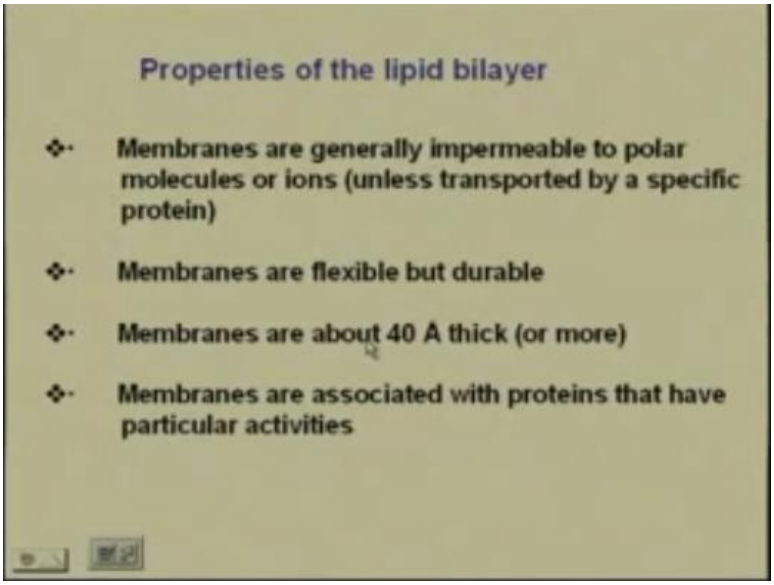
Biochemistry
Prof. S. Dasgupta
Department of Chemistry
Indian Institute of Technology, Kharagpur

Lecture -14
Lipids and Membranes - II

Okay, we continue at the discussion on lipids and membranes. And in the last class we learnt, what comprises lipids of the membrane. We learnt that we can have glycerophospholipid or sphingolipid that that will look or could assemble into basically by layer, okay. Now we going to look at the properties of the lipid bilayer and see how it forms and what are the basic physical and chemical properties of this bilayer and how it actually can—we will learn about a transportation later on from one end of the cell to the other.

(Refer Slide Time: 01:27)



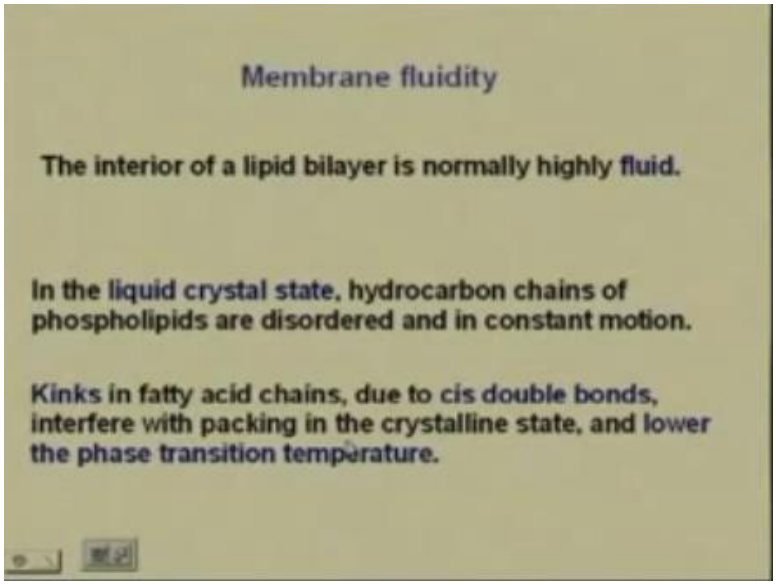
So if you look in the properties of the lipid bilayer they are usually impermeable to polar molecules or ions. Now you understand why that is so because you have the polar head groups on the surface only. And if we have to have to transportation from the inside of the cell to the outside or from the outside of the cell to the inside then it is not possible because of the hydrophobic chains that are present going in reversing the whole membrane.

So normally the membranes are impermeable to the polar molecules or ions unless we have some specific proteins that facilitate the transport. We will see how we can have active transport or

passive transport. The membranes themselves are flexible but they are very strong and they durable, they do not just rapture. Then membranes can be about Angstroms thick or even more than that.

And membranes are associated with specific proteins that have definite activities, okay. So the basic properties of the bilayer are that they do not allow the transport of ions unless assisted by a protein. They are flexible, they are quite thick 40 Angstroms and they are associated with proteins that have specific activities associated with it.

(Refer Slide Time: 03:10)

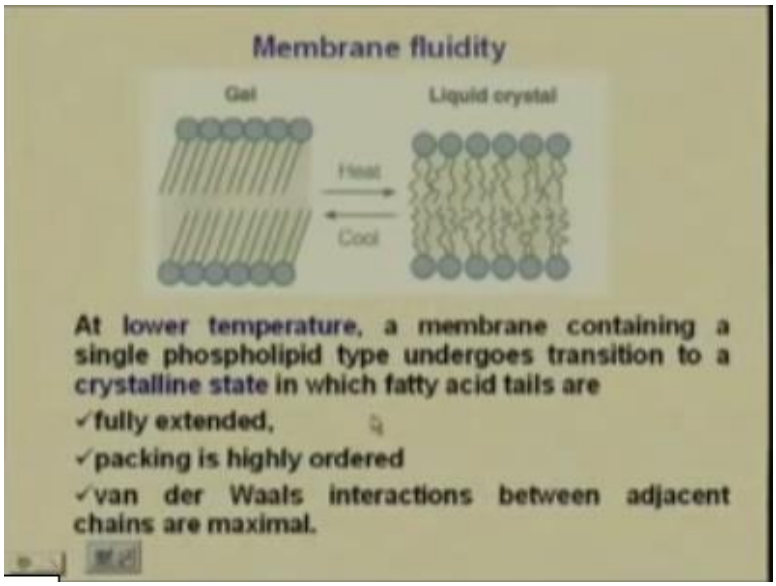


Now the interior of a lipid bilayer, now when you speak of the interior of the lipid bilayer it means we are speaking about the hydrophobic tails, okay that is what is the interior of the bilayer. The exterior of the bilayer is the polar position the polar head form the inside and the outside and the interior is highly fluid and we will see how that fluidity occurs, why it occurs and what's its usefulness.

Now in the liquid crystal state, the hydrocarbon chains of phospholipids are disordered. They are in constant motion, because they are in, you have to remember suspended, the cells are suspended in the plasma. Okay there is cytosol to it, there is a extra cellular matrices to it so they are all suspended. Now because of the constant movement they are in constant motion and they are highly disordered as well.

The Kinks we saw in the last class that are there in the fatty acid chains are due to the cis double bonds and they interfere with the packing in the crystalline state, and they lower what is called the phase transition temperature. Now what is this phase transition temperature.

(Refer Slide Time: 04:35)



Where we consider membrane fluidity, if we have straight chains we can form is called a Gel, a Liquid crystal so of a thing; we have a liquid crystal here and a gel. What we have in the gel is the perfect ordering of the chains. Now, when this is heating there is a lot of disruptions that can occur. Why this disruption occurs because there is a lot of possible rotation above the single bonds in this chains.

Because of this we can have what is called a transition temperature that is going to take from the perfectly ordered form to a liquid crystal form where we have a transition. Now what is this transition due to, transition is due to the flexibility of the single bond that we see here, okay. And if you had kink in the structure due to the presence of the cis double bonds than this at some points would set into a specific form that would give on heating and a transition that would result in a crystal structure. A liquid crystal structure like that.

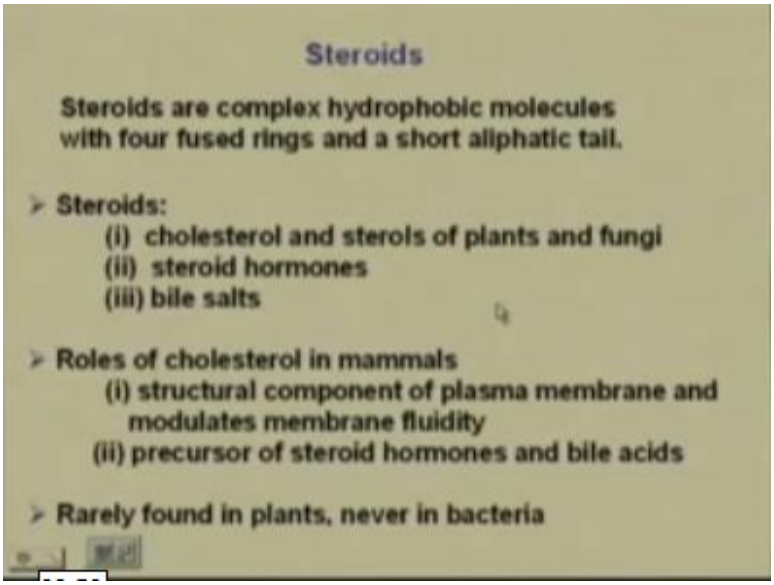
So at lower temperature, a membrane that contains a single phospholipid type, would undergo a transition to a crystalline state, so this would be our crystalline state where we would have the

fatty acid tails perfectly ordered, perfectly packed, fully extended and the maximum possible van der Walls interactions between the chains, okay. So we are talking about the single type of phospholipid attached to the polar head group.

So even if we had one fatty acid chain here have a cis double bond to it. It would on the formation of the crystalline state set into a perfect format where it would probably not be obviously completely straight but it would set into what it could in its crystalline form, okay. So we wouldn't set if we had the single type of phospholipid. But as soon as we have the different types of phospholipid it arises not only it to a single transition temperature.

But we have a range where this gradish and all this graduation from one to the other gradually takes place, the transition in that case gradually occur.

(Real Slide Time: 07:23)



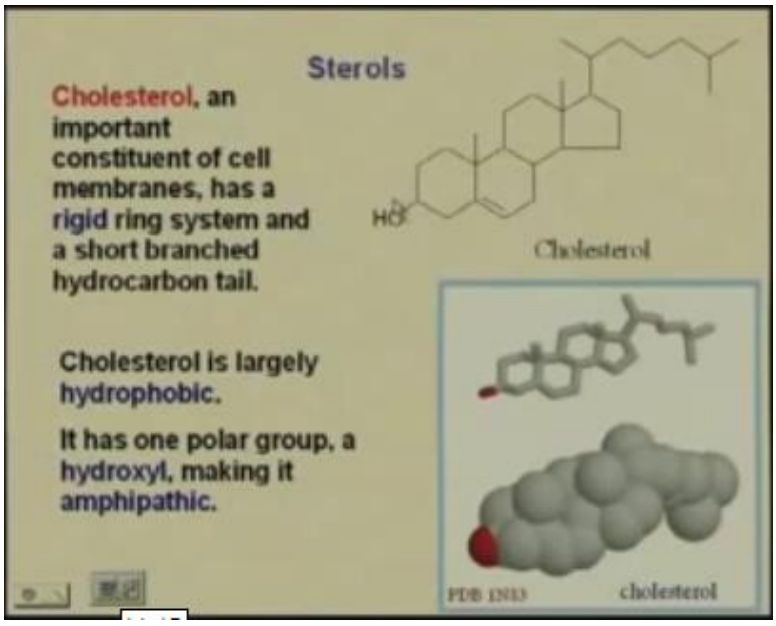
Now what we have for the fluidity of membranes is the introduction of Steroids, sterols particularly. We will see what these are and what the roles of these are. Now, steroids as you probably know are complex hydrophobic molecules that have four fused rings and they have a short aliphatic tail to it. This is the component or this is the structure of any steroids. The steroids that we see when they have the steroids at the particular position of the steroid.

When one of will know which position it is. When one of these groups is transferred to an OH we call it is sterol, okay. And we have cholesterol sterols of plants and fungi, we have steroid hormones and bile salts, the bail salts that help in our digestion are all derivatives of these cholesterols which is why you probably would have heard a gallstones are, there are lot of gallstones that are made of cholesterol and the combinations of these bile salt and cholesterol.

Now what are the roles of the cholesterol in mammals? All cholesterol you know that fat is good for you, okay. All cholesterol is not bad, you need some fat you need some cholesterol also, there is also cholesterol in the mammals is that they act the structural components of the plasma membrane and they modulate membrane fluidity. We will see how. And they also form precursor of steroid hormones and bile acids.

Now the bile acids are in extremely important for digestion. So you have to have some sufficient cholesterol for the formation of steroid hormones and for the formation of bile acids. And the cholesterol we will see is not found in plants, there is another form that is found in plants called stigmasterol, sterol which we will see in the next slide. So what are the uses of this cholesterol? The uses of this cholesterol are in the modulation of membrane fluidity and also as a structural component in the plasma membrane.

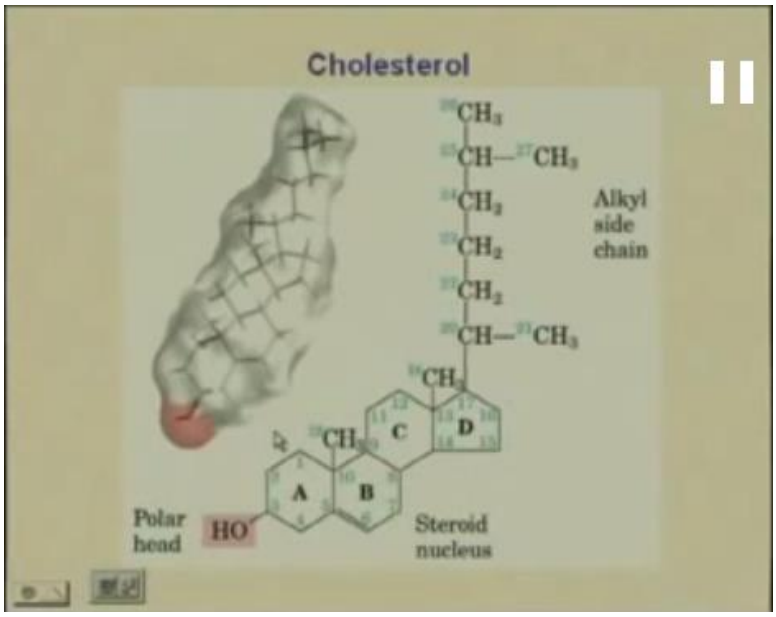
(Refer Slide Time: 10:06)



This is the structure of cholesterol. This is where the steroid becomes a sterol. It is OH okay. It has in it a rigid ring system, short branched hydrocarbon tail which we can see in the stick structure that I have here. What is this red one? The one is the oxygen. And this is the rigid hydrophobic structure, the rigid ring structure and this is a short aliphatic hydrocarbon tail that is attached to it.

So what do we see? We see that we have a hydrocarbon part and we have a polar part to it okay. So cholesterol is largely hydrophobic in nature but it has one hydroxyl this hydroxyl that mix it amphipathic in nature. So if this were to also be incorporated into the lipid bilayer it would this part that would interact with the hydrocarbon chain the fatty acid chain part of the lipid and it would be this OH that would interact with the polar head group of the lipid.

(Refer Slide Time: 11:28)



This is the numbering scheme for cholesterol. It is the three position that has an OH attached to it. We have four fused rings A, B, C, D. There are three six member rings and the D is a five membrane ring, fused with ring C. Now this is the polar head, the OH and the rest is the (())(12:06) steroid nucleus. This forms the part of every steroid; this is a steroid nucleus; the changes are in the Alkyl side chain.

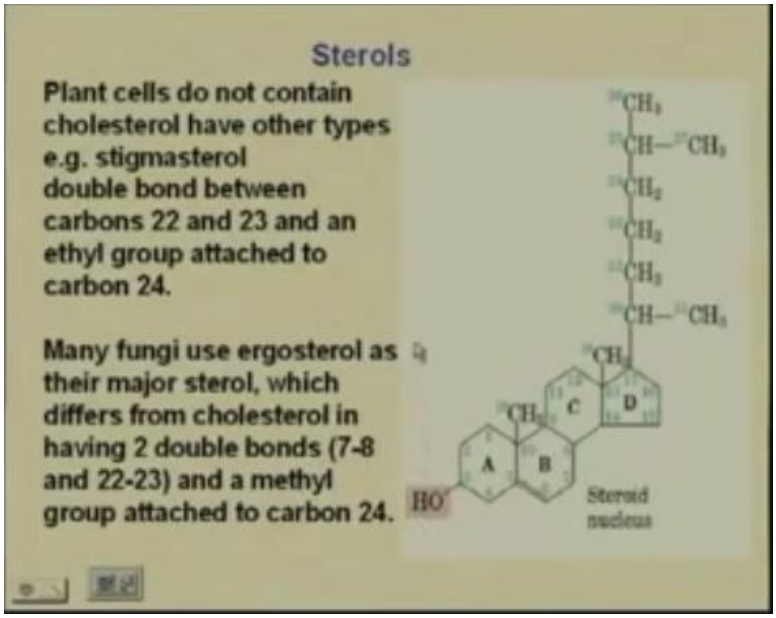
So any bile salt or any other sterol that we will see will have a difference in the alkyl side chain, a difference here also but this steroid nucleus remains intact. The numbering is starts from ring A

in 1,2,3 where the OH is attach to 3, 4,5 then it goes to the ring B there is a double bond between 5 and 6, so it forms 5,6,7,8,9,10. So that forms rings A and B. The numbering than begins at ring C where we have 11,12,13,14 at ring D now 15, 16, 17.

Then we have two mythoi groups attached one to carbon 13 and one to carbon 10. These are numbered 18; the one that is attached to 13 and 19 is the one that is attached to 10. Then we have the alkyl side chain where we have a mythoi group attached to the firs carbon atom and the mythoi group attached to the last carbon atom in the alkyl side chain. So this is the structure of cholesterol and what we have recognize here.

As this whole part is hydrophobic in nature and this OH part is a polar part in nature that is going to help in the fluidity of the membrane and will see how it can help in the fluidity.

(Refer Slide Time: 14:20)

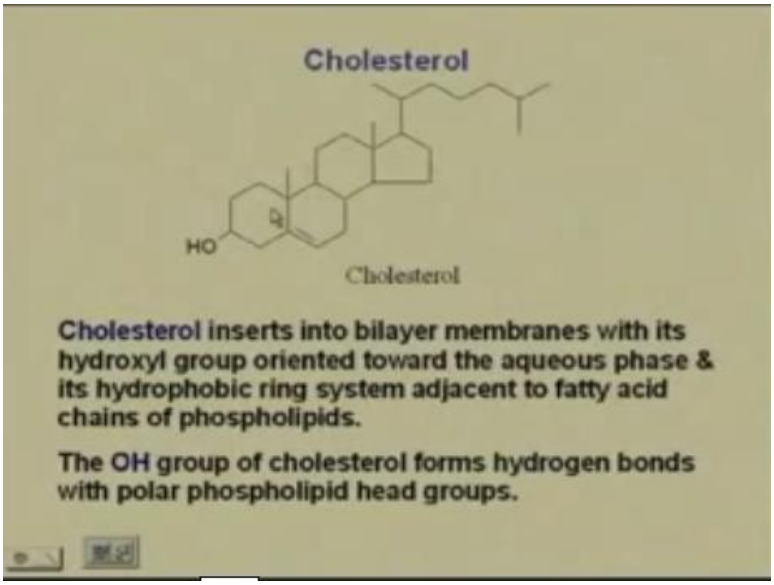


While refer we go there. As I mentioned before plant cells do not have cholesterol, they have what is called stigma sterol. The difference there is that there is a double bond between carbons 22 and 23. So 22 and 23 have a double bond and there is an additional ethyl group attached to carbon 24. Okay, so this is the basic structure of the cholesterol that I showed you in the previous slide and the difference between cholesterol and what plants have which is called stigma sterol.

Sterol is that there is a double bond between 22 and 23 and in ethyl group attached to 24. In fungi we have ergosterol which is their major sterol, this again differ again from cholesterol in having two double bonds, one again here in the B ring between 7 and 8 and again between 22 and 23 like stigma sterol and instead of the ethyl group that was attached in stigma sterol we have a methyl group attached in ergosterol.

Okay, so these are the different types of sterol that are commonly known. We have plant sterol, fungi sterol and cholesterol. Okay, this is the basic structure of cholesterol that has a steroid nucleus to it, because we call it is sterol it means it has an OH attached to it. The OH is attached at the key position and we have an alkyl chain here, and all of these still have the alkyl chain what we do have is just some saturation and additional alkyl chains attached. So the basic structure is still a hydrophobic part and a polar head group.

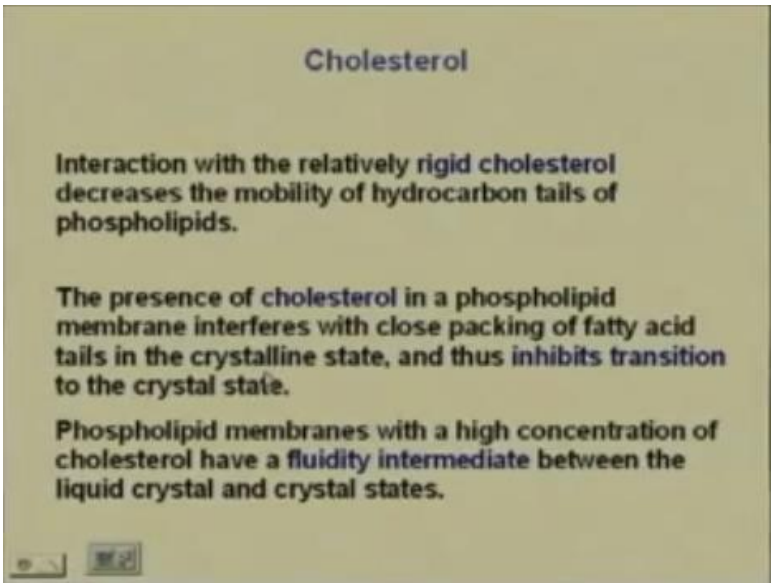
(Refer Slide Time: 16:23)



Okay. Now, this is our cholesterol. The cholesterol will insert into the bilayer membranes with its hydroxyl group oriented towards the aqueous phase associated with the polar head groups of the lipid bilayer and the hydrophobic ring system would be adjacent to the fatty acids in the glycerol or the sphingosine or whatever. And the OH group of the cholesterol would form hydrogen bond which is the polar phospholipid head groups, okay.

So and what we call the phospholipid bilayer we have the cholesterol embedded in it and because the cholesterol has this rigid structure and the alkyl chain it is this part that is going to interact with the fatty acids and this part that is going to interact with the polar head groups but it is this that is going to give the membranes some fluidity. Okay, it is going to allow some moments.

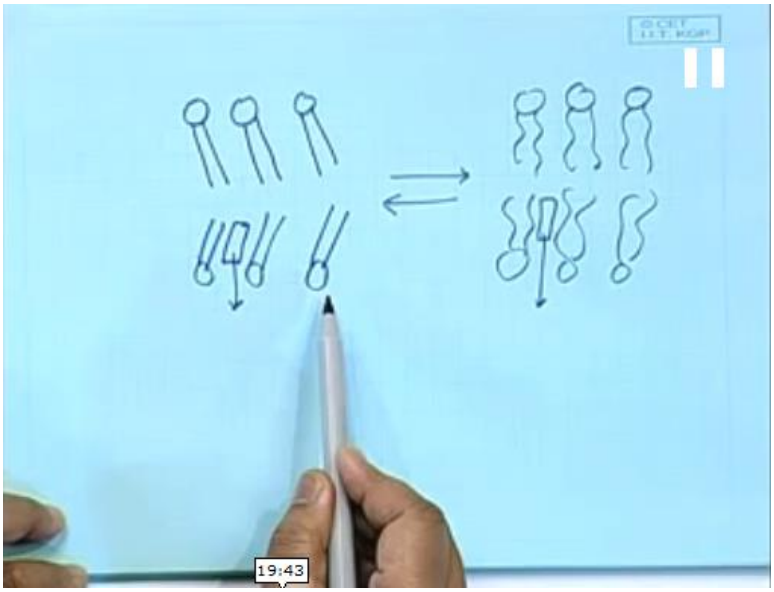
(Refer Slide Time: 17:17)



Now what happens is this interaction with the relevantly rigid cholesterol. Why is it rigid? Because of the fused steroid nucleus. So the interaction with the relatively rigid cholesterol decreases the mobility of the hydrocarbon tails of the phospholipids. Because you recognize that the long fatty acid chains have a lot of single bonds to them. Now the single bonds are free to move, they are flexible.

But, if the cholesterol is sitting beside it which has a very rigid steroid nucleus to it, the flexibility is now allowed in the hydrocarbon tails as such. But the presence a cholesterol in a phospholipid membrane it interferes with the close packing of the fatty acids. So normally, the way that the fatty acids would be packed would change with the presence of cholesterol.

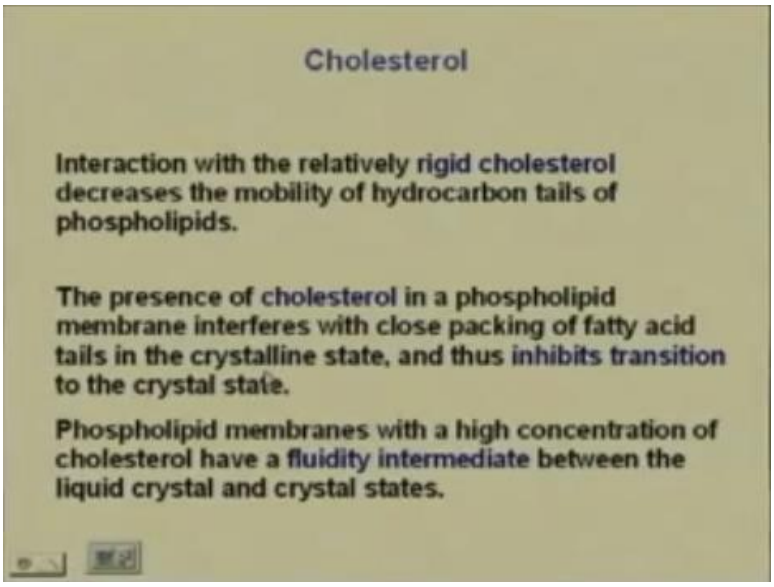
(Refer Slide Time: 18:41)



Remember I showed you in the first one of the slide, I showed you in the beginning we have perfect orientation. If we had a single type of phospholipid attached, we would have say a perfect orientation to our chains. Now when I heat this what is going to happen, it is going to form something like this, right. Now what happens? If now I have something sitting here, okay. It will be sitting here also.

So that is where the cholesterol comes into the picture. It will not allow it to perfect form this complete – perfect crystalline state. Okay. Because it disrupts in a sense the packing.

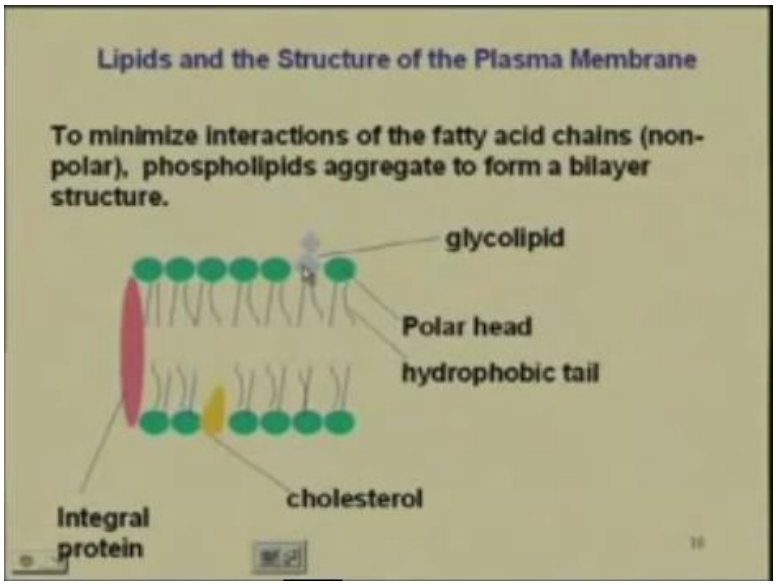
(Refer Slide Time: 19:43)



It is going to, the presence of the cholesterol as we see here is going to interfere with the close packing of the fatty acid tails and it is going to inhibit the transition to the crystal state. So the phospholipid membranes were the high concentration of cholesterol have a fluidity that is intermediate between the liquid crystal and the crystal state. Okay, so it in part in the sense of rigidity but at the same time it does not allow a close packing that is there in the crystal state.

So it sorts of give it a fluid feature, a fluid intermediate that is between this liquid crystal and the crystal state. And this is why, why is this so happening? It is due to the rigid crystal cholesterol structure. Why is the cholesterol structure? Is rigid? Because of the fused rings of the steroid, okay. And it is this part that is interacting with the hydrocarbon chain.

(Refer Slide Time: 21:00)

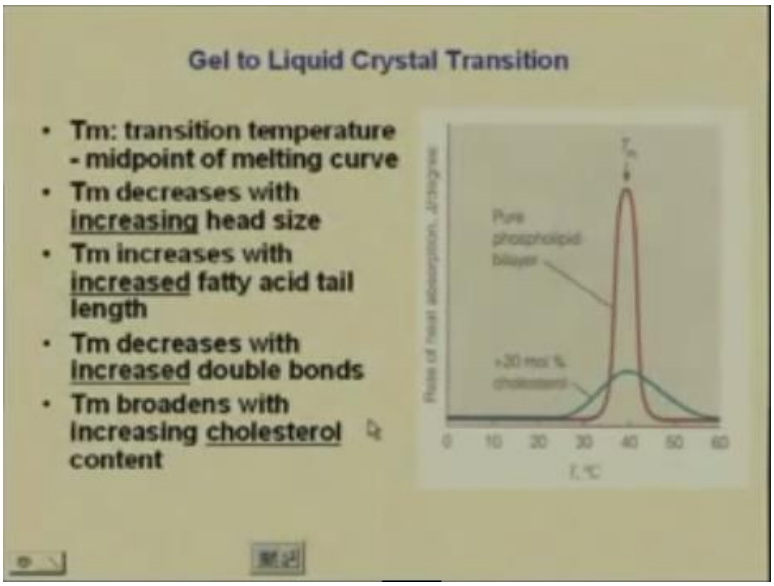


So this is what we have. So we know that we have the formation of our lipid bilayer. We have here now a glycolipid. What is a glycolipid? Something that has a sugar attach to it. All the green spheres have polar heads. All the blue lines here are hydrophobic tails. In here, we have cholesterol, okay. Now this cholesterol is there to impart some fluidity to the membrane. So that it does not revisit.

Here we have a protein molecule. Now we going to see how these protein molecules actually help in the transport. So, we have this phospholipid aggregate to form this bilayer future. We are already looked at the different types of phospholipid that we can have including the glycolipid

type where we have a sugar ring attached, like we would have in the cerobroside or a ganglioside.

(Refer Slide Time: 22:23)



Now we speak of a Gel to Liquid Crystal Transition. What does the Gel mean? The complete crystal form where all the hydrocarbon tails are perfectly oriented. We have what is called a transition temperature. What is this transition temperature? It is sort of a melting point, a melting curve that we get. And the midpoint of this melting curve is going to be the transition from the perfectly ordered form to a disordered form.

Now we going to look at the futures that are going to result in differences in this transition temperature. When we look at the heat absorption we have temperature along the x-axis here. When we or when the temperature is low everything is ordered. All the fatty acid chains are ordered in some fashion and at some point it moves over to the liquid crystal state because of a disruption in the order.

So the disruption in the order is going to give us a melting temperature that is the midpoint of the melting curve that is denoted as TN. Now what are the futures that can change the TN? If you have a pure phospholipid bilayer you are going to have a sharp transition. Why? Because all of them are perfectly ordered, because you have a pure phospholipid bilayer. The differences can

arise where you will get a ordered melting curve based on the difference of the fatty acid chains, that the phospholipid is comprises.

If we have increasing head side, you have lesser packing possible which is going to decrease the melting temperature. You have to recognize that a perfect crystal form or a perfect packing is being disrupted is being broken. How do you break this packing? You can break the packing by having an increased head size, because the increase head size will not allow a nice packing of the fatty acid chains.

If you have an increased fatty acid chain length you will have increased hydrophobic interaction, you will have increased TN because it will be harder to disrupt the ordering. You have to—look at the future and decide whether that ordering is easier to break or difficult to break. If it is easier to break the TN will decrease if it is harder to break the TN will increase. If you have an increased number of double bonds, larger number of kinks in the structure, it disrupts the ordering.

TN will decrease. In the presence of cholesterol what happens is the TN broadens, okay. So you have basically a flattered TN, a flattered curve, why? Because the cholesterol is now embedded in it and you do not have a sharp transition from a perfectly ordered Gel state or a Crystal state to a Liquid state, a Liquid Crystal State. Okay. So let us go over this once more. We are looking at a phospholipid bilayer and we are looking at the transition from an ordered state to a disordered state.

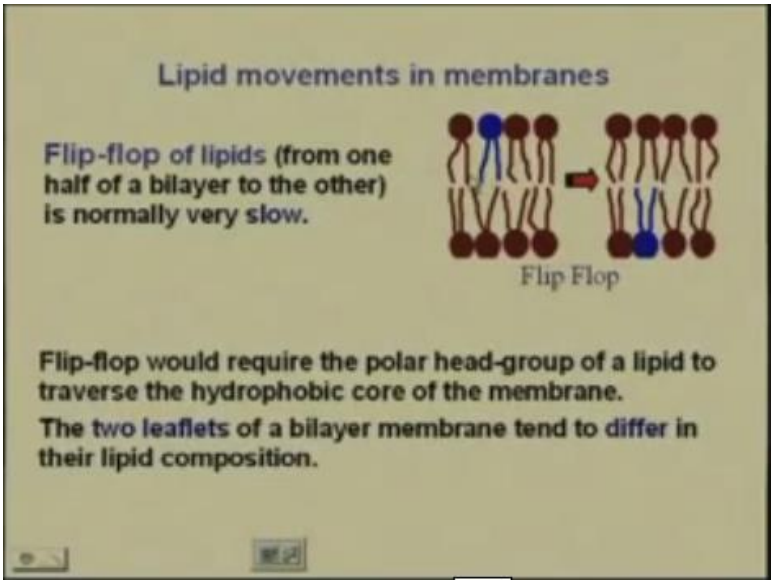
We know that the lipid bilayer is composed of—comprised of different lipids phospholipids and there are different properties of these lipids associated with different types of polar head groups and different types of fatty acid chains. That's a difference. If we have any property that is going to disrupt the structure, we will have a look over Tm. So if we have increasing head size that is not going to allow a proper packing, we are going to have decreased Tm.

If we have long fatty acid chains then, it is going to be harder to disrupt the fatty acid chain packing we will have a higher Tm. If we have increased double bonds we have increased number

of kinks, increased disruption; Tm is going to decreased. With the presence of cholesterol there is an increased in the cholesterol content meaning that the Tm is going to broaden means the transition will not the sharp.

Okay, so we are going to have a broaden amount of melting because there is going to be gradual disruption in the structure amounting to a gradual curve basically and not sharp transition. Okay.

(Refer Slide Time: 28:18)



Now, if we look at the times, so we are going to have these lipids movements. These lipids movements are actually what are causing some disruptions and some futures, specific future of the membranes. Now if you look at lipid movements in membranes Bond rotations occur at this level (10 power 12 – 10 power 13 per sec). The Rotational diffusion is about 10 power 8 – 10 power 9 per sec). So you see how the lipid membranes, the bilayers are actually moving in a sense.

We have a Translational motion that can be measured in microns per second. And we have Bilateral motion something called flip-flop that takes a – in the order of days for one such even to occur. When we speak of Lateral mobility of a lipid, within the plane of a membrane, we have the lipids actually moving around. So this blue lipid actually shifts, okay. So this is what it meant by lateral mobility.

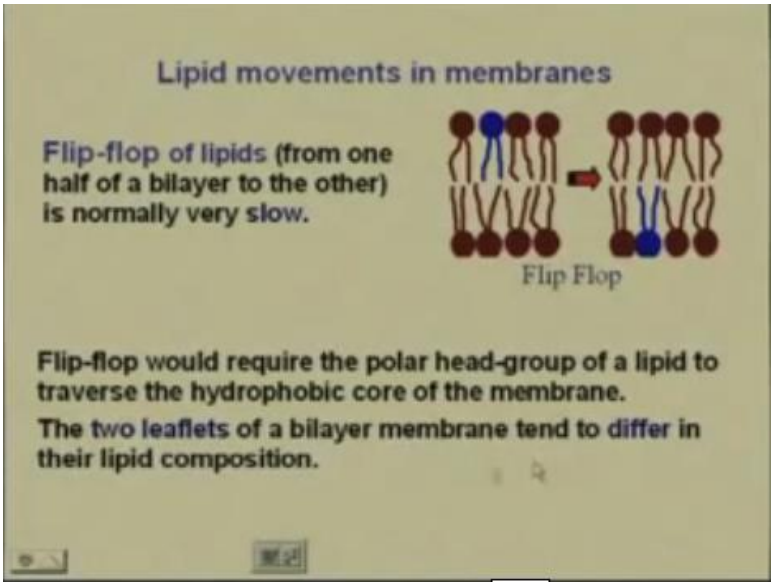
Now you have to recognize, or you have to realize that this lipid bilayer that has been shown here is just to (()) (29:51) representation. It is actually a surface, okay. So it's either going back of forth or left or right, because you have a surface that you are speaking about. So the two types of motion that can actually occur apart from bond rotation and rotational diffusion are translational motion that's lateral mobility.

And we will see how this lateral mobility is actually important because it will help the transport of any material inside to the outside or outside to the inside of the cell. Okay, we will see how that plays a role in a minute. The other type is Flip-Flop where this blue phospholipid instead of being in the top that is come to the bottom membrane. Okay. So that is what is called the Flip-flop of lipids where it moves from one half of the bilayer to the other half.

Now this requires more time and is less probable because, it is less probably then the lateral diffusion, why? Because this polar head group if it has to come to this side has to derivers the hydrophobic chain. It has to go through this hydrophobic reason which is unlikely for it to occur in the first place. What do we say? We are saying that when we consider the flip-flop, the lateral mobility is relatively easier for it to occur then the flip-flop.

Because here we are speaking of a lateral diffusion where the polar head group remains in a polar environment. But in the flip-flop case, we have the lipid go from one bilayer to the other bilayer. So in the event for this to occur, for this even to occur this would have to transverse the whole hydrophobic core of the membrane which would be unlikely. Now, if we consider the lipid bilayer and consider how it actually forms the cell, okay.

(Refer Slide Time: 32:31)

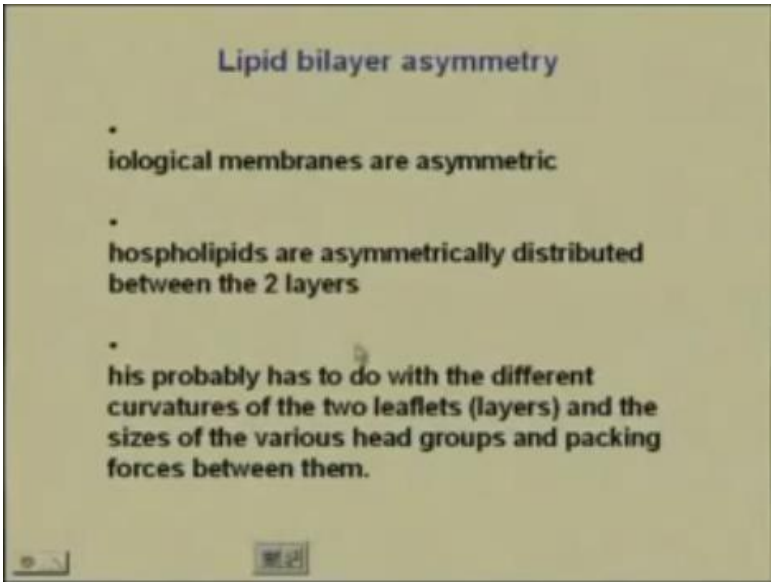


If could just draw that here considering a cell. So if we have part of the cell wall. This is inside and this is outside. We have a lipid bilayer, so we have all the polar head groups sitting here. We have another set of polar groups sitting here. Each of these have the tails. So the membrane actually looks like this. So this is what the membrane actually looks like. Now you see, that this part and this part have different curves. Okay.

Now, these are what are called two leaflets. Now for this curvature to occur or to be different the lipid bilayer to be asymmetric. For this curvature to occur you cannot have the same types of lipids in the inner part and in the outer part. Okay. So the lipid membrane is actually is not a trick in nature where the types of lipids on the outer surface are not the same as the lipids in the inner surface.

Okay, that is what mean by saying that the two leaflets of the bilayer membrane differ in the lipid composition. Okay. They have to differ in the lipid composition because their curvature is different.

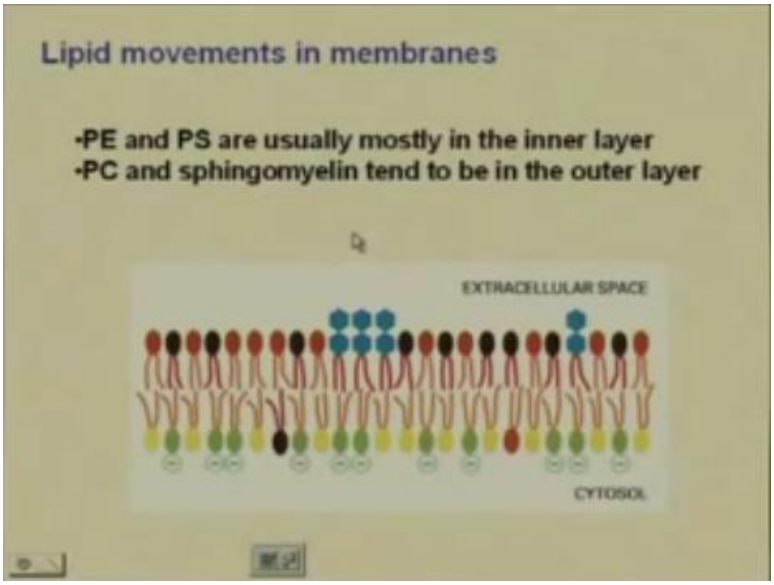
(Refer Slide Time: 34:39)



So, there is one letter missing from each of these. But we have the Lipid bilayer asymmetry. The biological membranes are asymmetric. The phospholipids are asymmetrically distributed between the two layers and this is due to the curvature of the leaflets or the two layers. And how can we bring that about by? By changing the type of fatty acid, changing the type of polar head group.

That is the way we can bring about a change in the curvature of the two layer by changing the size, changing the packing. How do we change the packing or changing a packing acid?

(Refer Slide Time: 35:29)

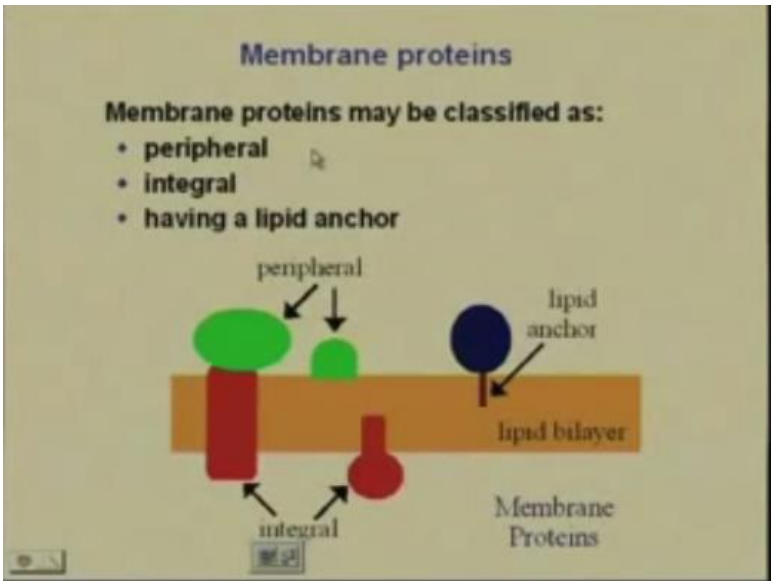


Okay. So this is what we can do. What we have here is the cytosol. What is the cytosol? It is inside the cell. Extra cellular space means it is outside the cell. What we have here, is we now know that we have all these different membranes so we have and the black ones and the blue ones with the sugars attach to them. More preferred on the surface and a few red and black ones in the inner surface—in the inner leaflet.

But populated more by green and yellow ones. Now—that mean what do we have? We have different polar head groups. The green, the yellow, the blue and the black are the different polar head groups and the chains are also going to be different depending on the type of fatty acid that we have. Phosphatidylethanolamine that's PE and Phosphatidylserine are usually in the inner layer.

So the ethanolamine type and serine type are preferred in the inner layer and in the outer layer we have this sphingomyelin and the choline, the phosphatidylcholine. Okay. So we have more of the phosphatidylcholine and the sphingomyelin on the outside and more of the phosphatidylethanolamine and the serine in the inside.

(Refer Slide Time: 37:11)

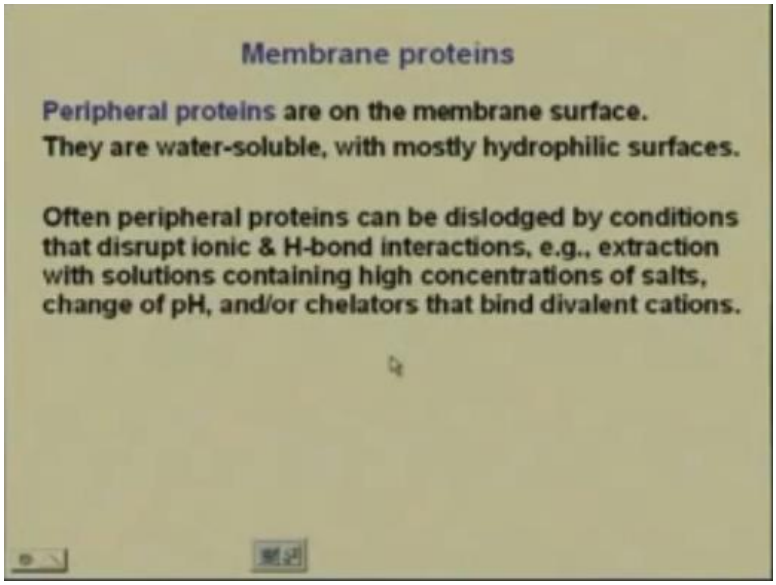


Now, we have to look at Membrane proteins. What a membrane proteins going to do? They are going to help in the transfer of ions okay. They are usually a three types. You could have peripheral proteins, integral proteins or once that have lipid a anchor. The peripheral proteins are

the ones that are marked in green here, that are on the peripherally of the membrane. The ones marked in red are integral proteins that are sort of embedded in the bilayer, okay.

The lipid anchor one have a lipid chain attach to them that the lipid chain of which interact with the hydrocarbon chains of the lipid fatty acids. Okay. So these are the three types of membrane proteins that you can have. And, we will see the properties of the membrane proteins.

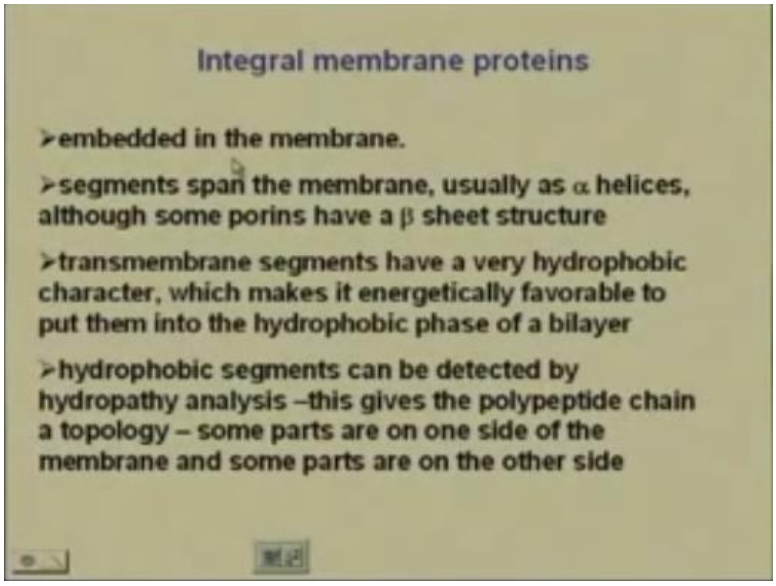
(Refer Slide Time: 38:19)



The Peripheral proteins are on the membrane surface. They are water-soluble and as you recognize they have to be, what does the surface have to be? Hydropholic in nature, so that they can interact with the polar head groups of the lipid bilayer. So they are water-soluble with mostly hydrophilic surfaces. So what can you do? You can just wash them of the membrane. How?

By adding specific chemicals or specific components that are going to disrupt the ionic and hydrogen bond interaction, so you can so you can add urea, change the PH just extract the proteins that are on the (()) (39:08). But if we look at integral protein they are not difficult to dislodged, you understand why? Because they are traversing the membrane.

(Refer Slide Time: 39:22)

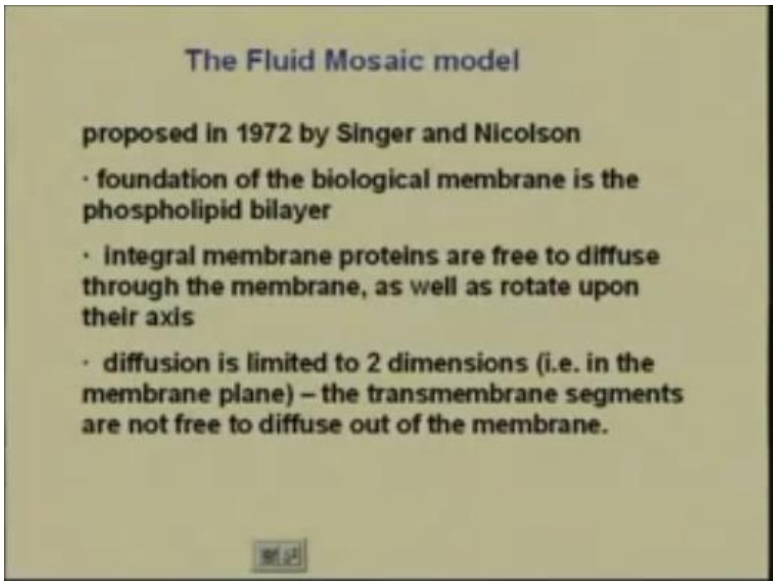


So what are the properties of the integral membranes? They are embedded in the membrane. The segments that span the membrane are usually as a Alpha helices. Remember in one of our very earlier classes what are hydropathic blocs and their we identified transmembrane helices. This is where the transmembrane helices occur in integral membrane proteins. There are some porins that have a bitter sheets structure to it.

The transmembrane segments we know from our previous classes that we have a very hydrophobic characters so that there is an energetic favorable interaction with the hydrophobic chains of the lipid bilayer and the hydrophobic segments can be detected by hydropathy analysis which is something we have done earlier and this gives the polypeptide chain a specific orientation a specific topology where we have some parts on one side of the membrane.

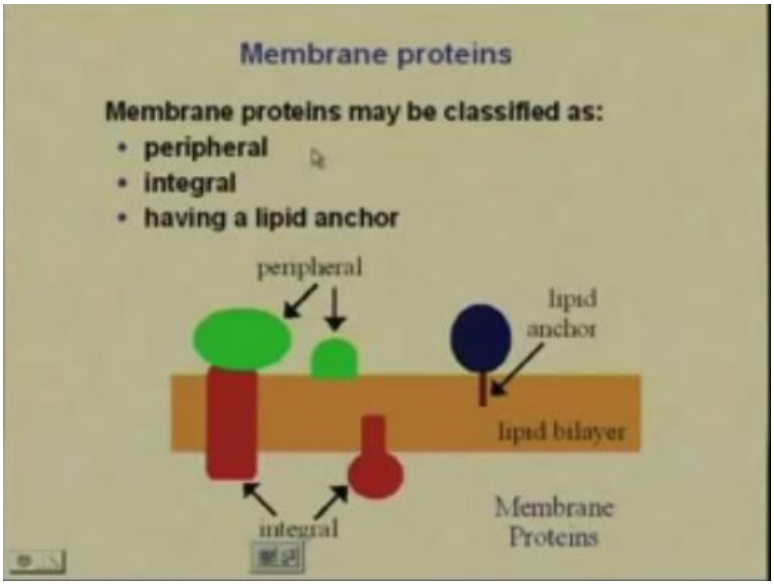
And some parts on the other side of the membrane. So this is the property of the integral membrane proteins. Okay.

(Refer Slide Time: 40:38)



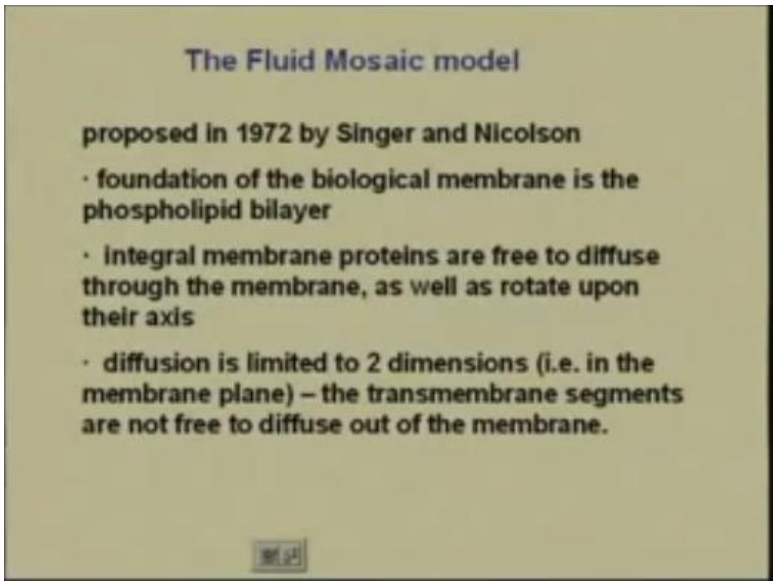
Now, for the lipid bilayer i.e. with these proteins embedded in it.

(Refer Slide Time: 40:44)



So this is basically a structure. We have a moment remember there is a bilateral moment to the lipid bilayer and we have all these proteins on the structure, so there has to be some model that denotes what this structure actually looks.

(Refer Slide Time: 41:07)

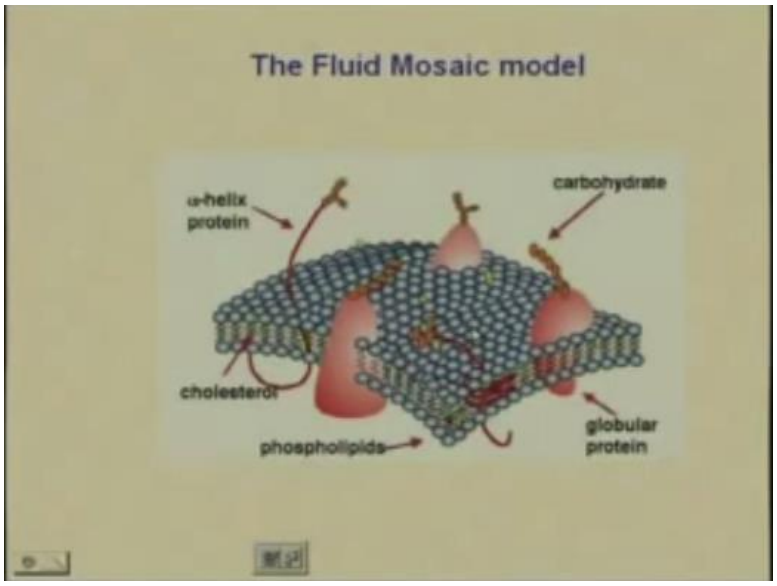


This was given in the 1972 and is called "The Fluid Mosaic model". So you can think of the lipid membrane like being a mosaic where you have some proteins. When you look at it from the top it will look like some polar head groups; different types of polar head groups, different types of proteins; integral proteins, peripheral proteins and the whole thing is sort of moving. So it is a fluid mosaic mode.

The foundation of, so what is a fluid mosaic model? The basic thing is the phospholipid bilayer. The integral membrane proteins are free to diffuse through the membrane because they have that membrane channel to it. And they can rotate about their axis. Because they have, they will have, what will they have? You have the lipid bilayer; you have the hydrocarbon chain sticking out. You have the integral membrane protein that can rotate.

Because all the surface hydrophobic in nature, so it will have a constant favorable interaction which is possible. Then the diffusion that you have limited to dimensions. The transmembrane segments do not flip-flop. They remain as they are once they are embedded.

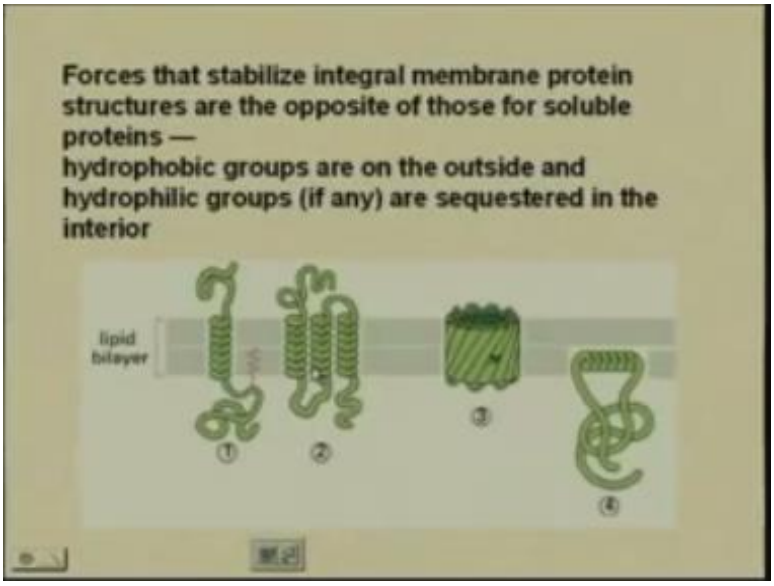
(Refer Side Time: 42:31)



So we have something that looks like this. This is what is a fluid mosaic model. So what are these blue groups that we see here, these are all the polar head groups of all the different types of lipids the glycerophospholipids or the spingolipids that we can have. All these zigzag chains are the fatty acid chains. The yellow blocks here are the cholesterols that have to be there imparting a fluidity.

These are integral membrane proteins. The globular proteins. These are some carbohydrate attached to the proteins that are called glycoproteins. We have an Alpha helices protein that could be in there that would form the single helices. So this would what the lipid bilayer membrane would look like with the proteins embedded in it. And since it's always moving the proteins are rotating, it is called a fluid mosaic model.

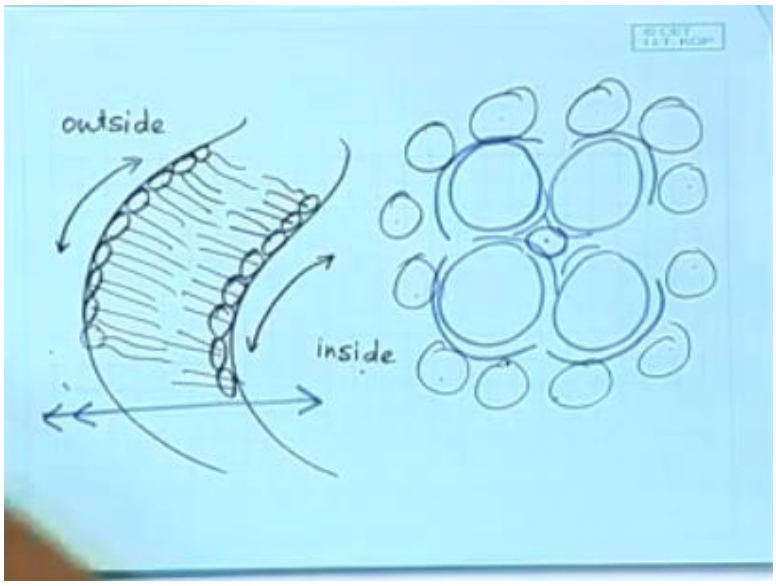
(Refer Slide Time: 43:36)



So, this is what we have the lipid bilayer and we have different types of proteins embedded in it. What are the different types of proteins? We have—we can have proteins that looks like this. We can have proteins that has a large number of transmembrane segments. Or we could have a protein that has a larger por, these are porins that are formed not from alpha helices but from beta sheets.

The beta sheets fold onto themselves and you have a large por. So you remember when we studied the forces that stabilize these membrane proteins. We studied that, it was these proteins that would have surface hydrophobic residues and within the group here, within the helices, suppose we had like a bundle of helices.

(Refer Slide Time: 44:47)

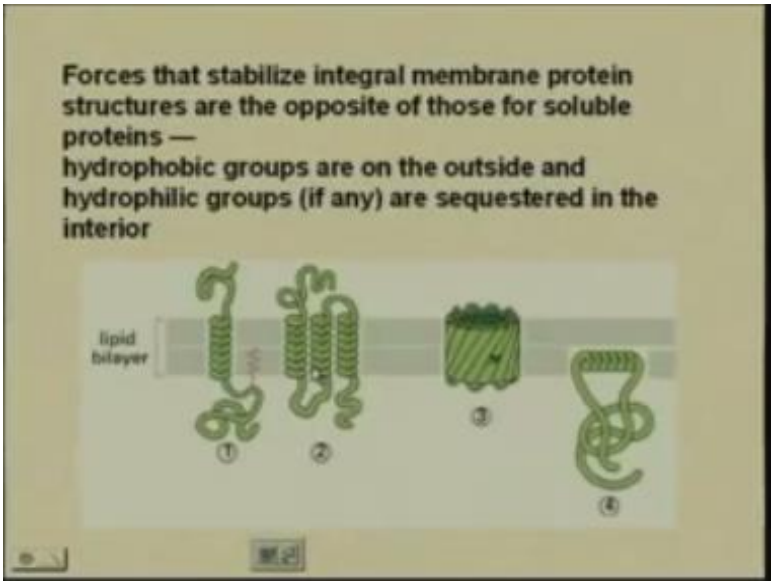


Like I mentioned this in the earlier classes, if we had—you recognize now when we looking at the top down to the membrane, these are the helices. We have now our polar head groups. So we are looking at the fluid mosaic model from the top. These- the blue one is the protein. What we have here, what types of groups? All hydrophobic groups, that are going to interact with the chains, fatty acid chains that are sticking out from these polar phospholipids. Okay.

So all the hydrophobic interactions that we see here are going to be down that way. What about the inner parts here? These are going to be polar. Right. Now why are these polar. Now we have to understand that these has to be polar so that we form a channel. Once we form a channel then this part is the surface say the outside and we have another part that's the inside. Okay. So once we have a channel formed here I can have transport.

It is only through these membrane proteins that you have ion channel por formation and the transport either from the inside to the outside or from the outside to the inside. Okay.

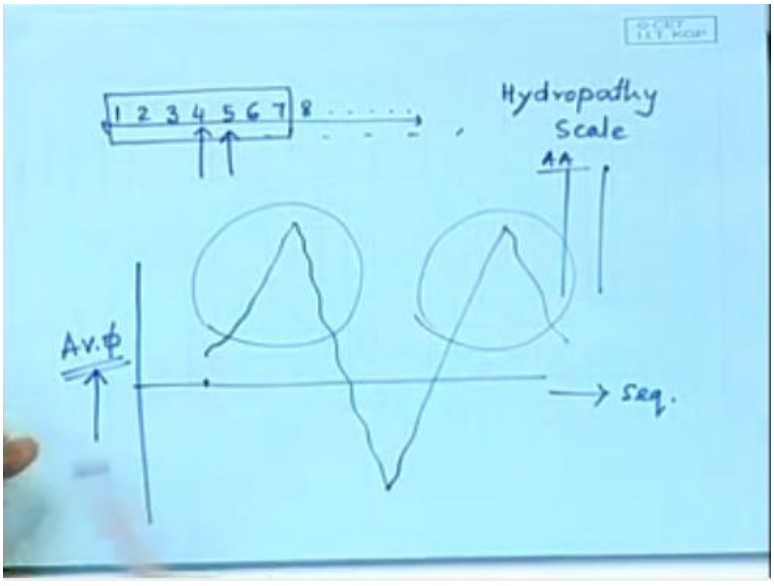
(Refer Slide Time: 46:38)



So what we have here are the hydrophobic groups that are going to be on the outside, hydrophilic groups that are going to the inside. So if we have this bitter sheet structure here, what is going to happen is all the hydrophobic chains are going to be on the surface and all the hydrophilic chains are going to be in the center and they are going to allow the movement. So when would we need a porin? When we have to transport a large ionic part, okay. Not just an OH- or CL-.

But when we have to transport, say a larger hydrated ion, then we would need the formation of this por. Now you remember how we are supposed to find out the transmembrane helices? Using the Hydropathic plot, okay. What do we do for the hydropathic plot?

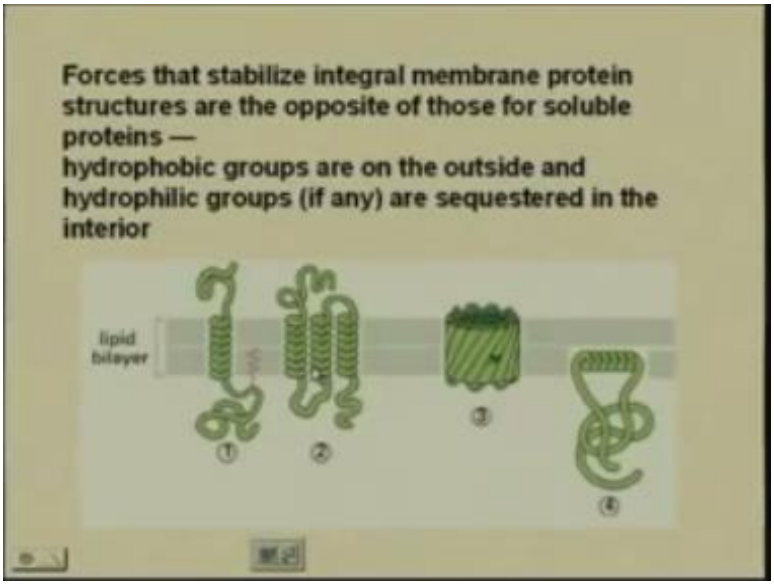
(Refer Slide Time: 47:41)



There is a certain sequence of amino acid that we have. Okay, so we have amino acids 1,2,3,4, say 5,6,7 and so on. We have a hydropathy scale, for every amino acid there is a hydropathy scale. What we do is we consider the sequences the long this X-axis and the average hydropathy index along the Y-axis. How do we calculate it? We have a series of numbers for the amino acids. Each of them have a specific scale.

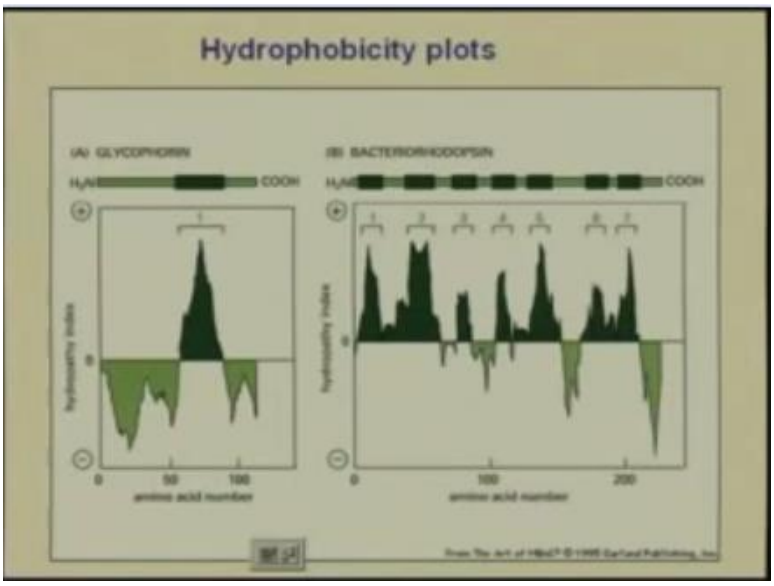
We use what is call a sliding window approach and we find he average of say the firs 7 or first 9, we usually use an odd number, so what we can assign the average value to the middle residue. So we find the average of the scale of this 7 residue, assign it to the 4th residue and determine where it lies in the sequence. In this plot, we continue this till we come to the end of the protein sequence and we determine regions of high hydrophobicity.

(Refer Slide Time: 49:23)



If we have hydrophobic regions, we consider those regions to the traverse in the membrane. And this hydropathy plots are used much more for membrane proteins then the depiction or the detection of any other sort of analysis of proteins.

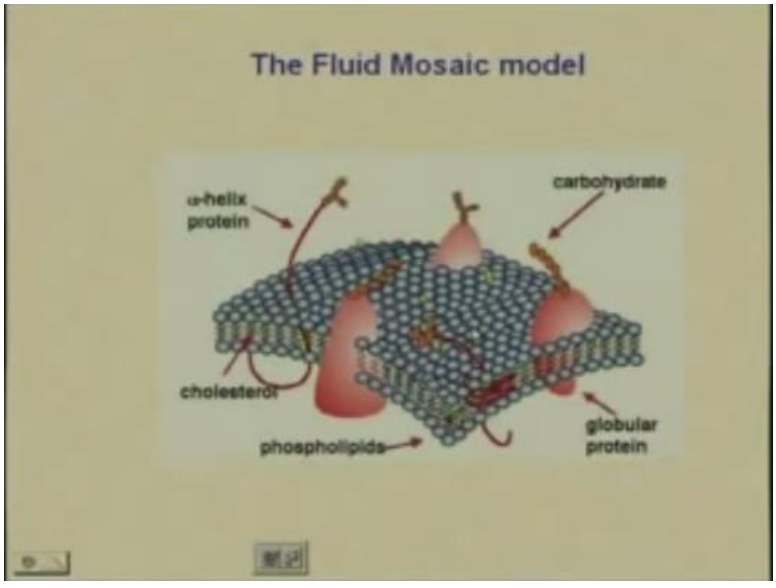
(Refer Slide Time: 49:47)



So when we do these plots for say glycophorin this case, we consider here the hydropathy index that has a negative value here and a positive value here. We have the specific amino acid number along the x-axis. In this case, what we see is that there is one transmembrane segment. The single transmembrane segment is determined by the positive hydropathy index in this hydrophobicity block.

When we consider bacterial reduction that have large number of such transmembrane helices, we have 7 such possible helices that form bacteriorhodopsin and this can be identified by again the positive regions of the hydropathy index on the hydrophobicity plot what we see.

(Refer Slide time: 50:52)



Now, so if we go back to the fluid mosaic model, we have i.e. our polar head groups. The polar head groups that have the specific fatty acid chains the globular proteins that are going to have transmembrane helices, the transmembrane helices are going to allow the transfer of ions on the outside of the cell to the inside of the cell. We also learnt that if you see there is a specific curvature to the cell, because the cell is globular in nature, okay.

So it has to turn around so to speak, okay. It has to form a spherical moiety. So if that has to happen then the composition of the phospholipids on the outer layer and the inner layer is different. The phospholipid composition of what is called the lipid leaflets are different. So the lipid bilayer is basically a fluid position or fluid layer where we have constant movement, we have constant free rotation, some diffusion also, and we have cholesterol embedded.

The cholesterol structure is such that it has the large hydrophobic region to it and a polar OH group to it. The polar OH interacts with the polar head groups, and it imparts some rigidity in the sense of the rigid steroid nucleus, but it allows a disruption in the overall structure and the composition of the layers is going to result in a different curvature and the proteins are going to result in the transport.

In our next class, we will see how we have this membrane transport and how these specific ions are transported from the inside to the outside and the inside – the outside to the inside of cells. Thank you.