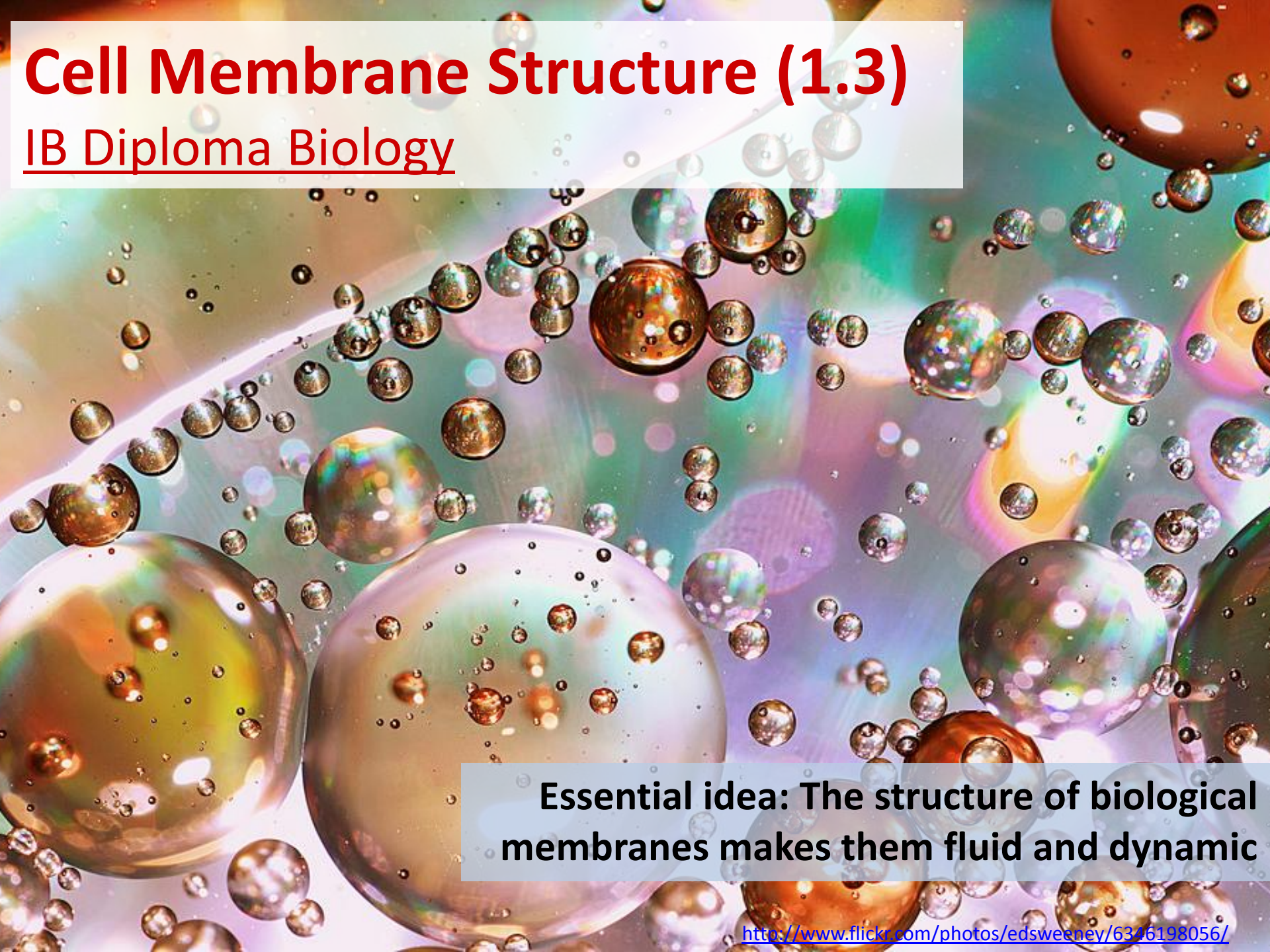
Cell Membrane Structure (1.3)

IB Diploma Biology



Essential idea: The structure of biological membranes makes them fluid and dynamic

http://www.flickr.com/photos/edsweeney/6346198056/

Functions of a plasma membrane

1. Hold the cell together

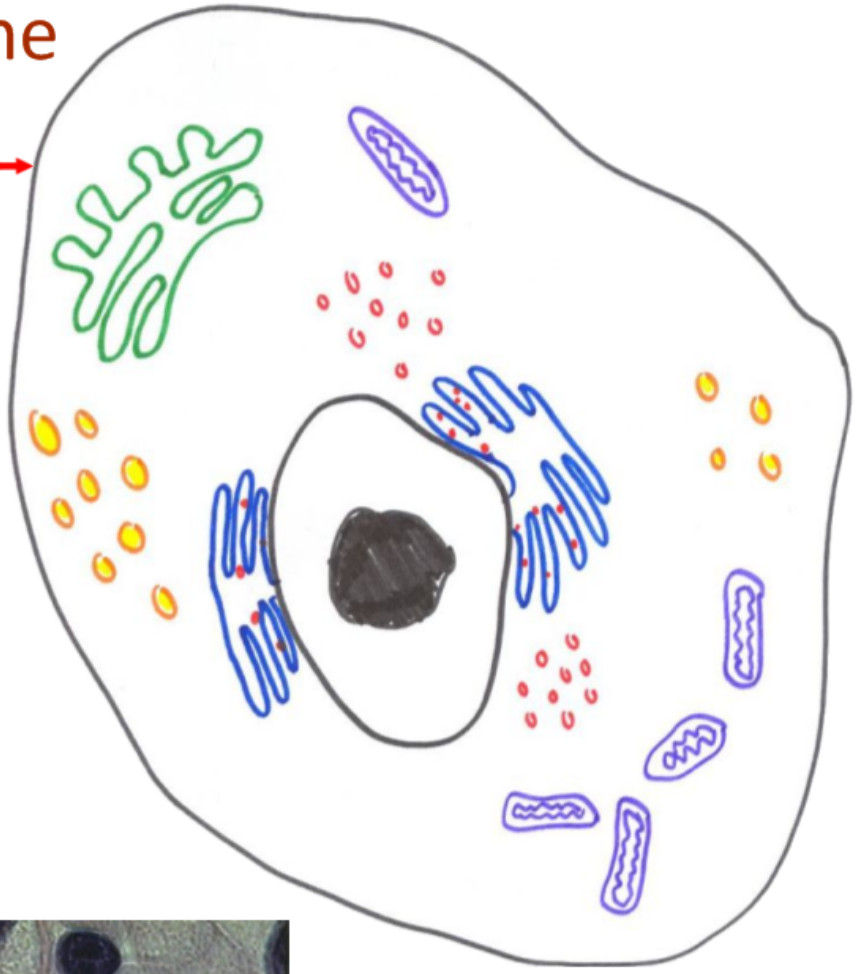
2. Control what goes in and out
   (diffusion, osmosis, active transport)

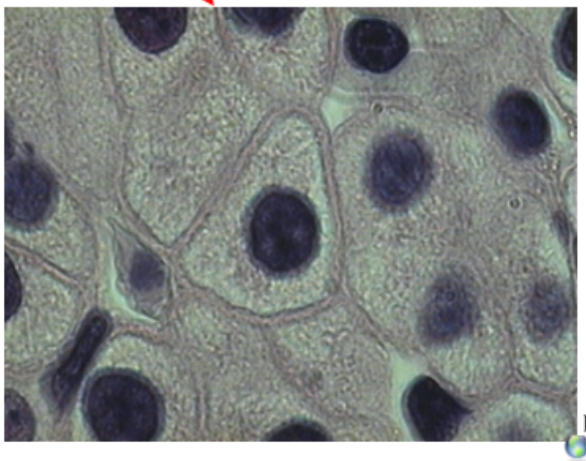
3. Protect the cell

4. Allow the cell to recognise and be recognised
   (cell signalling and immunity)

5. Bind to other cells and molecules

6. A site for biochemical reactions
   (enzymes, areas for reactions)





Liver cells binding to one another
http://hplusclub.com/hblog/files/2008/04/liver-cells.JPG

1.3.1 Phospholipids form bilayers in water due to the amphipathic properties of phospholipid molecules.

http://www.flickr.com/photos/zorin-denu/5385963280/

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The Oil droplet stays together and makes a perfect circular shape.

The oil molecules are **Hydrophobic**

Oil Molecules are **non-polar** and water molecules are **polar.**

http://www.flickr.com/photos/zorin-denu/5385963280/

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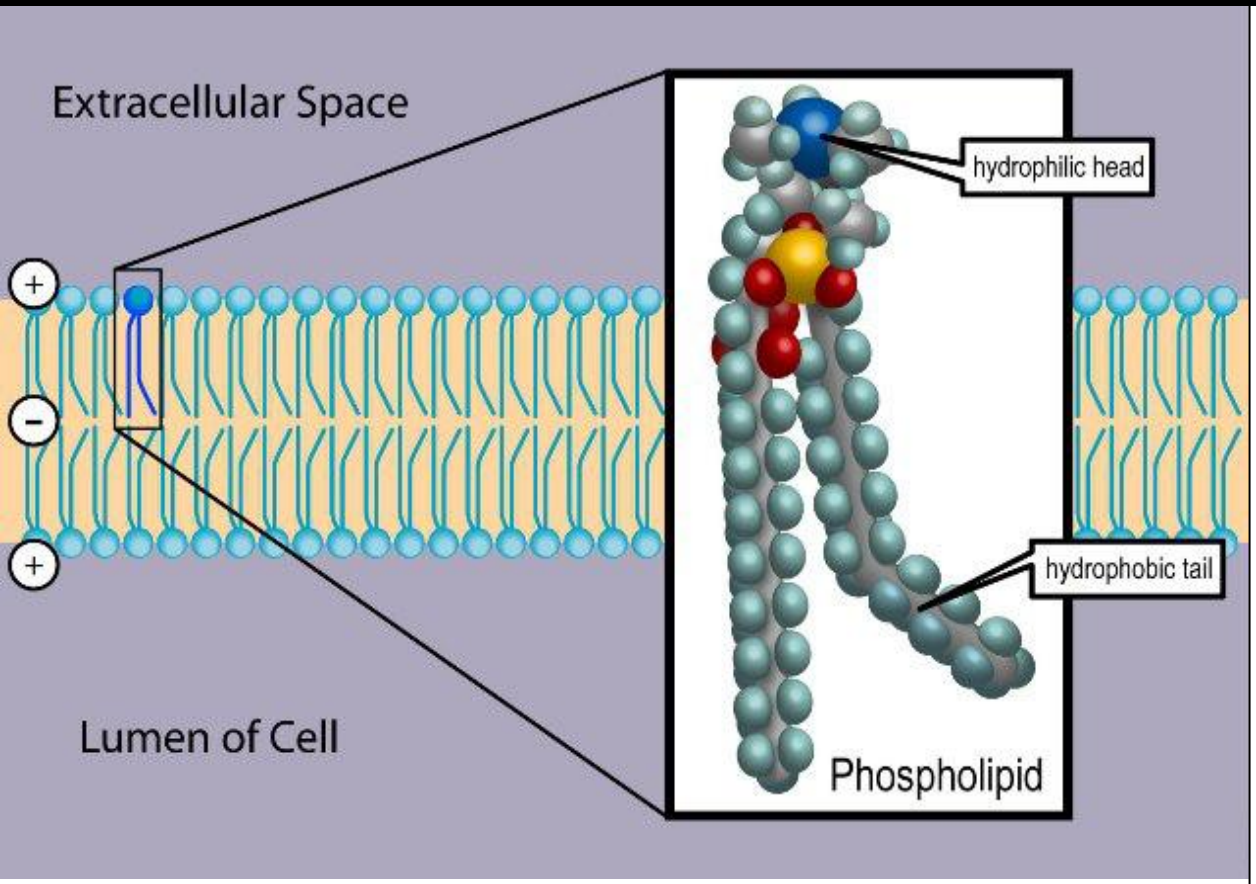
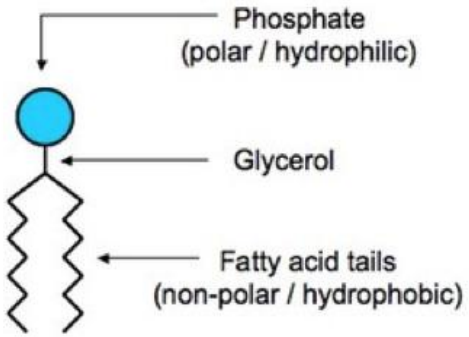




When drawing a diagram of a phospholipid this is a good example which shows all the key features

Phospholipid molecules have a polar (charged) phosphate head and long non-polar lipid tails

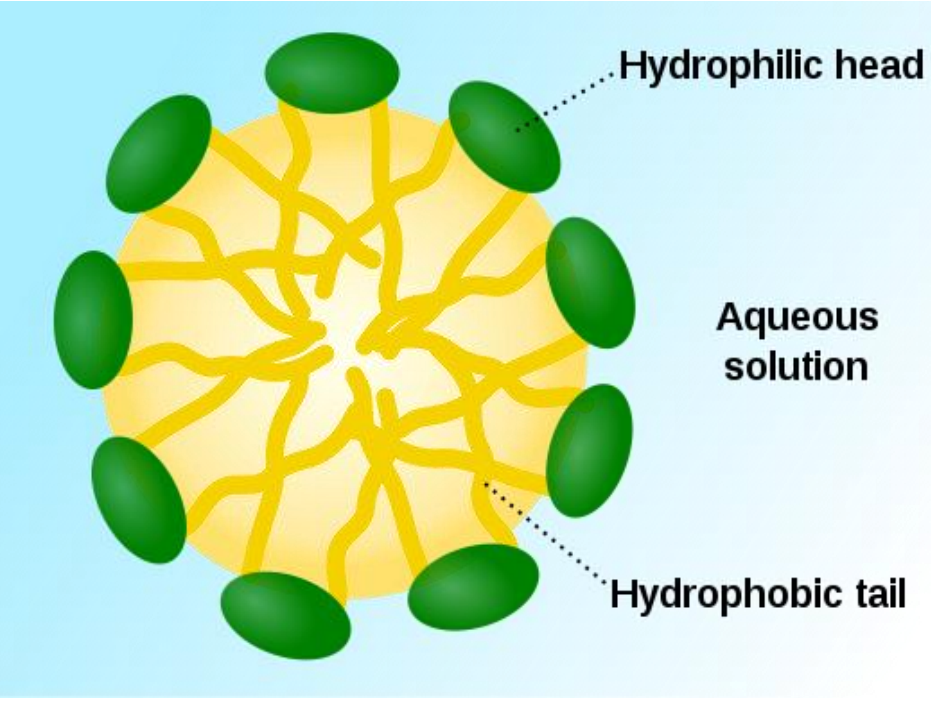
The head is **hydrophilic** (attracted to water)

The tails are **hydrophobic** (repelled by water)

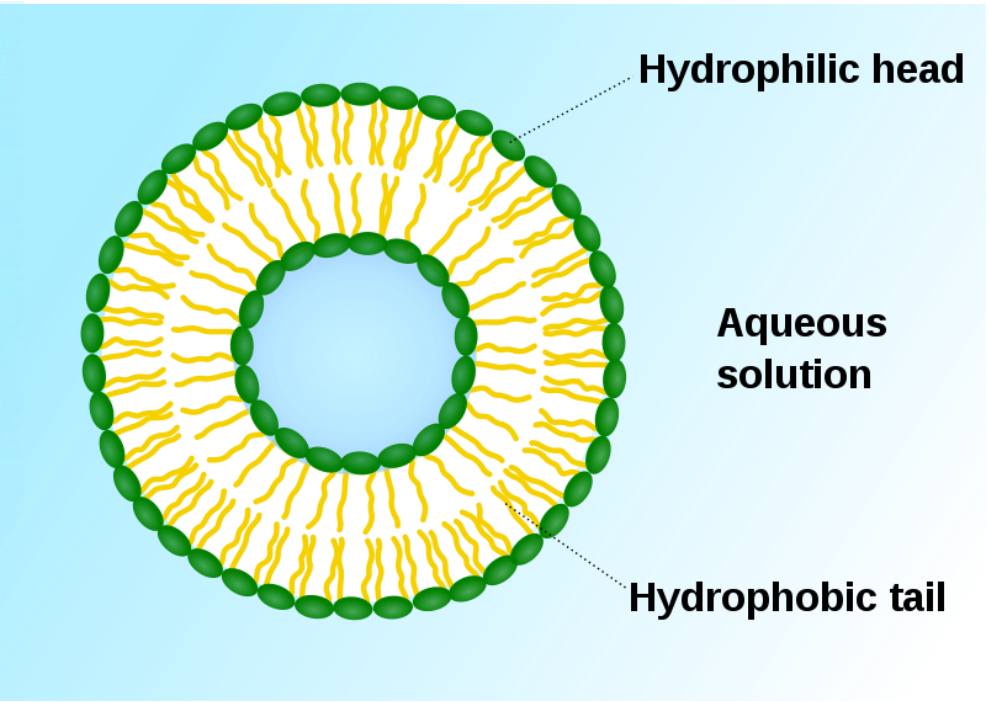
An example of an **amphipathic** molecule (w/ both polar and nonpolar regions)

1.3.1 Phospholipids form bilayers in water due to the amphipathic properties of phospholipid molecules.

When put into water, an ***emergent property*** is that phospholipids will self-organise to keep their heads 'wet' and their tails 'dry'



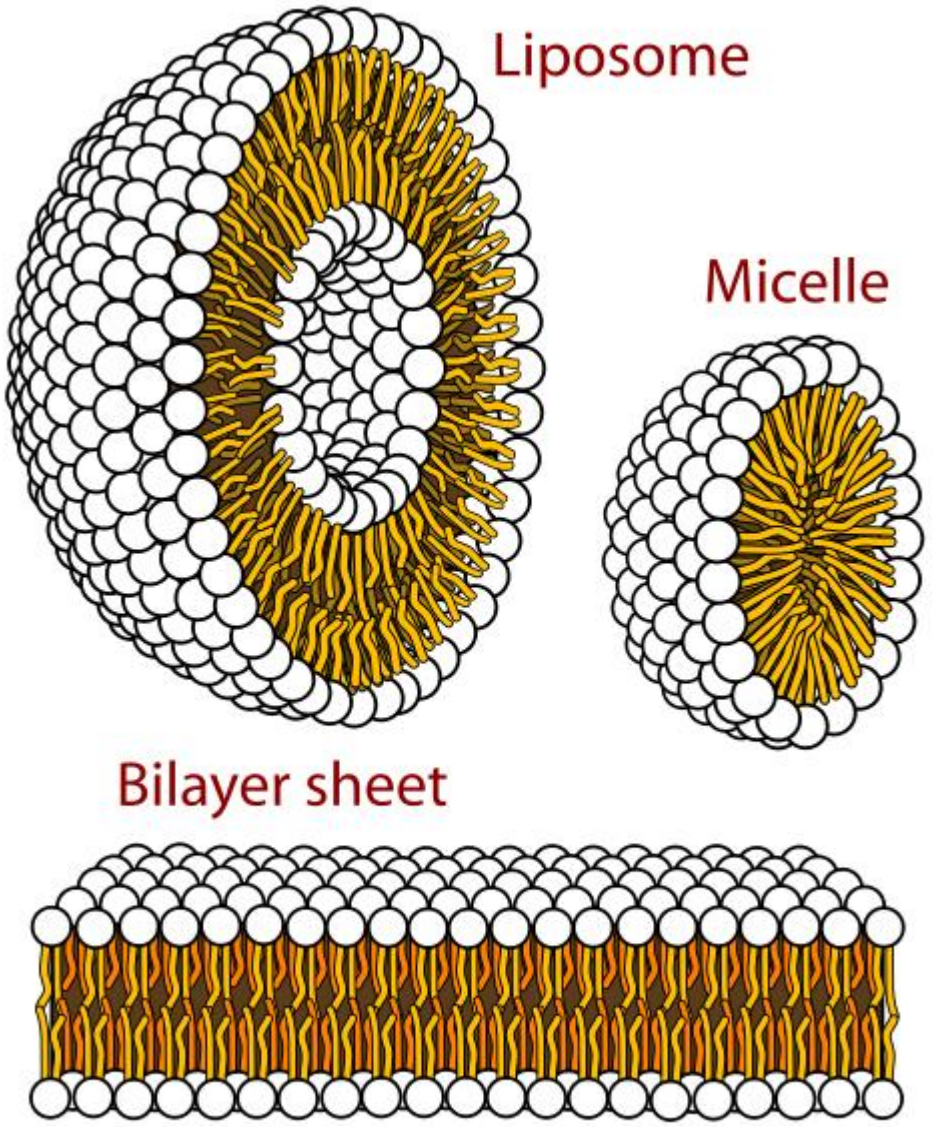
micelle



liposome

1.3.1 Phospholipids form bilayers in water due to the amphipathic properties of phospholipid molecules.

In this 3D representation you can see that a **phospholipid bilayer** is one way that the tails can be removed from the water.



Phospholipid molecules can flow past each other laterally but can't move vertically

1.3.1 Phospholipids form bilayers in water due to the amphipathic properties of phospholipid molecules.

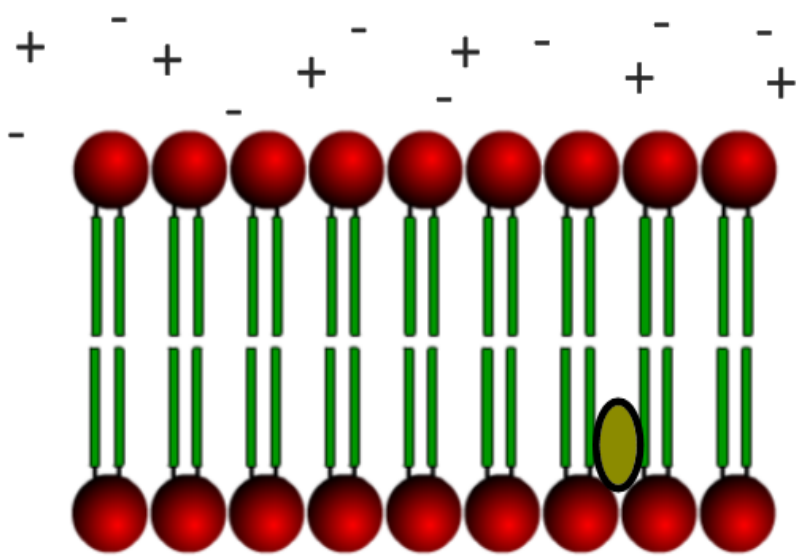
The phospholipid bilayer is selectively permeable

controlled — entry/ exit of molecules

Some molecules pass through easily (diffusion), or go through a 'tunnel' (facilitated diffusion)
Others need energy to get them through (active transport)
Large molecules use their own membrane to get them through (endo-/exo-cytosis)

polar heads:
attracted to other polar (charged) molecules

non-polar tails:
will repel any charged molecule, therefore preventing passage of ions through the membrane.

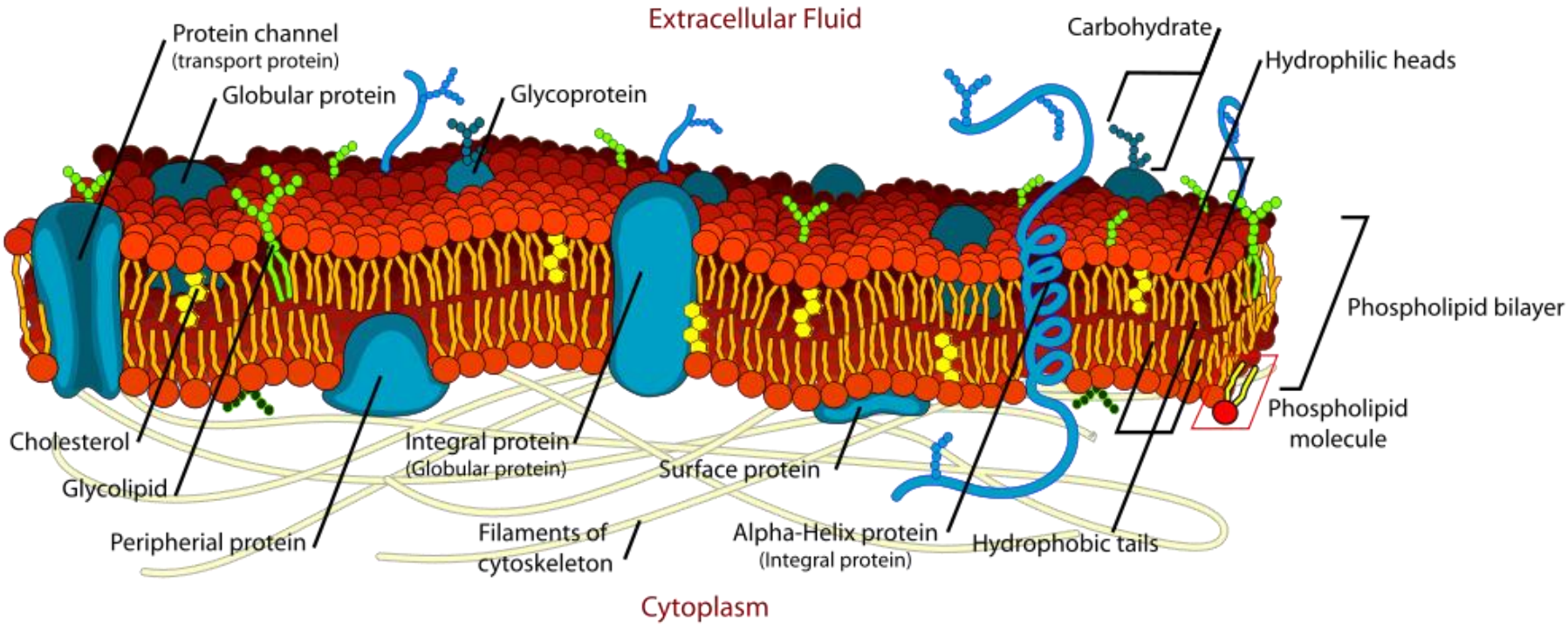


1.3.7 Analysis of the falsification of the Davison-Danielli model that led to the Singer-Nicolson model.

Our current model of the cell membrane is called the **Singer-Nicholson fluid mosaic model**

Key features:

- Phospholipid molecules form a bilayer - phospholipids are fluid and move laterally
- Peripheral proteins are bound to either the inner or outer surface of the membrane
- Integral proteins - permeate the surface of the membrane
- The membrane is a fluid mosaic of phospholipids and proteins
- Proteins can move laterally along membrane



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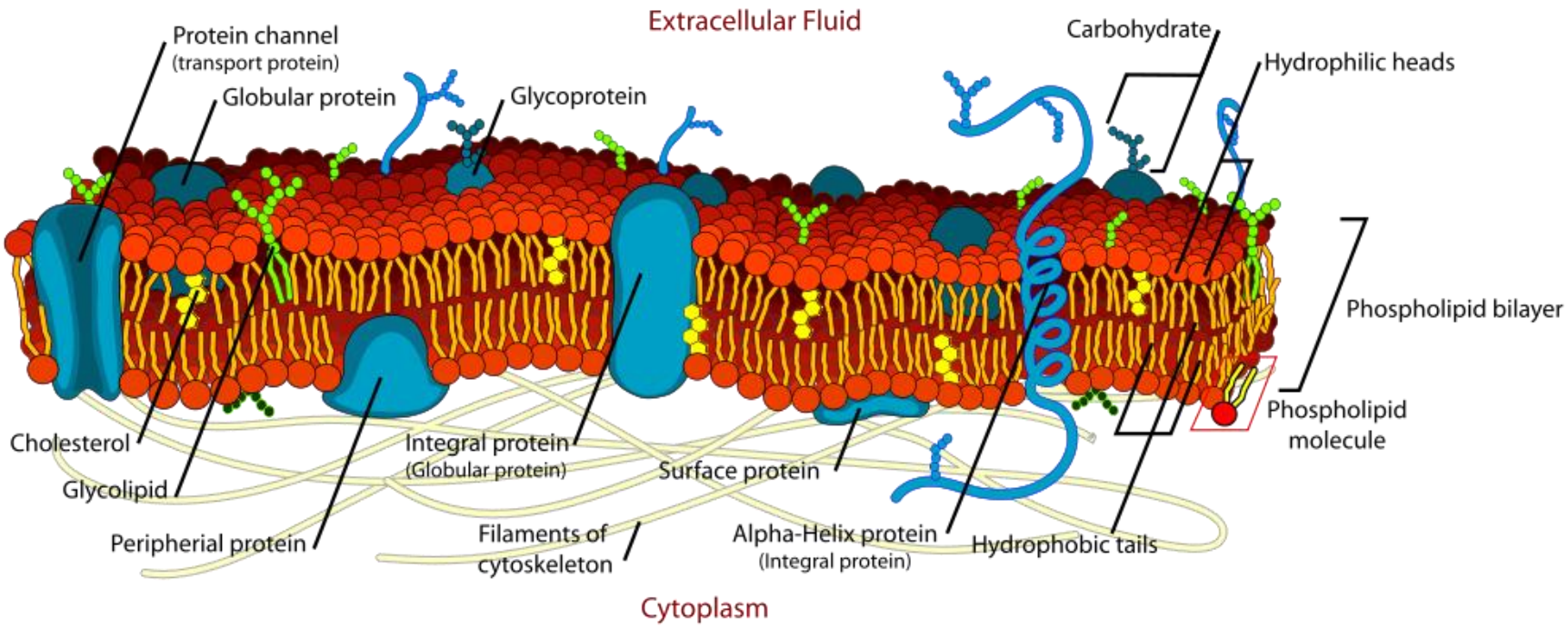
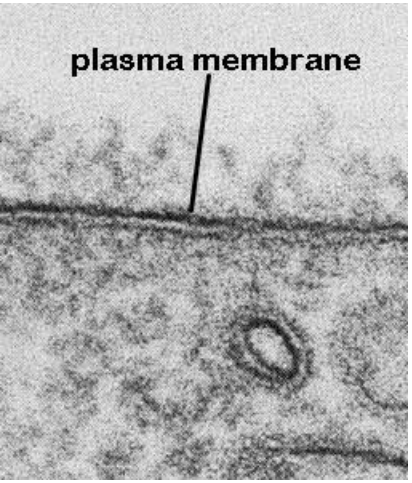


Singer-Nicolson model was first proposed in **1972**

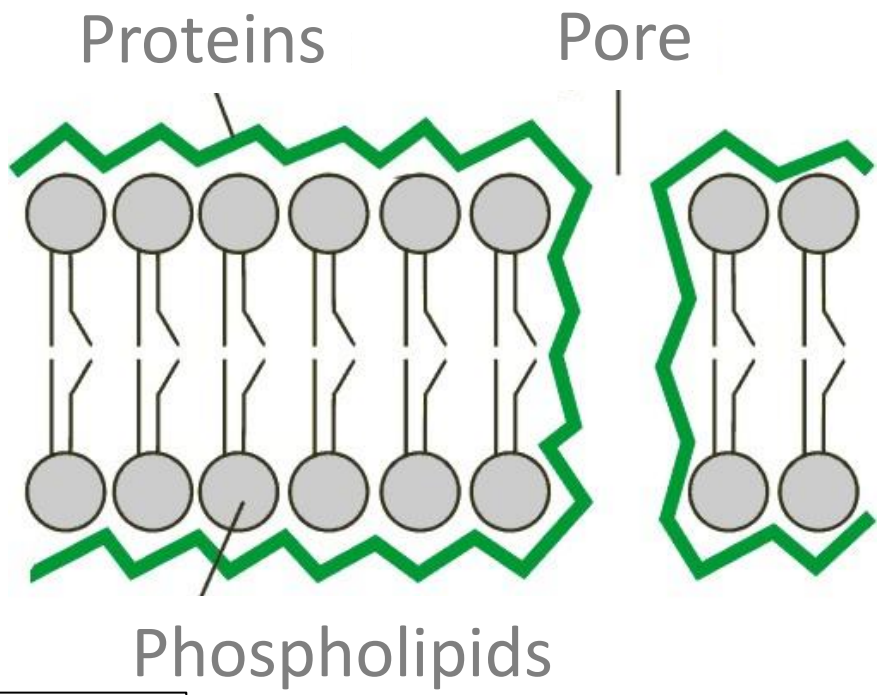
Before then Davson-Danielli model (1930) was widely accepted …

1.3.6 Analysis of evidence from electron microscopy that led to the proposal of the Davson-Danielli model.



The Evidence: In high magnification electron micrographs membranes appeared as two dark parallel lines with a lighter colored region in between. Proteins appear dark in electron micrographs and phospholipids appear light - possibly indicating proteins layers either side of a phospholipid core.

Davson-Danielli Model



The model:

- *A protein-lipid sandwich*
- Lipid bilayer composed of phospholipids (hydrophobic tails inside, hydrophilic heads outside)
- Proteins coat outer surface
- Proteins do not permeate the lipid bilayer

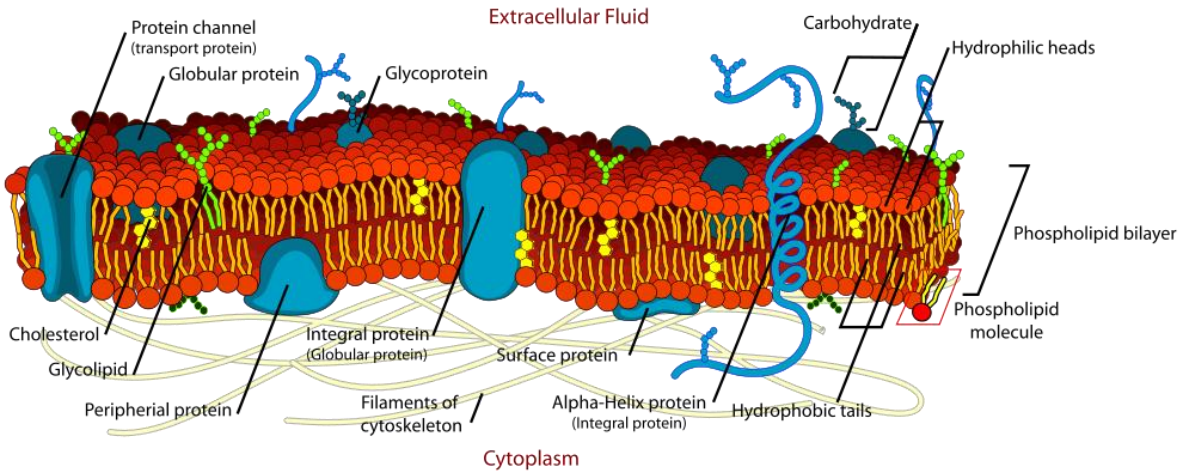
This explains: Despite being very thin membranes are an effective barrier to the movement of certain substances.

1.3.7 Analysis of the falsification of the Davison-Danielli model that led to the Singer-Nicolson model.

Through the 1950s and 1960s, experimental evidence began to show major flaws in the Davison-Danielli model…

Biochemical techniques

- Membrane proteins were found to be very varied in size and globular in shape



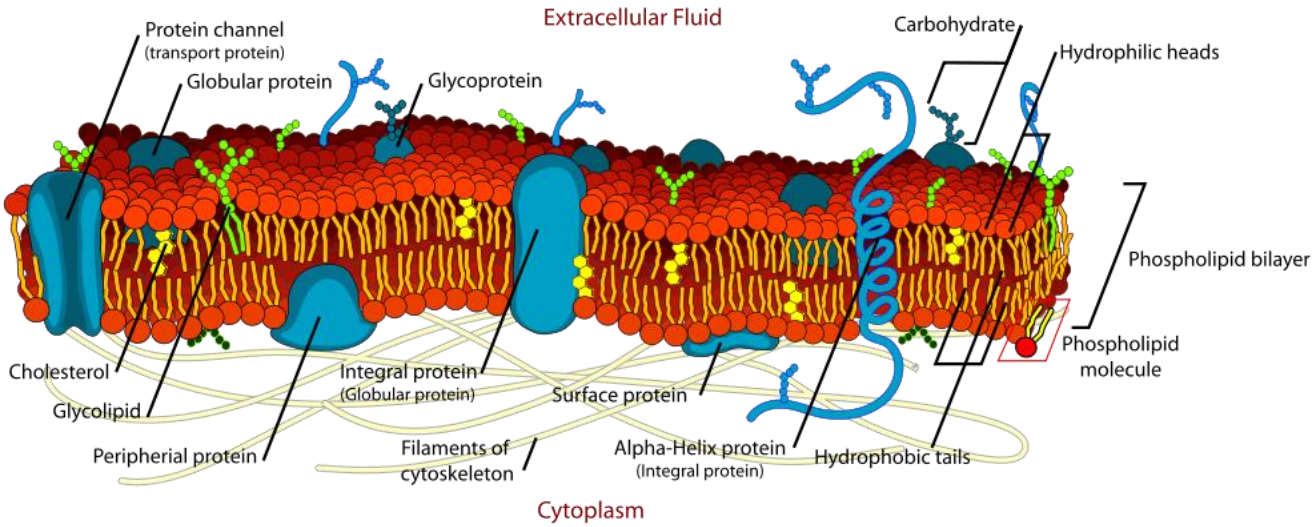
- **Such proteins would be unable to form continuous layers on the periphery of the membrane.**
- **The membrane proteins had hydrophobic regions and therefore would embed in the membrane not layer the outside**

1.3.7 Analysis of the falsification of the Davison-Danielli model that led to the Singer-Nicolson model.

Through the 1950s and 1960s, experimental evidence began to show major flaws in the Davison-Danielli model…

Fluorescent antibody tagging

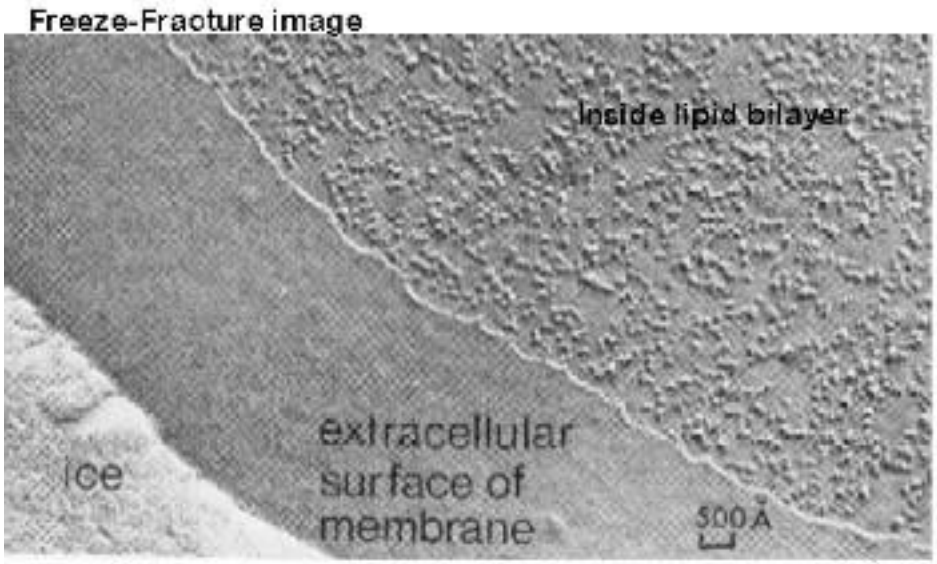
- Red or green fluorescent markers attached to antibodies which would bind to membrane proteins
- The membrane proteins of some cells were tagged with red markers and other cells with green markers.
- The cells were fused together.



- Within 40 minutes the red and green markers were mixed throughout the membrane of the fused cell
- **This showed that membrane proteins are free to move within the membrane rather than being fixed in a peripheral layer.**

1.3.7 Analysis of the falsification of the Davison-Danielli model that led to the Singer-Nicolson model.

freeze fracturing



This technique involves rapid freezing of cells and then fracturing them.

Interpreting the image:

- The fracture occurs along lines of weakness, including the centre of membranes.
- The fracture reveals an irregular rough surface inside the phospholipid bilayer
- **The globular structures were interpreted as trans-membrane proteins.**

Conclusion:

This is contrary to the Davson-Danielli model which only involves proteins coating the surface of the membrane. A new model is needed to explain the presence of as trans-membrane proteins.

1.3.7 Analysis of the falsification of the Davison-Danielli model that led to the Singer-Nicolson model.

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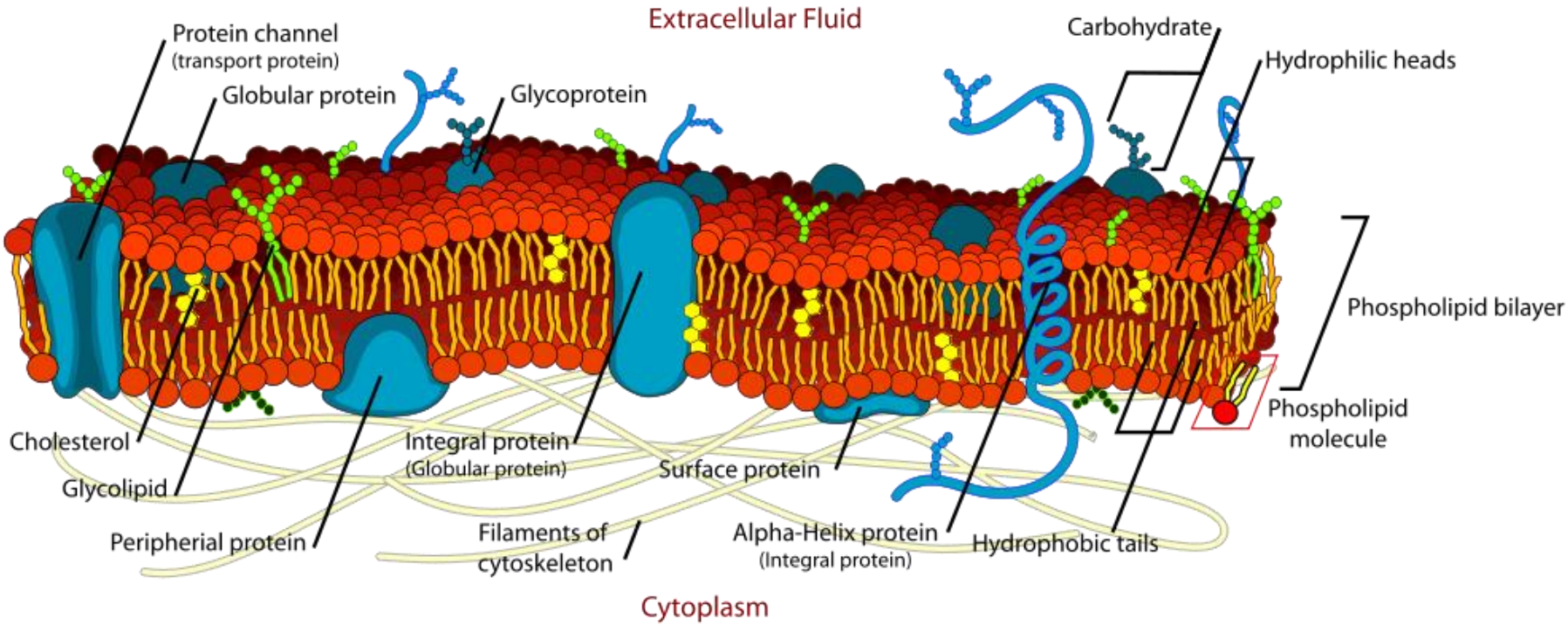
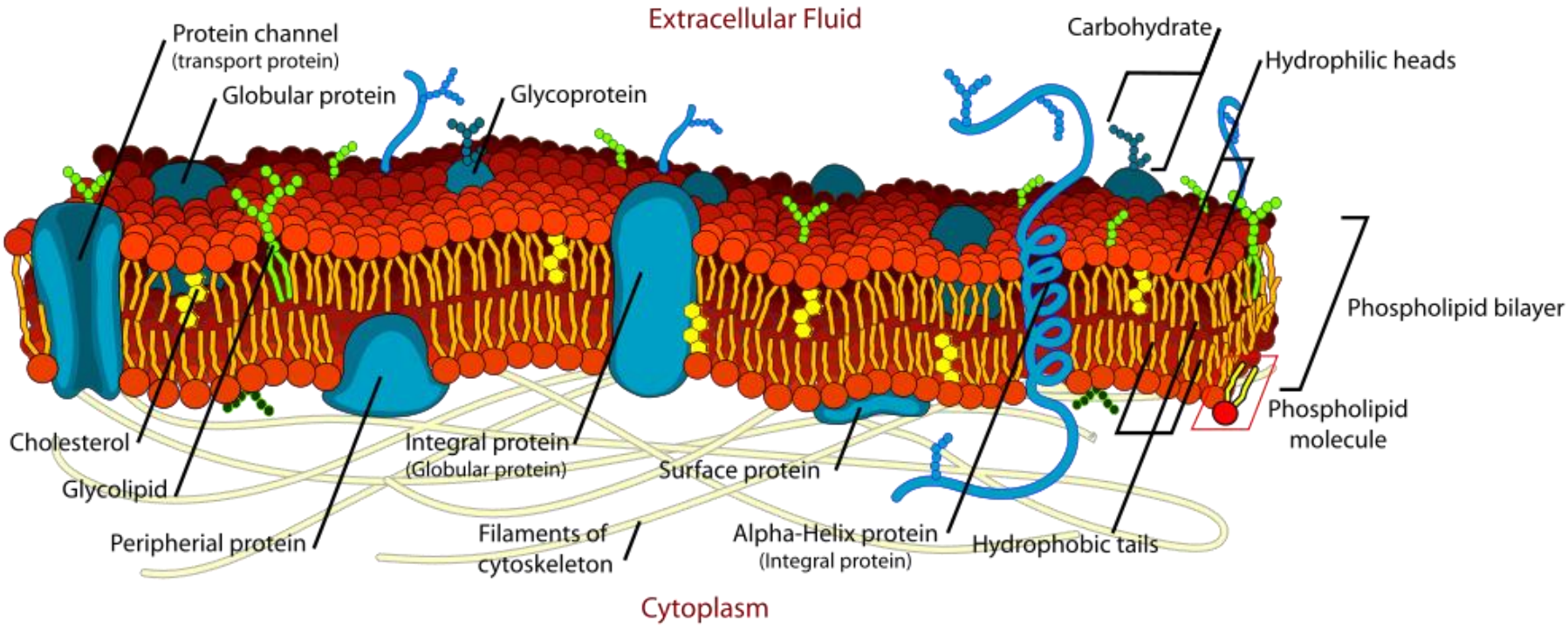


1.3.2 Membrane proteins are diverse in terms of structure, position in the membrane and function.

Proteins:

Integral proteins are permanently embedded, many go all the way through and are **polytopic** (poly = many, topic = surface), integral proteins penetrating just one surface are **monotopic.**

Peripheral proteins usually have a temporary association with the membrane, they can be **monotopic** or attach to the surface



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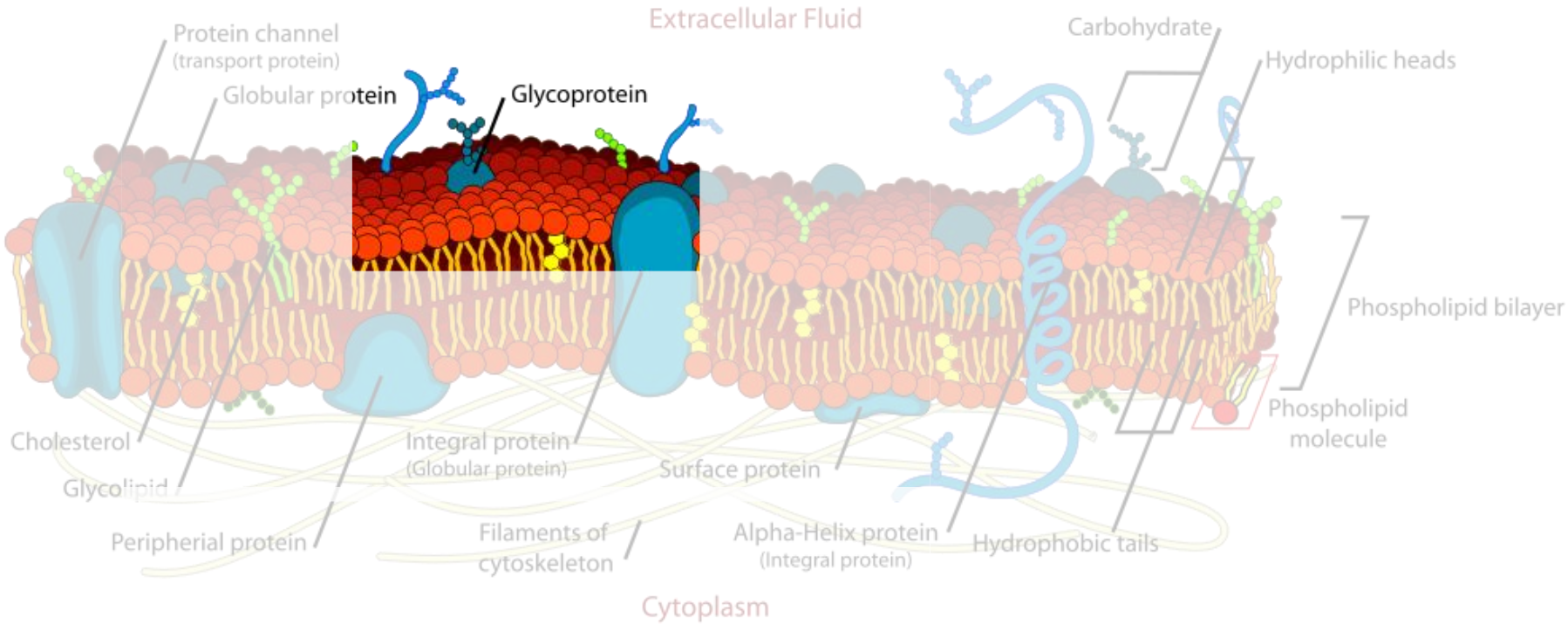
Glycoproteins:

Are proteins with an **oligosaccaride** (oligo = few, saccharide = sugar) chain attached.

They are important for cell **recognition by the immune system** and as **hormone receptors**



1.3.2 Membrane proteins are diverse in terms of structure, position in the membrane and function.

Proteins associated with membranes have many functions.
Can you think of any 'jobs' that proteins could help cells do?

Let's look at

6

1

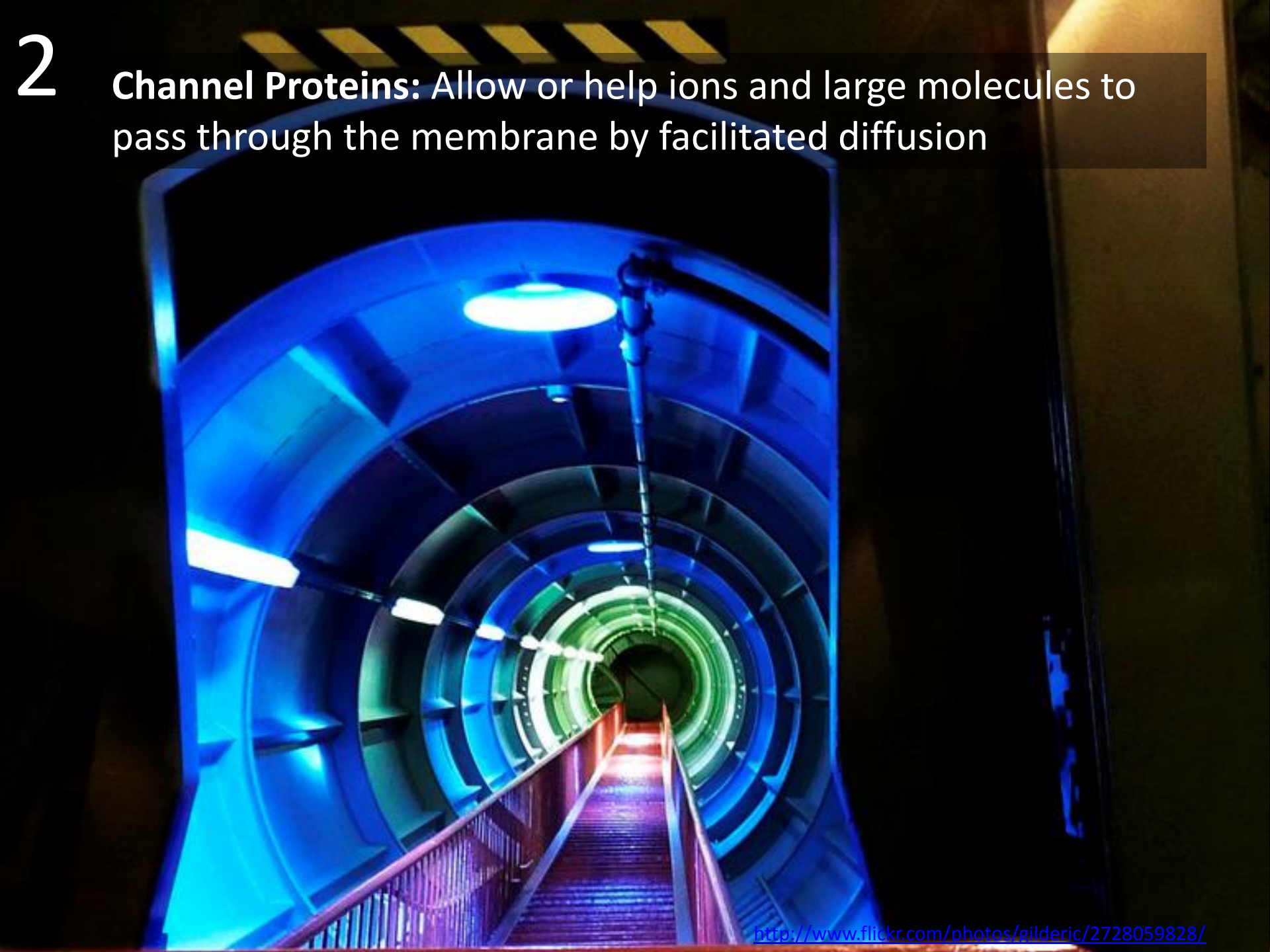
Cell Adhesion Molecules:
Enable cells to make tight connections to one another

They may play a part in the immune response.

http://www.flickr.com/photos/silveraquarius/1395277674/

2

Channel Proteins: Allow or help ions and large molecules to pass through the membrane by facilitated diffusion



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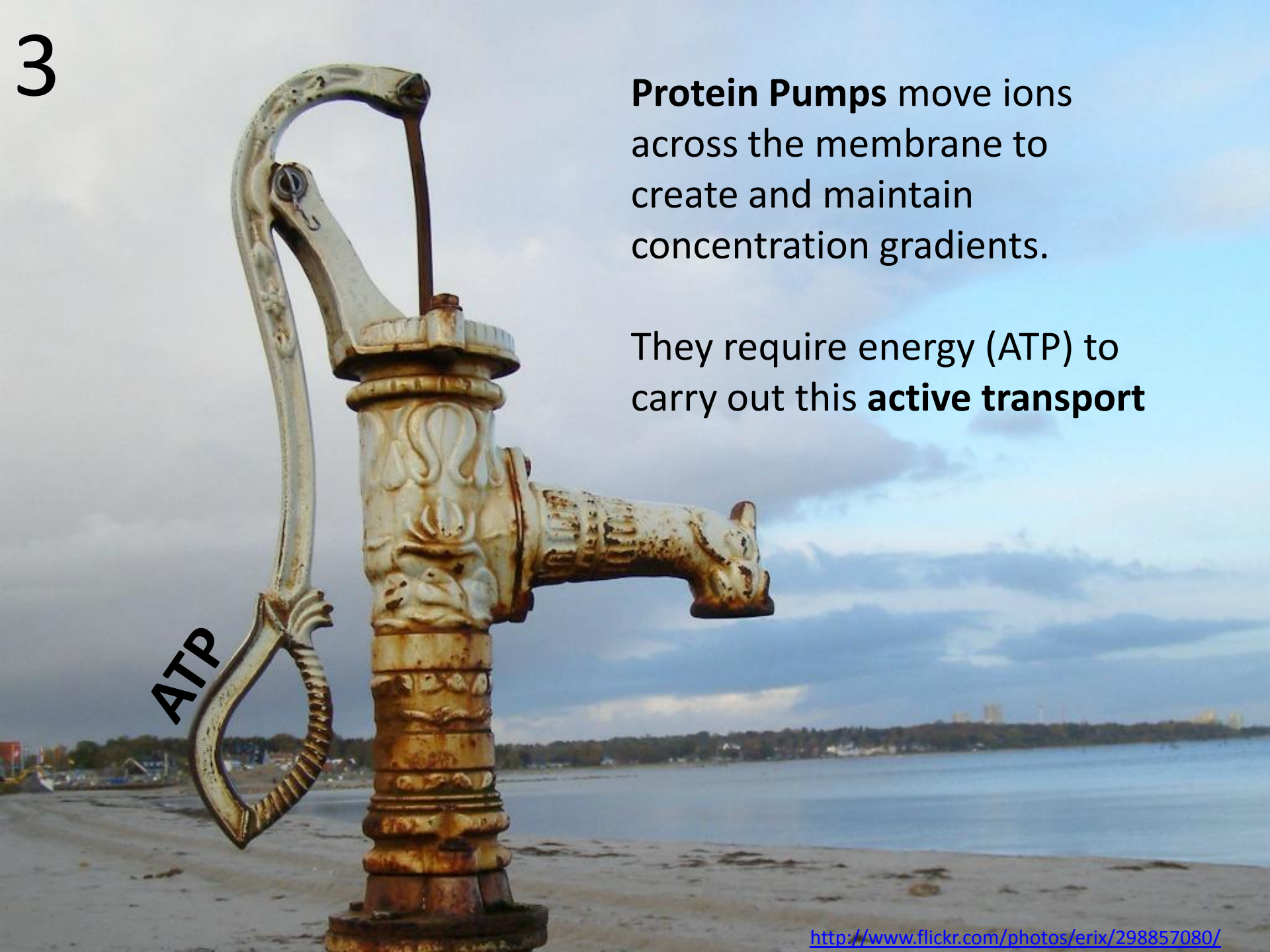


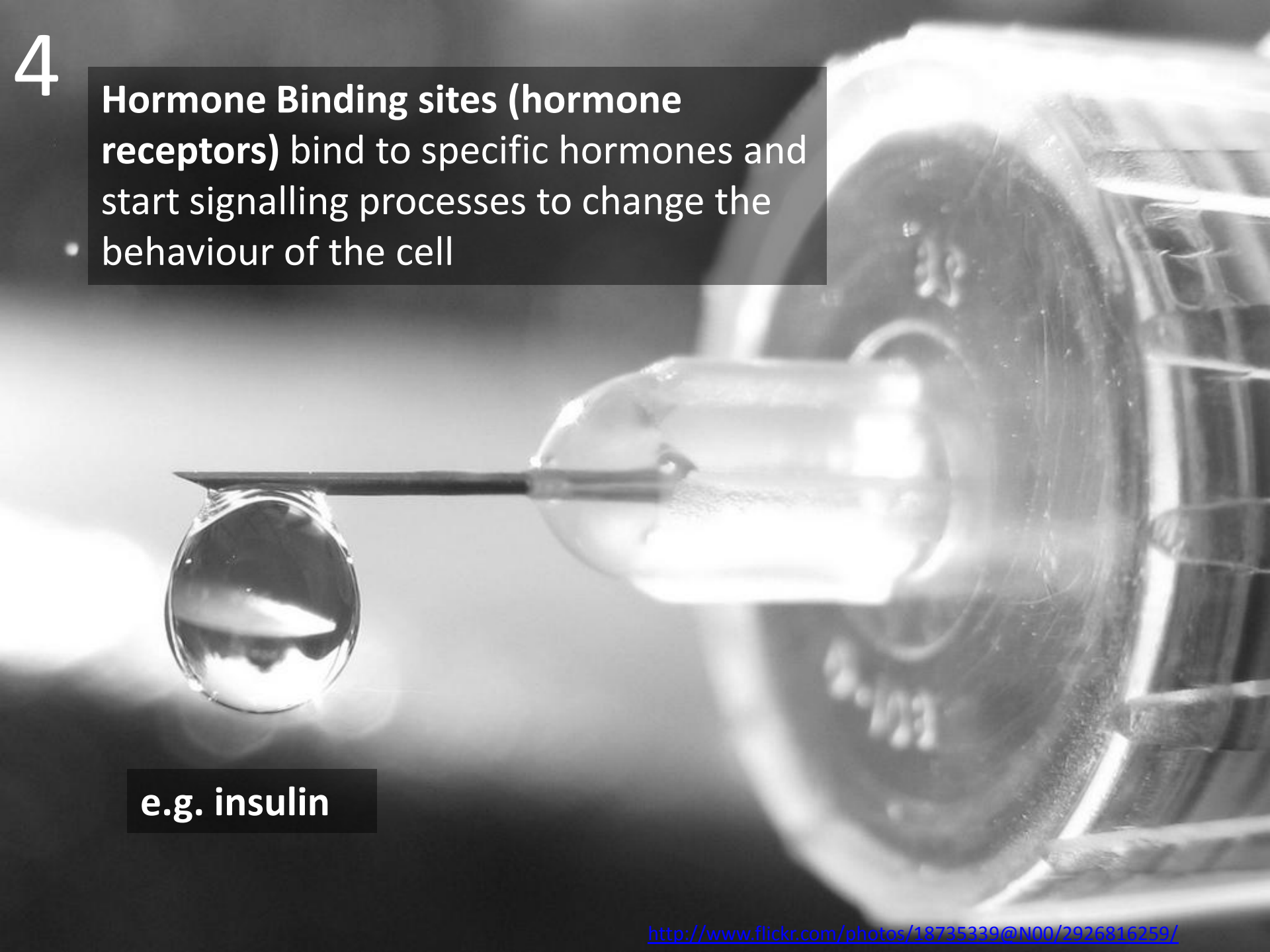
Protein Pumps move ions across the membrane to create and maintain concentration gradients.

They require energy (ATP) to carry out this **active transport**

http://www.flickr.com/photos/erix/298857080/

4

Hormone Binding sites (hormone receptors) bind to specific hormones and start signalling processes to change the behaviour of the cell



e.g. insulin

http://www.flickr.com/photos/18735339@N00/2926816259/

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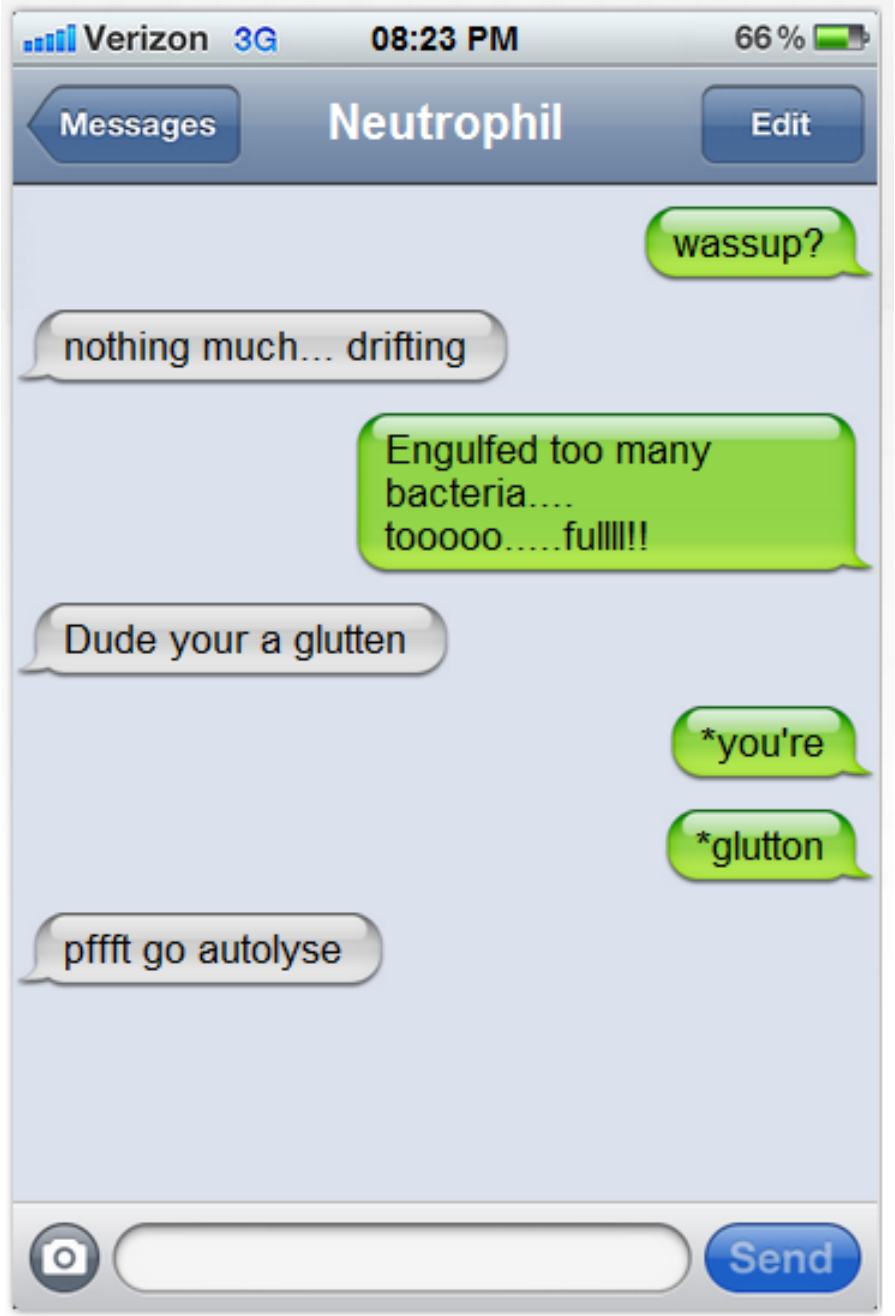
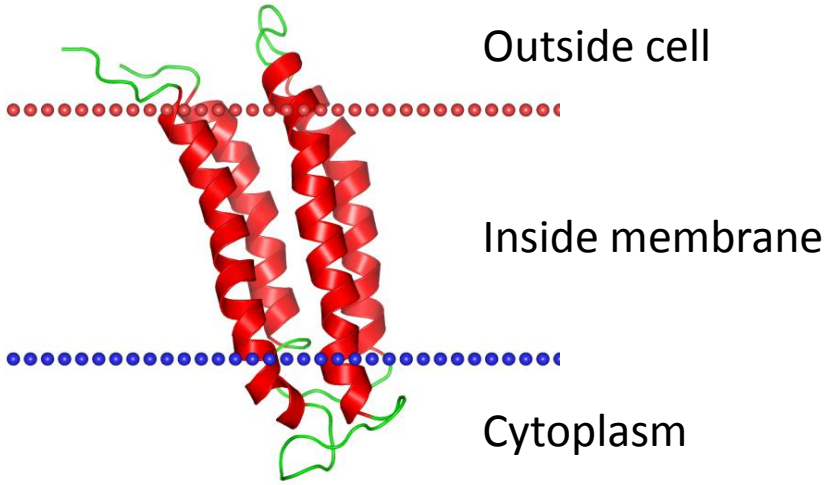


Cell to cell communication:
e.g. receptors for neurotransmitters at synapses



Nicotinic acetylcholine receptor, beta2 subunit

http://ifaketext.com/
http://opm.phar.umich.edu/protein.php?pdbid=2ksr

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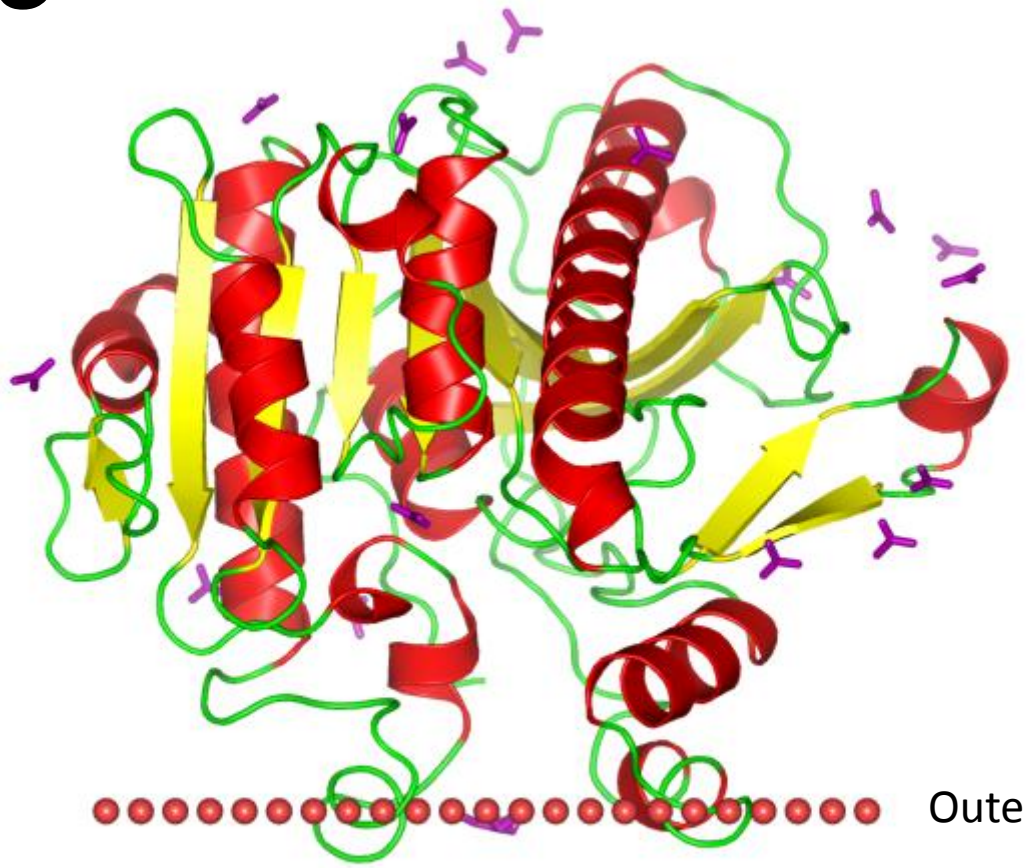


Immobilized Enzymes on the surface of the cell

Outer surface of membrane

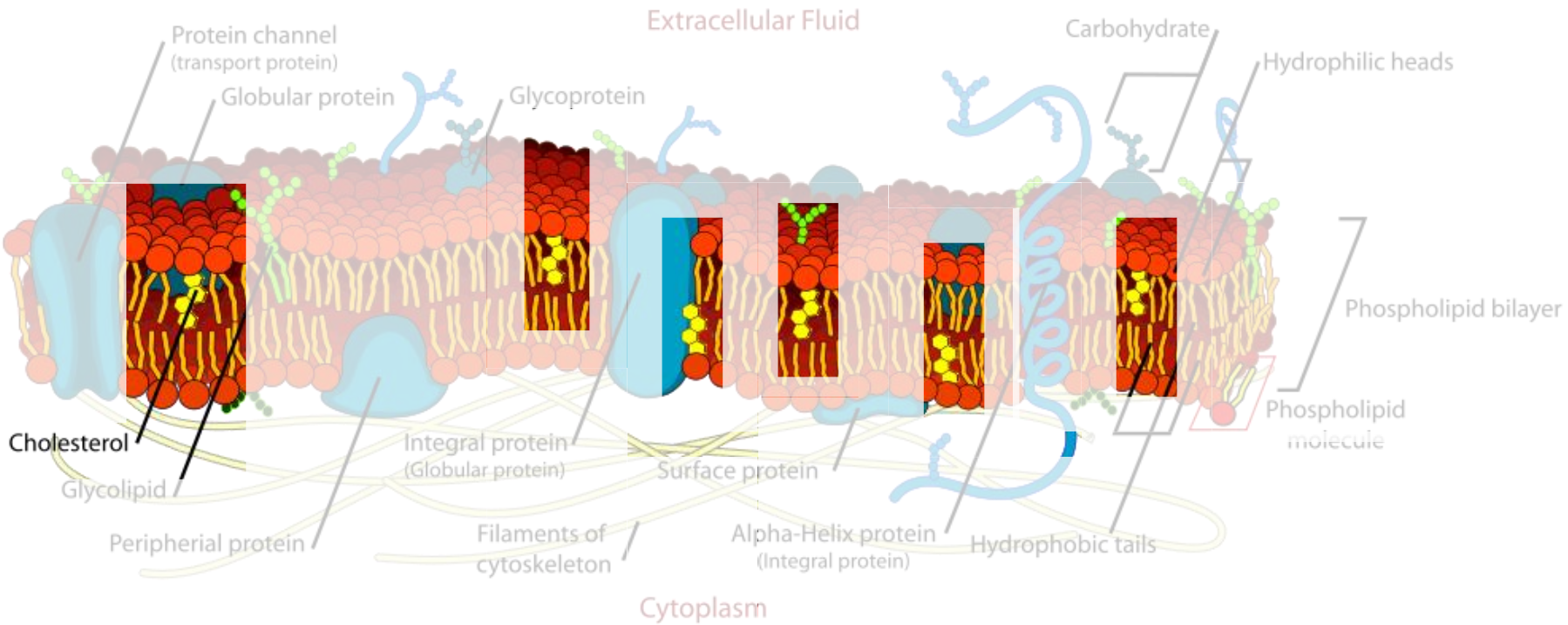
Plasma platelet activating factor acetylhydrolase

1.3.3 Cholesterol is a component of animal cell membranes.

Cholesterol: (It's not all bad!)

It makes the phospholipids pack more tightly and **regulates the fluidity and flexibility** of the membrane.

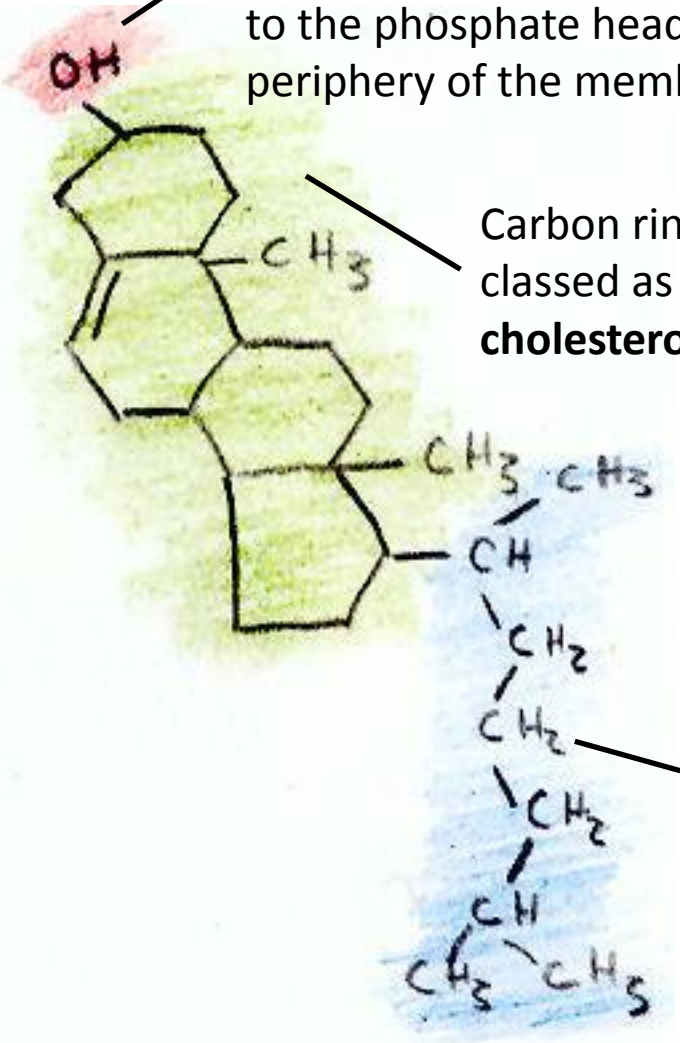
Bad analogy: imagine a room full of people wearing fluffy sweaters. It is crowded but they can slip past each other easily enough. Now sprinkle the crowd with people wearing Velcro suits…



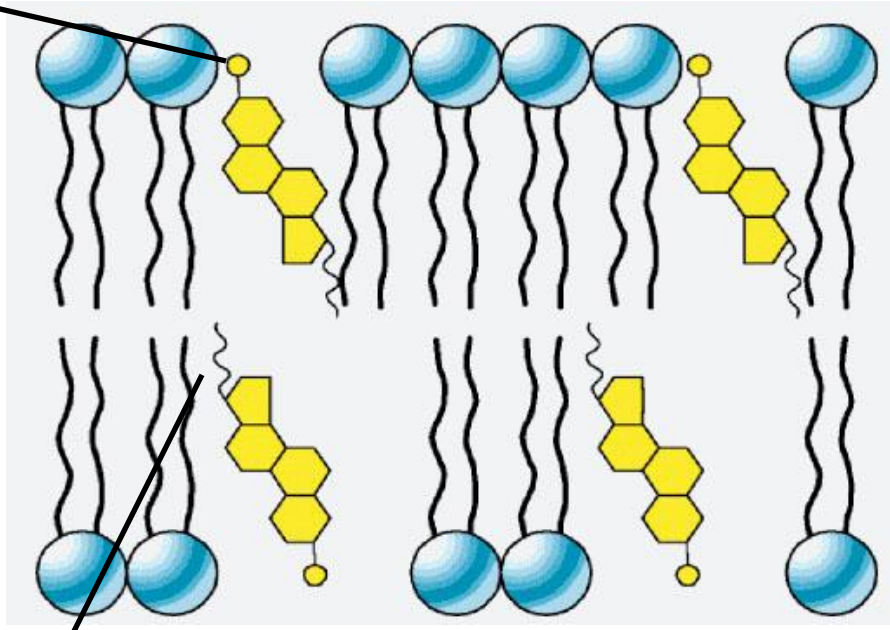
1.3.3 Cholesterol is a component of animal cell membranes.

Cholesterol

Hydroxyl group makes the head polar and hydrophilic - attracted to the phosphate heads on the periphery of the membrane.



Carbon rings – it's not classed as a fat or an oil, **cholesterol is a steroid**



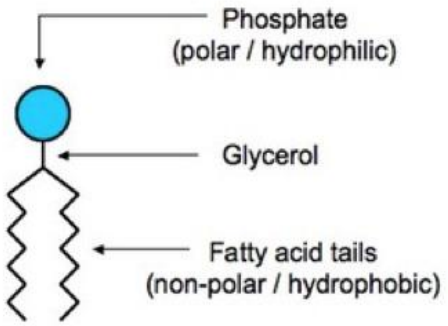
Non-polar (hydrophobic) tail – attracted to the hydrophobic tails of phospholipids in the centre of the membrane

http://www.uic.edu/classes/bios/bios100/lectf03am/cholesterol.jpg

http://www.cholesterol-and-health.com/images/Cholesterol_Structure.jpg

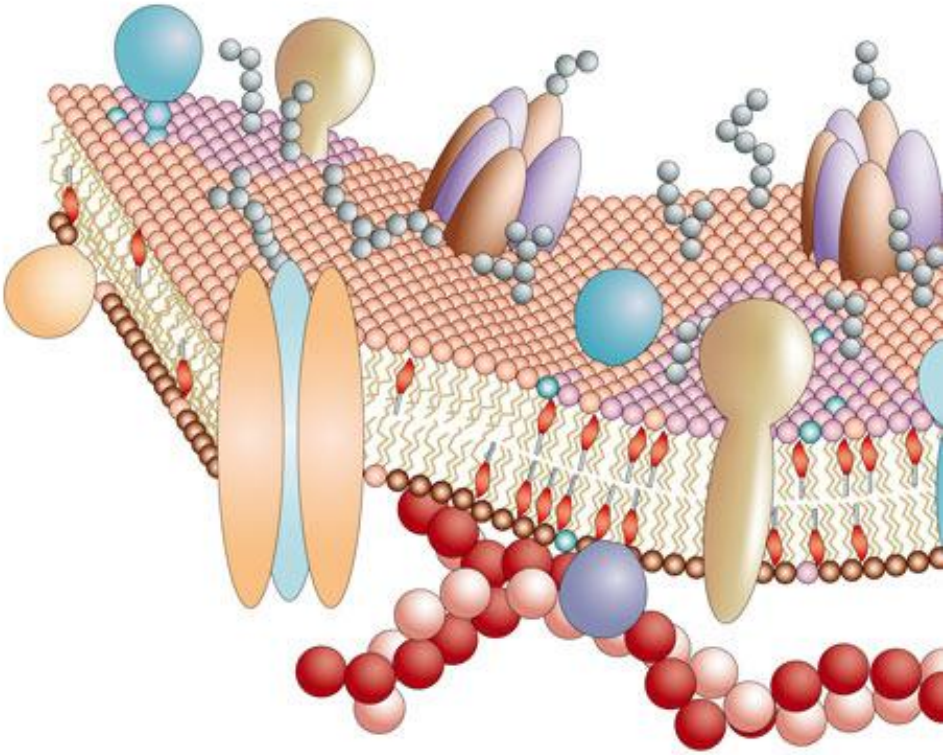
1.3.4 Cholesterol in mammalian membranes reduces membrane fluidity and permeability to some solutes.

Membrane fluidity



The hydrophobic hydrocarbon tails usually behave as a **liquid**. Hydrophilic phosphate heads act more like a **solid**.

Though it is difficult to determine whether the membrane is truly either a solid or liquid it can definitely be said to be ***fluid***.

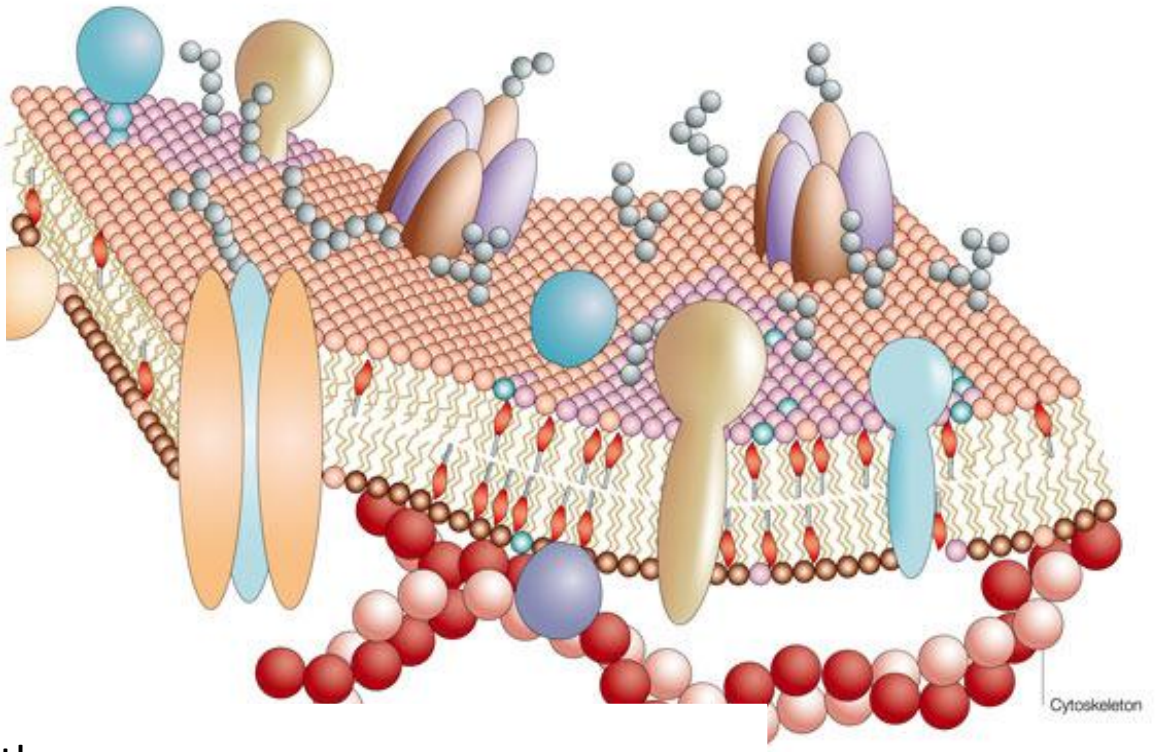


It is important to regulate the degree of fluidity:

- Membranes need to be fluid enough that the cell can move
- Membranes need to be fluid enough that the required substances can move across the membrane
- If too fluid however the membrane could not effectively restrict the movement of substances across itself and could be easily broken apart…

1.3.4 Cholesterol in mammalian membranes reduces membrane fluidity and permeability to some solutes.

Cholesterol's role in membrane fluidity



1. The presence of cholesterol in the membrane **restricts the movement of phospholipids** and other molecules – this reduces membrane fluidity.

2. The presence of cholesterol disrupts the regular packing of the of the hydrocarbon tails of phospholipid molecules - this **increases the flexibility** as it prevents the tails from crystallising and hence behaving like a solid.

3. Cholesterol also **reduces the permeability to hydrophilic/water soluble molecules and ions** such as sodium and hydrogen.

1.3.5 Draw the fluid mosaic membrane model

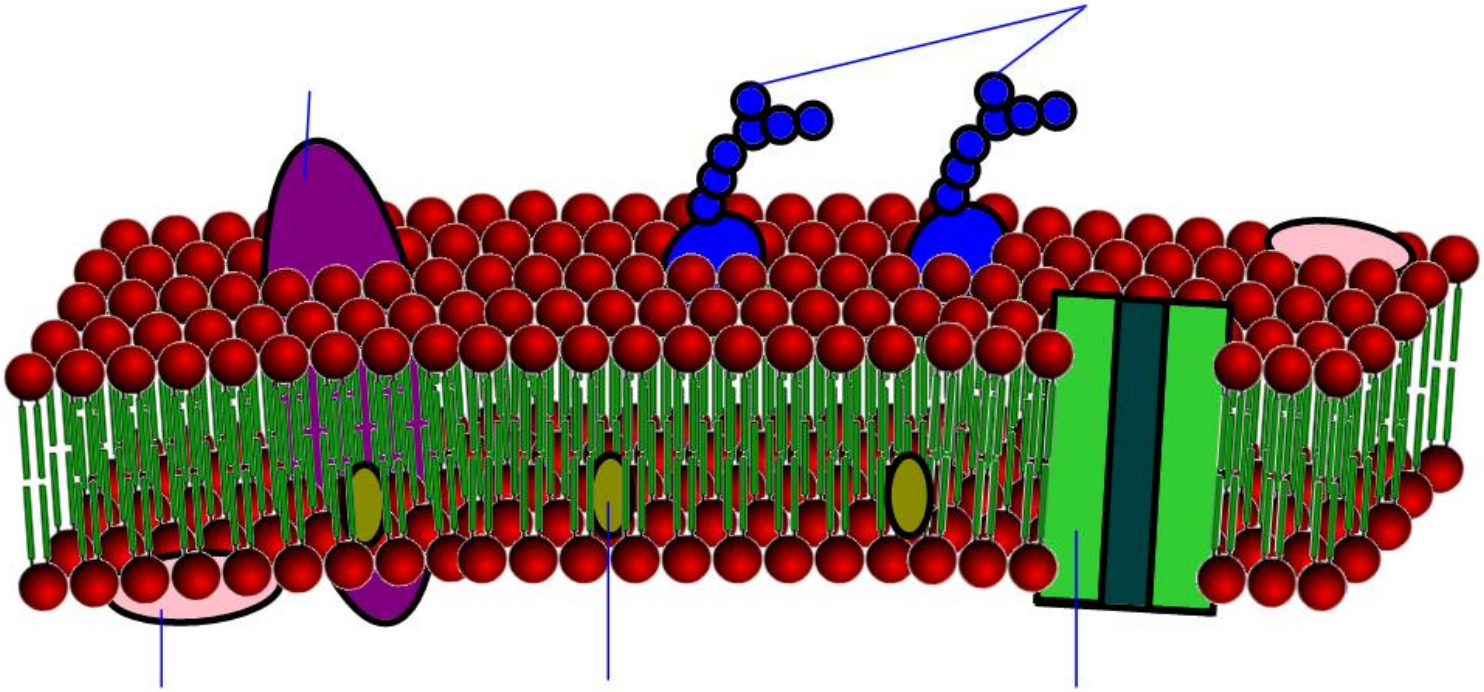
The **Fluid** Mosaic Model

always moving, not solid

collection of things stuck together

representation of real life

What are the names and functions of these parts of the plasma membrane?



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The Mosaic:

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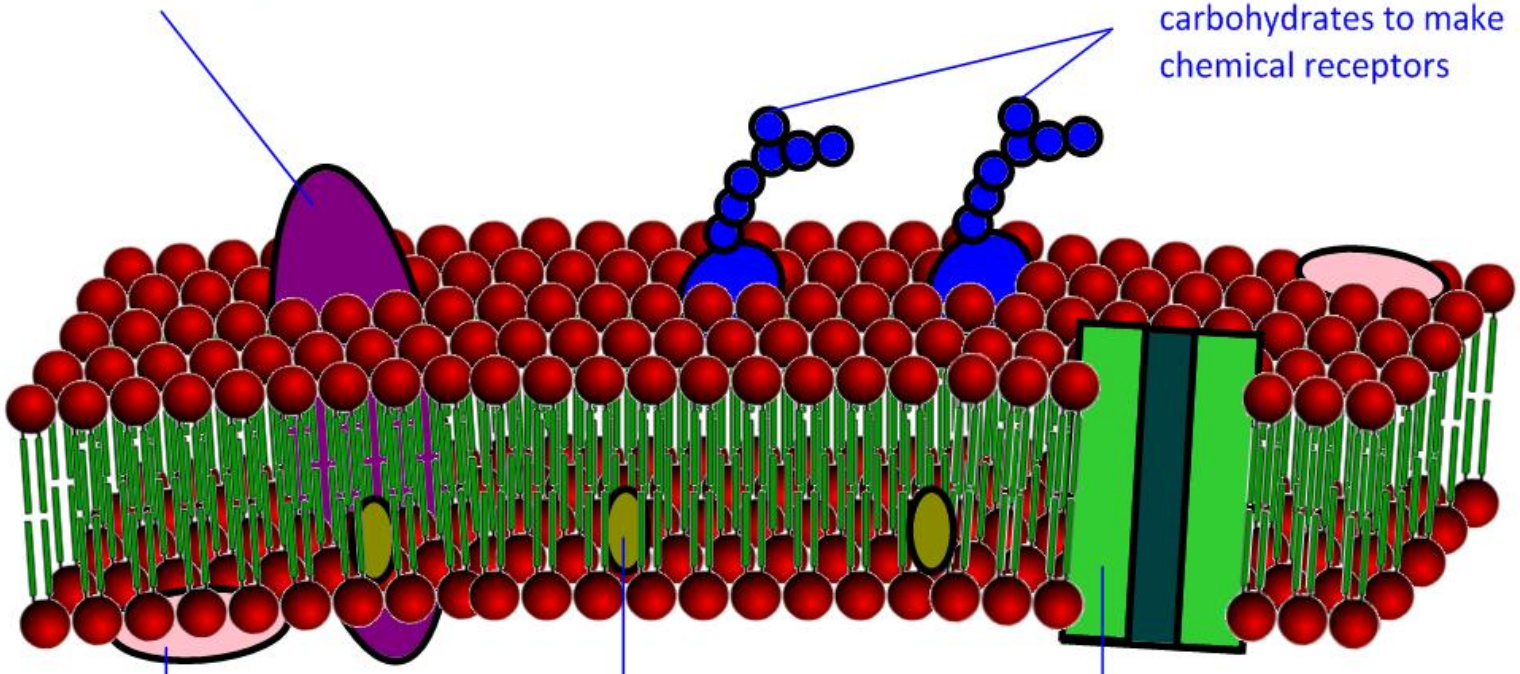

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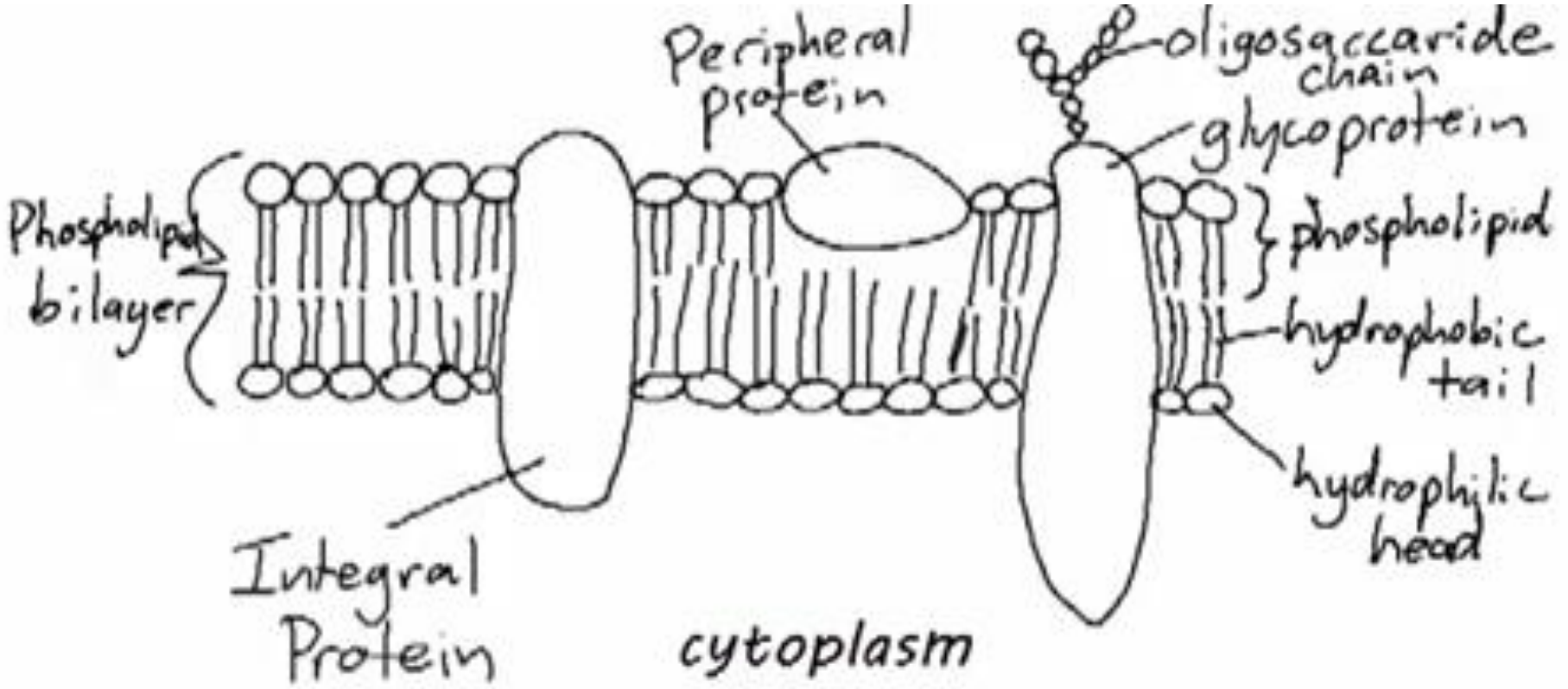

Reminder of features that make good diagrams:

- Good use of space
- Clear strong lines
- **Label lines are straight**
- Labels clearly written
- (Scale bar if appropriate)
- **Lines touch the labeled structure**
- No unnecessary shading or coloring