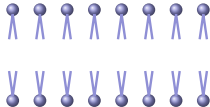


Cell Structure and Function

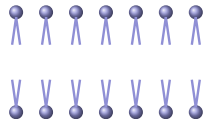
AP Biology ■ Unit 2

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



1

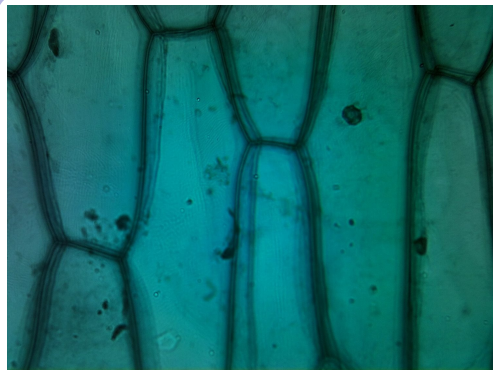
Organelles

Organelles and the endomembrane system

A **eukaryotic** 真核的 cell divides work among **organelles** 细胞器:

- **nucleus** 细胞核 – stores DNA
- **mitochondria** 线粒体 – make ATP
- **ribosomes** 核糖体 – build proteins
- **ER** 内质网 + **Golgi** 高尔基体 – pack and ship

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



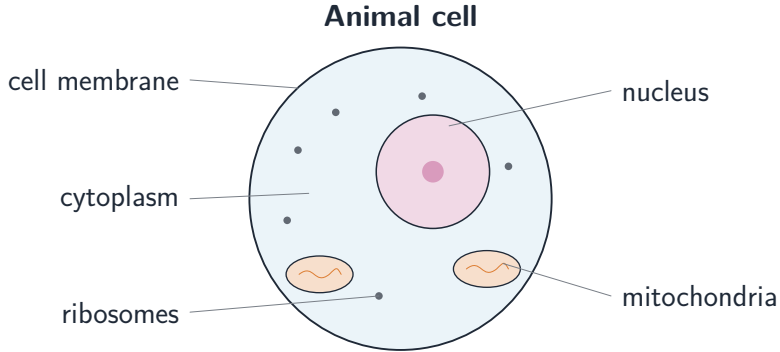
Organelles divide labour inside the cell

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.

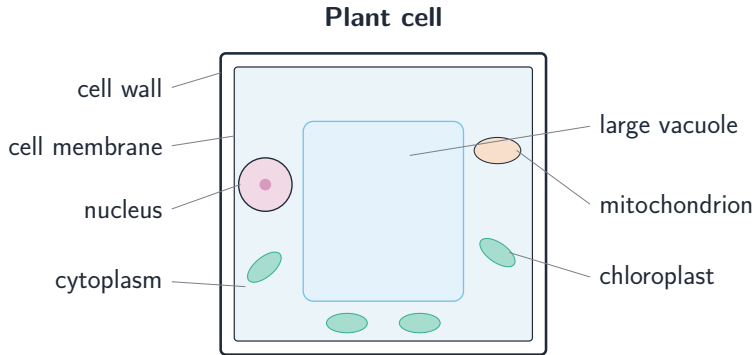
Follow one protein from ribosome to ER to Golgi to vesicle. That single path organises most of this unit.

An animal cell and its organelles



Membrane-bound organelles (nucleus, mitochondria, ER, Golgi) mark it as **eukaryotic**; unlike a plant cell it has **no cell wall, no chloroplasts and no large central vacuole**.

A plant cell: wall, vacuole and chloroplasts



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

2

SA:V

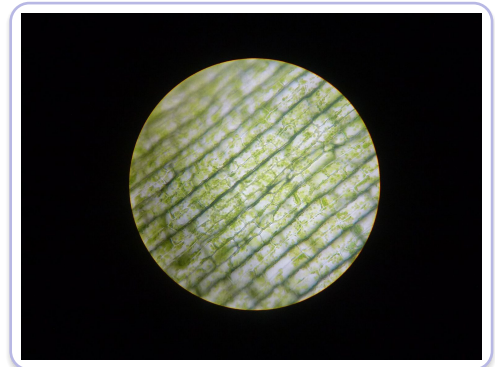
Surface area-to-volume ratio

Materials cross the **surface** 表面积; the **volume** 体积 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** 褶皱).



Many small cells keep a high surface area for their volume

3

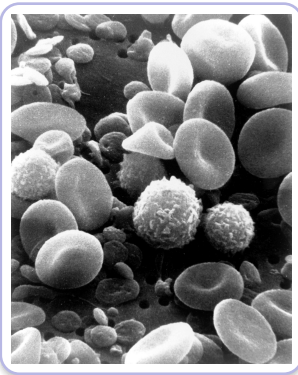
Membrane

The fluid mosaic membrane

The **fluid mosaic model** 流动镶嵌模型: a **phospholipid bilayer** 磷脂双分子层 (hydrophilic heads out, hydrophobic tails in) with drifting proteins.

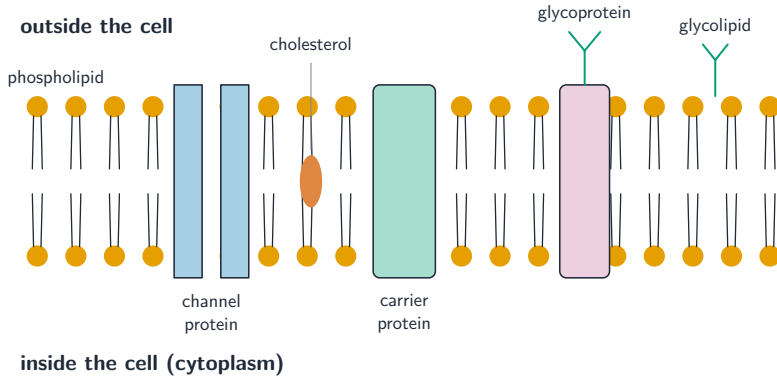
- **membrane proteins** 膜蛋白 – channels, pumps, receptors
- **cholesterol** 胆固醇 – steadies the fluidity

Selectively permeable 选择性通透的 – it maintains **homeostasis** 稳态.



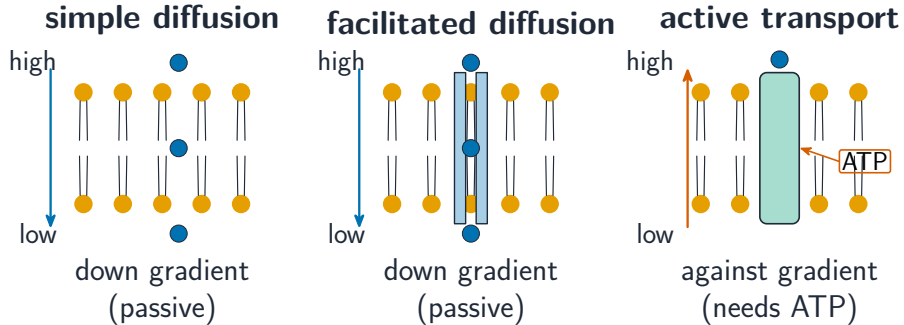
Red blood cells bend through capillaries because the membrane is fluid

The fluid mosaic model of the cell membrane



Phospholipids drift sideways and proteins float among them; cholesterol keeps the membrane's fluidity steady across temperatures.

Three ways substances cross the membrane



Passive transport moves solutes down their gradient without ATP (diffusion, facilitated diffusion); active transport spends ATP to move them against it.

Compartmentalization inside the cell, and its origins

Membranes create separate

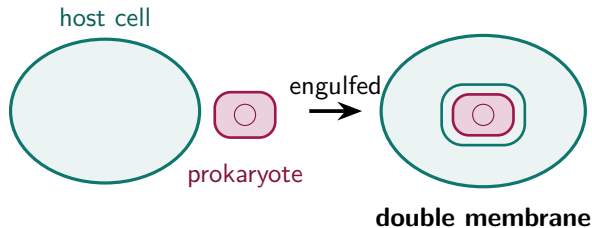
compartments 区室:

- incompatible reactions run **at once**
- pH and ion levels tuned **locally**
- internal membranes add **surface area**

The **endosymbiotic**

theory 内共生学说: a larger cell

engulfed free-living prokaryotes that went on living inside it.



Evidence: mitochondria and chloroplasts have their own **circular DNA**, own **ribosomes** and a **double membrane**.

4

Crossing

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** 葡萄糖, Na^+)

Facilitated diffusion 易化扩散:

channel 通道蛋白/**carrier** 载体蛋白 proteins – passive, but **saturates**.

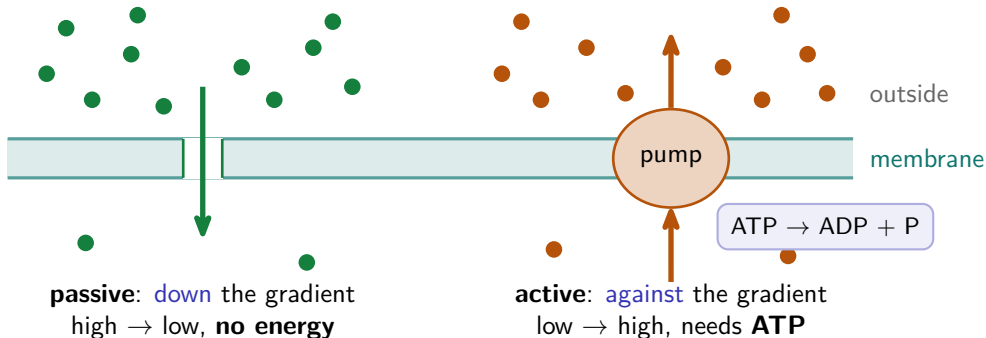
Passive: down the gradient,
no ATP

Active: against the gradient,
uses *ATP*

Osmosis 渗透 = diffusion of water.

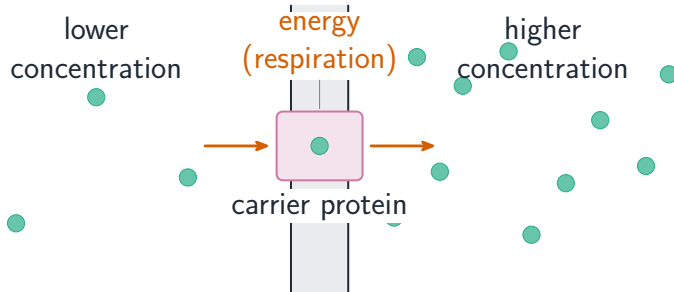
Endo/exocytosis move bulk cargo.

Passive and active transport



Passive transport 被动运输 (**diffusion** 扩散) is free; **Active transport** 主动运输 spends ATP: the sodium-potassium pump.

Passive and active transport, in detail



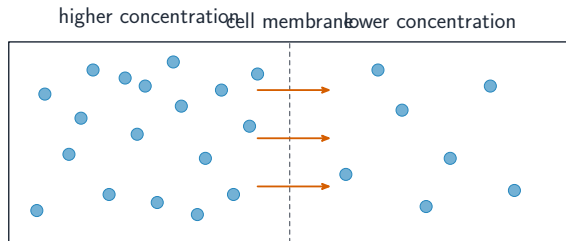
particles moved against the gradient, using energy

Against the gradient, using ATP and a carrier protein

Facilitated diffusion

Facilitated diffusion 易化扩散 is passive transport *through* a membrane protein – a channel or a **carrier** 载体 – 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.



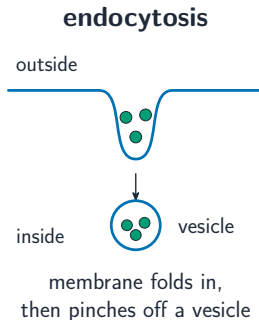
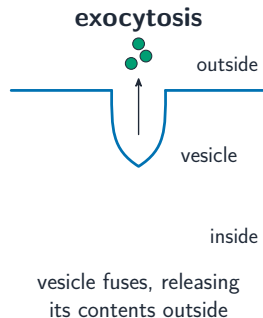
net movement of particles down the concentration gradient

Bulk transport by vesicle

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

- **endocytosis** 内吞 brings material **in**
– the membrane engulfs it;
- **exocytosis** 外排 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.



5

Tonicity

Tonicity and endosymbiosis

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

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

Endosymbiotic theory 内共生学说:
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 水勢 Ψ predicts the direction: water moves to the **lower** (more negative) Ψ .

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

i ions per particle, C in M, $R = 0.0831 \text{ L bar}/(\text{mol K})$, T in K

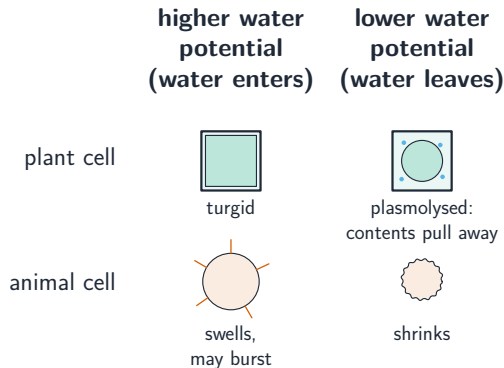
0.1 M sucrose in an open beaker at 25 °C; a cell at $\Psi = -1.0 \text{ bar}$ sits in it

Sucrose does not ionise ($i = 1$); open beaker, so $\Psi_p = 0$.

$$\Psi_s = -iCRT = -(1)(0.1 \text{ M})(0.0831 \text{ L bar}/(\text{mol K}))(298 \text{ K}) = -2.48 \text{ bar}$$

$-2.48 \text{ bar} < -1.0 \text{ bar}$: water **leaves the cell** and it loses turgor.

Water potential, and which way water moves, in detail



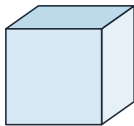
Plant and animal cells in solutions of different water potential

Why Cells Stay Small



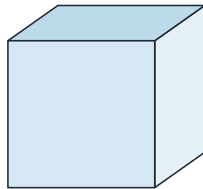
side $L = 1$

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.

6

Recap

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

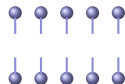
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Transport

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)