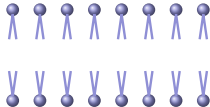


Cell Structure and Function

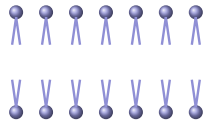
AP Biology ■ Unit 2

AP Biology



What we will cover

- 1 Organelles and the endomembrane system
- 2 Surface area-to-volume ratio
- 3 The fluid mosaic membrane
- 4 What crosses the membrane
- 5 Passive and active transport
- 6 Tonicity and endosymbiosis



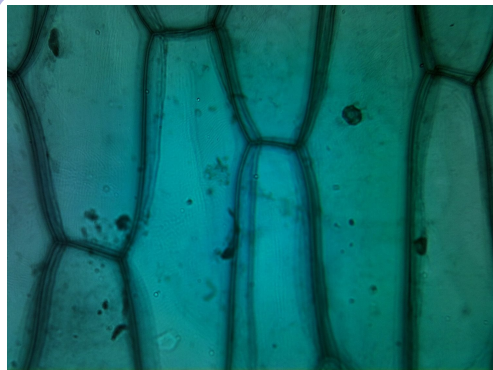


Organelles and the endomembrane system

A **eukaryotic** cell divides work among **organelles** :

- **nucleus** – stores DNA
- **mitochondria** – make ATP
- **ribosomes** – build proteins
- **ER + Golgi** – pack and ship

The endomembrane team traces a protein: nucleus → rough ER → Golgi → vesicle → membrane.



Organelles divide labour inside the cell

Three organelles, and one job of the membrane

Endoplasmic reticulum

The **endoplasmic reticulum**: rough (with ribosomes) makes and transports proteins; smooth makes lipids and detoxifies.

Lysosomes

Lysosomes hold hydrolytic enzymes at low pH and digest worn organelles and engulfed material.

Golgi

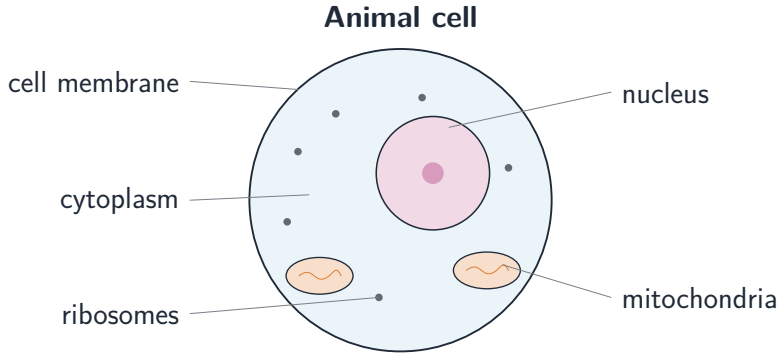
The Golgi modifies, sorts and packages what the ER sends, then ships it out in vesicles.

Osmoregulation

Osmoregulation is the cell's control of its own water balance – a contractile vacuole in a paramecium, turgor in a plant.

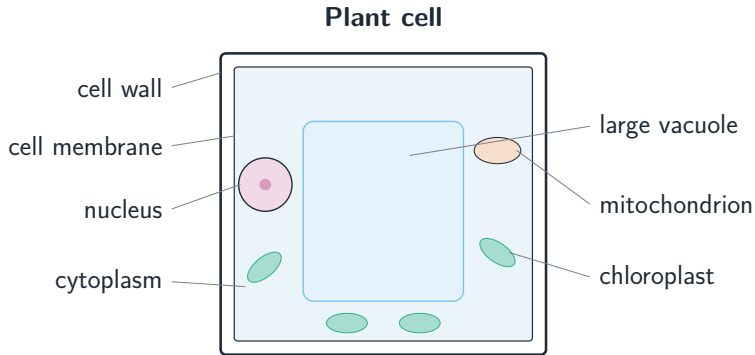
Follow one protein from ribosome to ER to Golgi to vesicle. That single path organises most of this unit.

A generalised animal cell and its organelles – one



A generalised animal cell and its organelles

A generalised animal cell and its organelles – two



A plant cell also has a cell wall, a large vacuole, and chloroplasts



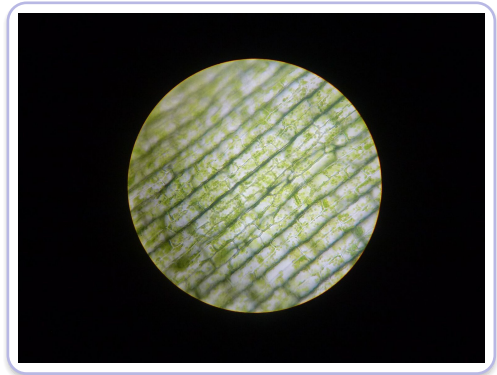
Surface area-to-volume ratio

Materials cross the **surface** ; the **volume** must be served. As a cell grows, volume outpaces surface:

A cube of side s

$$\frac{\text{area}}{\text{volume}} = \frac{6s^2}{s^3} = \frac{6}{s}$$

The ratio **shrinks** as s grows – so cells stay small (or add **folds**).



Leaf cells micrograph

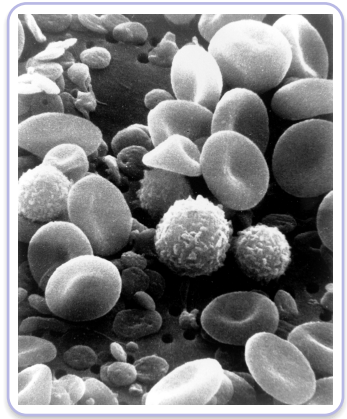


The fluid mosaic membrane

The **fluid mosaic model** : a **phospholipid bilayer** (hydrophilic heads out, hydrophobic tails in) with drifting proteins.

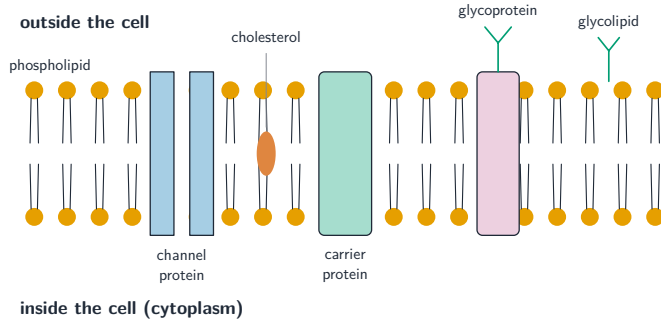
- **membrane proteins** – channels, pumps, receptors
- **cholesterol** – steadies the fluidity

Selectively permeable – it maintains homeostasis .



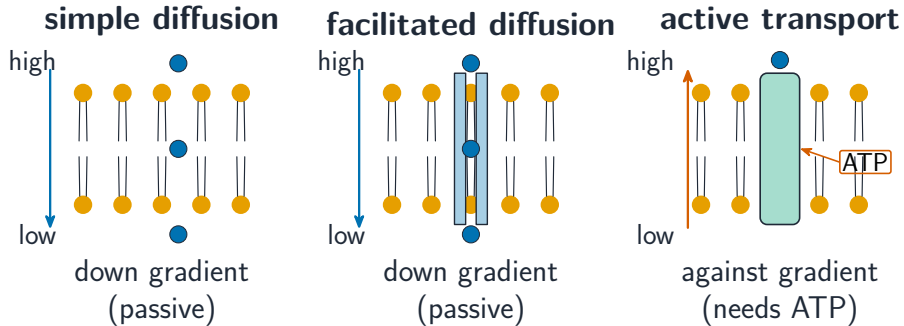
Rbc SEM

The fluid mosaic model of the cell membrane



The fluid mosaic model of the cell membrane

Three ways substances cross the membrane



Three ways substances cross the membrane

Compartmentalization Inside the Cell

Membranes create separate **compartments** so incompatible reactions can run at once and conditions (pH, ion levels) can be tuned locally.

This organization boosts efficiency – the internal membranes also add surface area for reactions.

The Origins of Cell Compartmentalization

The **endosymbiotic theory** explains mitochondria and chloroplasts: they arose when a larger cell engulfed free-living prokaryotes that then lived inside it.

The evidence – their own circular DNA, their own ribosomes, and double membranes – supports this shared evolutionary origin.



What crosses, and how

The hydrophobic core decides what crosses directly:

- cross easily – small **nonpolar** (O_2 , CO_2), and water
- blocked – large or charged (**glucose**, Na^+)

Facilitated diffusion : **channel** / **carrier** proteins – passive, but **saturates**.

Passive: down the gradient,
no ATP

Active: against the gradient,
uses *ATP*

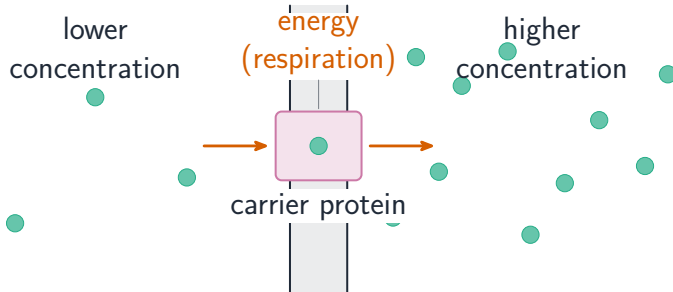
Osmosis = diffusion of water.

Endo/exocytosis move bulk cargo.

Passive and active transport

- **Passive transport** moves substances **down** the gradient, high $\rightarrow$ low, with **no energy** – **diffusion** .
- **Active transport** moves them **against** it, low $\rightarrow$ high, and so needs **ATP** and a protein pump – the sodium–potassium pump.

Passive and active transport, in detail



particles moved against the gradient, using energy

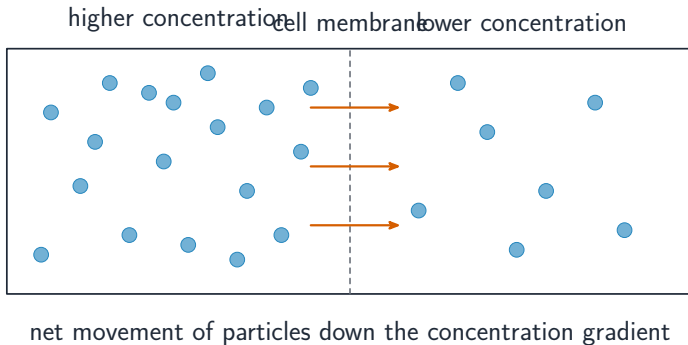
Against the gradient, using ATP and a carrier protein

Facilitated diffusion

Facilitated diffusion is passive transport *through* a membrane protein – a channel or a **carrier** – for particles that cannot cross the lipid alone.

Still down the gradient, still no energy – but the rate **saturates** once every protein is busy. That plateau is what distinguishes it from simple diffusion in a graph question.

Facilitated diffusion, in detail



Particles spread from higher to lower concentration

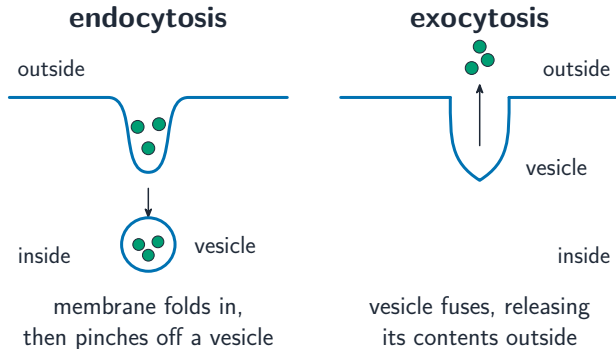
Bulk transport by vesicle

Large materials cross in bulk, wrapped in **vesicles**:

- **endocytosis** brings material **in** – the membrane engulfs it;
- **exocytosis** sends material **out** – a vesicle fuses with the membrane.

Both cost energy. This is how a cell imports and secretes molecules too big for any protein channel.

Bulk transport by vesicle, in detail



The membrane itself does the carrying: it folds **inwards** to make a vesicle, or a vesicle **fuses** with it to release the contents.



Tonicity and endosymbiosis

Water moves toward the **saltier** side. **Water potential** $\Psi = \Psi_S + \Psi_P$.

- **hypertonic**: cell shrinks
- **hypotonic**: cell swells
- **isotonic**: steady volume

Endosymbiotic theory : mitochondria & chloroplasts were once bacteria – own circular DNA, double membranes, own ribosomes.



Water leaves cells in a hypertonic solution

Water potential, and which way water moves

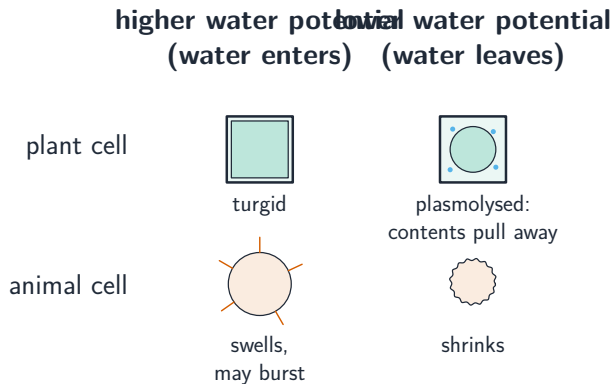
Water potential predicts the direction: water moves to the **lower** Ψ .

$$\Psi = \Psi_p + \Psi_s, \quad \Psi_s = -iCRT$$

0.1 M sucrose, open beaker, 25 °C

$\Psi_s = -(1)(0.1)(0.0831)(298) \approx -2.48$ bar, and $\Psi_p = 0$, so $\Psi \approx -2.48$ bar. A cell at $\Psi = -1.0$ bar sits in it: the solution is **more negative**, so water leaves the cell and it loses turgor.

Water potential, and which way water moves, in detail



Plant and animal cells in solutions of different water potential

Compartments, and where they came from

Membranes create separate **compartments** so incompatible reactions run at once and pH and ion levels are tuned locally. The internal membranes also **add surface area** for those reactions.

The **endosymbiotic theory** explains mitochondria and chloroplasts: a larger cell engulfed free-living prokaryotes that went on living inside it.

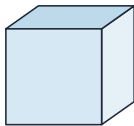
The evidence is three-fold – their own **circular DNA**, their own **ribosomes**, and **double membranes**.

Why Cells Stay Small



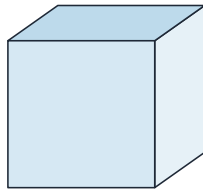
side $L = 1$

SA:V = 6 : 1



side $L = 2$

SA:V = 3 : 1



side $L = 3$

SA:V = 2 : 1

a bigger cube (or cell) has a **smaller** surface area : volume ratio

The surface-area-to-volume ratio falls as a cell gets bigger

Exam tips

- Use the two AP-formula skills: **surface-area-to-volume ratio** (why cells stay small) and **water potential** $\Psi = \Psi_p + \Psi_s$ ($\Psi_s = -iCRT$).
- Water moves toward the **lower (more negative) water potential**; predict swelling or shrinking from tonicity (hypo/hyper/isotonic).
- **Passive transport and osmosis need no energy** (down the gradient); **active transport** needs ATP (against the gradient).
- Distinguish diffusion, facilitated diffusion (a channel/carrier protein), and active transport.
- Explain membrane selectivity from the **phospholipid bilayer** – small non-polar molecules cross, large/charged ones need help.



Unit 2 – key takeaways

1

Organelles

compartments for parallel reactions; endomembrane ships proteins

2

SA:V

ratio $6/s$ shrinks with size – cells stay small

3

Membrane

fluid mosaic bilayer; selectively permeable

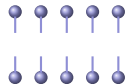
4

Transport

passive down / active up the gradient; osmosis

Check yourself

- 1 As a cell grows, does its surface-to-volume ratio rise or fall?
- 2 Why can O_2 cross the membrane but Na^+ cannot?
- 3 Does active transport use ATP?
- 4 Name one piece of evidence for endosymbiosis.



Answers 1. it falls 2. Na^+ is charged; O_2 is nonpolar 3. yes 4. own circular DNA (or double membrane)