Cycling of matter in living systems slide deck

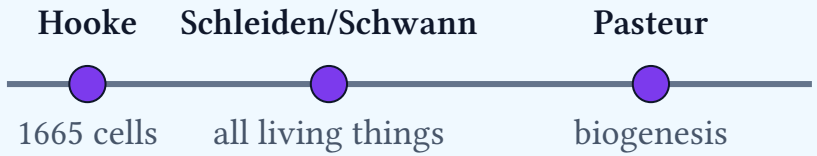
Science 10

Unit C: Cycling of matter in living systems

Cell theory and spontaneous generation

Pasteur’s experiment

- Air entered Pasteur’s swan-neck flask, but dust and microorganisms remained trapped in the curved neck.
- The sterile broth stayed clear until it contacted trapped particles.



Cells come from cells

- Pasteur showed that cells arise from existing cells under the tested conditions, and sterile broth stayed clear of new life.
- Broth exposed to air stayed clear until it contacted particles carrying existing cells.
- Air is distinguished from dust-borne microorganisms and the conclusion matches the experiment.

Key terms

cell theory

The model that organisms are made of cells, cells are the basic unit of life, and cells come from existing cells.

spontaneous generation

The rejected claim that living organisms routinely arise from non-living matter.

biogenesis

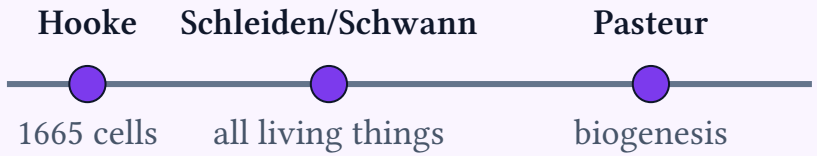
The principle that living cells arise from existing living cells.

controlled experiment

A test in which relevant variables are controlled so competing explanations can be compared.

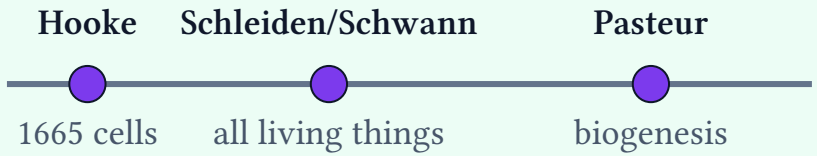
Cell theory timeline

- Hooke, Schleiden, Schwann, and Pasteur each added an observation this theory still uses.
- Viruses and prions lack cells of their own but depend on cells, so they sit at the edge of the theory.



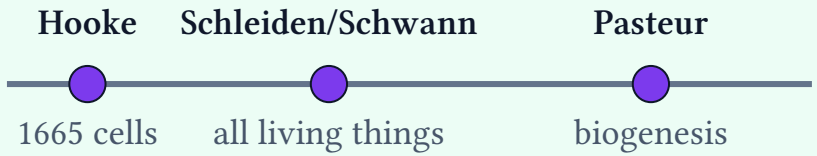
Claim and evidence

- Identify Pasteur’s claim, one observation, and the reasoning linking them.
- A complete answer separates air from microorganisms carried on dust, and the conclusion matches the experiment.



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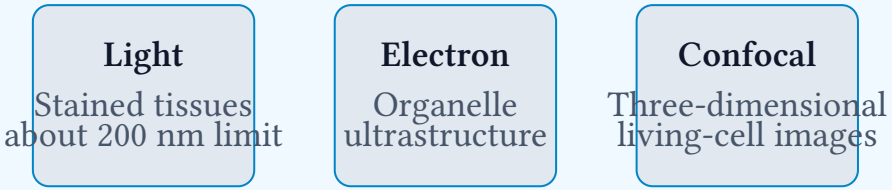
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Unit C: Cycling of matter in living systems

Microscopy and modern cell research

One specimen under different microscopes

- A light microscope can show whole cells and some living processes.
- Electron and confocal microscopes reveal different details because they use different signals and preparation methods.



Information in an image

- Images depend on preparation, staining, signal detection, scale, and instrument limits.
- Resolution, living-sample needs, depth, preparation, and the structure being studied require different methods.
- Choose a method for its resolution, whether the sample can stay alive, and the structure you need to see.

Key terms

resolution

The ability to distinguish two close points as separate.

magnification

How many times larger an image appears than the object.

electron microscope

A microscope that uses electrons to image structures at high resolution.

confocal microscopy

Optical imaging that collects thin focal sections to build detailed three-dimensional views.

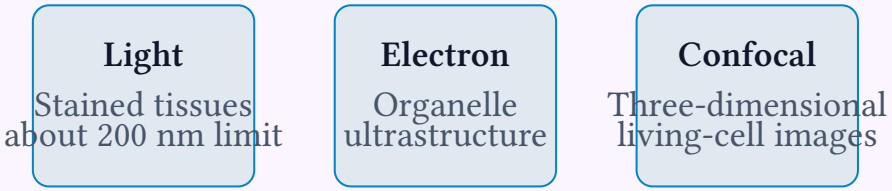
Key terms

stain

A substance or marker used to increase contrast or identify structures.

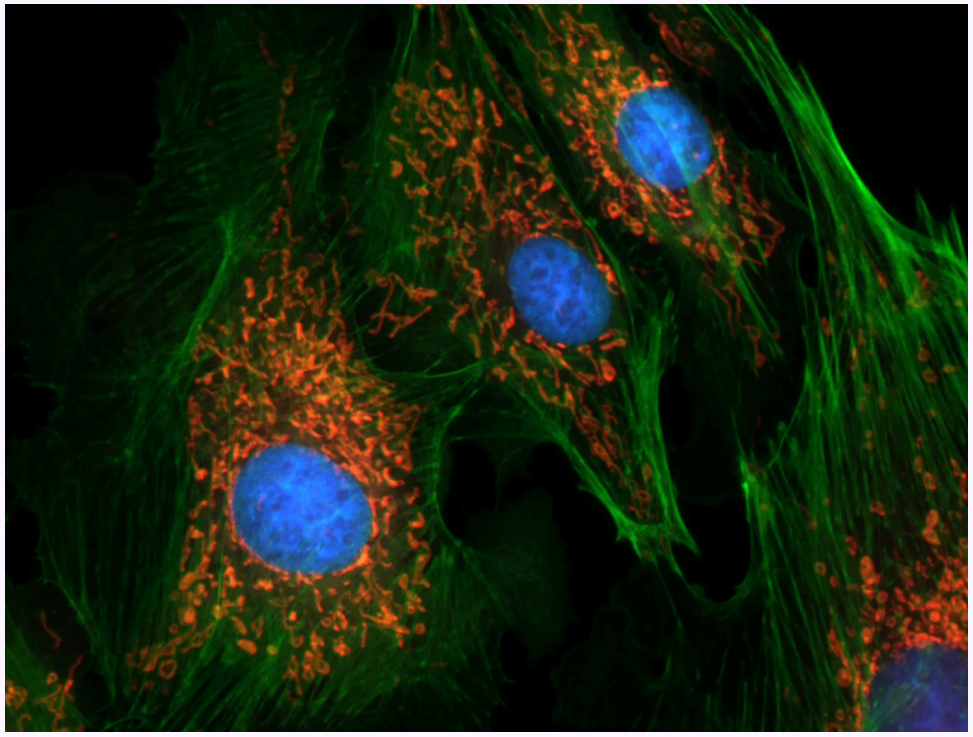
Imaging technology

- A light microscope, an electron microscope, and a confocal laser scanning microscope answer different questions.
- A stain can make a structure visible that would otherwise blend into the background.
- Pick the instrument that gives the evidence you need. The biggest magnification number is only one factor.



Molecular research

- A micrograph shows where something is. Proving what that structure does takes further evidence.
- Fluorescent labels, gene maps, and transport-rate experiments add the molecular evidence.
- Controls are how you tell a real signal from a preparation artifact.
- Imaging and molecular tests answer different questions.



Choosing an instrument

- Select an imaging method for three research questions and justify each selection.
- A complete answer mentions resolution, living samples, depth, or the structure being studied, as well as magnification.

Image credits

Erin Rod, Bovine Pulmonary Artery Endothelial Cells Fluorescent Image, CC BY 4.0

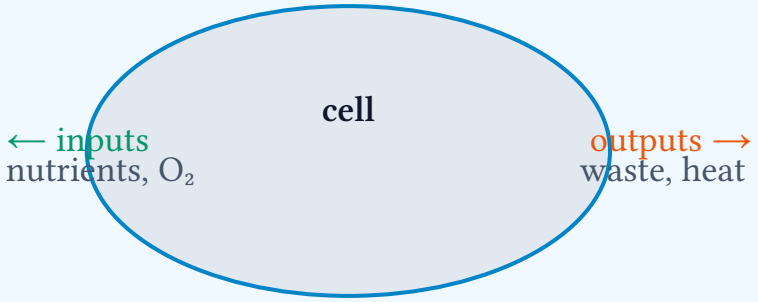
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Unit C: Cycling of matter in living systems

The cell as an open system

Exchange and cell survival

- Cells require continuing inputs such as water, nutrients, and gases.
- Cells release products such as carbon dioxide, wastes, and thermal energy.



Boundaries of an open cell

- The membrane selectively regulates exchange; open refers to matter and energy crossing the boundary.
- Matter and energy cross the cell boundary while internal processes transform them.
- Model cells as open systems that exchange matter and energy with their surroundings.

Key terms

open system

A system that exchanges matter and energy with its surroundings.

input

Matter or energy entering a chosen system.

output

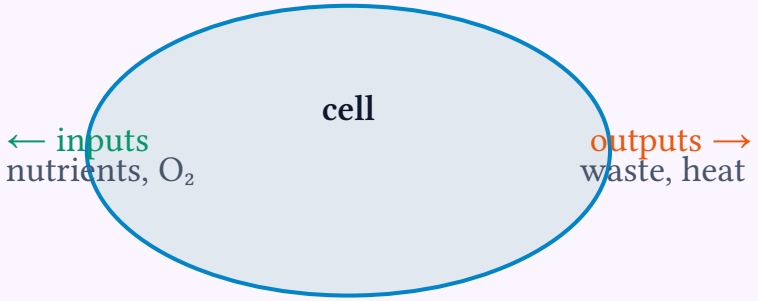
Matter or energy leaving a chosen system.

cell membrane

The selectively permeable boundary that regulates exchange with the environment.

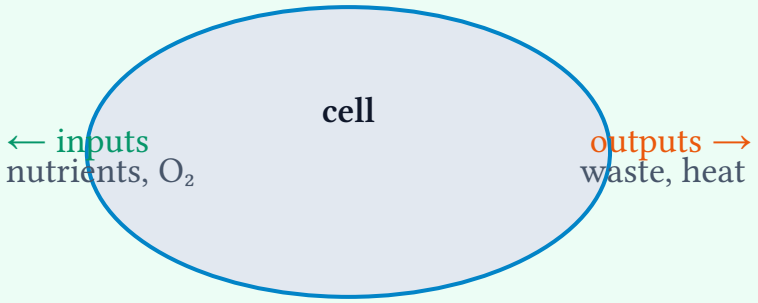
Open systems

- Nutrients, water, and gases can enter a cell. Wastes and thermal energy can leave.
- Both matter and energy cross the membrane.
- Draw the membrane as the boundary. It selects what crosses. It works like a gate that chooses what gets through.



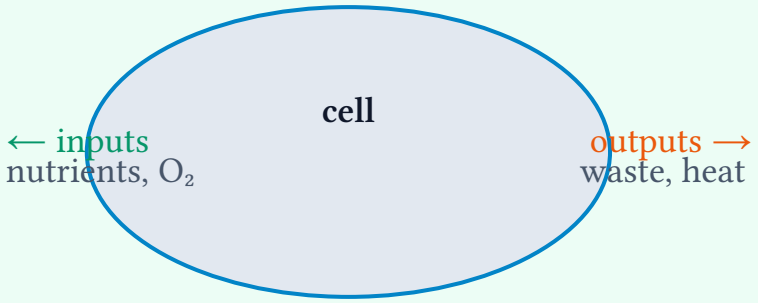
Cell boundary audit

- Classify listed substances and energy transfers as inputs, outputs, or internal transformations.
- A complete answer shows the direction across the membrane and names the system boundary.



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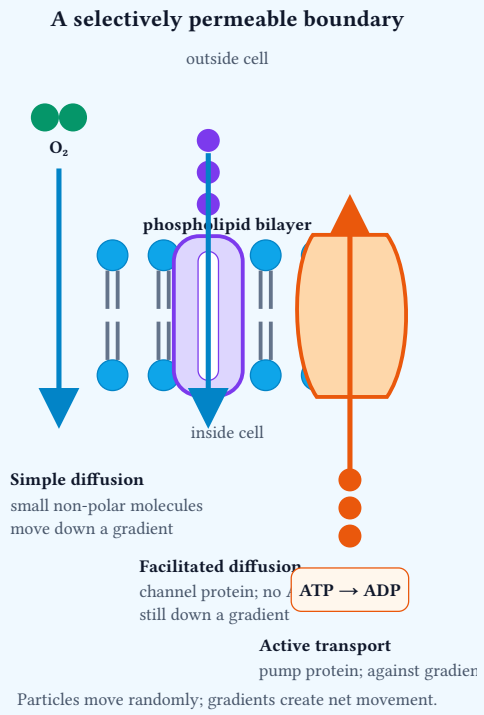
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Unit C: Cycling of matter in living systems

Membrane transport

Food colouring in water

- Dye particles move randomly and spread from higher concentration to lower concentration.
- Net spreading continues until concentration is more uniform, even though particles still move.



Random motion and net movement

- Individual motion is random; the concentration difference produces net movement statistically.
- Random motion continues, but there is no net movement in one direction.
- Name the particle or the water, the direction of the gradient, what the membrane does, and whether the cell spends energy.

Key terms

diffusion

Net movement of particles from higher concentration to lower concentration.

osmosis

Net movement of water across a selectively permeable membrane.

active transport

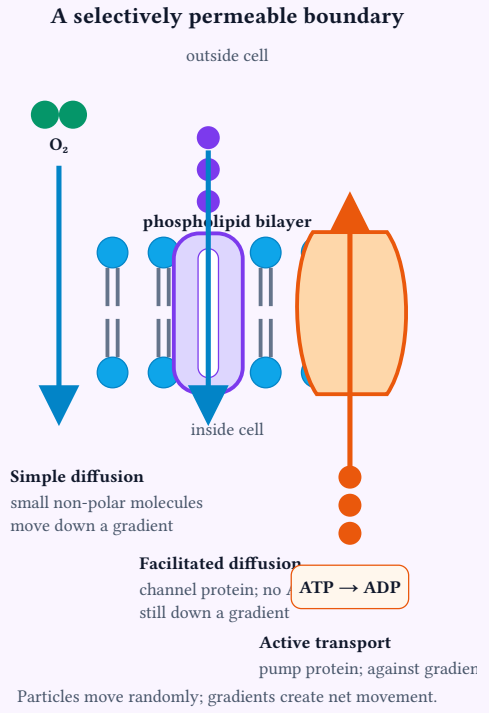
Membrane transport against a concentration gradient using cellular energy.

concentration gradient

A difference in concentration across distance or a membrane.

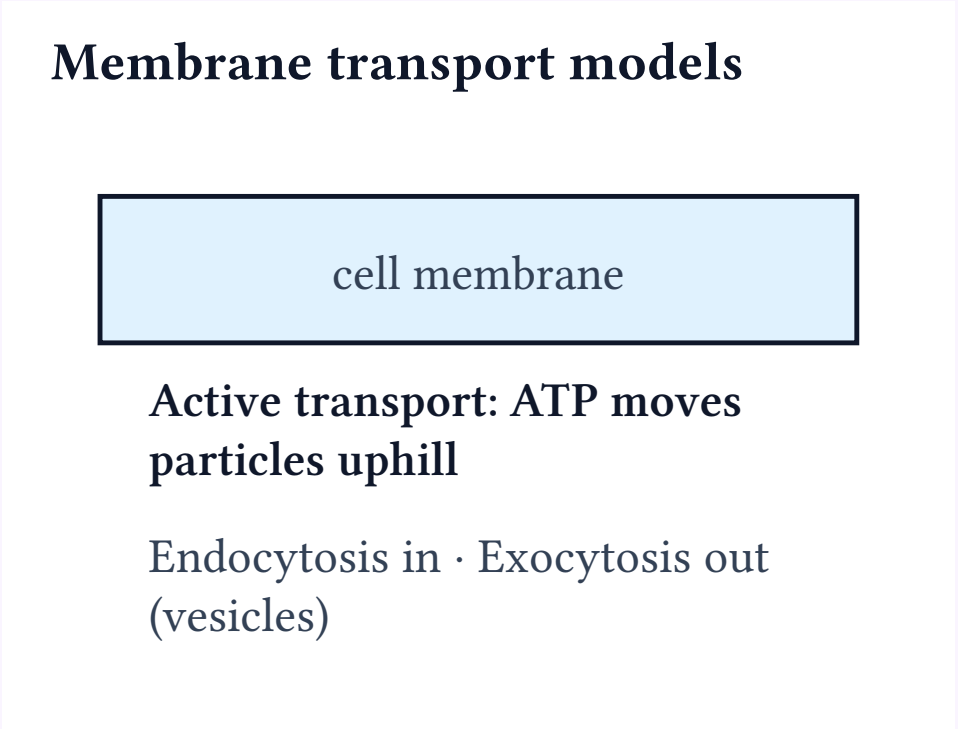
Passive transport

- Particles spread from where they are crowded toward where they are scarce.
- Osmosis is that kind of spread for water, across a membrane that blocks some solutes.
- At equilibrium the particles still move. The two directions match, so concentrations stop changing.
- Predict the net direction from the concentration difference and from what the membrane allows.



Models

- Active transport spends cellular energy to move particles toward the higher concentration.
- Endocytosis wraps cargo in a vesicle. Exocytosis merges a vesicle with the membrane to release cargo.
- Carrier proteins move smaller loads than a vesicle does.
- Direction, cargo size, and energy use are the three comparisons.



Transport sort

- Classify membrane scenarios as diffusion, osmosis, or active transport and justify the energy requirement.
- A complete answer names the particle or the water, the direction of the gradient, the membrane's role, and whether the cell must supply energy.

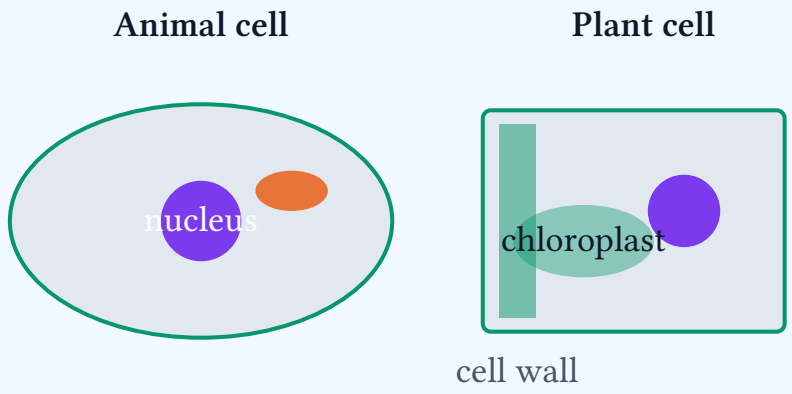
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Unit C: Cycling of matter in living systems

Organelles and cell types

The cell as a city

- One cell can perform respiration, protein synthesis, and waste management.
- Specialized parts (organelles) divide the labour.



Organelle locations and jobs

- Compare a cheek cell with an Elodea leaf cell.
- List the organelles you can see, and the ones you infer from what the cell does.
- Chloroplasts and a cell wall show up in the leaf cell; the cheek cell lacks both.

Key terms

organelle

A specialized structure within a cell that performs a particular function.

nucleus

The organelle that stores genetic information and directs the cell's activities.

mitochondrion

Organelle where much of aerobic cellular respiration and adenosine triphosphate production occurs.

chloroplast

Plant-cell organelle where photosynthesis occurs.

Key terms

cell wall

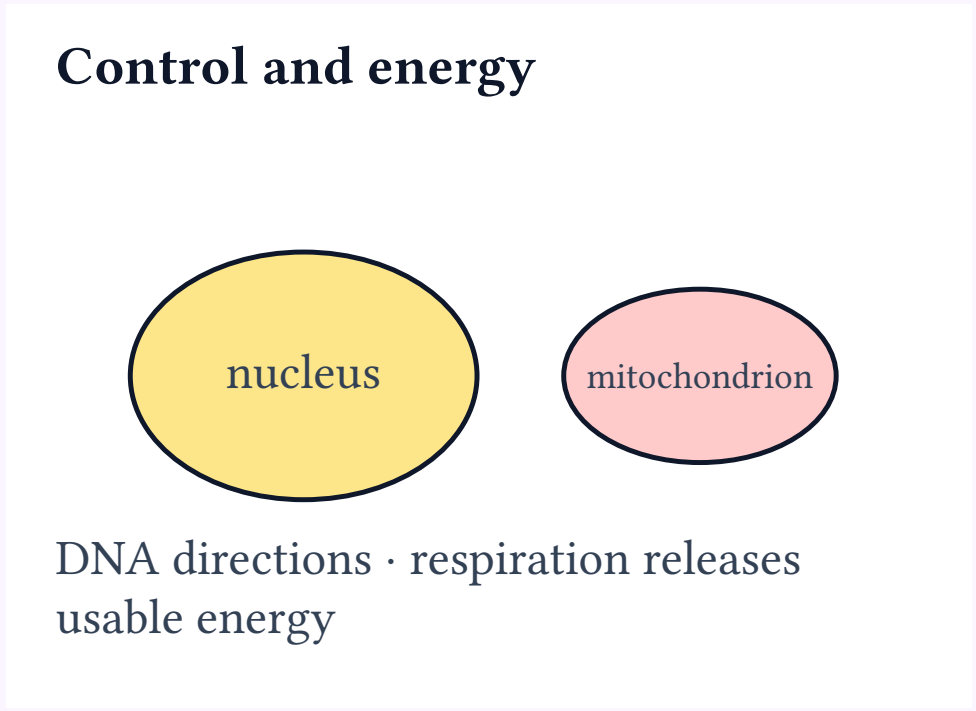
Rigid layer outside the cell membrane that supports and protects plant cells.

vacuole

Membrane-bound compartment used for storage and, in plants, maintenance of turgor.

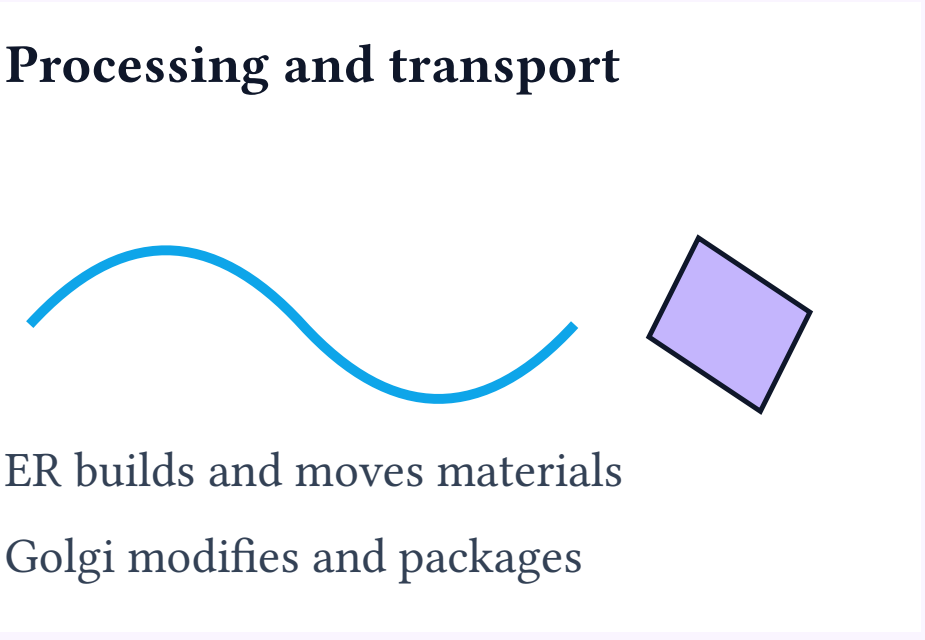
Control and energy

- The nucleus stores genetic information and directs the cell's activities.
- Mitochondria release usable energy through cellular respiration.
- Ribosomes build proteins, either free in the cytosol or attached to rough endoplasmic reticulum.



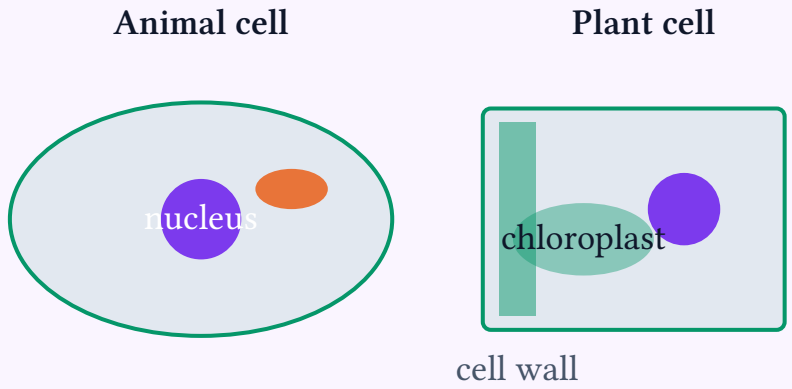
Processing and transport

- The endoplasmic reticulum is a membrane network that helps build and move materials.
- The Golgi apparatus modifies proteins, packages them, and sends them onward.
- Lysosomes break materials down for reuse. They stand out more in many animal cells than in plant cells.



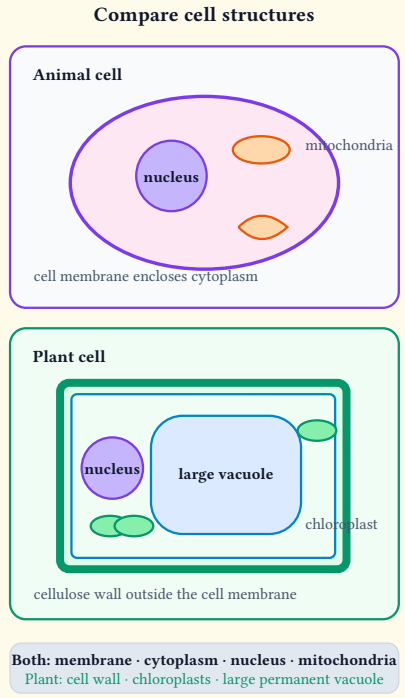
Plant structures

- Chloroplasts capture light for photosynthesis. They belong in plant cells; a typical animal cell lacks them.
- A large central vacuole stores materials and presses outward, which helps the plant cell keep its shape.
- The cell wall is a rigid layer outside the membrane. In plants it contains cellulose.



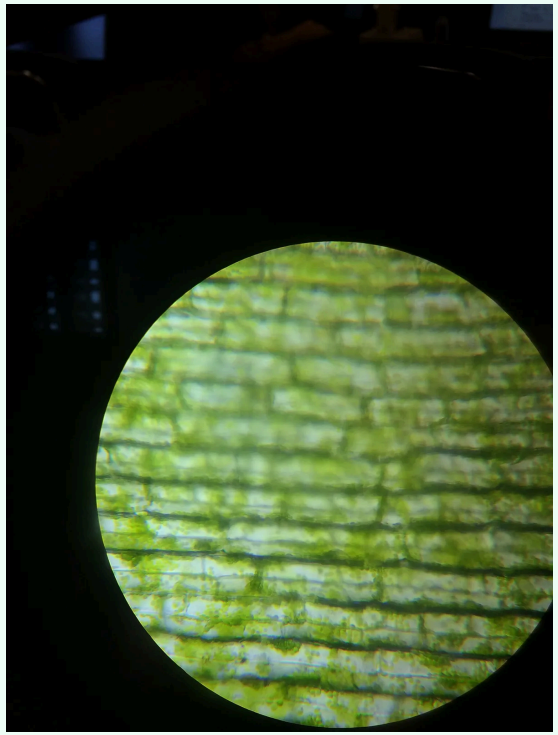
Comparing two cells

- List the organelles you can see, or reasonably infer, in a cheek cell and in an Elodea leaf cell.
- For each structure, say how it supports that organism's life processes.



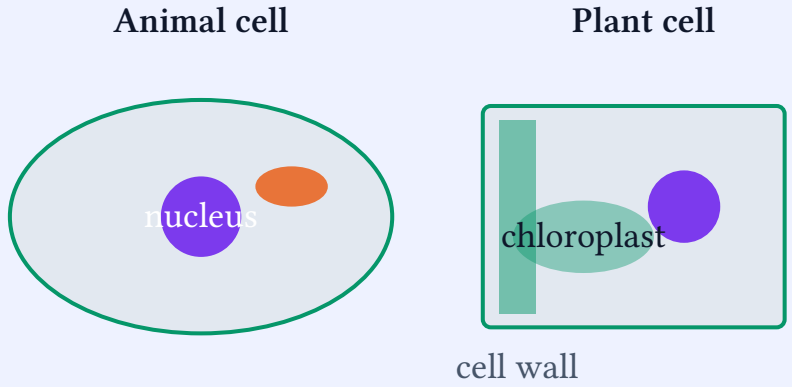
Gallery walk

- At each station, record the organelle's function and whether it is found in plants, animals, or both.
- Connect at least two organelles to one life process, such as making and exporting a protein.



Applications

- Medical imaging and cell biology depend on knowing organelle targets.
- Biotechnology questions often start from how a cell structure works.
- Name the organelle a technique is aimed at, along with the illness or the product.



Organelle match

- Match each structure to its function, and say whether it belongs in plant cells, animal cells, or both.
- A complete answer puts chloroplasts and the cell wall in plant cells only. Centrioles are an optional extension.

Cell structure retrieval check

- Trace a protein from genetic information in the nucleus to export from the cell.
- Name two structures typical of plant cells and explain their functions.
- Explain why a plant cell needs both chloroplasts and mitochondria.

Image credits

Lilyviolet, Anacharis Magnified, CC BY 4.0

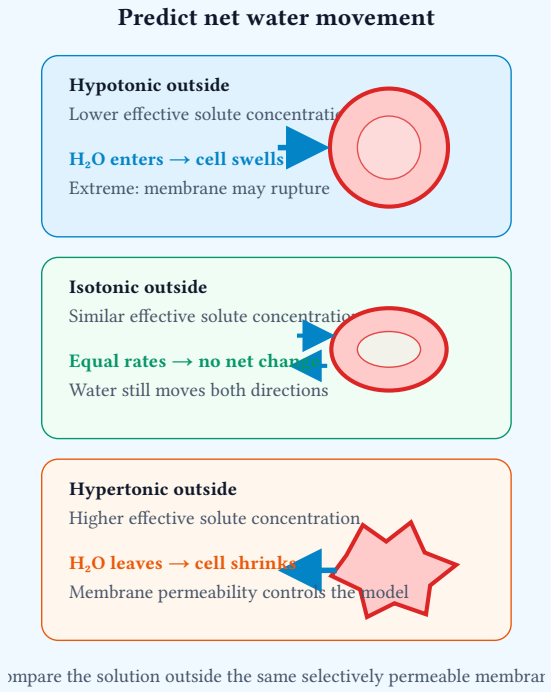
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Unit C: Cycling of matter in living systems

Membrane equilibrium and applications

Intravenous saline

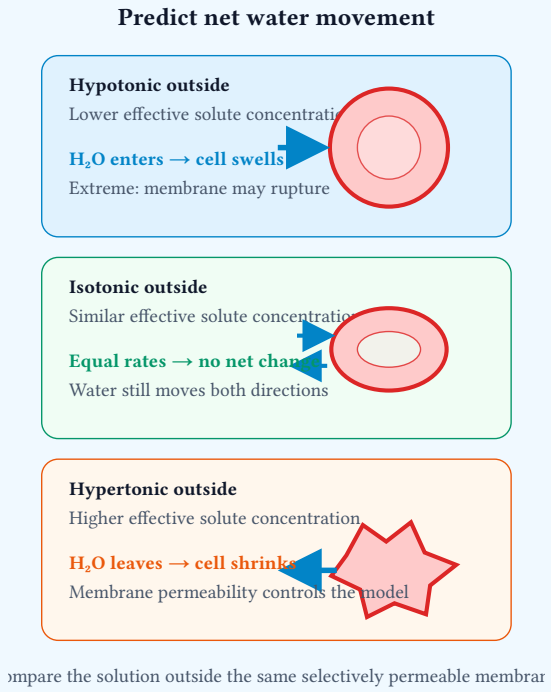
- Red blood cells gain water and may burst in a strongly dilute solution.
- They lose water and shrink in a strongly concentrated solu-tion.



ompare the solution outside the same selectively permeable membrar

Selective permeability

- Predict the direction water moves by comparing the concentrations on the two sides.
- Remember that the membrane lets some particles through and blocks others.



ompare the solution outside the same selectively permeable membrar

Key terms

isotonic

A solution that causes no net water movement into or out of a cell.

hypotonic

A solution with lower effective solute concentration that drives net water movement into a cell.

hypertonic

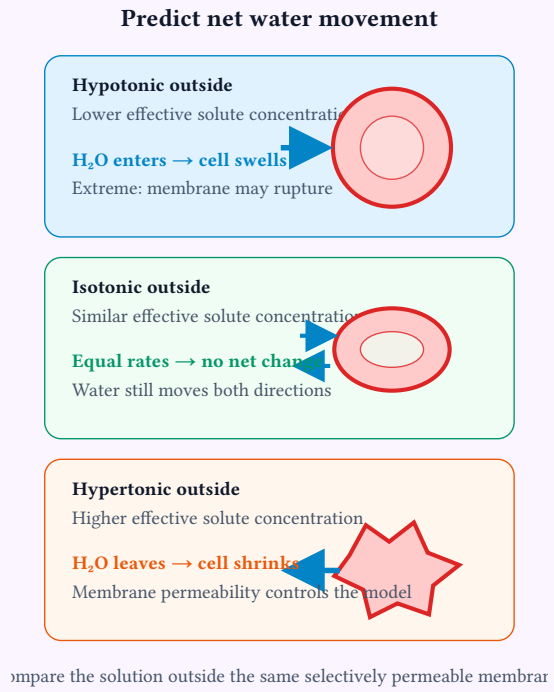
A solution with higher effective solute concentration that drives net water movement out of a cell.

equilibrium

A dynamic state with no net change even though particles continue moving.

Equilibrium

- Particles keep crossing after the concentrations level off.
- Equal rates in both directions are what balanced means here.
- Change the outside concentration and the net water flow changes until a new balance forms.
- A cell can be steady without being frozen in place.



Applications

- Dialysis lets small wastes cross a membrane and holds back cells and large proteins.
- Desalination can push water through a membrane that blocks most ions.
- A high sugar or salt level can preserve food by leaving microbes too little available water.
- The membrane decides which particles are part of the balance.



Cell response

- Predict water movement and cell shape in isotonic, hypotonic, and hypertonic solutions.
- A complete answer gives the direction of the water, uses the relative concentrations, and treats the membrane as selective.

Image credits

James Grellier, Reverse osmosis desalination plant, CC BY-SA 3.0

Science 10

Unit C: Cycling of matter in living systems

Surface area to volume and cell size

Exchange limits in two cubes

- A 1 cm cube has a surface-area-to-volume ratio of 6:1.
- A 3 cm cube has a ratio of 2:1, so each cubic centimetre has less surface available for exchange.

Area and volume growth

- Larger cells have more total area but less area relative to each unit of volume.
- Volume grows with length cubed while surface area grows with length squared.
- Quantify how cell size changes surface-area-to-volume ratio and limits exchange.

Key terms

surface area

The total area of an object's outer boundary.

volume

The three-dimensional space occupied by an object.

surface-area-to-volume ratio

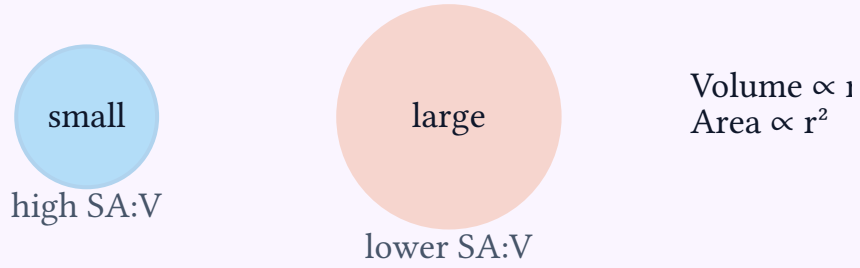
Surface area divided by volume; a measure of exchange area relative to internal demand.

exchange rate

Amount of matter or energy crossing a boundary per unit time.

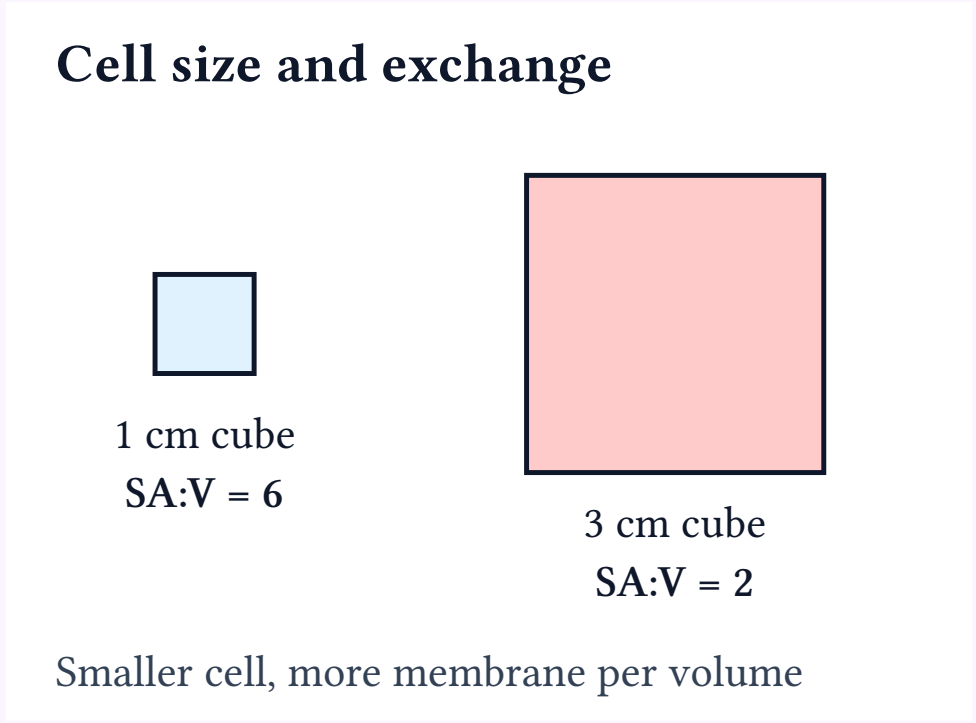
Surface area to volume ratio

- Compare a tiny cell with a larger one of the same shape.
- Volume increases faster than surface area as the side length grows.
- The bigger cell has more membrane in total and less membrane for each unit inside.
- Nerve cells, blood cells, root hairs, and leaf cells stay small or folded for that reason.



Cell size and exchange

- The inside of a cell has to be supplied through its surface.
- If volume outgrows the membrane, exchange falls behind.
- Organisms answer that limit with many small cells, folds, and transport tissues.
- Plants and animals solve the problem with many small cells.



Calculation and explanation

- Calculate ratios for two cubes and connect the result to membrane exchange.
- A complete answer uses the right formulas and units, reports the ratios, and explains relative surface area, the surface for each unit of volume.

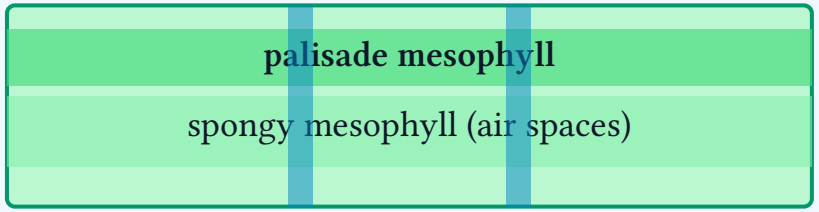
Science 10

Unit C: Cycling of matter in living systems

Plant specialization and leaf systems

Leaf layers

- Palisade cells near the upper surface contain many chloroplasts for light capture.
- Spongy mesophyll contains air spaces that support gas movement to and from cells.



Vascular bundles (xylem/phloem) run through the leaf

Leaf tissue functions

- Palisade tissue receives strong light; spongy air spaces shorten gas-diffusion paths; vascular tissue connects transport.
- Leaf tissues contain specialized cells with structures suited to different functions.
- Name the tissue first, then the job it does for light, gases, or transport.

Key terms

palisade mesophyll

Closely packed, chloroplast-rich leaf tissue specialized for photosynthesis.

spongy mesophyll

Leaf tissue with air spaces that support gas exchange.

vascular bundle

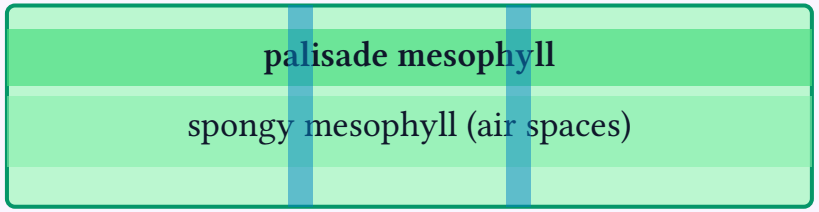
Leaf xylem and phloem that transport water, minerals, and sugars.

specialization

Structural adaptation of a cell or tissue for a particular function.

Multicellular organisms

- A plant needs many cells to share all its jobs.
- Root hairs take in water. Xylem carries it. Phloem carries sugars. Leaves handle light and gases.
- Those tissues depend on each other.
- Specialization answers the size problem, and it creates interdependence.



Vascular bundles (xylem/phloem) run through the leaf

Leaf system

- The epidermis lets light through and protects the leaf.
- Palisade cells pack chloroplasts near the top surface.
- Spongy tissue leaves air spaces so gases can diffuse.
- Xylem brings water in. Phloem carries sugars out. Guard cells set the stomata.



Labelling with reasons

- Label a leaf cross-section and give one structure-function link for each tissue.
- A complete answer puts each tissue in the right place and gives a cause-and-effect link between structure and function.

Image credits

Bioham, Mesophytic leaf micrograph, CC BY-SA 4.0

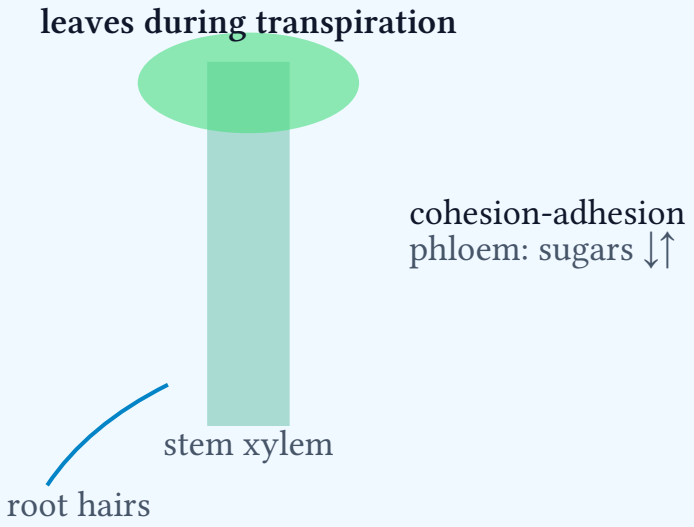
Science 10

Unit C: Cycling of matter in living systems

Plant water transport and transpiration

Water transport in tall trees

- A tall tree has no heart-like pump, yet its leaves can release litres of water on a sunny day.
- Cohesion, adhesion, and pressure differences move the column.



From root hair to stoma

- Follow water from the soil into a root hair, up the xylem, and out through a stoma.
- Water enters root hairs when a water-potential difference produces net osmosis into root cells.
- Cohesion holds water molecules together, while adhesion attracts water to xylem walls and helps stabilize the column.

Key terms

xylem

Plant vascular tissue that transports water and dissolved minerals mainly upward.

phloem

Plant vascular tissue that transports sugars and other organic substances between sources and sinks.

transpiration

Loss of water vapour from plant surfaces, mainly through stomata.

cohesion

Attraction between molecules of the same substance, such as water molecules.

Key terms

adhesion

Attraction between molecules of different substances, such as water and xylem walls.

turgor

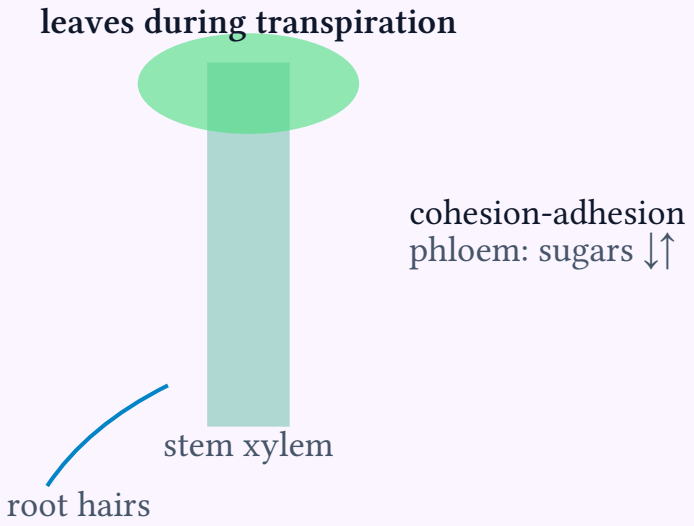
Pressure of cell contents against the cell wall after water enters a plant cell.

root hair

A root epidermal-cell extension that increases surface area for water and mineral uptake.

Xylem and upward flow

- Xylem vessels carry water and dissolved minerals from roots to shoots.
- Transpiration from stomata lowers water potential in leaves: pull on the water column.
- Cohesion (water-water) and adhesion (water-xylem wall) help maintain the column.



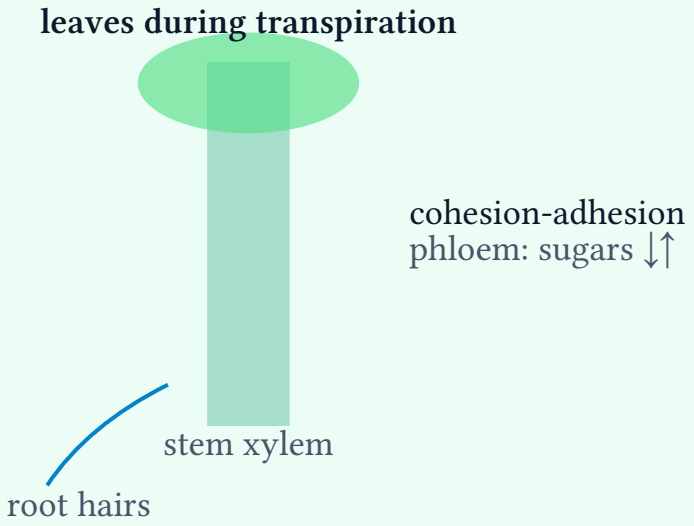
Roots and phloem

- Root hairs add surface area, and water enters those cells by osmosis before it reaches the xylem.
- Phloem carries sugars from leaves toward roots and fruits, and that flow can change direction.



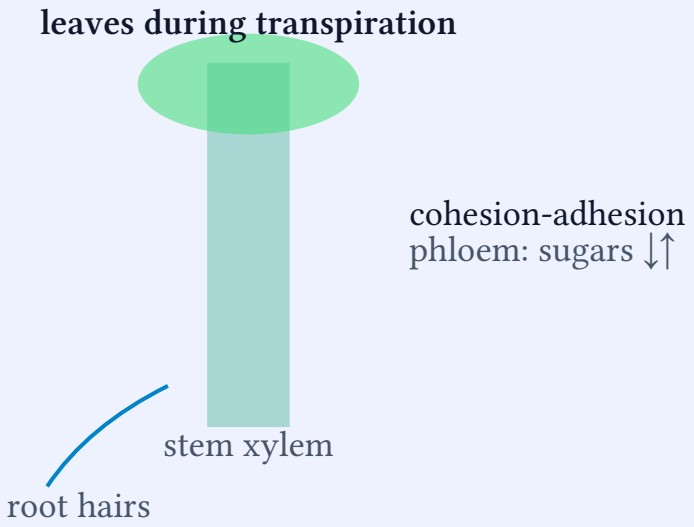
Dye in celery

- Coloured water in the xylem shows the path. Predict which tissue changes colour first.
- When a cell loses enough water, it loses turgor and the tissue wilts.



Alberta agriculture

- Crop irrigation and drought stress link to transpiration rates and soil moisture.
- On the prairies, irrigation is a stewardship choice because crops lose water through their leaves.
- A hot windy afternoon raises transpiration, so the watering decision depends on soil moisture.



Pathway diagram

- Sketch the path from soil to a root hair, up the xylem, out of the leaf, and into the air.
- Label osmosis, cohesion and adhesion, and transpiration on that path.

Plant transport retrieval check

- Trace water from soil through a root hair, xylem, leaf, and stoma.
- Explain the different roles of cohesion, adhesion, and transpiration.
- Contrast xylem transport with phloem translocation.

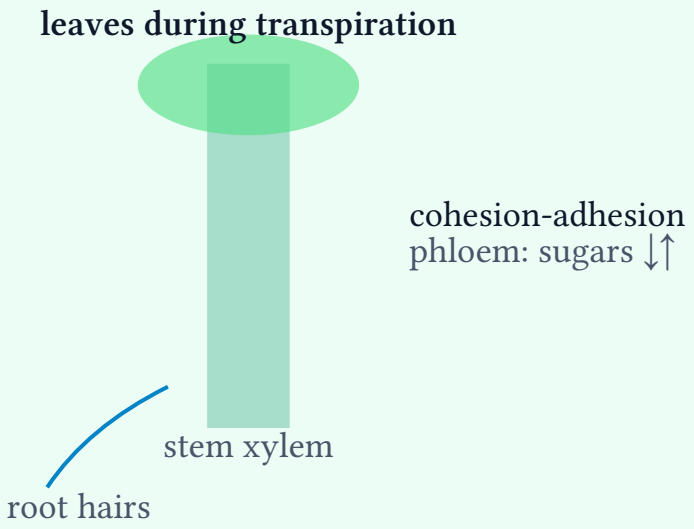


Image credits

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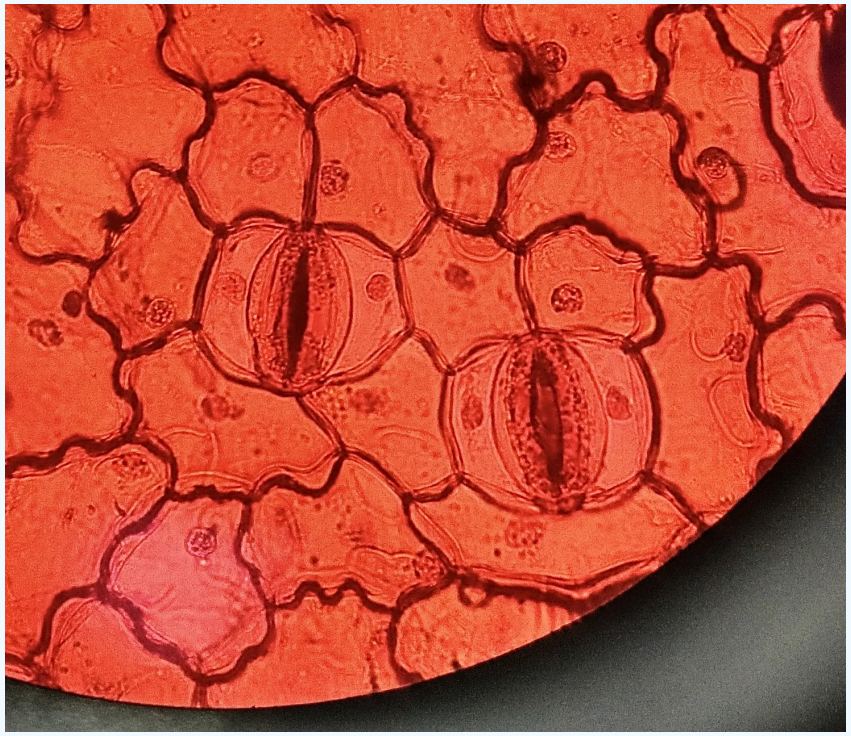
Science 10

Unit C: Cycling of matter in living systems

Gas exchange and tropisms in plants

Stomata and water balance

- Open stomata allow carbon dioxide to enter a leaf but also allow water vapour to leave.
- Guard cells change shape to adjust the pore as water conditions and light change.



Water cost of gas exchange

- Gases move mainly by diffusion; guard cells regulate the opening through which diffusion occurs.
- Carbon dioxide uptake supports photosynthesis, but transpiration increases water loss.
- Describe the diffusion, the water the leaf gives up, the stimulus, and the direction of growth.

Key terms

stoma

A microscopic pore in the leaf epidermis; plural: stomata.

guard cell

A specialized cell that changes shape to regulate a stoma.

transpiration

Loss of water vapour from plant surfaces, mainly through stomata.

phototropism

Directional plant growth in response to light.

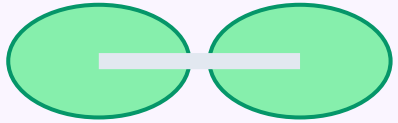
Key terms

gravitropism

Directional plant growth in response to gravity.

Gas exchange

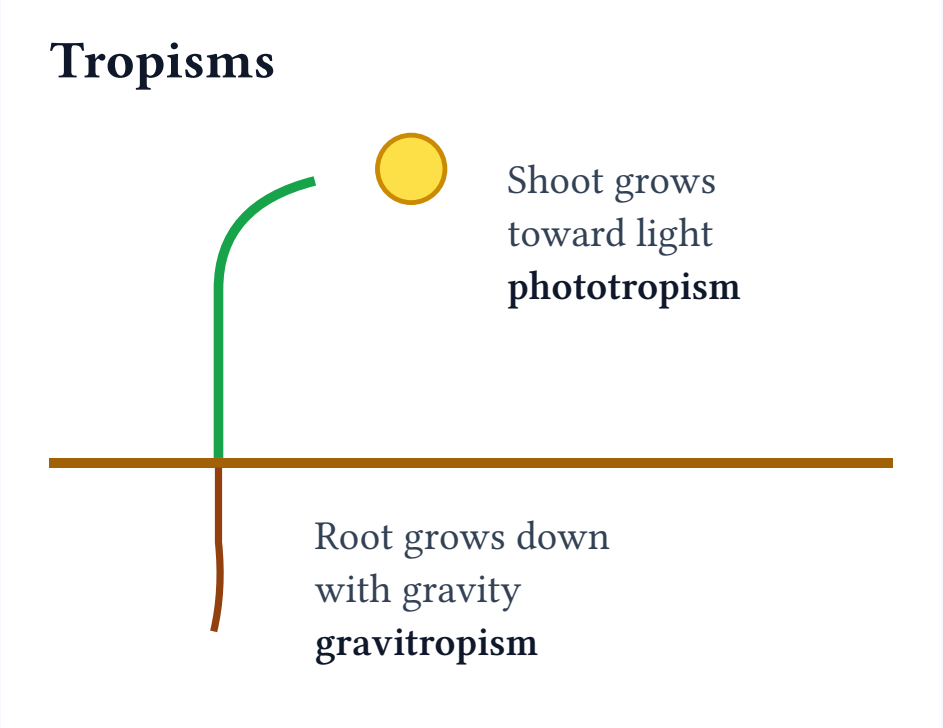
- Carbon dioxide enters a leaf. Oxygen and water vapour can leave.
- Guard cells open or close the stomata by changing their water pressure.
- An open pore gains carbon dioxide and loses water.
- Light, drought, humidity, and temperature all push on that tradeoff.



Open: CO_2 in · H_2O vapour out
Guard cells swell with water to open the pore

Tropisms

- Phototropism is growth bent by the direction of light. Gravitropism is growth oriented by gravity.
- The evidence runs from Darwin's experiments on the shoot tip to Went's chemical signal.



Stimulus and response

- Explain one stomatal response and classify shoot and root growth by tropism.
- A complete answer uses diffusion language, names the water trade-off, names the stimulus, and gets the growth direction right.

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