DP Biology – B2.1

Membranes

- How do lipid and protein molecules come together to form membranes?
- What decides whether a substance can cross a membrane?

SL statements B2.1.1–10. Textbook pp. 223–236.
Image: proteins in a cell membrane, seen by atomic force microscopy. Nucturra, CC0.



Objectives for each class

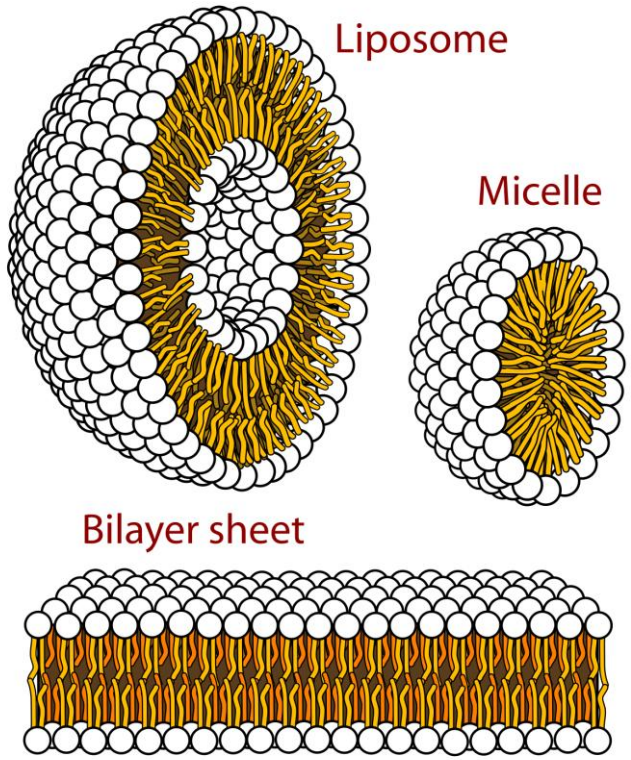
Class	Statements	By the end of the class, you can…
1	B2.1.1–4	Explain how phospholipids form a bilayer, why it is a barrier, and what integral and peripheral proteins are
2	B2.1.5–6	Explain osmosis, aquaporins and facilitated diffusion through channel proteins
3	B2.1.7–8	Explain active transport by pumps, and compare what makes each route selective
4	B2.1.9–10	Describe glycoproteins and glycolipids, and draw the fluid mosaic model

Overview of this chapter

Part	Statements	What it covers
The bilayer	B2.1.1–2	Phospholipids in water, and why membranes are barriers
Passive routes	B2.1.3, 5, 6	Simple diffusion, osmosis and channel proteins
Proteins	B2.1.4	Integral and peripheral proteins
Active route	B2.1.7–8	Pumps, ATP and selective permeability
The whole model	B2.1.9–10	Glycoproteins, glycolipids and the fluid mosaic

Phospholipids form bilayers

B2.1.1



Phospholipids in water. LadyofHats, public domain.

- A phospholipid has a **hydrophilic** phosphate head and two **hydrophobic** hydrocarbon tails
- A molecule with both properties is **amphipathic**
- In water, heads face the water and tails face each other
- This forms a continuous double layer without any energy being used, and it can reseal itself

Key idea

Membranes form because of how the molecules behave in water.

Membranes surround cells, and also compartments inside eukaryotic cells such as mitochondria and the rough ER.

Why the bilayer is a barrier

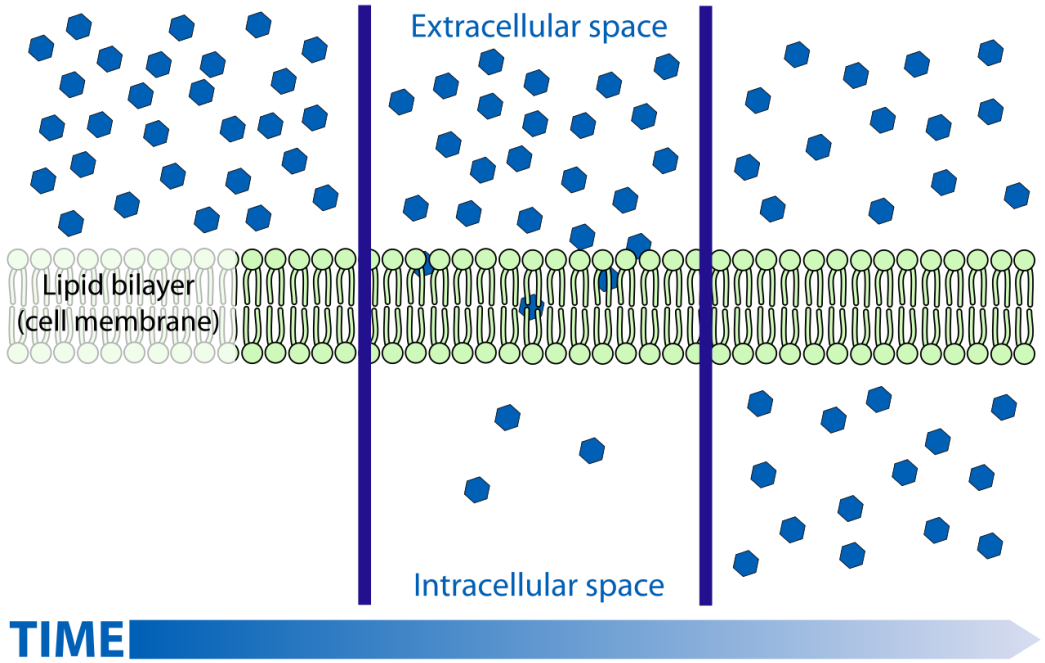
- The core of the membrane is made of **hydrophobic hydrocarbon chains**
- This core has low permeability to **large molecules** and to **hydrophilic particles**
- So a membrane separates two watery solutions from each other

Type of particle	Examples	Crosses the bilayer?
Small and non-polar	Oxygen, carbon dioxide	Easily
Small and polar	Water, ethanol, urea	Slowly
Large and polar	Glucose, sucrose	Very little
Ions	Na^+, K^+, Cl-	Almost not at all

Key idea

Charged particles are held back by the hydrophobic core, not by the heads.

Simple diffusion across membranes



Simple diffusion. LadyofHats, public domain.

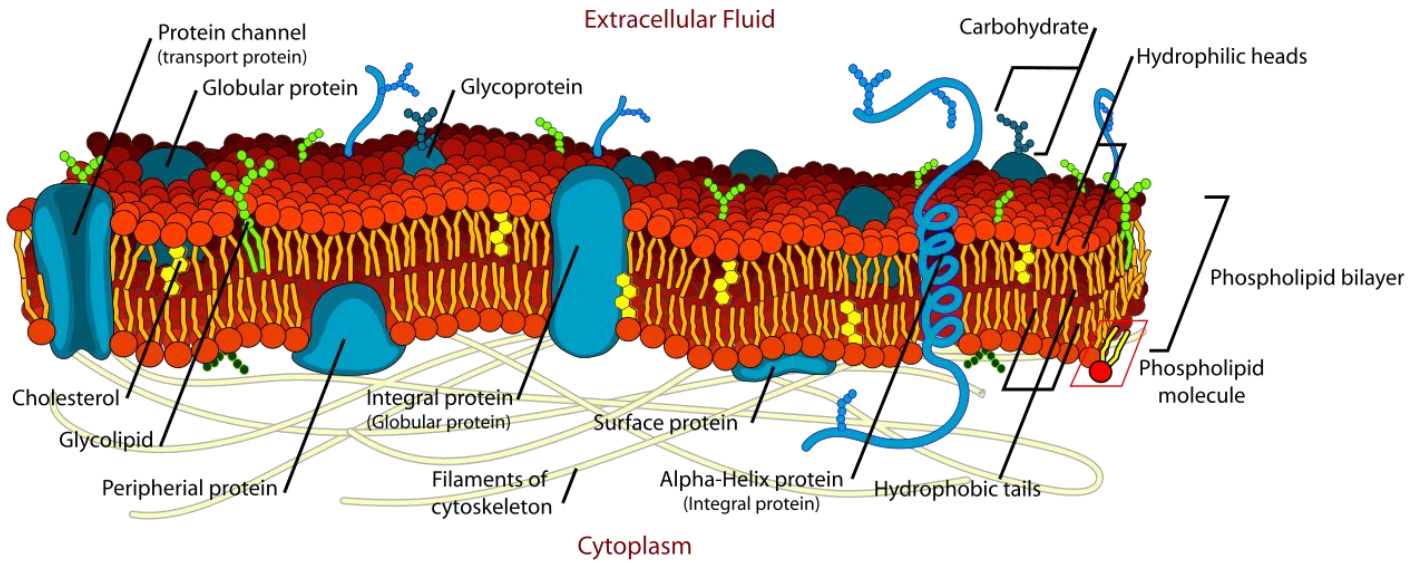
- **Diffusion** is net movement from higher to lower concentration
- It is passive, so no ATP is used
- Oxygen and carbon dioxide pass between the phospholipids
- Particles move in both directions; the **net** movement is down the gradient

Practical idea

Glue a crystal of potassium manganate(VII) to the bottom of two beakers. Add hot water to one and cold water to the other, at the same moment. Describe and explain what you see. Then list other factors that could change the rate: gradient, distance and surface area.

Integral and peripheral proteins

B2.1.4



Cell membrane. Mariana Ruiz, public domain.

	Integral proteins	Peripheral proteins
Position	Embedded in one or both lipid layers	Attached to one surface of the bilayer
Surface	Hydrophobic where they touch the core	Hydrophilic

Membrane proteins vary widely in structure and role: channels, pumps, enzymes, receptors and adhesion. More active membranes have more protein.

Osmosis: water crossing membranes

B2.1.5

- **Osmosis** is the net movement of water across a membrane, from a region of **lower** solute concentration to a region of **higher** solute concentration
- Water molecules move randomly in both directions
- The membrane does not let the solute through, so a difference in solute concentration remains
- Solute particles attract water molecules, so fewer water molecules are free to move on the concentrated side

Common mistake

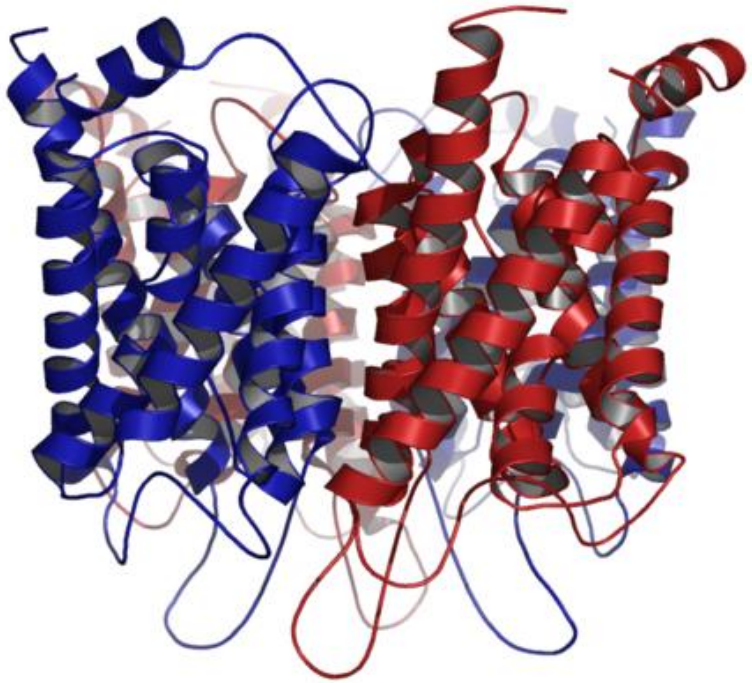
Write about solute concentration. Avoid saying that water moves from high water concentration, and avoid saying that the solute moves.

Discussion

A drop of very concentrated sugar solution is placed on one side of a membrane, with pure water on the other. Predict what will happen to the volumes on each side, and why it will eventually slow.

Aquaporins speed up osmosis

B2.1.5



Aquaporin from the side. Vossman, CC BY-SA 3.0.

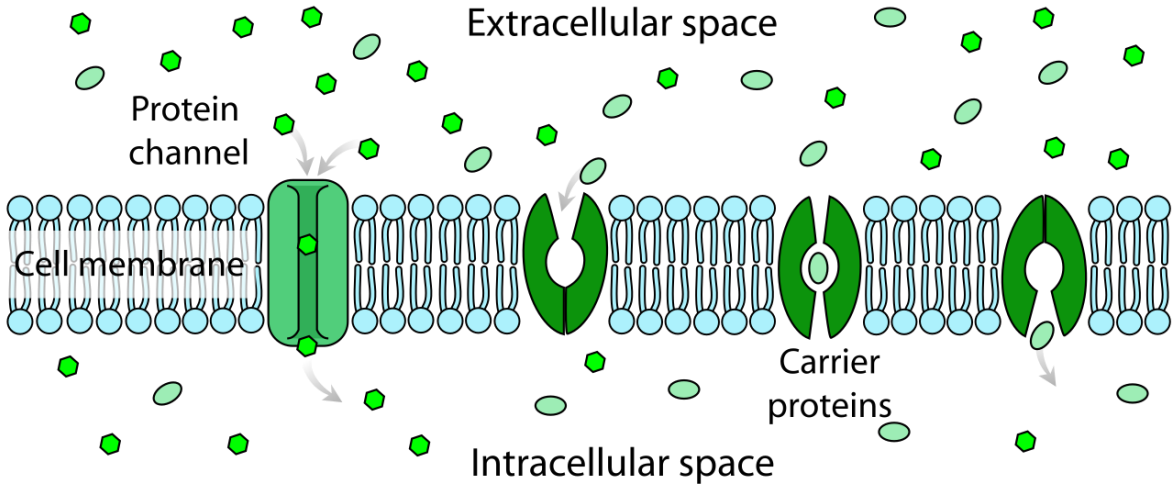
- Water is polar, but small enough to cross the bilayer slowly
- An **aquaporin** is a channel protein for water
- It lets water through far faster, while blocking ions
- Cells that move a lot of water have many, such as kidney collecting duct cells and root hair cells

Key idea

Aquaporins change how fast water crosses a membrane. The direction still depends on solute concentrations.

Channel proteins and facilitated diffusion

B2.1.6



Facilitated diffusion. LadyofHats, public domain.

- A channel is a protein with a hydrophilic **pore**
- Its diameter and charge decide **which particle** can pass
- Many channels are **gated**, so they open and close
- Movement is passive and down the gradient

Key idea

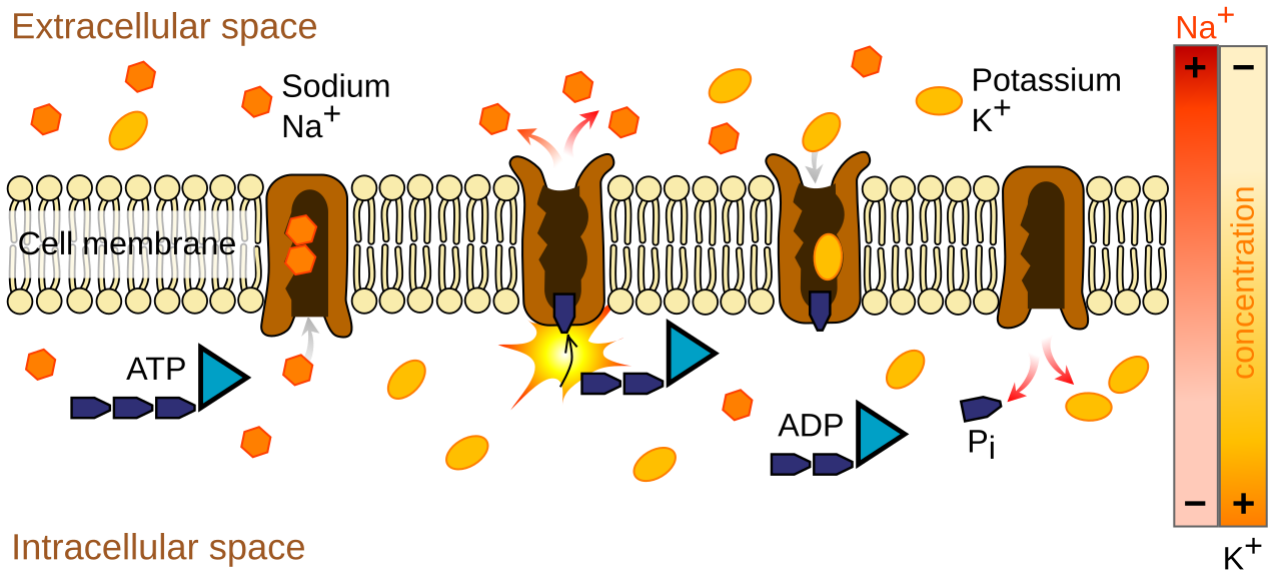
Each channel admits specific ions when open and none when closed, and this makes the membrane selectively permeable.

Data question

As concentration rises, simple diffusion keeps increasing, but facilitated diffusion levels off. Suggest why. Think about what limits the second process.

Pump proteins and active transport

B2.1.7



The sodium-potassium pump. LadyofHats, public domain.

- A pump uses **energy from ATP**
- It moves a specific particle **against** its gradient
- ATP causes the protein to change shape
- Pumps usually work in one direction only

Common mistake

Active transport does not create energy, and it is not the same as facilitated diffusion. Both use proteins, but only pumps use ATP and move particles against a gradient. Cells with much active transport, such as root hair cells, usually have many mitochondria.

Comparing the four routes

B2.1.3, 5–7

Route	ATP?	Protein?	Direction	Example
Simple diffusion	No	No	Down gradient	Oxygen
Osmosis	No	Sometimes	To higher solute concentration	Water
Facilitated diffusion	No	Channel	Down gradient	Potassium ions
Active transport	Yes	Pump	Against gradient	Sodium ions

Activity

Close the table. For glucose, oxygen, sodium ions and water, say which route each takes across a membrane and give a reason using its size and polarity.

Selective permeability

B2.1.8

Route	Is it selective?	Depends on
Simple diffusion	No	Only size and hydrophobic or hydrophilic properties
Facilitated diffusion	Yes	Which channel proteins the membrane has
Active transport	Yes	Which pump proteins the membrane has

- A cell controls what crosses by controlling which proteins are in its membrane
- Different cell types therefore have different permeabilities

Key idea

This answers the second guiding question: size, polarity and charge, and the proteins present, decide what can cross.

Glycoproteins and glycolipids

B2.1.9

	Glycoprotein	Glycolipid
Made of	Carbohydrate linked to a protein	Carbohydrate linked to a lipid
Position	Protein in the membrane, carbohydrate outside	Lipid in the membrane, carbohydrate outside

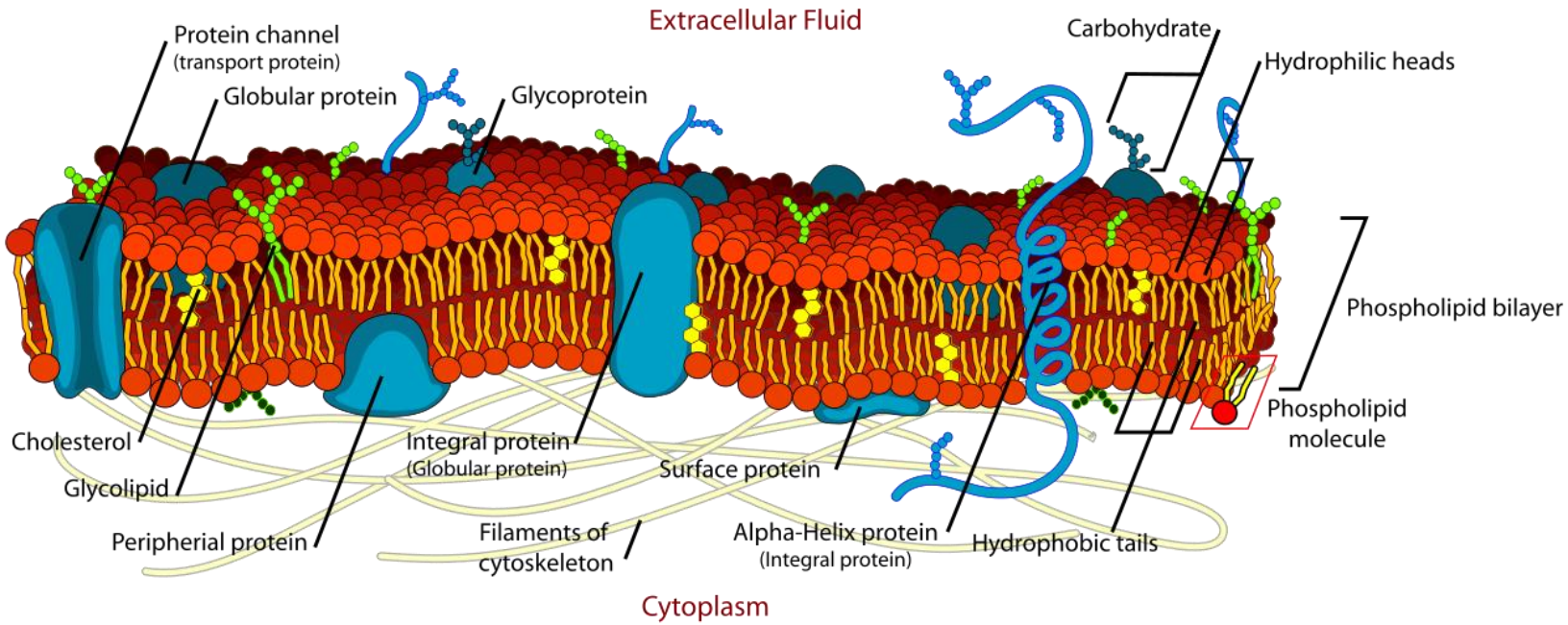
- The carbohydrate always faces the **extracellular** side
- Together they form a sugar-rich coat on animal cells, the **glycocalyx**
- Roles: **cell adhesion** and **cell recognition**

Link

The immune system uses these molecules to tell self from non-self (C3.2), and ABO blood groups depend on carbohydrates on red blood cells (D3.2).

The fluid mosaic model

B2.1.10



Cell membrane. Mariana Ruiz, public domain.

- **Fluid**: molecules move sideways
- **Mosaic**: proteins are scattered among lipids

Draw it in two dimensions. Label all of these:

- Phospholipids, with hydrophilic and hydrophobic regions
- Integral and peripheral proteins
- Glycoproteins, with the carbohydrate outside
- Cholesterol, among the tails

Check that you can explain

1. Why phospholipids form bilayers
2. Why the bilayer is a barrier
3. Simple diffusion of oxygen and carbon dioxide
4. Integral and peripheral proteins
5. Osmosis and aquaporins
6. Channel proteins
7. Pump proteins and ATP
8. What makes a membrane selective
9. Glycoproteins and glycolipids
10. How to draw the fluid mosaic model

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. Explain why sodium ions cannot pass easily through the phospholipid bilayer.
2. State two differences between facilitated diffusion and active transport.
3. Sketch the fluid mosaic model and label four components.

Image credits

Cell membrane with proteins visualized by AFM.jpg – Nucturra – CC0

Phospholipids aqueous solution structures.svg – Mariana Ruiz Villarreal, LadyofHats – Public domain

Scheme simple diffusion in cell membrane-en.svg – LadyofHats Mariana Ruiz Villarreal – Public domain

Cell membrane detailed diagram en.svg – Mariana Ruiz – Public domain

Aquaporin-Sideview.png – Vossman – CC BY-SA 3.0

Scheme facilitated diffusion in cell membrane-en.svg – LadyofHats Mariana Ruiz Villarreal – Public domain

Scheme sodium-potassium pump-en.svg – LadyofHats Mariana Ruiz Villarreal – Public domain

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