Membrane Structure

A Level

C C C

Part A Membrane lipids

Match the membrane lipid to the description.

- [ ]: form a bilayer which is the main component of a membrane.
- [ ]: found throughout the membrane. Regulates membrane fluidity.
- [ ]: consist of a lipid bound to a carbohydrate. Involved in cell-cell interactions.

Items:

cholesterol glycerol fatty acids phospholipids glycolipids

Part B Membrane proteins

Although the main component of a membrane is the phospholipid bilayer, proteins also make up a large part.

Membrane proteins can broadly be categorized into two types: ______/extrinsic proteins (which are bound to the phospholipid bilayer but do not penetrate it) and ______/intrinsic proteins (which are embedded within the phospholipid bilayer). Within the latter category, some proteins span both sides of the membrane. These are called ______ proteins. Some of these proteins are required for the movement of specific ions/molecules across the membrane. These are called ______ proteins. Some of these are simple "channel proteins", which allow specific ions/molecules to diffuse across the membrane. Others are "carrier proteins", which bind to the specific ions/molecules and change shape in order to move them across the membrane.

Some membrane proteins have a carbohydrate group. These are called ______, and often act as binding sites for hormones, antibodies, and other cells.

Items:

transmembrane | integral | extracellular | lipoproteins | glycoproteins | peripheral | transport | intracellular

Part C Membrane identification

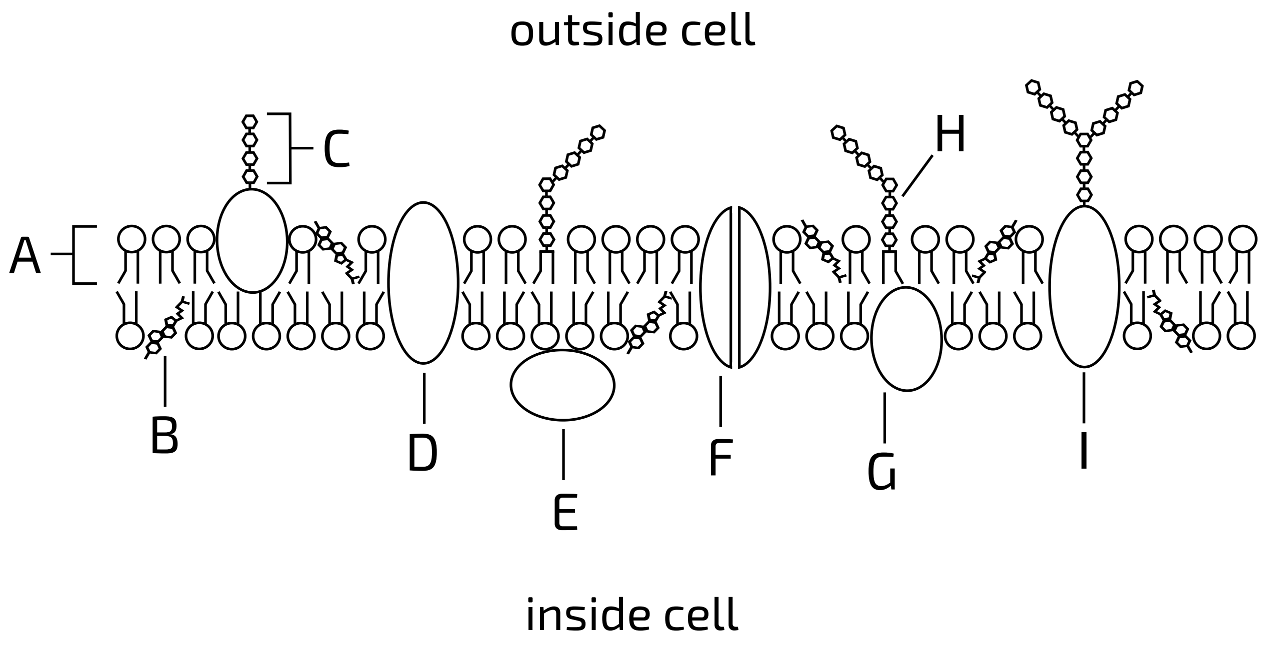

Figure 1: A schematic (2D) of part of a cell membrane.

Match the membrane components to the labels in Figure 1.

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

Items:

peripheral protein **phospholipid** **glycolipid** **cholesterol** **transmembrane glycoprotein**

integral protein **transmembrane transport protein**

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

Created for isaacphysics.org by Lewis Thomson

Gameboard:
STEM SMART Biology Week 12

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
- Facilitated diffusion
- Osmosis

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 | glucose | O_2 | polar | Na^+

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:

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

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:

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

Created for isaacphysics.org by Lewis Thomson

Gameboard:

STEM SMART Biology Week 12

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 down their concentration gradient (i.e. from high concentration to low concentration)
- active transport requires energy whereas passive transport does not
- 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 can only happen from inside the cell to outside the cell, not the other way around
- active transport can only happen from outside the cell to inside the cell, not the other way around
- active transport occurs through carrier proteins whereas passive transport does not

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 ileum. 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:

cotransporters **down** **uniporters** **up** **glycosylation** **phosphorylation** **ADP**

facilitated diffusion **active transport** **ATP**

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 neurons.

Items:

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

Created for isaacphysics.org by Lewis Thomson

Gameboard:

STEM SMART Biology Week 12

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:

ribosome **Exocytosis** **vesicle** **lysosome** **pinocytosis** **Endocytosis** **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 **Endocytosis** **receptors** **Exocytosis** **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.

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

Emphysema

A Level

In the disease emphysema, the walls of the alveoli break down so that several smaller alveoli fuse to form a single large alveolus.

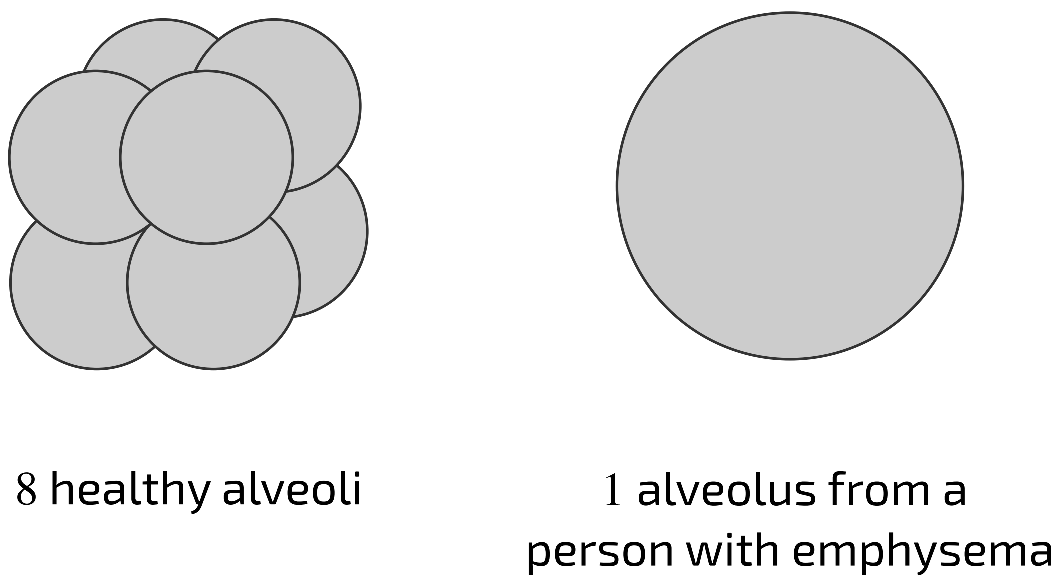

Figure 1: The effect of emphysema on alveoli. The radius of a healthy alveolus is x, and the radius of an alveolus from a person with emphysema is $2x$. The shape of an alveolus (of both types) can be approximated as a sphere.

Part A Surface area and membrane transport

How do differences in cell surface area affect membrane transport? Select all that apply.

- [ ] A higher cell surface area increases diffusion rate because there is more area for molecules to diffuse across.
- [ ] A higher cell surface area can increase passive/active transport rate because the cell can have more transport proteins in its membrane.
- [ ] A lower cell surface area increases passive/active transport rate because the membrane transport proteins are closer together.
- [ ] A lower cell surface area increases diffusion rate because there is less area for molecules to diffuse across.

Part B Surface area to volume ratios

Surface area of a sphere $= 4\pi r^2$; volume of a sphere $= \frac{4}{3}\pi r^3$, where r is the radius.

What is the surface area to volume ratio for the 8 healthy alveoli in Figure 1? Enter your answer as the simplest possible fraction in terms of x (e.g. $\frac{5}{2x}$).

The following symbols may be useful: x

What is the surface area to volume ratio for the emphysema alveolus in Figure 1? Enter your answer as the simplest possible fraction in terms of x (e.g. $\frac{5}{2x}$).

The following symbols may be useful: x

Part C Diffusion rates

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

- [ ] The surface-area-to-volume ratio of the 8 healthy alveoli is $2\times$ that of the single emphysema alveolus.
- [ ] The surface-area-to-volume ratio of the 8 healthy alveoli is $3\times$ that of the single emphysema alveolus.
- [ ] For the same concentration gradient, the rate of diffusion of oxygen into the blood from a single healthy alveolus will be greater than for a single emphysema alveolus.
- [ ] For the same concentration gradient, the rate of diffusion of oxygen into the blood from a single emphysema alveolus will be greater than for a single healthy alveolus.
- [ ] For the same concentration gradient, the rate of diffusion of oxygen into the blood from 8 healthy alveoli will be greater than for a single emphysema alveolus.
- [ ] For the same concentration gradient, the rate of diffusion of oxygen into the blood from a single emphysema alveolus will be greater than for 8 healthy alveoli.

Adapted with permission from NSAA 2020 Section 2 Q49