Physics. You work it out.

Home Gameboard Biology Cell Biology Membrane Transport Membrane Structure

Membrane Structure

A Level
P P P

Biological membranes are important structures that separate the inside of cells/organelles from the outside. All membranes share the same general structure, which includes several types of molecules.

Part A Membrane molecules

Match the molecule to the description in the table below.

Molecule type	Description
	form a bilayer which is the main component of the membrane
	regulate membrane fluidity
	molecules, made of a protein covalently bonded to a carbohydrate, that act as receptors in cell-cell recognition and signalling
	molecules, made of a lipid covalently bonded to a carbohydrate, that act as receptors in cell-cell recognition and signalling
	allow/control movement of molecules and ions across the membrane

Items:

glycoproteins **phospholipids** **cholesterol** **glycolipids** **transport proteins**

Part B Transport proteins

Transport proteins are transmembrane proteins (i.e. proteins that span both sides of the membrane) that allow/control the movement of molecules and ions across the membrane.

They can be roughly categorised into two types: channel proteins and carrier proteins.

Fill in the table below to compare these types of transport proteins.

	Channel proteins	Carrier proteins
Transport mechanism		
Open/closed state		
Type(s) of transport involved in		
Relative speed of transport		

Items:

- **acts as simple pores to allow specific molecules/ions to diffuse through**
- **bind to specific molecules/ions and change shape in order to move them across the membrane**
- **only one side is open at any given moment**
- **both sides can be open at once**
- **passive transport and active transport**
- **passive transport only**
- **faster**
- **slower**

Part C Diagram labelling

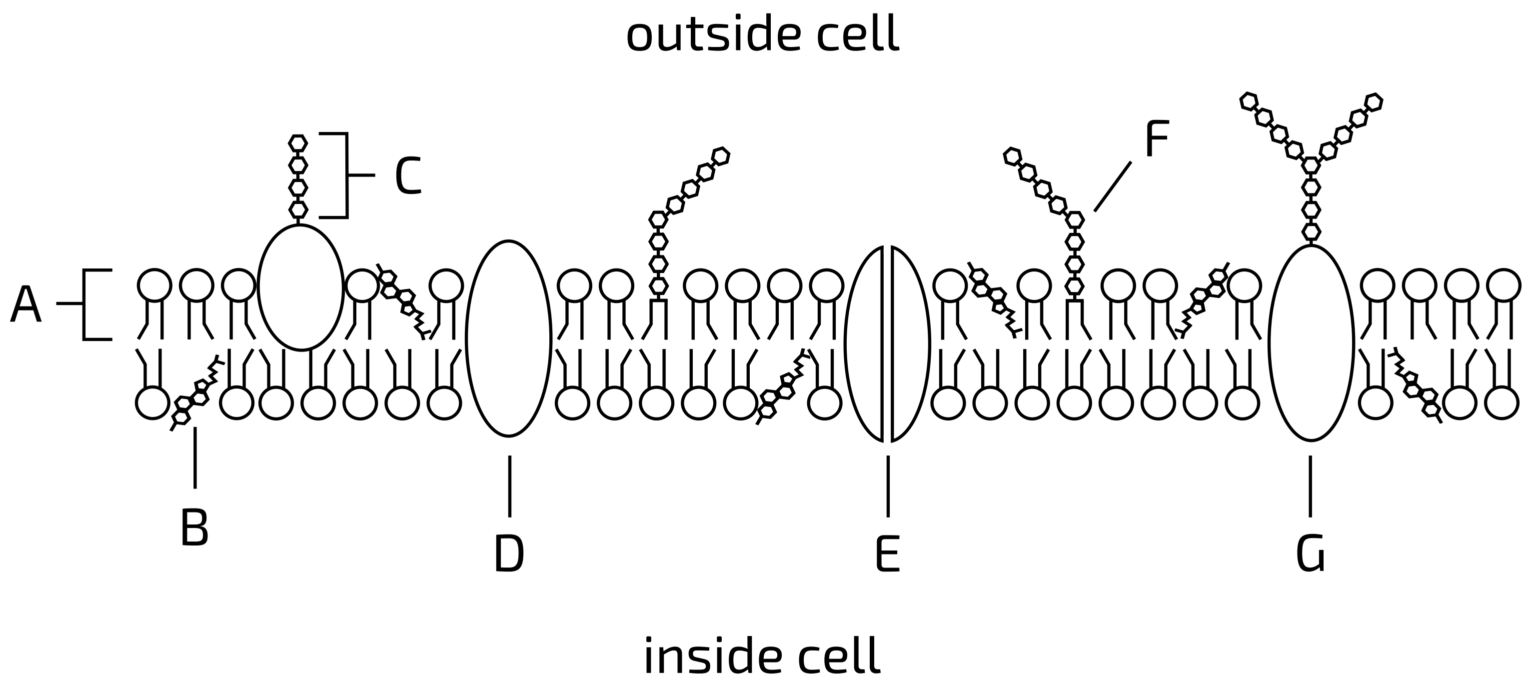

Figure 1: A schematic (2D) of part of a cell membrane.

Match the membrane components to the labels in **Figure 1**.

Letter	Membrane component
A	
B	
C	carbohydrate
D	protein
E	
F	
G	

Items:

phoshpholipid glycolipid glycoprotein cholesterol transport protein

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Home Gameboard Biology Cell Biology Membrane Transport Membrane Fluidity and Permeability

Membrane Fluidity and Permeability

A Level
P P P

Part A Fluidity factors

Membrane fluidity is affected by the spacing between phospholipid molecules within each layer. The more tightly-packed the phospholipids are, the less fluid the membrane is.

Which of the following would increase the fluidity of a cell membrane? Select all that apply.

- [ ] a higher proportion of unsaturated phospholipid fatty acids
- [ ] a higher proportion of saturated phospholipid fatty acids
- [ ] a decrease in temperature
- [ ] an increase in temperature

Part B Effect(s) of cholesterol

Another factor that affects membrane fluidity (as well as [ ] and fatty acid saturation) is the amount of cholesterol in the membrane. However, the relationship between cholesterol and membrane fluidity is not a simple linear relationship.

Cholesterol molecules are found in-between phospholipid molecules within each layer. The hydrophobic region of a cholesterol molecule binds to the phospholipid [ ] on either side, binding them together. At [ ] temperatures, the presence of cholesterol molecules stops the phospholipids from packing too tightly (i.e. the presence of cholesterol [ ] membrane fluidity). At [ ] temperatures, the presence of cholesterol molecules stops the phospholipids from spreading out too much (i.e. the presence of cholesterol [ ] membrane fluidity).

Cholesterol, therefore, maintains membrane fluidity within an appropriate range by limiting the effects of temperature changes.

Items:

temperature **heads** **tails** **high** **low** **increases** **decreases**

Part C Permeability

The phospholipid bilayer is permeable to small, non-polar molecules (e.g. O_2 and CO_2), which are able to diffuse between the phospholipids. Which of the following statements are true? Select all that apply.

- [ ] a decrease in membrane fluidity will increase membrane permeability
- [ ] a decrease in membrane fluidity will decrease membrane permeability
- [ ] an increase in membrane fluidity will increase membrane permeability
- [ ] an increase in membrane fluidity will decrease membrane permeability

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Gameboard:

STEM SMART Biology Week 7 - Membrane Structure & Transport

Physics. You work it out.

Home Gameboard Biology Cell Biology Membrane Transport Passive Transport

Passive Transport

A Level
P P P

Part A Definition and types

What is the definition of passive transport?

- the movement of ions/molecules across a membrane down their concentration gradient (i.e. from high concentration to low concentration)
- the movement of small molecules across a membrane without the need of transport proteins (i.e. by passing directly through the phospholipid bilayer)
- the movement of ions/molecules across a membrane through transport proteins
- the movement of ions/molecules across a membrane up their concentration gradient (i.e. from low concentration to high concentration)

Which of the following are types of passive transport?

- Active transport
- Simple diffusion
- Osmosis
- Facilitated diffusion

Part B Simple diffusion

Simple diffusion is the movement of molecules directly through the phospholipid bilayer (i.e. not through transport proteins) down their concentration gradient. Only small, [ ] molecules are able to do this. Molecules that are too large cannot fit between the phospholipids, and ions and [ ] molecules cannot pass through because they will be repelled by the [ ] phospholipid tails within the membrane.

[ ] is an example of a molecule that moves across membranes by simple diffusion.

Items:

non-polar Na^+ **glucose** **polar** O_2

Part C Facilitated diffusion

Facilitated diffusion is the movement of substances (molecules/ions) through membrane transport proteins down their concentration gradient.

[ ] proteins are a type of transport protein that allow specific substances to pass through their hydrophilic interior. Some types are always open, while others can open and close in response to particular signals. When they are open, both sides are open, and so the protein acts as a tunnel that allows the substances to diffuse freely from one side to the other. There are specific channel proteins for various [ ] including Na^+, Ca^{2+}, and K^+.

[ ] proteins are a type of transport protein that move specific substances across the membrane by changing shape in response to binding those specific substances. The substances bind on one side of the membrane, which causes a conformational change in the protein, such that the protein "closes" on that side and "opens" on the other side. This causes the substances to move from one side to the other. Therefore, unlike channel proteins, only one side is open at a time. [ ] is an example of a molecule that moves across membranes by facilitated diffusion through specific carrier proteins.

Items:

active transport **Glucose** O_2 **facilitated diffusion** **ions** **Channel** **Carrier**

Part D Osmosis

Osmosis is the movement of water from a higher water potential to a lower water potential across a [ ] membrane (i.e. a membrane that is permeable to some molecules but not to others). Osmosis occurs both by simple diffusion and by facilitated diffusion.

Osmosis can occur by simple diffusion (i.e. the water molecules can pass directly between the phospholipids) because, even though water molecules are [ ], they are [ ] enough to fit between the phospholipids. However, while the [ ] interior of the cell membrane does not completely stop water molecules moving across, it does slow the process down. This is why cells also have specialised [ ] called aquaporins, which enable osmosis by facilitated diffusion.

Items:

non-permeable **channel proteins** **small** **large** **partially permeable** **polar** **non-polar**

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Gameboard:
STEM SMART Biology Week 7 - Membrane Structure & Transport

Osmotic Effects

A Level

C C C

Part A Sugar solutions

A cell from the epithelium of an animal was removed. The cytoplasm of this cell can be considered as a 2% sugar solution. The living cell was placed in a 4% sugar solution.

Which of the following statements are correct? Select all that apply.

- Osmosis was most rapid when the cell was first placed in the solution.
- Water moved into the cell by osmosis.
- Sugar moved into the cell by osmosis.
- Water moved out of the cell by osmosis.
- Water continued to move across the cell membrane after equilibrium was reached.
- At equilibrium, the sugar concentration in the cell was 6%.

Part B K^+ concentrations

The table below shows the concentration of potassium ions in several different locations.

Location	Concentration of potassium ions
bacterial cell cytoplasm	$30\,\mathrm{mmol\,dm^{-3}}$
mammalian blood plasma	$4\,000\,\mu\mathrm{mol\,dm^{-3}}$
mammalian heart cell cytoplasm	$1.0 \times 10^2\ \mathrm{mmol\,dm^{-3}}$
seawater	$3.0 \times 10^4\ \mu\mathrm{mol\,dm^{-3}}$
yeast cell cytoplasm	$300\,\mathrm{mmol\,dm^{-3}}$

Which of the following statements are correct? Select all that apply.

- [ ] If a yeast cell is placed in seawater then it will lose potassium ions by osmosis.
- [ ] A mammalian heart cell has a higher concentration of potassium ions than a yeast cell.
- [ ] If a yeast cell is placed in seawater then it will gain water by osmosis.
- [ ] There is no concentration gradient for potassium ions between a bacterial cell and seawater.
- [ ] A mammalian heart cell needs energy from respiration in order to obtain more potassium ions from blood plasma.

Part C Catalase catalysis

Catalase is an enzyme found inside plant and animal cells. When catalase is added to hydrogen peroxide, bubbles of oxygen gas are formed.

Red blood cells were placed into either pure water or blood plasma, and were placed in the dark.

Plant cells were placed into either water or $0.5\,\mathrm{mol\,dm^{-3}}$ sucrose solution, and were placed in the dark.

Hydrogen peroxide was then added to each of the four experimental setups.

Assume that hydrogen peroxide and catalase do not cross the cell surface membrane.

In which experimental setup will oxygen bubbles form? Select all that apply.

- [ ] red blood cells in plasma
- [ ] plant cells in a $0.5\,\mathrm{mol\,dm^{-3}}$ sucrose solution
- [ ] red blood cells in pure water
- [ ] plant cells in pure water
- [ ] none of the above

Why did the cells need to be placed in the dark for the researchers to investigate osmotic effects on cells? Select all that apply.

- [ ] In the light, plant cells would produce oxygen by respiration, and so oxygen bubbles would form regardless of any interaction between catalase and hydrogen peroxide.
- [ ] Hydrogen peroxide only breaks down into water and oxygen in the dark.
- [ ] In the light, blood cells would produce oxygen by respiration, and so oxygen bubbles would form regardless of any interaction between catalase and hydrogen peroxide.
- [ ] In the light, plant cells would produce oxygen by photosynthesis, and so oxygen bubbles would form regardless of any interaction between catalase and hydrogen peroxide.
- [ ] Catalase is denatured by light.
- [ ] In the light, blood cells would produce oxygen by photosynthesis, and so oxygen bubbles would form regardless of any interaction between catalase and hydrogen peroxide.

Question elements adapted with permission from NSAA 2018 Section 1 Q62, NSAA 2020 Section 1 Q71, and NSAA 2020 Section 1 Q77

Gameboard:

STEM SMART Biology Week 7 - Membrane Structure & Transport

Active Transport

A Level

P P P

Part A Transport truths

Which of the following statements are true? Select all that apply.

- active transport is the movement of ions/molecules across a membrane up their concentration gradient (i.e. from low concentration to high concentration)
- active transport requires energy whereas passive transport does not
- active transport occurs through carrier proteins whereas passive transport does not
- active transport can only happen from inside the cell to outside the cell, not the other way around
- active transport is the movement of ions/molecules across a membrane down their concentration gradient (i.e. from high concentration to low concentration)
- active transport can only happen from outside the cell to inside the cell, not the other way around

Part B Primary vs secondary active transport

Some carrier proteins move substances down their concentration gradient (i.e. by _____), while others move substances up their concentration gradient (i.e. by _____). To transport ions/molecules up their concentration gradient, energy is required.

In primary active transport, energy is provided via the _____ of the carrier protein by _____ (which becomes hydrolysed to _____). This causes the required conformational change in the protein to move the ions/molecules from one side of the membrane to the other. Carrier proteins that do this are called transmembrane ATPases. An example is Ca^{2+}ATPase, which actively transports calcium ions out of the cell.

In secondary active transport, energy is provided by coupling passive transport with active transport. One type of ion/molecule is transported _____ its concentration gradient, in order to provide the energy needed to transport another type of ion/molecule _____ its concentration gradient. Carrier proteins that do this are called _____. Some of these proteins move both types of ions/molecules across the membrane in the same direction (symporters), while others move them in opposite directions (antiporters). An example is the sodium/glucose cotransporter, which is a symporter found in cells lining the small intestine. Na^+ ions and glucose molecules bind on the outside of the cell and are both transported into the cell, with the Na^+ ions moving down their concentration gradient and the glucose molecules moving up their concentration gradient.

Items:

active transport **glycosylation** **up** **phosphorylation** **ATP** **facilitated diffusion** **ADP** **cotransporters** **down** **uniporters**

Part C The sodium-potassium pump

An important example of primary active transport is the sodium-potassium pump. This carrier protein transports both Na^+ ions and K^+ ions up their concentration gradients.

Three Na^+ ions bind on the inside of the cell. One molecule of [ ] then binds to the protein and [ ] it, causing a conformational change in the protein. This causes the release of the Na^+ ions out of the cell, and allows two K^+ ions to bind on the outside of the cell. This binding of K^+ ions [ ] the protein, which causes it to change back to its original shape. This causes the release of the K^+ ions into the cell. The carrier protein is then ready to begin the process again.

To summarise: for every 1 molecule of ATP hydrolysed, the sodium-potassium actively transports [ ] Na^+ ions [ ] the cell, and [ ] K^+ ions [ ] the cell. This establishes concentration gradients that can then be used for secondary active transport (e.g. sodium-glucose transport). It also establishes an electrical gradient across the membrane which is particularly important for neurones.

Items:

phosphorylates | ADP | dephosphorylates | out of | into | 3 | 2 | ATP

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STEM SMART Biology Week 7 - Membrane Structure & Transport

Physics. You work it out.

Home Gameboard Biology Cell Biology Membrane Transport Endocytosis and Exocytosis

Endocytosis and Exocytosis

A Level

P P P

Some molecules/particles may be too large to fit through membrane transport proteins. They are transported across the membrane by a different mechanism of transport called bulk transport. There are two main types of bulk transport: endocytosis and exocytosis.

Part A Import

_____ is the form of bulk transport in which large molecules/particles are imported into the cell. The molecules/particles are engulfed by an infolding of the cell membrane. This infolded portion of cell membrane buds off to form a _____ within the cell. In most cases, this then fuses with a _____, and the imported material is then digested by digestive enzymes. This process can be further categorised into _____ (the import of liquid particles) or _____ (the import of solid particles). An example of the latter is found in macrophages, a type of white blood cell that ingests and digests pathogens (including bacterial cells).

Items:

Exocytosis **vesicle** **ribosome** **lysosome** **Endocytosis** **pinocytosis** **phagocytosis**

Part B Export

[ ] is the form of bulk transport in which large molecules/particles are exported from the cell. The molecules/particles are packaged within a [ ], which is moved to the cell membrane. It then fuses with the cell membrane to release its contents outside the cell. An example of this is found in [ ], which release neurotransmitters by this process. These neurotransmitters then bind to membrane [ ] of the neighbouring cell.

Items:

muscle cells **Exocytosis** **receptors** **Endocytosis** **vesicle** **neurons**

Part C Vesicle transport

What structure/organelle moves vesicles around the cell?

Part D Energy requirements

Which of the following directly require ATP hydrolysis? Select all that apply.

- [ ] exocytosis
- [ ] primary active transport
- [ ] secondary active transport
- [ ] phagocytosis
- [ ] facilitated diffusion
- [ ] simple diffusion
- [ ] pinocytosis

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