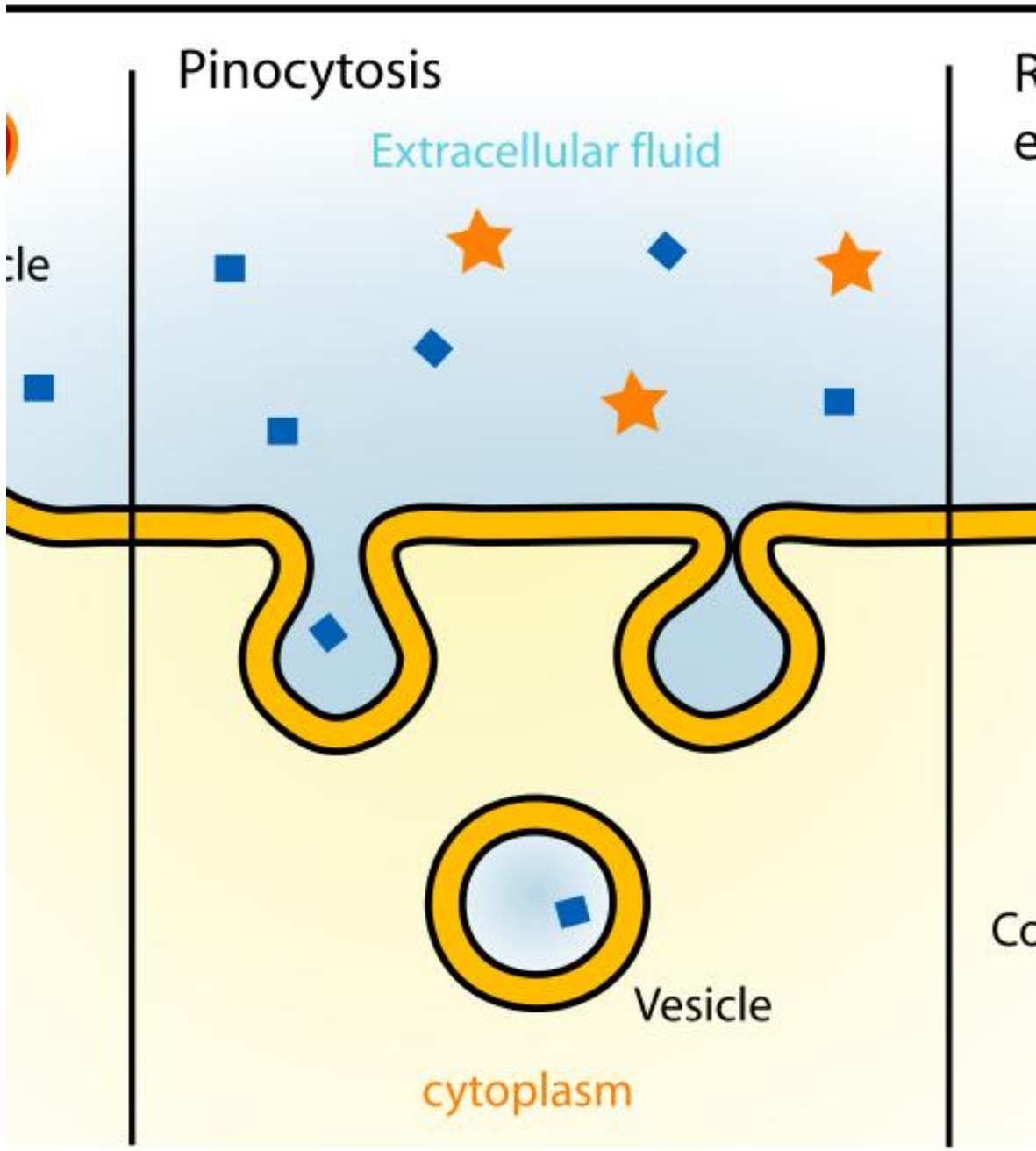
DP Biology – B2.1 (HL extension)

Membranes: fluidity, gates and pumps

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



HL statements B2.1.11–17. Textbook pp. 237–243.
Image: three kinds of endocytosis. Mariana Ruiz Villarreal, public domain.

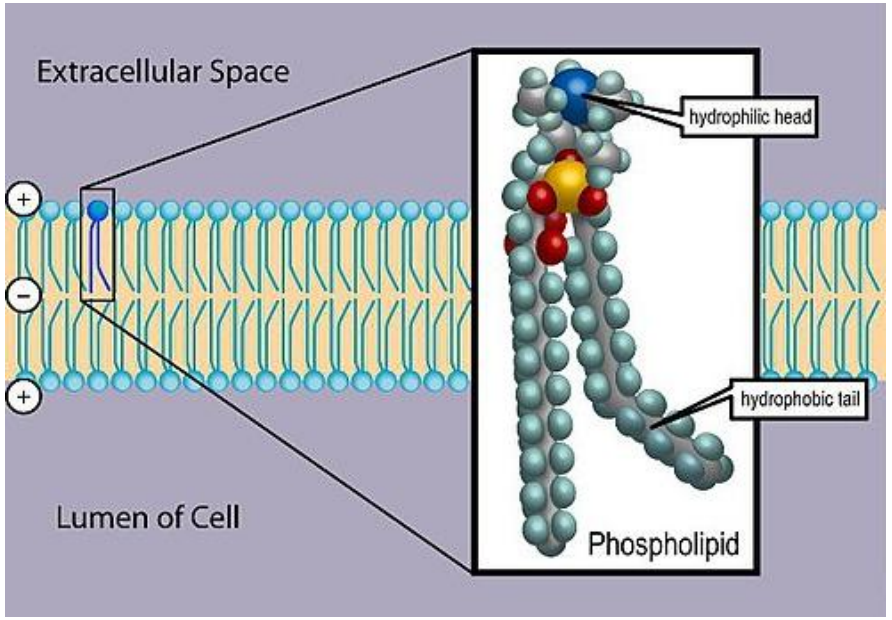
Objectives for each class

Class	Statements	By the end of the class, you can…
1	B2.1.11–13	Explain how fatty acids and cholesterol control membrane fluidity, and why fluidity allows vesicles to form and fuse
2	B2.1.14–15	Compare voltage-gated and neurotransmitter-gated channels, and explain the sodium-potassium pump
3	B2.1.16–17	Explain indirect active transport of glucose, and how cell-adhesion molecules hold tissues together

Fatty acids and membrane fluidity

B2.1.11

	Saturated tails	Unsaturated tails
Shape	Straight	Kinked at C=C double bonds
Packing	Close together	Further apart
Melting point	Higher	Lower
Effect on membrane	Less fluid, stronger when warm	More fluid, stays flexible when cold



A phospholipid in a membrane. T. van Brussel, free use.

Key idea

Membranes must be fluid enough for proteins to move and work, but not so fluid that they leak. Shorter fatty acid tails also make a membrane more fluid.

Adapting membranes to temperature



Lake sturgeon. Ryan Hagerty, USFWS, public domain.

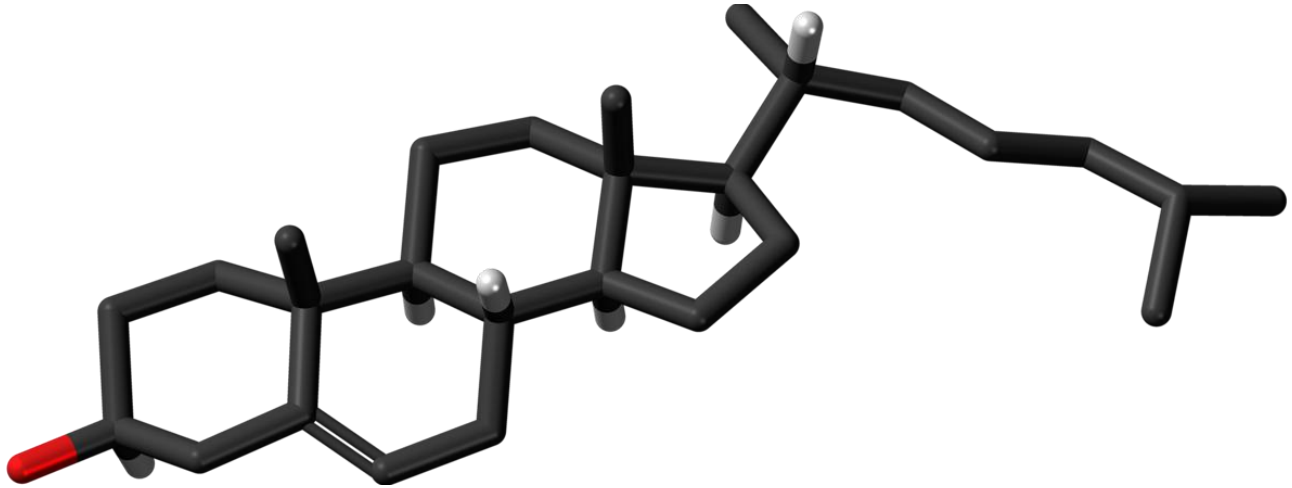
- Lake sturgeon live in cold northern lakes and overwinter for months
- When water cools from 16 to 1 °C, the share of unsaturated fatty acids in their membranes rises
- This keeps membranes fluid in the cold: **homeoviscous adaptation**

Think about it

Predict how the membranes of a bacterium living in a hot spring would differ from those of a fish in Arctic water. Explain your prediction in terms of how the fatty acid tails pack together.

Cholesterol: a fluidity buffer

B2.1.12



Cholesterol: the red atom is the oxygen of the -OH group. Jynto, CC0.

Part	Position in the bilayer
-OH group (polar)	Next to the phosphate heads
Rings and tail (non-polar)	Among the fatty acid tails

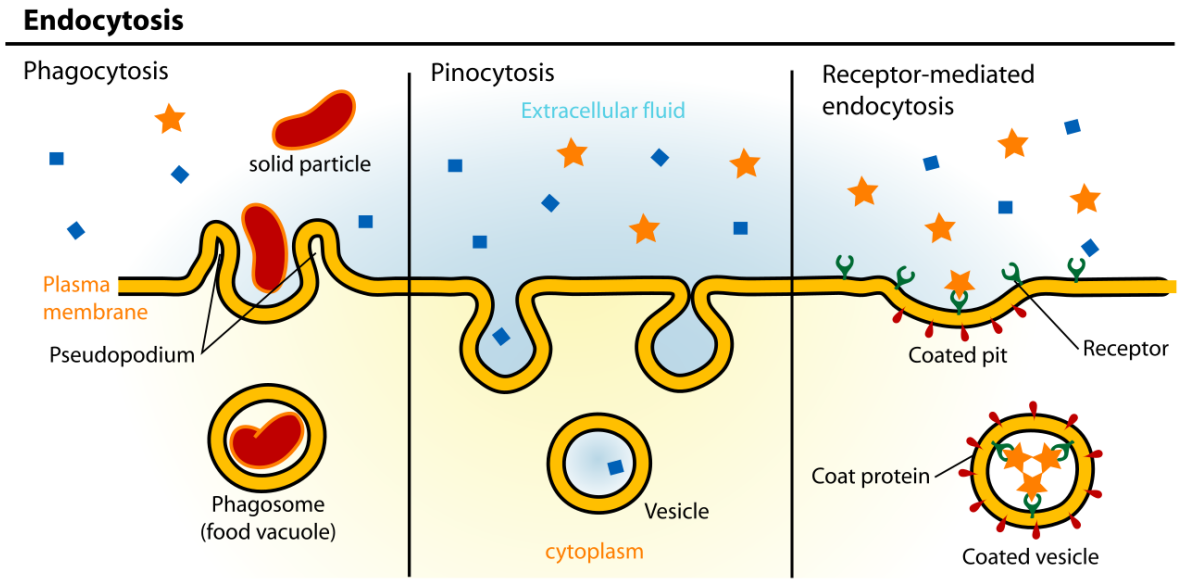
Temperature	Effect of cholesterol
Low	Keeps phospholipids apart, so the membrane stays fluid
High	Restricts movement of tails, so the membrane is less fluid and less leaky

Common mistake

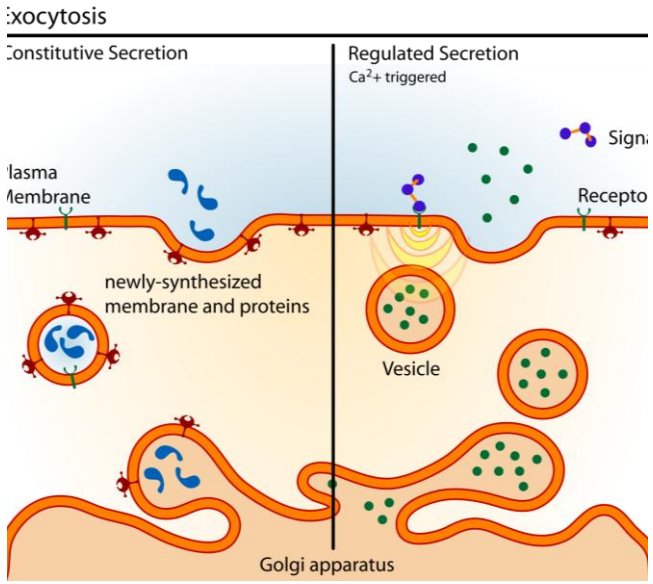
Fluidity is not the same as permeability. Cholesterol also reduces the leak of small ions.

Fluid membranes make vesicles possible

B2.1.13



Endocytosis. M. Ruiz Villarreal, public domain.



Exocytosis. M. Ruiz, public domain.

- Needs ATP
- Vesicles move along the cytoskeleton

	Endocytosis	Exocytosis
Direction	Material taken into the cell	Material released from the cell
Membrane	Pinches inwards to form a vesicle	Vesicle fuses with the plasma membrane
Example	Macrophages engulf old red blood cells	Plasma cells secrete antibodies; neurons release acetylcholine

Membranes on the move

B2.1.13

1. **Explain** why a vesicle can fuse with the plasma membrane without leaving a hole.
2. **Predict** what happens to the surface area of the plasma membrane during exocytosis, and during endocytosis.
3. A gland cell secretes protein all day. **Suggest** how it keeps its plasma membrane the same size.
4. **Distinguish** between phagocytosis and pinocytosis.

Hint

Both membranes are phospholipid bilayers. Because the molecules can flow, the two bilayers can join into one, and membrane can be added or removed.

Gated ion channels in neurons

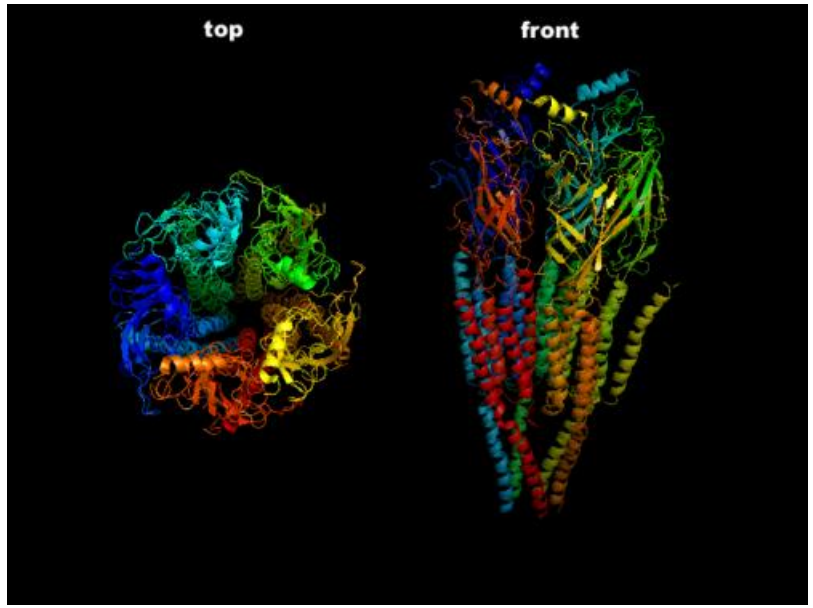
B2.1.14

	Voltage-gated	Neurotransmitter-gated
Opened by	A change in membrane potential	A neurotransmitter binding, such as acetylcholine
Example	Na^+ and K^+ channels in axons	Nicotinic acetylcholine receptor
Where	Along the axon	Post-synaptic membrane
Ions	Only Na^+ or only K^+	Mainly Na^+ (cations)
Transport type	Facilitated diffusion	Facilitated diffusion

Both are channel proteins that open and close. Ions move down their electrochemical gradient, so no ATP is used by the channel.

Two gates in action

B2.1.14



Nicotinic acetylcholine receptor. Public domain.

Neurotransmitter-gated

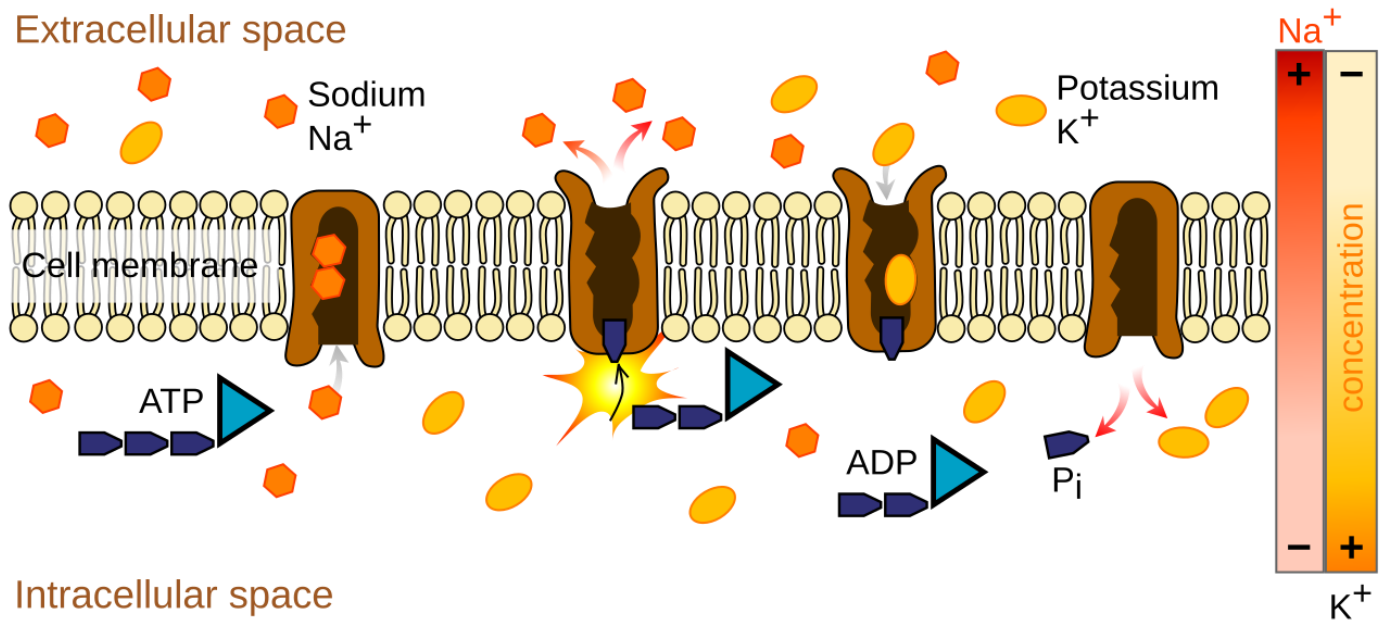
Acetylcholine binds to the receptor on the post-synaptic membrane. The protein changes shape, opening a central pore, and Na^+ flows in. When acetylcholine leaves the binding site, the pore closes.

Voltage-gated K^+ channel

At rest the channel is closed. When the inside of the axon becomes positive, charged parts of the protein move and the channel opens, so K^+ diffuses out. A ball of protein on a flexible chain then plugs the pore, so the channel stays shut until the membrane has repolarized.

The sodium-potassium pump

B2.1.15



Sodium-potassium pump. M. Ruiz Villarreal, public domain.

Why it matters

It is an exchange transporter: Na^+ out and K^+ in, both against their gradients, using ATP. It builds the gradients that neurons use for impulses and that cotransporters use.

1. 3 Na^+ bind inside

2. ATP phosphorylates the pump

3. Pump opens outwards, releasing 3 Na^+

4. 2 K^+ bind outside; phosphate leaves

5. Pump opens inwards, releasing 2 K^+

Indirect active transport of glucose

B2.1.16

Na^+/K^+ pumps on the blood side pump Na^+ out of the cell → Na^+ inside the cell stays low → Na^+ diffuses in through a cotransporter, bringing glucose with it → Glucose builds up and leaves by facilitated diffusion into the blood

Feature	Sodium-dependent glucose cotransporter
Where	Small intestine villi; kidney proximal tubule
Ratio	2 Na^+ for each glucose
Energy	Indirect: from the Na^+ gradient made by the pump

Why "indirect"?

The cotransporter uses no ATP itself. Glucose can be moved against its gradient only because the pump has already used ATP to make a Na^+ gradient.

What if the pump stops?

B2.1.16

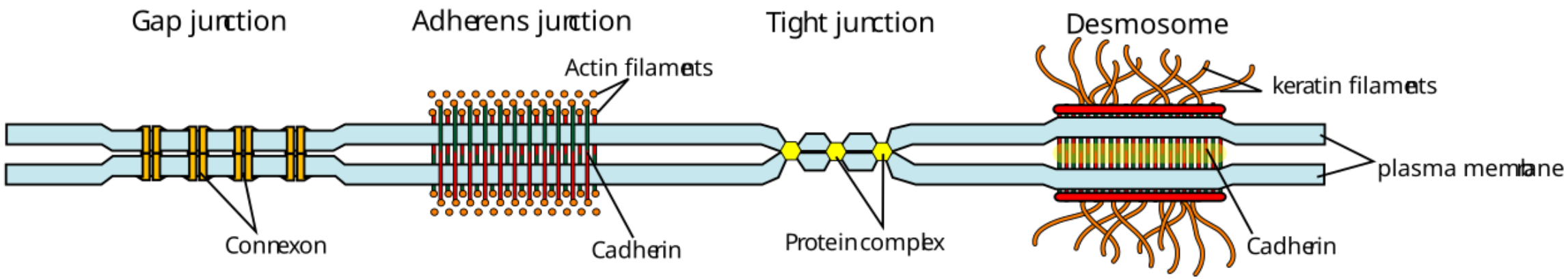
1. Ouabain is a plant toxin that blocks the Na^+/K^+ pump. **Predict** the effect on glucose uptake by intestinal cells, and explain.
2. Cyanide stops ATP production. **Explain** why it also stops glucose absorption, even though the cotransporter does not use ATP.
3. **Suggest** why glucose appears in the urine when blood glucose is very high.

Link

This links to C1.2 (ATP from respiration), C2.2 (nerve impulses) and D3.3 (kidney function).

Cell adhesion: building tissues

B2.1.17



Cell junctions: gap, adherens, tight and desmosome. M. Ruiz Villarreal, public domain.

Junction	Role
Tight junction	Seals the gap between epithelial cells, so substances must pass through cells
Anchoring junction	Links cytoskeletons of neighbouring cells, giving strength (for example in skin)
Gap junction	A channel joining the cytoplasm of two cells, so small molecules and signals pass

Cell-adhesion molecules

B2.1.17

- **Cell-adhesion molecules (CAMs)** are membrane proteins that bind to CAMs on other cells, or to the extracellular matrix
- **Cadherins** usually join cell to cell; **integrins** usually join cell to matrix
- Different CAMs make different junctions
- Plant cells use few CAMs: their walls interlock, and plasmodesmata link their cytoplasm

Why it matters

Cancer cells that lose cadherins can break away from a tumour and spread (metastasis). Adhesion keeps cells in the right place and lets them communicate.

Check that you can explain

1. How saturated and unsaturated fatty acids affect fluidity
2. How cholesterol buffers fluidity at low and high temperatures
3. Why fluid membranes can form and fuse vesicles
4. The difference between voltage-gated and neurotransmitter-gated channels
5. The steps of the sodium-potassium pump
6. Why glucose cotransport is indirect active transport
7. Three types of cell junction and the role of CAMs

Exit activity: 5 minutes

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

1. State how unsaturated fatty acids affect membrane fluidity.
2. Outline one difference between a voltage-gated and a neurotransmitter-gated channel.
3. Explain why glucose uptake in the intestine depends on ATP.

Image credits

Endocytosis types.svg – Mariana Ruiz Villarreal LadyofHats – Public domain
Phospholipid TvanBrussel.jpg – Author not stated – Copyrighted free use
Lake sturgeon (Acipenser fulvescens).png – Ryan Hagerty/USFWS – Public domain
Cholesterol molecule skeletal.png – Jynto (talk) – CC0
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Scheme sodium-potassium pump-en.svg – LadyofHats Mariana Ruiz Villarreal – Public domain
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