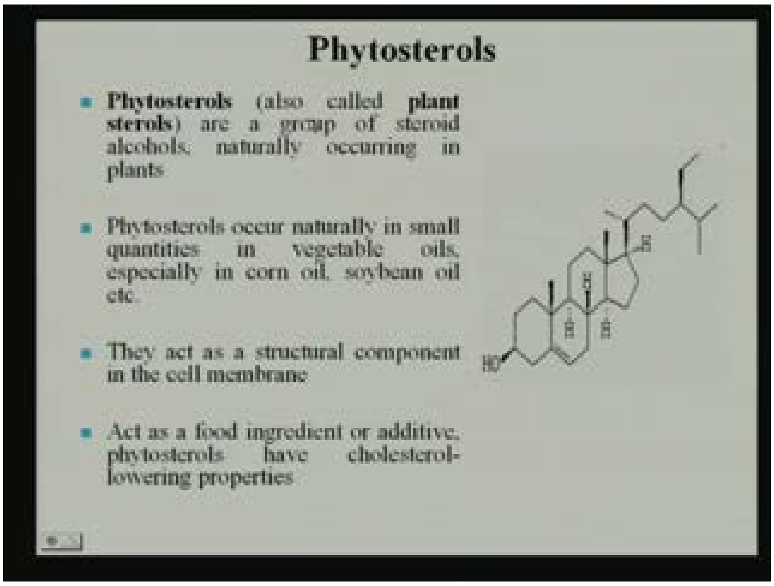

While coming to phytosterols, phytosterols is also called the plant sterol. Phytosterols are a group of steroid alcohols, naturally occurring in plants. Phytosterols occur naturally in small quantities in vegetable oils, especially in corn oil, soybean oil etcetera. They act as a structural component in the cell membrane and it also acts as a food ingredient or additive. That is, phytosterols have cholesterol lowering properties. That means, this phytosterols, as I have already mentioned that, cholesterol is present in the animal system and similarly, phytosterol is found in the plant system.

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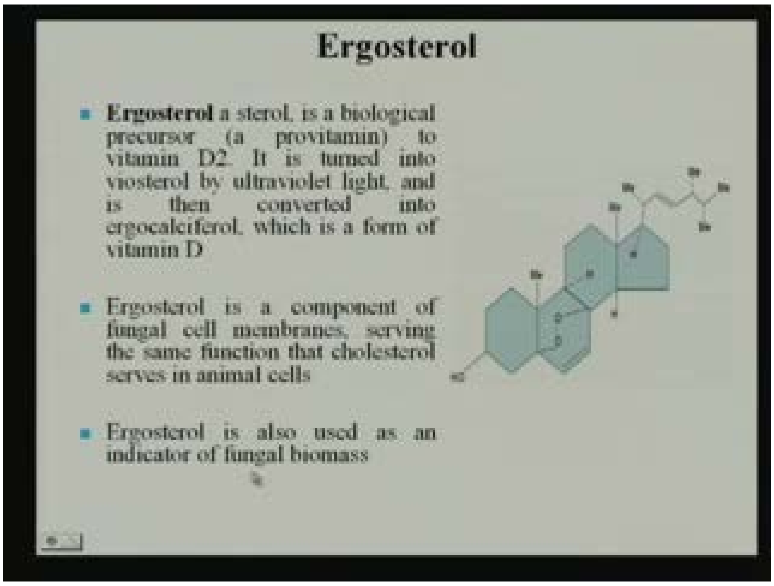

When we are coming to this ergosterol, it is also a sterol. It is a biological precursor or the provitamin of vitamin D2. It is turned into viosterol by ultraviolet light is then converted into ergocalciferol, which is a form of vitamin D. Ergosterol is component of fungal cell membrane, serving the same function that cholesterol serves in the animal cell. Ergosterol is also used as an indicator of the fungal biomass estimation. Now, this ergosterol, as I have told that, phytosterol is present in a plant and ergosterol is also present. In another type of microbial word, that is the fungus, the filamentous fungus. In any case of this fungal biomass, this ergosterol is present.

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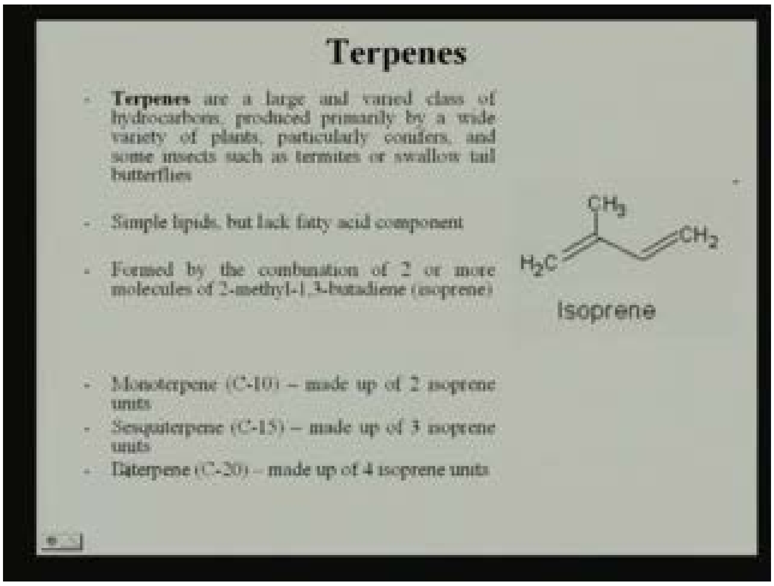

Coming to another component, that is the terpenes. Terpenes are the large and varied class of hydrocarbons produced primarily by the wide variety of plants, particularly coniferous and some insects such as termites or swallow tail butterflies. Now, this is the isoprene molecule. When two such isoprene molecules are coming in association with each other, they form the terpenes. It is a simple lipid but, lack fatty acid component within its core moieties. It forms the combination of two such moieties, that means one isoprene molecule is having five carbon. Now, when two such moieties are associated with each other, so total carbon of carbon atoms present in that structure is C 10. So, monoterpene is the example of that. It is made up of two isoprene units. When three such isoprene molecules are associated, it is called sesquiterpene. When whole isoprene units are there, it is called diterpene terpene and so on.

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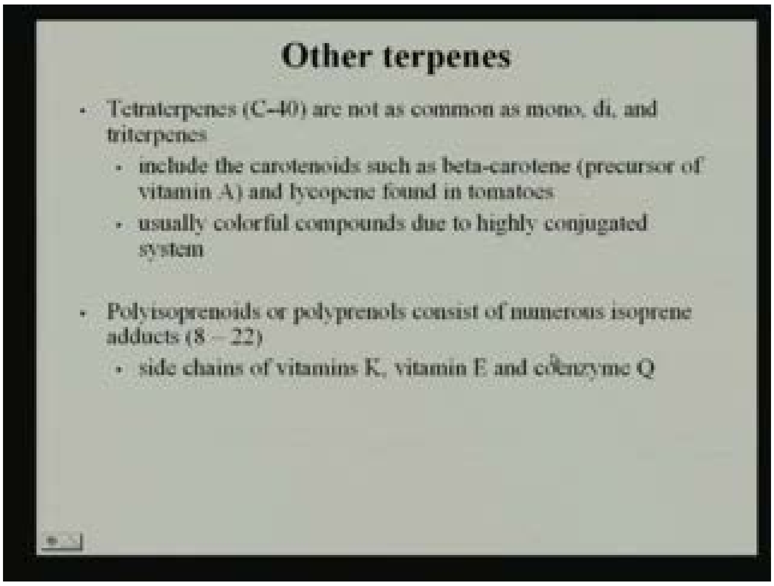

If we see the other terpenes, then tetraterpenes are also present, where the total number of carbon atom is 40. Tetraterpenes are not as common as mono, di and triterpenes. It includes the carotenoids, such as beta carotenoid as a precursor of vitamin A and lycopene of the tomatoes. Lycopene is the colour component. It is usually colourful compounds due to highly conjugated systems are there. Polyisoprenoids or polyprenols consist of numerous isoprene adducts, that is 8 to 22 of such and side chain of vitamin K, vitamin E and coenzyme Q are some of the examples of polyisoprenoids molecule.

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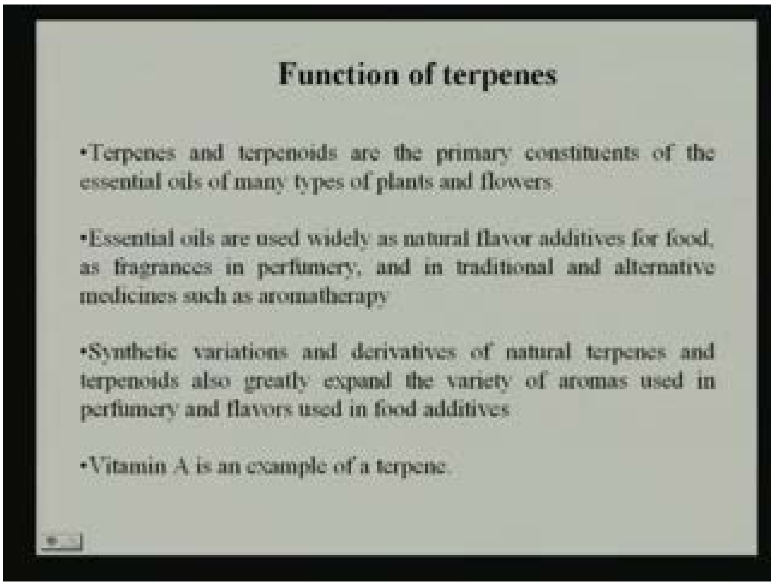

If we see the function of the terpene, then terpenes and terpenoids are the primary constituents of the essential oil of many types of plants and flowers. One of the main applications of this terpinoids are in the field of medicine, such as aromatherapy. The synthetic variation and derivatives of natural terpenes and terpenoids also greatly expand the variety of aromas used in the perfumery and flavors, which is used in the food industries or food additives. Vitamin A is an example of a terpene molecule. Now, if we are talking about these particular terpenes, that are gerin oil, limonin, menthol and so on. These are some of the example of this flavor component or constituent which is nothing but, the terpene molecules.

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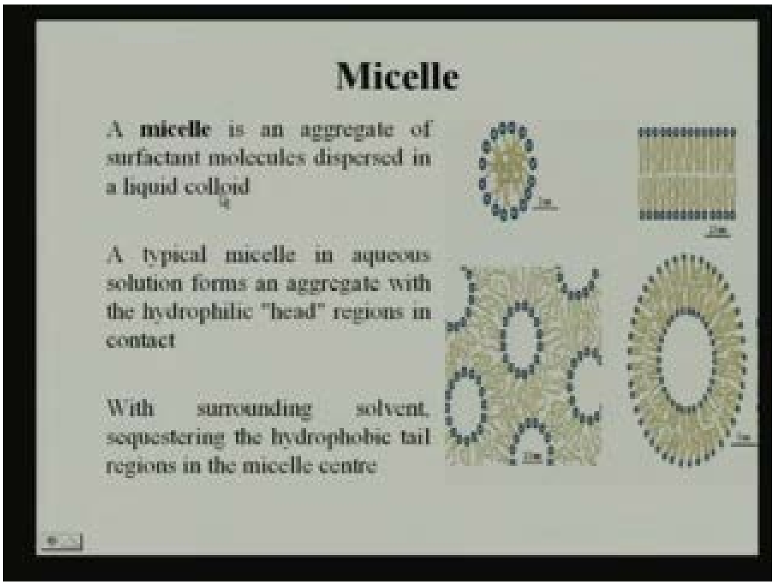

So, when we are coming to this micelle, the micelle is the aggregate of surfactant molecules dispersed in liquid colloid. Now, as I have already mentioned you that, while discussing the structure, we have seen that fatty acid has got a polar end and a nonpolar tail.

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Now, when a typical micelle in aqueous solution forms an aggregate with the hydrophilic head regions in contact, with the surrounding solvent, sequestering hydrophobic tail region in the micelle centre. Now see, when it is in the aqueous environment, what is happening? This heads, all the heads in the aqueous environment, what is happening? This aqueous, if it is the aqueous environment, then aqueous environment is very good for this hydrophilic molecule to go and it is not at all suitable for the hydrophobic.

So, this is the aqueous. So, hydrophilic in polar head is getting exposed outside and it is just bringing the hydrophobic tail to inside. When such types of associations are there, then it forms the micelle structure. This is the micelle in the aqueous solution. When it is present in a bilayer formation, here is the polar head and nonpolar tails are there. When two bilayer forms are there, see here, the polar head and nonpolar tails. Here also you see, the outer layer, the polar head and nonpolar tails are there. When it forms this type of moieties, it is called the liposome.

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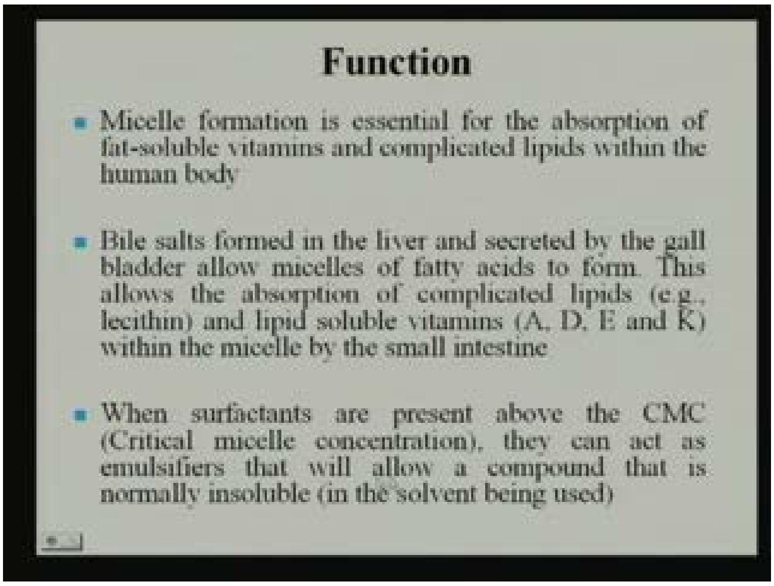

Now, the function of these micelles are, the micelle formation is essential for the absorption of fat-soluble vitamins and complicated lipids within human body. Bile salts formed in the liver and secreted by the gallbladder allow micelles of fatty acid to form. This allows the absorption of complicated lipid, that is a lecithin type of lipid and lipid soluble vitamins, that is vitamin A D E and K, within the micelle by the small intestine. When surfactants are present above the critical micelle concentration, they can act as emulsifies that will allow a compound that is normally insoluble in nature.

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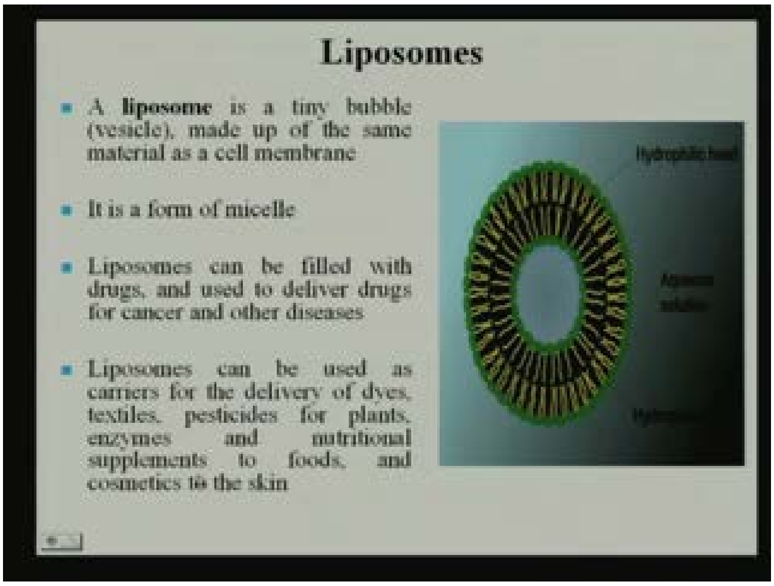

Coming to this liposome. The liposome, as I have mentioned that, the liposome is a tiny bubble vesicles made up of the same material as a cell membrane. It is a form of micelle. Liposomes are filled with the drugs and used to deliver drugs for cancer and other diseases. So here, this aqueous head in the, this is the polar head and this, here also, the polar head and it is the bilayer. It is hydrophobic inside and it helps the drug to transport from one place to another. This type of system is used for drug delivery. Liposome can be used as a carrier for delivery of dyes, textiles, pesticides for plants, enzymes and nutritional supplement to foods and cosmetics to the skin.

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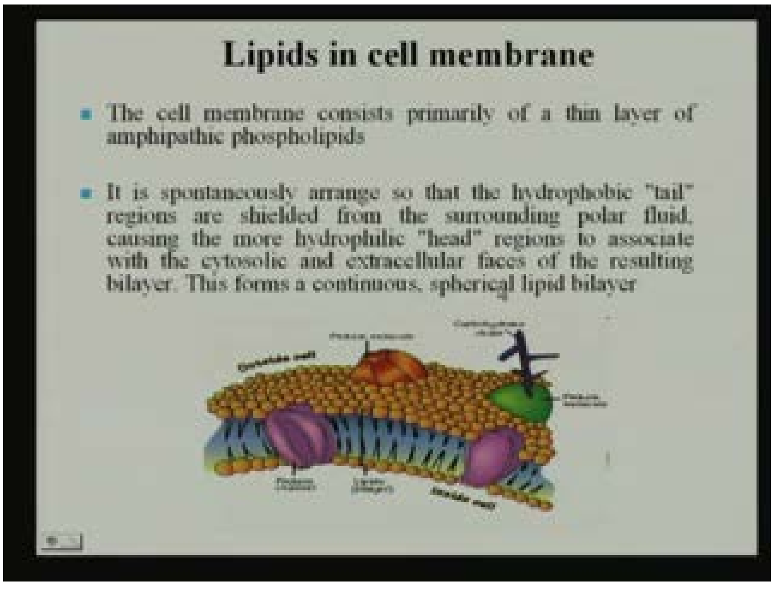

Coming to this lipid in the cell membrane. The cell membrane consists of primarily the thin layer of amphipathic phospholipids molecules. Here, you just see, this lipid bilayer are there. This polar head and here also lipid, this polar heads are there and nonpolar tails are there inside. It is spontaneously arranged, so that, the hydrophobic tail region is shielded from the surrounding polar fluid, causing the more hydrophilic head reason to associate with cytosolic and extra cellular faces of the resulting bilayer. This forms a continuous, spherical lipid bilayer.

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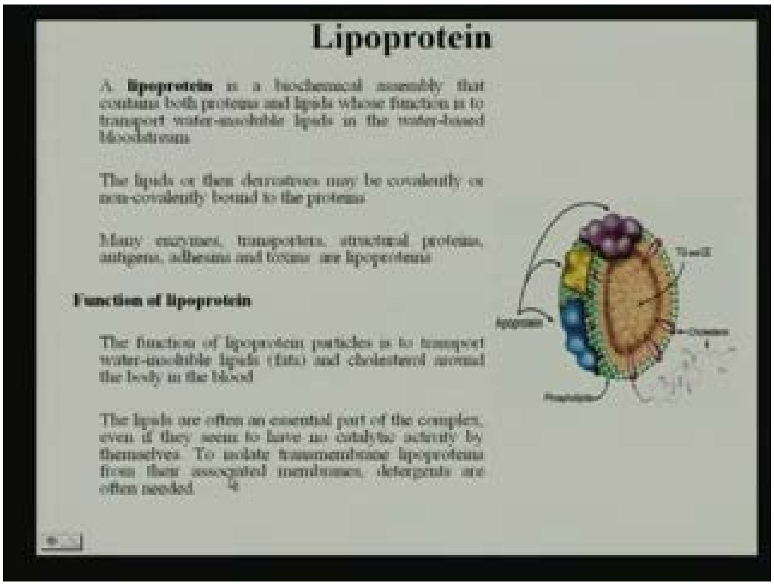

Now, if we come to this lipoprotein, we can find that a lipoprotein is a biochemical assembly that contains the polar proteins. It contains both proteins and lipids whose function is to transport water insoluble lipid in the water based bloodstream. That means, this is, this lipoprotein is mainly acting in the transport of water insoluble lipids from one side to another through the bloodstream. This lipids or their derivatives may be covalently or non-covalently bound with the protein molecule. Many enzymes, transporters, structural proteins, antigen, adhesins and toxins are some of the example of lipoprotein.

Now, if we see the function of lipoprotein, then the main function of lipoprotein particles is to transport water insoluble lipids. That is, fat and cholesterol around the body in the blood. That means, through the bloodstream. The lipids are often an essential part of the complex, even if they seem to have no catalytic activity by themselves to isolate trans membrane lipoprotein from there associated membrane and that is the reason detergents are often used for this purpose.

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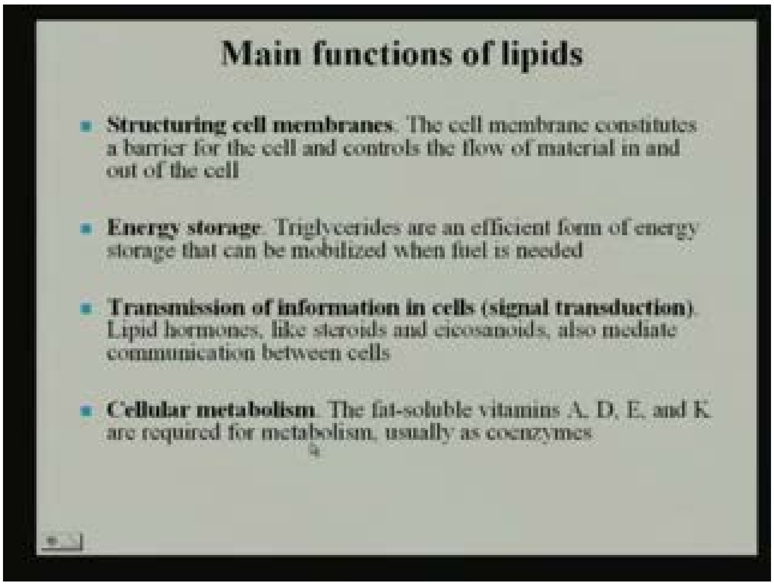

Now, if we see the main function of lipids, then we can find that, the main function is the structuring the cell membrane, energy storage, transmission of information in the cell, that is the signal transduction and cellular metabolism, that is the fat-soluble vitamins A D E and K are required for metabolism, which are usually acting as an coenzyme. That means, we can find that lipid is one of such macromolecules which are present and they do not have any catalytic activity. But, it is forming; it is present within the cell system in a conjugated form. It is forming the complete structure with other different macromolecules, which is present in the cell system.

It performs different activities. The major role is the soluble, the polar and nonpolar end which are there. Because of this amphipathic in nature, the polar head and nonpolar tail are getting associated and they are just doing the function of, by exposing the head to the aqueous space and tail away from that particular environment. They do different functions like drug delivery and different lipid insoluble, this, the water insoluble transportation of different biomolecules from one side to another. So, with this, today I am concluding the macromolecule which is entirely different. Its character is entirely different from the other macromolecules, which we have already discussed and we have learned. Thank you very much.