Science 10 full slide deck

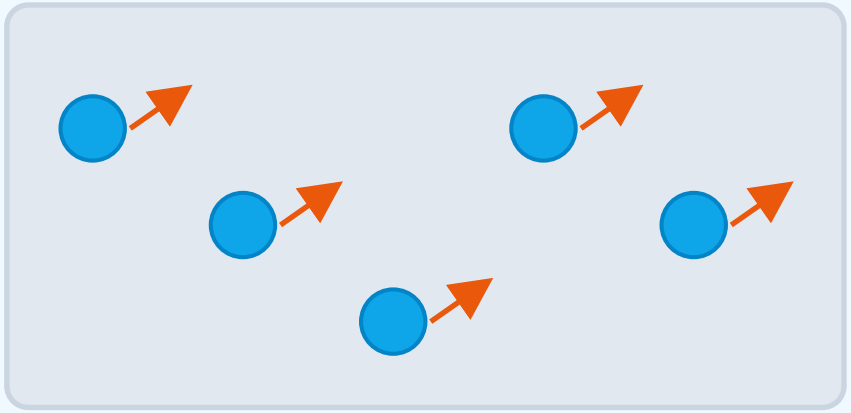
Science 10

Unit A: Energy and matter in chemical change

Particles of matter

Sugar in tea

- Solid sugar disappears into hot tea, the tea tastes sweet, and the glass has gained mass.
- The question is whether the sugar is still there, and what kind of change that was.
- The particle model is how this lesson answers that question.



Particles have space between them and move. Heating increases motion.

Dissolved sugar

- Dissolving sugar in tea is a powerful Grade 10 example of the particle model.
- The sweet taste and unchanged total mass show that sugar particles are still present.
- Those particles spread among water particles. They remain present.
- Dissolving is a physical change: no new chemical substance forms, which is different from burning sugar.

Key terms

particle model

The idea that all matter is made of tiny particles in motion with space between them.

pure substance

Matter with fixed composition (an element or a compound).

mixture

Two or more substances physically combined; composition can vary.

element

A pure substance made of one type of atom (one atomic number).

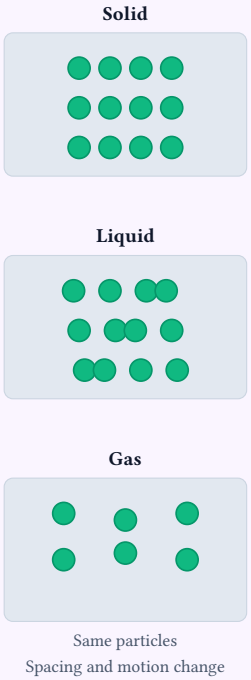
Key terms

compound

A pure substance with two or more elements chemically bonded in fixed ratios.

Particle model of matter

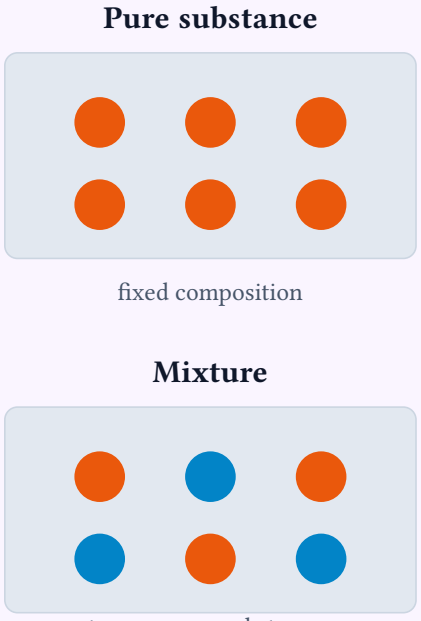
- All matter is made of tiny particles with space between them.
- Those particles move, and they move faster when the thermal energy increases.
- In a solid they stay close and vibrate. In a liquid they slide past one another. In a gas they are far apart and move quickly.



Same particles
Spacing and motion change

Pure substances and mixtures

- Copper and distilled water each have a fixed composition, so each is a pure substance.
- Salt water can be saltier or weaker, because a mixture's composition can vary.
- Salt water looks the same throughout. Gravel mixed with sand looks patchy.

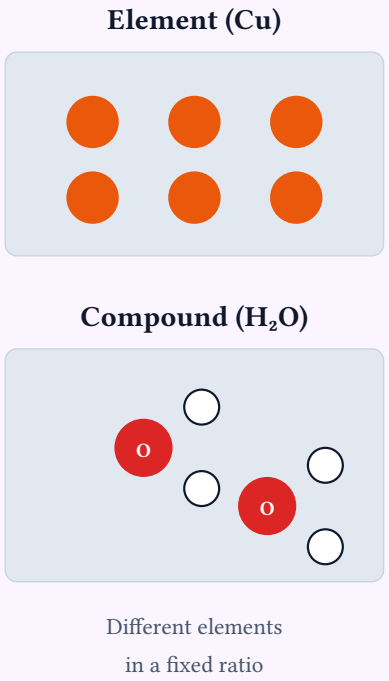


Materials and human needs

- Before contact, First Nations communities used living and non-living materials to meet basic needs.
- Plant extracts for dyes/medicines; minerals for tools; animal products for clothing and shelter.
- Knowledge was tested and passed on: an early form of empirical science.

Elements and compounds

- An element, such as copper or oxygen, is one kind of atom.
- A compound bonds two or more elements in a fixed ratio.
- A physical change keeps the same substances. A chemical change produces new ones.



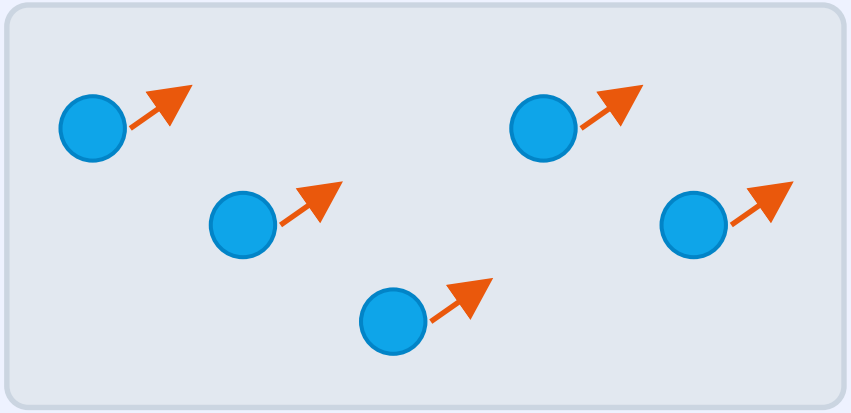
Different elements in a fixed ratio

Classifying samples

- Sort these samples: air, distilled water, salt water, gold, carbon dioxide, and gravel mixed with sand.
- Label each one as an element, a compound, a homogeneous mixture, or a heterogeneous mixture.
- Justify each label with the particle model.

Uses of models

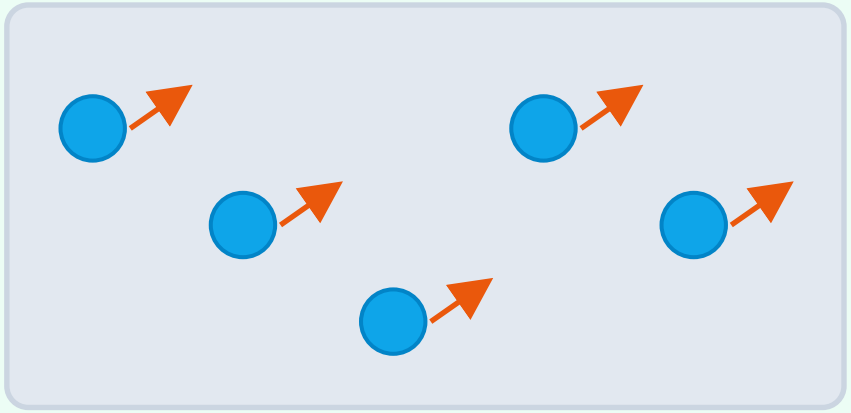
- Science uses models to explain and predict: models are re-vised when evidence demands.
- Technologies (microscopes, mass spectrometers) extend what we can observe.



Particles have space between them and move. Heating increases motion.

Evidence and opinion

- What observation would convince you that matter is made of particles?
- A convincing answer uses an observation other people could repeat.



Particles have space between them and move. Heating increases motion.

Particle-model retrieval check

- Classify copper, distilled water, air, and muddy water as elements, compounds, or mixtures.
- Explain dissolving sugar without saying the sugar disappears.
- State one observation that supports the particle model, even though atoms are too small to see.

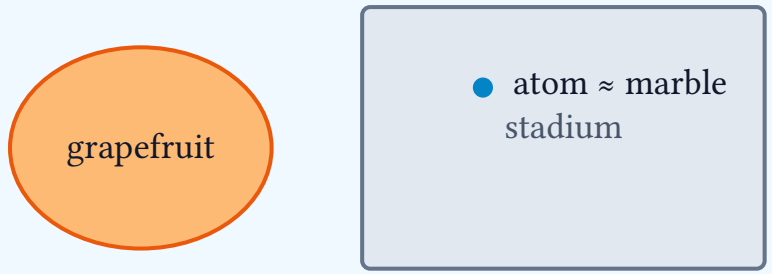
Science 10

Unit A: Energy and matter in chemical change

Atomic models and evidence

The size of an atom

- If you expanded a grapefruit to stadium size, atoms would be marble-sized.
- Atoms are far too small for classroom microscopes: how do we know their structure?



If a grapefruit were an atom, a stadium models its relative size

Two experiments on atomic structure

- Cathode rays bend toward a positive plate, evidence that atoms contain negatively charged electrons.
- Most alpha particles passed through the gold foil.
- A few deflected sharply, which is evidence of a tiny, dense, positive nucleus.
- For carbon-12, atomic number 6 means 6 protons; mass number 12 means 6 protons plus 6 neutrons.

Key terms

proton

Positively charged particle in an atomic nucleus.

neutron

Uncharged particle in an atomic nucleus.

electron

Negatively charged particle found outside an atomic nucleus.

nucleus

Dense central region of an atom containing protons and neutrons.

Key terms

atomic number

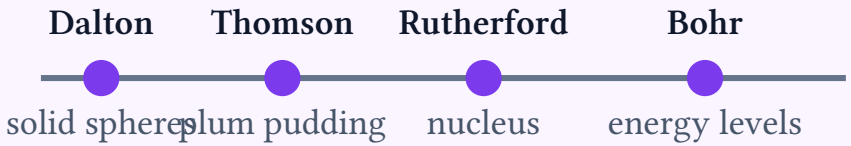
Number of protons in an atom's nucleus.

mass number

Total number of protons and neutrons in a particular atom.

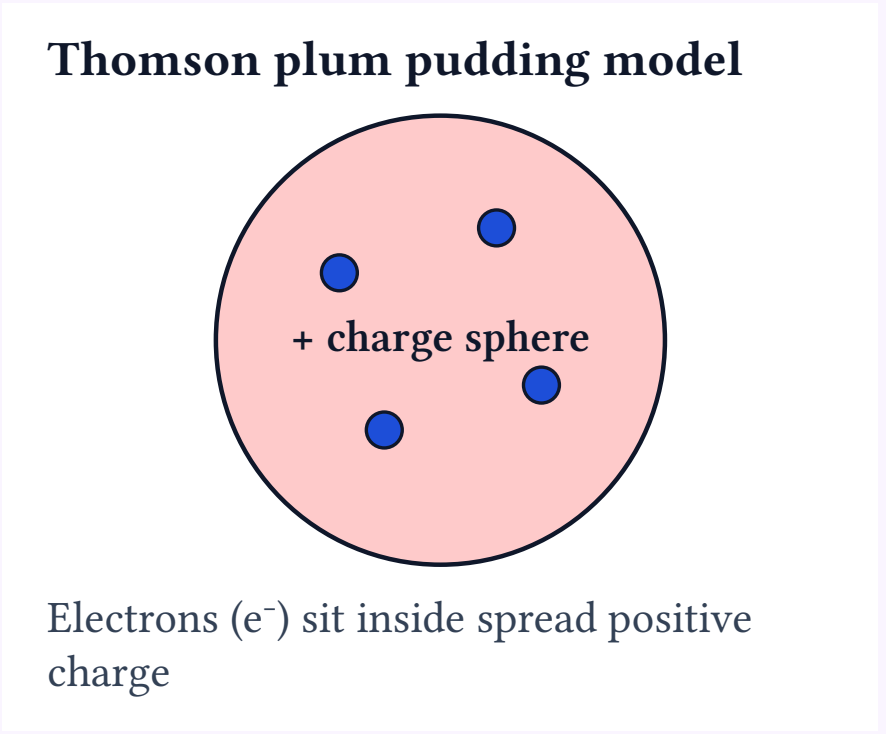
Dalton’s solid sphere model

- Dalton pictured each element’s atoms as solid spheres that stayed whole.
- That picture explains why a compound always combines elements in the same proportion.
- It leaves electric charge unexplained.



Thomson’s plum pudding model

- Thomson’s cathode-ray experiments showed that atoms contain electrons, which are negatively charged.
- He placed those electrons inside a sphere of positive charge, the picture nicknamed plum pudding.
- That picture failed to explain why some alpha particles bounce back from thin gold foil.

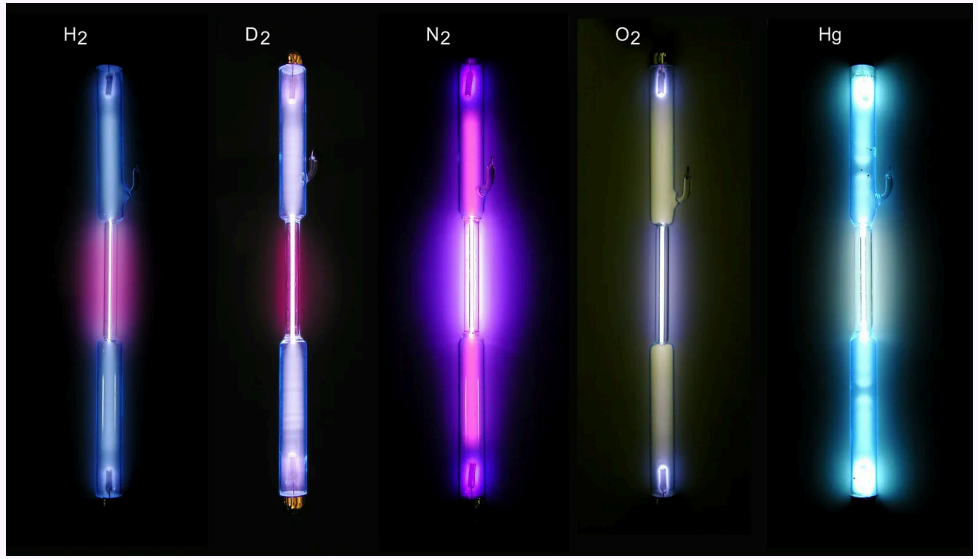


Rutherford’s nuclear model

- Most alpha particles passed straight through the foil, so the atom is mostly empty space.
- The few that bounced require a tiny region that is both dense and positively charged.
- Electrons sit outside that nucleus. The foil results replaced the spread-out positive charge.

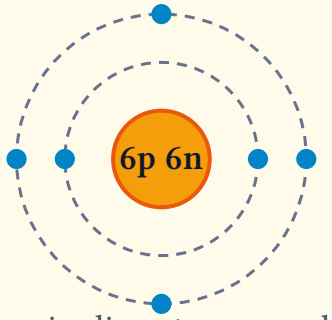
Bohr's energy level model

- Bohr allowed electrons only certain energies, a limited set of orbits.
- Those allowed energies explain the bright-line spectrum of hydrogen.
- A later model describes an electron as a cloud of probability. In this course you name that cloud. Calculating it comes in later courses.



Subatomic inventory

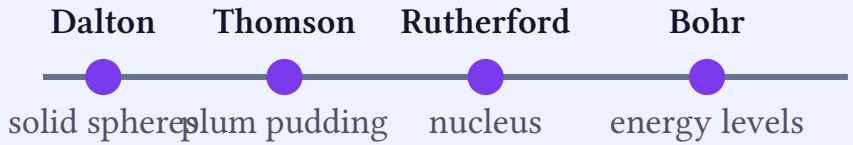
- A neutral carbon-12 atom has 6 protons, 6 neutrons in the common isotope, and 6 electrons.
- Atomic number is the proton count. Mass number is protons plus neutrons.



rade 10 model: electrons in discrete energy levels (2 + 4 for carbo

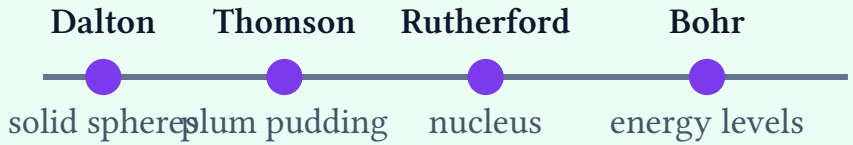
Careers using atomic structure

- Chemical engineering, cosmetology, and food processing use atomic evidence in different jobs.
- In Alberta that evidence shows up in oil-sands analysis, water treatment, medical tests, and farming.



Timeline sort

- Put the models in historical order, from the solid sphere to allowed energy levels.
- For each model, name one observation that the older model failed to explain.



Atomic evidence retrieval check

- Match cathode-ray deflection to the particle Thomson added to the atomic model.
- Match rare large alpha-particle deflections to Rutherford's nuclear revision.
- For carbon-12, determine proton, neutron, and electron counts in a neutral atom.

Image credits

Alchemist-hp www.pse-mendelejew.de, Gase-in-Entladungsroehren, CC BY-SA 3.0

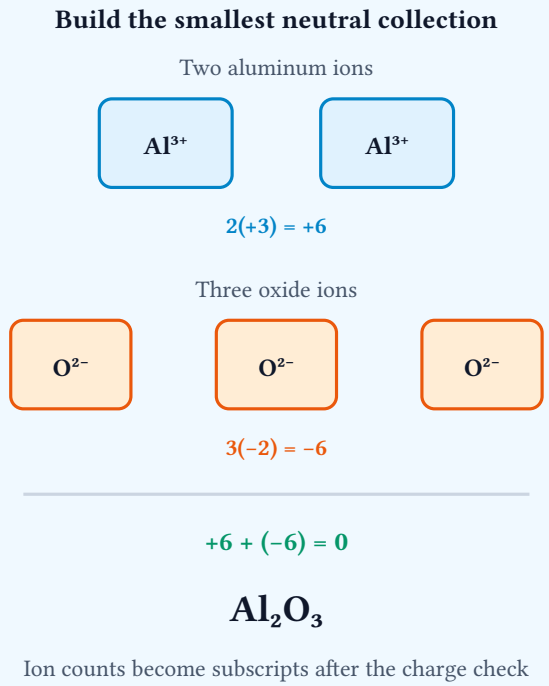
Science 10

Unit A: Energy and matter in chemical change

Periodic table patterns and combining ratios

The fixed formula of sodium chloride

- Sodium chloride is NaCl. $NaCl_2$ and Na_2Cl_5 are wrong.
- That repeating formula has to come from how the atoms are built.



Three decisions in this chapter

- Use main-group periodic position to predict common outer-electron behaviour and ion charge.
- Build the smallest whole-number ion ratio that makes total charge zero.
- Distinguish an ionic formula-unit ratio from the atom counts in a molecular formula.

Key terms

group

A vertical column of the periodic table whose elements often have similar chemical properties.

period

A horizontal row of the periodic table.

valence

The combining capacity associated with an atom’s outer electrons in the Grade 10 model.

ion

An atom or group of atoms with a net electric charge after gaining or losing electrons.

Key terms

ionic bond

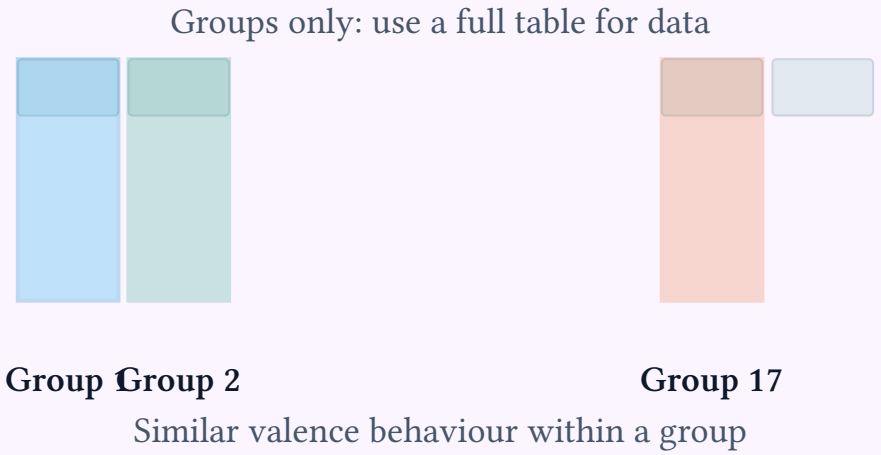
Attraction between oppositely charged ions after electron transfer.

covalent bond

Electrons shared between atoms in a molecule.

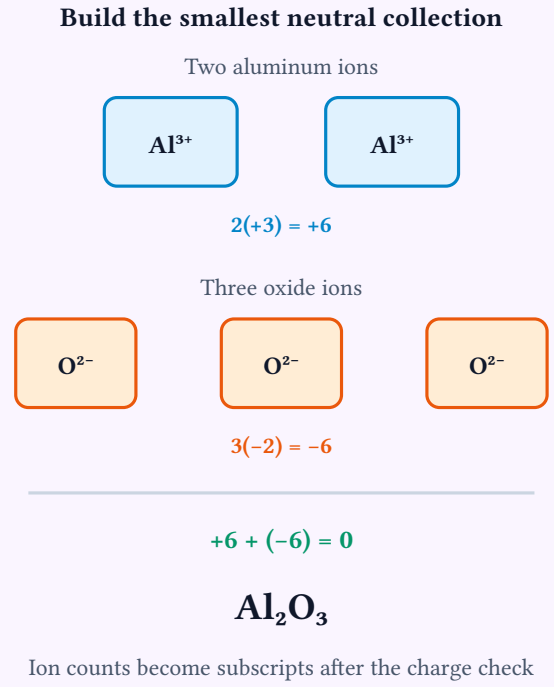
Periodic position and outer electrons

- A period shows the occupied energy levels in the Grade 10 model; a main-group column shows a recurring outer-electron pattern.
- Group 1 and 2 metals commonly form 1+ and 2+ ions by losing outer electrons; Group 17 and 16 non-metals commonly form 1− and 2− ions by gaining electrons.
- Two non-metals often share electrons, forming a covalent bond.



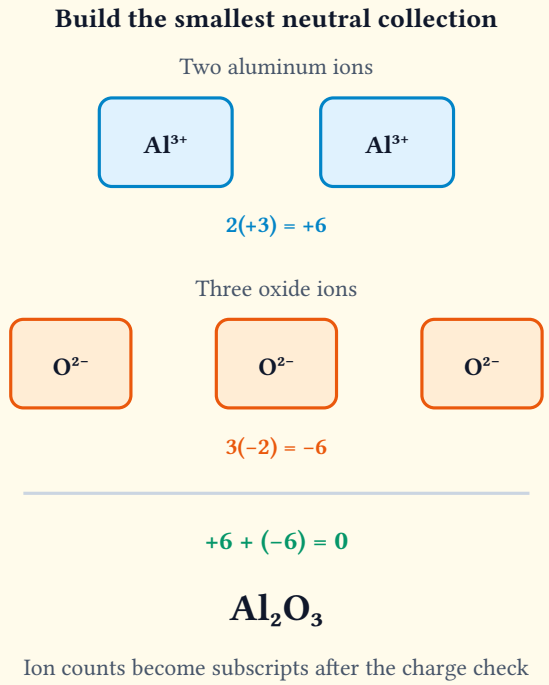
Smallest neutral ion ratio

- Write each ion with its charge, then combine ions until total positive charge equals total negative charge.
- Use the smallest whole-number ratio: two Al^{3+} ions give +6 and three O^{2-} ions give −6, so the formula is Al_2O_3.
- Check neutrality and reduce the ratio before removing charge symbols; keep each ion's internal subscripts exactly as they are.



From periodic position to formula

- Aluminum is in Group 13 and commonly forms Al^{3+}; oxygen is in Group 16 and commonly forms O^{2-} in this course model.
- The smallest neutral collection is two Al^{3+} ions and three O^{2-} ions.
- Write Al_2O_3, then verify $2(+3) + 3(-2) = 0$.



Formula practice

- Write formulas for magnesium oxide, sodium sulfide, and aluminum fluoride.
- For each compound, show ion charges, the smallest neutral ratio, and a total-charge check.
- Attempt all three before opening the solution; correct the first reasoning step that differs.

Communicating formulas

- A formula states which atoms are present and in what ratio.
- $CaCl_2$ and CaCl are separate formulas. The subscript changes the substance in this model.
- Laboratories and emergency crews rely on that ratio.
- A wrong ratio can waste a reaction or create a hazard.



Periodic pattern and formula retrieval check

- Predict the common ion charges for magnesium and chlorine from their periodic-table groups.
- Use charge balance to write magnesium chloride.
- Explain why MgCl and $MgCl_3$ both fail as neutral ionic compounds.

Image credits

James St. John, Halite crystals (four), CC BY 2.0

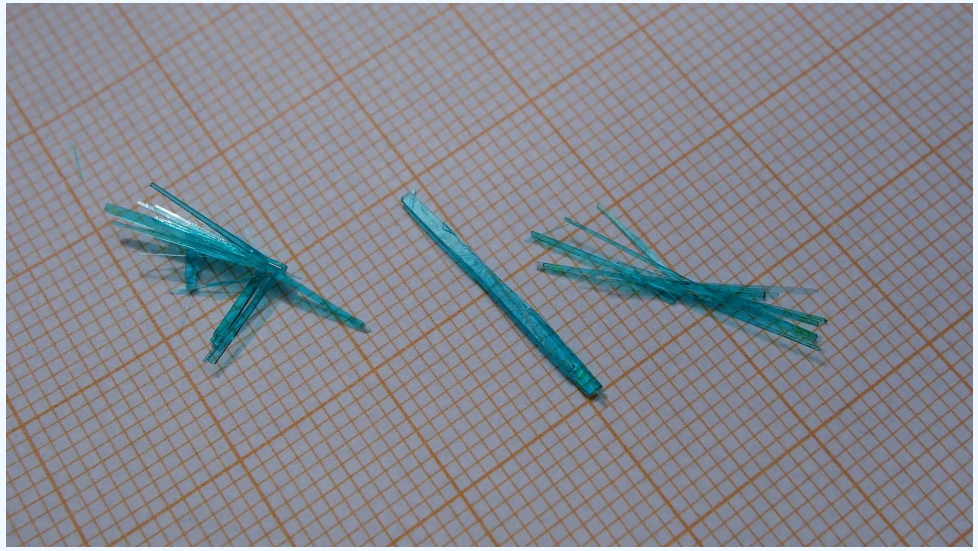
Science 10

Unit A: Energy and matter in chemical change

Naming ionic and molecular compounds

An incomplete label

- A shelf label that says only “copper chloride” could refer to CuCl or $CuCl_2$.
- The formulas contain different copper-ion charges and identify different compounds.
- A systematic name must preserve the evidence needed to identify the intended substance.



Choosing a naming system

- Metal or ammonium with an anion: use the ionic path and determine whether a Roman numeral is required.
- Two non-metals: use the binary molecular path and let prefixes state atom counts.
- A formula beginning with hydrogen and marked aqueous: use the required acid naming path.

Key terms

International Union of Pure and Applied Chemistry (IUPAC)

International organization that develops standardized chemical naming recommendations.

prefix

A word part that indicates the number of atoms in a molecular-compound name.

binary molecular

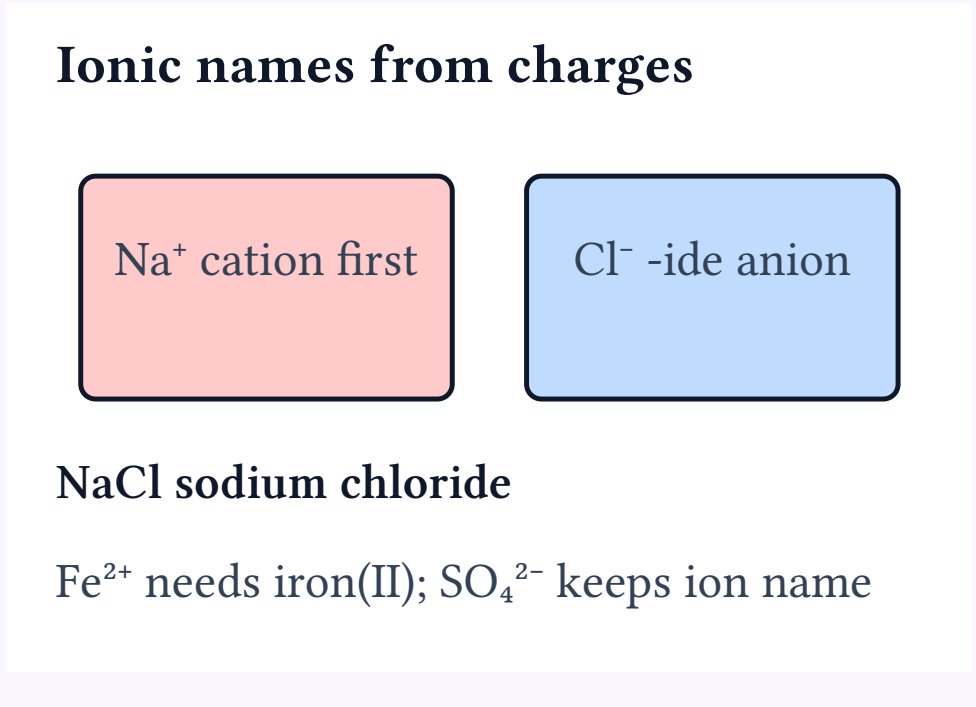
Describing a molecular compound made from two different elements.

polyatomic ion

A charged group of covalently bonded atoms that acts as one ion.

Ionic names from charges

- Name the cation first; a fixed-charge metal needs no Roman numeral, while a variable-charge metal does.
- A monatomic anion ends in -ide; a polyatomic ion keeps its established ion name.
- For $FeCl_3$, three Cl^- ions total −3, so iron is Fe^{3+} and the name is iron(III) chloride.



Molecular naming

- Prefixes show atom counts: carbon dioxide, dinitrogen tetroxide.
- Second element ends in -ide with prefix even if mono- (monoxide).

mono-	= 1	CO (carbon monoxide)
di-	= 2	CO_2 (carbon dioxide)
tri-	= 3	SO_3
tetra-	= 4	CCl_4

Aqueous solutions and acid names

- HCl(g) is hydrogen chloride; HCl(aq) is hydrochloric acid in the required acid-naming set.
- For a binary acid, identify the anion stem, then use hydro- + stem + -ic acid.
- Reverse-check the completed acid name against the aqueous formula and the supplied ion table.

Naming and writing

- Name K_2S, $CuCl_2$, SF_6, and $HNO_3(aq)$; classify each before applying a rule.
- Write formulas for sodium carbonate, iron(III) oxide, sulfur trioxide, and hydrochloric acid.
- Reverse-check every answer by rebuilding the starting name or formula.

Safety

Labels matter

- A prefix, a Roman numeral, or an ion name can point to a different substance.
- Match the full name to the formula before you look up hazards.
- The same name can still need different handling if the concentration or state changes.
- Use the product label and the safety data sheet. Check each name against the formula.

Chemical naming retrieval check

- Name Na_2SO_4 and explain why no molecular prefixes are used.
- Name P_4O_{10} using molecular prefixes.
- Write formulas for calcium chloride and dinitrogen monoxide.

mono-	= 1	CO (carbon monoxide)
di-	= 2	CO_2 (carbon dioxide)
tri-	= 3	SO_3
tetra-	= 4	CCl_4

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Science 10

Unit A: Energy and matter in chemical change

Acid and base safety

Household chemicals

- A window cleaner and a drain opener can both look like clear liquids, but their particles, pH, and hazards can be very different.
- A chemical with a familiar household use can still cause harm; concentration, exposure route, and amount all matter.
- Before use, read the product label and safety data sheet. To identify a chemical, use its label and safety data sheet; colour and smell are unreliable.

pH and other hazards

- A solution with pH below 7 is acidic, and a solution above 7 is basic.
- pH leaves out other hazards printed on the label.
- A conducting solution contains mobile charged particles, so conductivity helps you classify it; naming the exact chemical takes more tests.
- A corrosive pictogram or hazard statement changes how a product is handled, stored, and cleaned up.

Key terms

acid

A substance that produces hydronium ions in water in the Grade 10 model.

base

A substance that produces hydroxide ions or accepts protons in the Grade 10 model.

pH

Logarithmic measure related to hydronium-ion concentration in an aqueous solution.

conductivity

Ability of a material or solution to carry electric current.

Key terms

Workplace Hazardous Materials Information System (WHMIS)

Canadian system for communicating workplace chemical hazards through labels, pictograms, and safety data sheets.

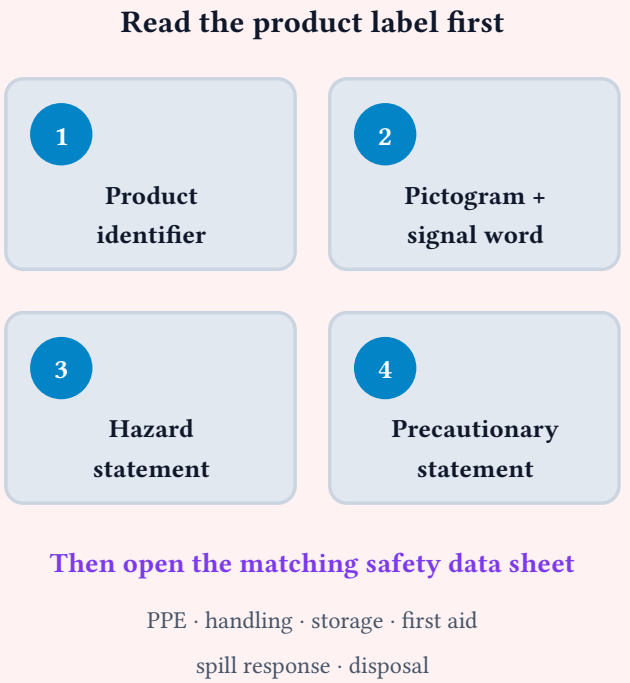
safety data sheet

Document describing a product's hazards, handling, storage, emergency, and disposal information.

Safety

Safety gate before chemical testing

- Identify the product and teacher-approved procedure before opening or testing a chemical.
- Read the container label first; use the safety data sheet for protective equipment, storage, first aid, spill response, and disposal.
- If the label, container, or conditions differ from the approved procedure, stop and notify the teacher.



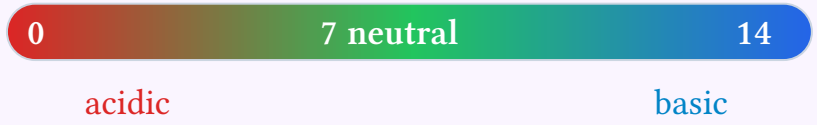
Classifying solutions by pH

- Hydrochloric acid, HCl(aq), has pH below 7 and conducts because ions are present after ionization in water.
- Sodium hydroxide, NaOH(aq), has pH above 7 and conducts because the ionic solid dissociates into mobile ions.
- Sodium chloride, NaCl(aq), can conduct while remaining near neutral, so pH is the test that decides acid or base.



pH scale

- The midpoint of the classroom pH scale is 7. Acids sit below it, and bases sit above it.
- To decide how dangerous a bottle is, use the label and safety data sheet. The pH number is only one clue.
- Concentration, the amount you have, and the safety data sheet still decide how you handle it.



erational Grade 10: acids below 7, bases above 7 in aqueous soluti

Societal hazards

- Hazard depends on the substance, its concentration, and how someone is exposed.
- A strong acid and a concentrated solution are two separate descriptions.
- Labels and safety data sheets say how to store, handle, and dispose of a product.
- Alcohol, nicotine, heavy metals, strong acids, and flammable gases each need their own procedure.

Classifying three evidence cards

- Sample A: pH 2, high conductivity, clear solution: classify the aqueous behaviour and state the evidence.
- Sample B: pH 7, high conductivity, clear solution: explain why pH decides acid or base, while conductivity only shows that ions are present.
- Sample C: pH 11, low but measurable conductivity: classify the aqueous behaviour without guessing the product identity.

Acid and base safety

- Classify a conducting solution with pH 2 using the Grade 10 acid/base model.
- Explain what you need besides pH to judge whether a product is safe to handle.
- Name the two product-specific sources to consult before using a classroom chemical.

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Science 10

Unit A: Energy and matter in chemical change

Polarity and solubility

Oil and water

- After shaking, oil forms droplets in water and then separates back into a layer on top.
- Oil floats because it is less dense than water, and polarity explains why the liquids fail to mix.
- Water is polar and cooking oil is mostly non-polar, so their particle attractions favour separation.

Molecular polarity

- Water is polar because its bent molecule has a partially negative oxygen side and partially positive hydrogen sides.
- Hydrogen bonds are attractions between neighbouring polar molecules; the covalent bonds inside one water molecule are a separate, stronger link.
- Call a substance soluble only for a named solvent and conditions.
- Sodium nitrate is soluble in water under typical classroom conditions.

Key terms

polar

Having an uneven distribution of electrical charge.

hydrogen bond

Attraction involving a partially positive hydrogen and an electronegative atom on another particle.

soluble

Able to dissolve to an appreciable extent in a stated solvent and condition.

insoluble

Dissolving only to a very small extent in a stated solvent and condition.

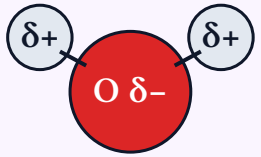
Key terms

like dissolves like

Guideline that substances with similar polarity tend to dissolve one another.

From bond polarity to water's properties

- Oxygen attracts shared electrons more strongly than hydrogen, so each O-H bond has partial charges.
- Water's bent shape keeps the bond dipoles from cancelling, making the whole molecule polar.
- Attractions between neighbouring water molecules require energy to disrupt, helping explain water's high heat capacity and evaporative cooling.



hape → polar molecule; explains cohesion and many solubility pa

Solubility charts as evidence

- Identify the cation and anion in the proposed ionic compound.
- Locate the ion combination on the approved chart and check any listed exception.
- Use the chart to assign aqueous or solid state; trust the chart over the idea that “all ionic compounds dissolve.”

Solubility chart check

1. Name cation and anion
2. Find the pair on the chart

$Ag^+ + Cl^-$

→ **insoluble (exception)**

Check listed exceptions before deciding

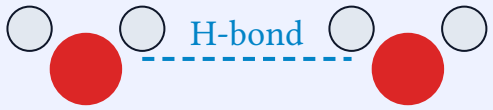
Precipitate prediction

- Mix $AgNO_3(aq)$ and $NaCl(aq)$: list Ag^+, NO_3^-, Na^+, and Cl^- before predicting new ion pairs.
- Ion exchange gives possible products $AgCl$ and $NaNO_3$; the solubility chart identifies $AgCl$ as relatively insoluble.
- Write $AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$, then verify atoms and charge are accounted for.



Water and energy transfer

- Equal energy input usually produces a smaller temperature change in water than in many other common substances.
- Part of the transferred energy disrupts attractions between water molecules before their average motion increases greatly.
- In lakes and organisms, this behaviour moderates temperature; evaporation can remove energy with escaping water molecules.



δ+ on H attracted to δ− on O of neighbouring molecule

Polarity and solubility retrieval check

- Explain why oil floating on water and oil staying separate from water require two different ideas.
- Use the solubility chart to predict whether AgCl forms when $AgNO_3(aq)$ and NaCl(aq) mix.
- State what else you need, besides conductivity, to identify dissolved ions or judge whether something is toxic.

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Science 10

Unit A: Energy and matter in chemical change

Evidence of chemical change

Baking with baking powder

- When baking powder becomes wet, its ingredients react and produce carbon dioxide gas.
- The gas forms bubbles that become trapped in the batter; heating expands the bubbles and helps the baked product rise.
- Gas formation supports a chemical-change claim when the reactants can produce a new gaseous substance; bubbles from boiling alone are a physical change.

Reaction patterns

- Magnesium and oxygen forming magnesium oxide is synthesis; one more complex product forms from simpler reactants.
- Hydrogen peroxide breaking into water and oxygen is decomposition, while methane reacting with oxygen is combustion.
- Zinc displacing copper from a compound is single replacement.
- Two ionic compounds that exchange ions and form a precipitate are double replacement.

Key terms

synthesis

Reaction in which simpler substances combine to form a more complex product.

decomposition

Reaction in which one compound breaks into simpler substances.

combustion

Reaction with oxygen that releases energy; complete hydrocarbon combustion forms carbon dioxide and water.

single replacement

Reaction in which one element replaces another element in a compound.

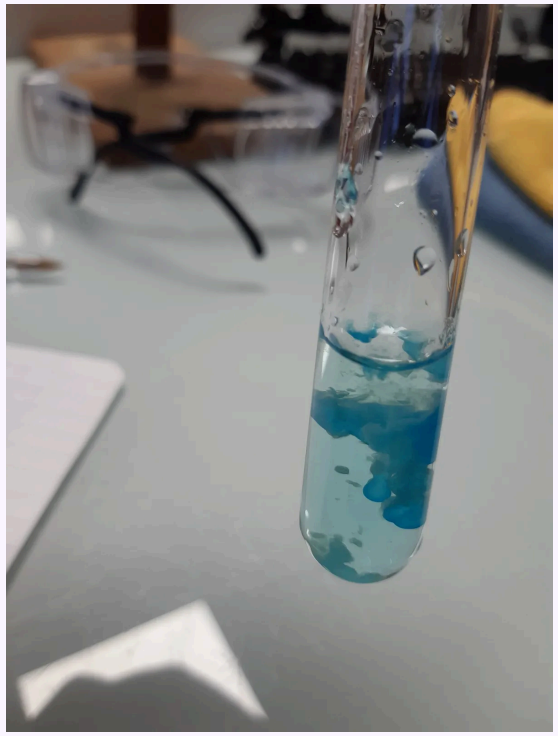
Key terms

double replacement

Reaction in which ions in two compounds exchange partners.

Evidence checklist

- Look for at least one sign that a new substance formed, such as an unexpected gas, a new colour, or a solid appearing.
- A change of state keeps the same chemical formula. Melted ice is still water.



Energy in reactions

- An exothermic reaction releases thermal energy to the surroundings. Many combustions do this.
- Photosynthesis, taken as a whole, absorbs energy, so this course treats it as endothermic.

Five categories

- The five patterns are synthesis, decomposition, hydrocarbon combustion, single replacement, and double replacement.
- Recognize the pattern from how the reactants and products are arranged.

Synthesis: $A + B \longrightarrow AB$

Decomposition: $AB \longrightarrow A + B$

Single replacement: $A + BC \longrightarrow AC + B$

Double replacement: $AB + CD \longrightarrow AD + CB$

Combustion (hydrocarbon): $C_xH_y + O_2 \longrightarrow CO_2 + H_2O$

Reactions in society

- Photosynthesis, respiration, combustion, and decay are chemical changes with different jobs.
- Combustion and respiration both release stored chemical energy. They are separate processes.
- Whether a process helps depends on its products and how people use them; the reaction type is just its name.
- Rate, amount, emissions, and conditions decide the impact.

Classifying equations

- Read the words of the equation before you look for a type.
- Synthesis joins reactants into one product. Decomposition splits one reactant apart.
- Single replacement swaps one element. Double replacement swaps two partners.
- Leave coefficients for the next lesson. This pass is classification only.

Evidence and reaction retrieval check

- Two clear aqueous solutions form a white solid. Name the evidence of chemical change and the likely reaction category.
- Methane reacts with oxygen to form carbon dioxide and water. Classify the reaction and identify the energy evidence you would expect.
- For each case, name one observation that would make you reconsider your classification.

Image credits

Wikisquack, Un précipité bleu dans une solution aqueuse incolore, CC BY 4.0

Science 10

Unit A: Energy and matter in chemical change

Word equations and balancing

Lavoisier and the balance

- In a closed system, total mass before a chemical reaction equals total mass after, within measurement uncertainty.
- Atoms are rearranged during a reaction. None are created or destroyed.



Same atoms: rearranged, not created or destroyed

aw of conservation of mass ↔ balanced equations ↔ mole ratio

Mass in a closed system

- A closed system keeps all of its matter inside its boundary.
- Its measured mass stays constant during a chemical reaction, within the precision of the balance.
- Lavoisier compared masses before and after reactions in closed containers.

Key terms

reactant

A starting substance in a chemical reaction; written on the left side of an equation.

product

A substance formed in a chemical reaction; written on the right side of an equation.

coefficient

A whole number placed before a formula that multiplies every atom in that formula.

subscript

A number within a chemical formula that states the fixed atom ratio in that substance.

Key terms

conservation of mass

In a closed system, total mass remains constant during physical and chemical changes.

Word equations

- A word equation names substances: methane + oxygen ⟶ carbon dioxide + water.
- A skeleton equation uses correct formulas and states: $CH_4(g) + O_2(g) \longrightarrow CO_2(g) + H_2O(g)$.

Word and skeleton equations

Words: methane + oxygen ⟶ CO_2 + water

$CH_4(g) + O_2(g) \longrightarrow CO_2(g) + H_2O(g)$

Skeleton uses formulas and state symbols

Skeleton and balanced equations

- Keep every chemical formula fixed.
- Choose whole-number coefficients so each element has the same atom count on both sides.

Unbalanced:

$H_2 + O_2 \longrightarrow H_2O$

H: 2 = 2 ✓ · O: 2 ≠ 1 ×

Balanced:

$2\ H_2 + O_2 \longrightarrow 2\ H_2O$

H: 4 = 4 · O: 2 = 2

Coefficients multiply entire formulas: never change subscrip

Combustion of propane

- Skeleton: $C_3H_8 + O_2 \longrightarrow CO_2 + H_2O$.
- Balanced: $C_3H_8 + 5\ O_2 \longrightarrow 3\ CO_2 + 4\ H_2O$.
- Balance carbon first, then hydrogen, then oxygen, and recount every element.

Unbalanced:

$H_2 + O_2 \longrightarrow H_2O$

H: 2 = 2 ✓ · O: 2 ≠ 1 ×

Balanced:

$2\ H_2 + O_2 \longrightarrow 2\ H_2O$

H: 4 = 4 · O: 2 = 2

Coefficients multiply entire formulas: never change subscrip

Practice set

- Synthesis: $Mg + O_2 \longrightarrow MgO$.
- Single replacement: $Zn + HCl \longrightarrow ZnCl_2 + H_2$.
- Double replacement: $NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$.

Unbalanced:

$H_2 + O_2 \longrightarrow H_2O$

H: 2 = 2 ✓ · O: 2 ≠ 1 ×

Balanced:

$2\ H_2 + O_2 \longrightarrow 2\ H_2O$

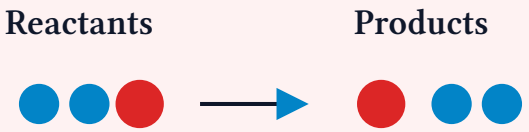
H: 4 = 4 · O: 2 = 2

Coefficients multiply entire formulas: never change subscrip

Safety

Lab conservation demo

- Measure a sealed flask before and after an effervescent reaction at room temperature.
- Keep a reacting sealed container closed and away from heat; follow the teacher's procedure.



Same atoms: rearranged, not created or destroyed

aw of conservation of mass ↔ balanced equations ↔ mole ratio

Review

- Translate: hydrogen + oxygen ⟶ water.
- Balance the skeleton equation and verify both atom counts.
- Count the atoms of each element on both sides before you call the equation balanced.

Unbalanced:

$H_2 + O_2 \longrightarrow H_2O$

H: 2 = 2 ✓ · O: 2 ≠ 1 ×

Balanced:

$2\ H_2 + O_2 \longrightarrow 2\ H_2O$

H: 4 = 4 · O: 2 = 2

Coefficients multiply entire formulas: never change subscrip

Industrial equations

- Electrolysis: $2\ H_2O(l) \longrightarrow 2\ H_2(g) + O_2(g)$.
- The coefficients show twice as many hydrogen molecules as oxygen molecules.
- Industrial decisions also consider electricity source, gas storage, cost, and worker safety.

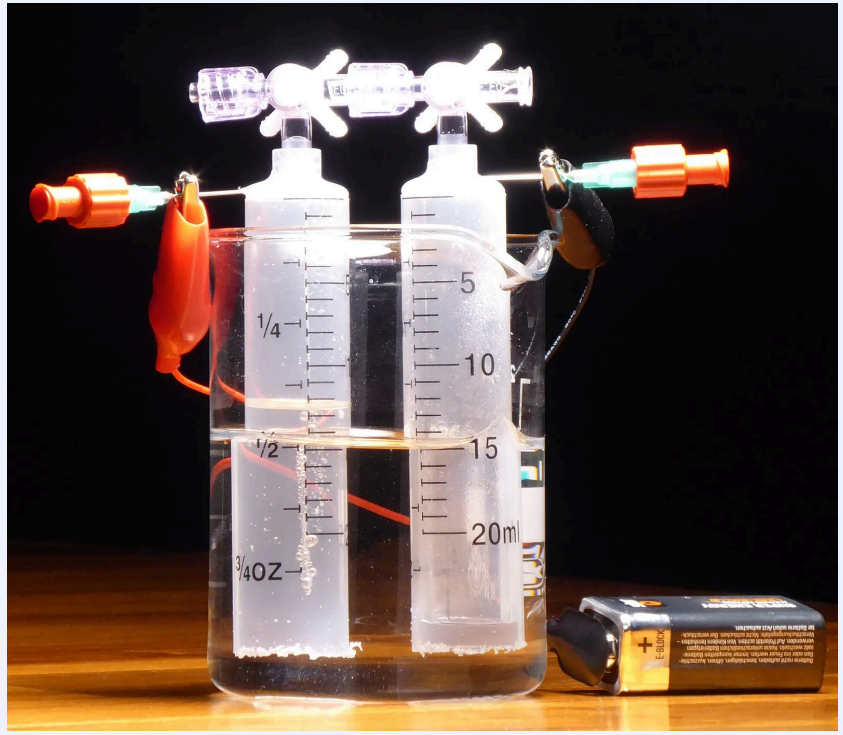


Image credits

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Science 10

Unit A: Energy and matter in chemical change

Predicting products and balancing

Predicting products

- Iron placed in copper(II) sulfate solution can form iron(II) sulfate and solid copper because iron is above copper in the activity series.
- The prediction tells the chemist what colour, solid product, and hazards to expect before mixing substances.
- After predicting correct formulas, coefficients are adjusted so every element has the same atom count on both sides.

Products and solubility

- Because iron is above copper in the activity series, the prediction is $Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$.
- For two aqueous ionic compounds, exchange the ions and check the solubility chart.
- Write a precipitate only when a product is relatively insoluble.
- For complete hydrocarbon combustion, predict carbon dioxide and water, then balance carbon, hydrogen, and oxygen.

Key terms

activity series

A ranking used to predict whether one element can replace another in a reaction.

solubility

Maximum amount of a substance that dissolves under stated conditions.

complete combustion

Combustion with sufficient oxygen that produces carbon dioxide and water for a hydrocarbon fuel.

Synthesis and decomposition

- Synthesis has several reactants and one product; establish the product formula before balancing.
- Decomposition has one reactant and multiple products; use the taught reaction family or supplied conditions to identify products.
- Atom counts verify a completed prediction; product identity comes from the reaction pattern.

Synthesis and decomposition

Synthesis: A + B ⟶ AB

Decomposition: AB ⟶ A + B

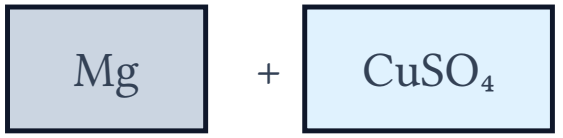
Name the product formula, then balance coefficients

Single replacement

- A free metal replaces a metal ion only when the activity series places the free metal higher.
- Magnesium is above copper, so Mg + $CuSO_4$ ⟶ $MgSO_4$ + Cu is supported.
- Copper is below magnesium, so Cu + $MgSO_4$ is recorded as no reaction under the stated conditions.

Single replacement

Mg + $CuSO_4$ ⟶ $MgSO_4$ + Cu



Mg is higher on the activity series than Cu

Double replacement and combustion

- Double replacement: exchange ions, write charge-balanced formulas, then use the solubility chart to decide whether a precipitate supports reaction.
- Complete hydrocarbon combustion: predict CO_2 and H_2O, then balance carbon, hydrogen, and oxygen in that order.
- These pathways use different evidence and should be checked in separate panels.

Synthesis: $A + B \longrightarrow AB$

Decomposition: $AB \longrightarrow A + B$

Single replacement: $A + BC \longrightarrow AC + B$

Double replacement: $AB + CD \longrightarrow AD + CB$

Combustion (hydrocarbon): $C_xH_y + O_2 \longrightarrow CO_2 + H_2O$

Full workflow

- Classify Mg + $AgNO_3$ as possible single replacement, then use the activity series to test the prediction.
- Write $Mg(NO_3)_2$ and Ag from ion identity and charge balance before adding coefficients.
- Balance and verify: $Mg + 2AgNO_3 \longrightarrow Mg(NO_3)_2 + 2Ag$.

Four prediction stations

- Station 1: synthesis and decomposition: identify the family, establish products, then balance.
- Station 2: single replacement: include one supported reaction and one no-reaction decision.
- Stations 3 and 4: double replacement with chart evidence, then complete hydrocarbon combustion.

Product-prediction retrieval check

- Predict and balance the products for magnesium reacting with oxygen.
- Use the activity series to decide whether copper replaces zinc in zinc sulfate.
- For sodium chloride mixed with silver nitrate, predict products and identify any precipitate.

Science 10

Unit A: Energy and matter in chemical change

The mole and conservation of mass

The mole

- A dozen always means 12 objects; one mole always means 6.022×10^{23} representative particles.
- Individual atoms and molecules are too small to count directly, so chemists count moles by measuring a sample's mass.
- About 18.02 g of water is one mole of water molecules because water's molar mass is about 18.02 g/mol.

Amount and number of particles

- A 0.50 mol water sample contains about 3.011×10^{23} water molecules because amount is multiplied by Avogadro's number.
- Each water molecule contains three atoms, so 0.50 mol of water molecules contains about 9.033×10^{23} atoms in total.
- In a balanced reaction, coefficients compare amounts in moles, for example, 2 mol hydrogen reacts with 1 mol oxygen.

Key terms

mole

The International System of Units (SI) amount unit: 6.022×10^{23} representative particles. (mol)

Avogadro's number

The number of representative particles in one mole: 6.022×10^{23} per mole. (N_a)

molar mass

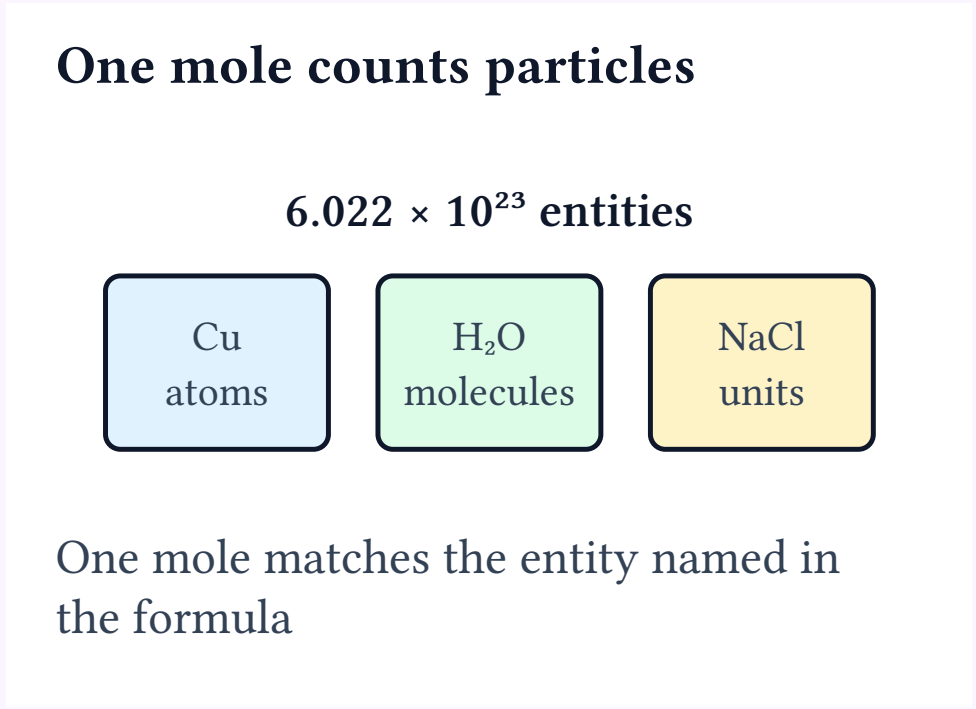
The mass of one mole of a substance, usually measured in grams per mole.

coefficient

A whole number placed before a chemical formula that multiplies every atom in that formula.

What one mole counts

- One mole contains 6.022×10^{23} specified representative entities.
- Use atoms for elements such as copper, molecules for substances such as water, and formula units for ionic compounds such as sodium chloride.
- A numerical particle answer is incomplete unless the entity and unit are named.



Molar mass

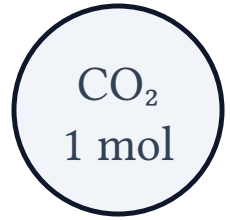
- For CO_2, add one carbon atomic mass and two oxygen atomic masses.
- Calculation: 12.01 g/mol + 2(16.00 g/mol) = 44.01 g/mol.
- A coefficient changes the amount of CO_2 present; the molar mass of CO_2 stays the same.

Molar mass of CO_2

C 12.01 g/mol

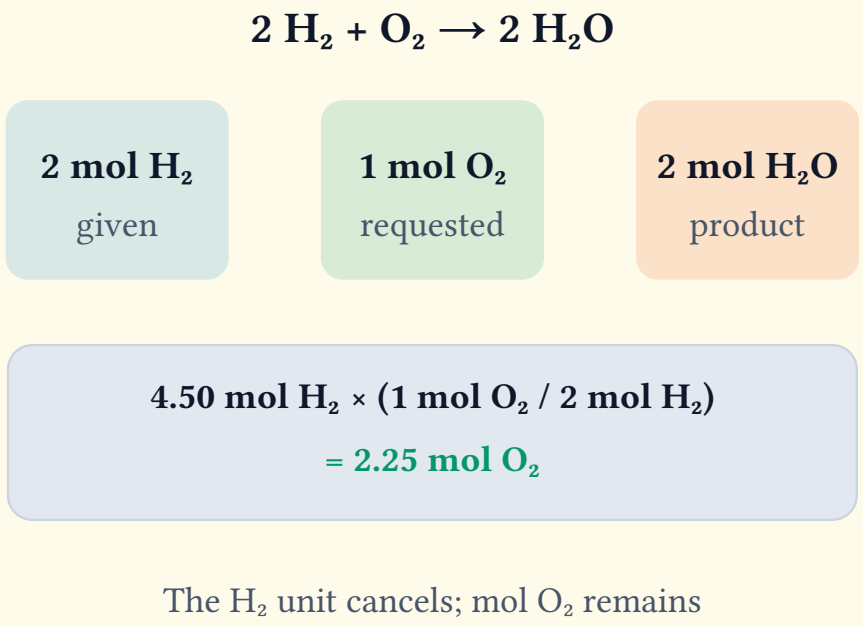
O 16.00 g/mol × 2

12.01 + 2(16.00) = 44.01 g/mol



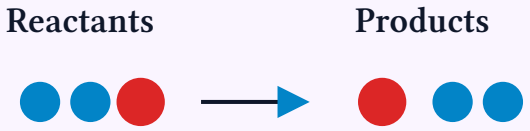
From equation to mole ratios

- In $2H_2 + O_2 \longrightarrow 2H_2O$, the coefficient ratio H_2:O_2:H_2O is 2:1:2.
- For 4.50 mol H_2, multiply by 1 mol O_2 / 2 mol H_2 to obtain 2.25 mol O_2.
- The H_2 unit cancels; the remaining mol O_2 unit identifies the requested substance and amount.



Conservation revisited

- For $2H_2 + O_2 \longrightarrow 2H_2O$, both sides contain 4 mol of H atoms and 2 mol of O atoms.
- The total amount of chemical substances changes from 3 mol of reactants to 2 mol of product; conservation applies to atoms and mass, so substance moles can change.
- Using molar masses gives 4.032 g H_2 + 32.00 g O_2 = 36.032 g H_2O, so total mass is conserved.



Same atoms: rearranged, not created or destroyed

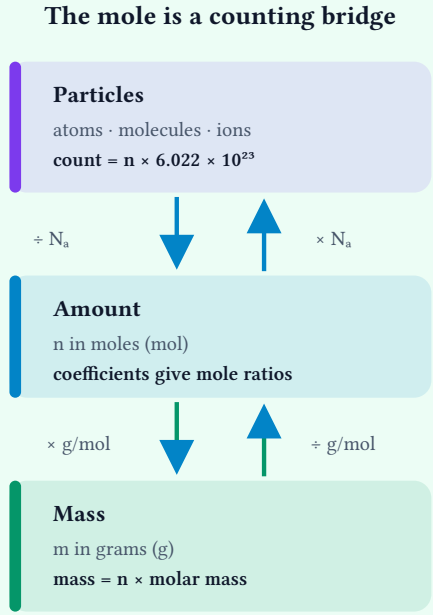
aw of conservation of mass ↔ balanced equations ↔ mole ratio

Calculations

- Mole ratio: 4.0 mol H_2 × (1 mol O_2 / 2 mol H_2) = 2.0 mol O_2.
- Particle count: 0.500 mol NaCl × 6.022×10^{23} formula units/mol = 3.011×10^{23} formula units.
- In each calculation, choose the relationship, show unit cancellation, and name the representative entity.

Directions on the mole map

- Convert 1.2044×10^{24} water molecules to moles of water.
- Convert 0.125 mol water to number of water molecules.
- Before calculating, state whether the map calls for division or multiplication and identify the final unit.



Start from the known quantity; keep units beside every value.

Mole and conservation retrieval check

- Convert 0.25 mol of water molecules to number of molecules.
- Find the molar mass of carbon dioxide from its formula.
- Use $2H_2 + O_2 \longrightarrow 2H_2O$ to find oxygen required for 6.0 mol hydrogen.

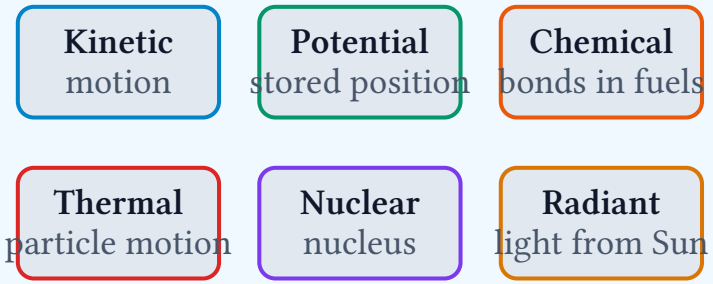
Science 10

Unit B: Energy flow in technological systems

Forms of energy

Locating energy

- A falling ball, a burning candle, and a solar panel all involve energy, and each one shows a different form.
- Alberta classrooms: furnace heat, bus fuel, wind turbines on the horizon.



· transforms between forms: total energy is conserved in a closed

Energy as a measured property

- Energy is a property we measure in a system, like its speed or temperature.
- Solar energy is radiation from the Sun, and it is Earth's main incoming supply.

Key terms

mechanical energy

Energy associated with motion or position.

chemical energy

Potential energy associated with the arrangement of atoms and bonds.

thermal energy

Energy associated with the random motion and interactions of particles in a system.

nuclear energy

Energy associated with changes in atomic nuclei.

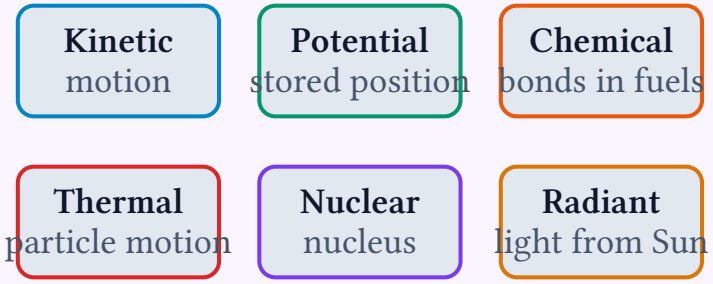
Key terms

solar energy

Electromagnetic energy transferred from the Sun.

Five forms of energy

- Mechanical energy is the energy of motion and of position.
- Chemical energy is stored in fuels, food, and ATP.
- Thermal energy is the energy of particle motion, which shows up as a temperature change.
- Nuclear energy comes from changes in the nucleus, as in a reactor or in the Sun.
- Solar energy is the radiation that arrives from the Sun.



· transforms between forms: total energy is conserved in a closed

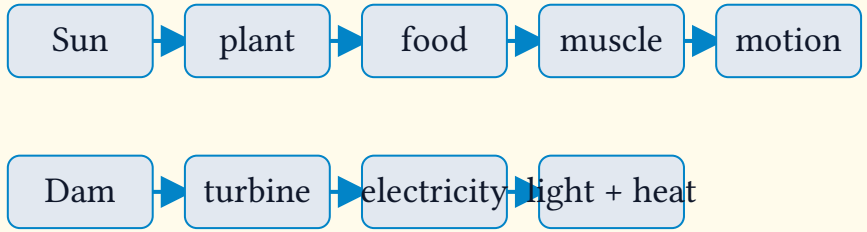
Observing energy

- You notice energy when it transfers from one place or form to another.
- Look for changes in motion, shape, temperature, or light.
- Constant temperature and constant speed (no friction): no net energy transfer into the system.



An energy chain

- Follow sunlight stored in wheat, then in bread, then in a student's motion and body heat.
- Name the form at each stage, and name the evidence you would actually observe.

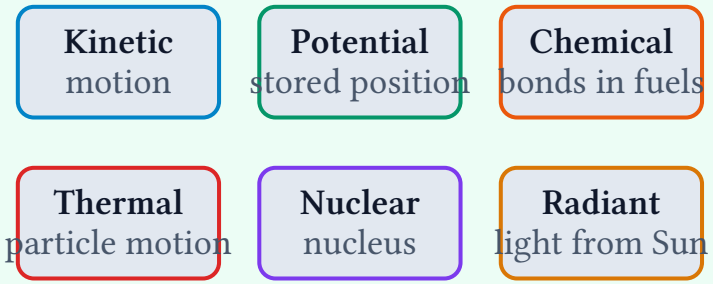


Each step: measurable changes in temperature, motion, or light

Alberta examples: hydro, oil sands upgrading, wind, solar farms

Station classification

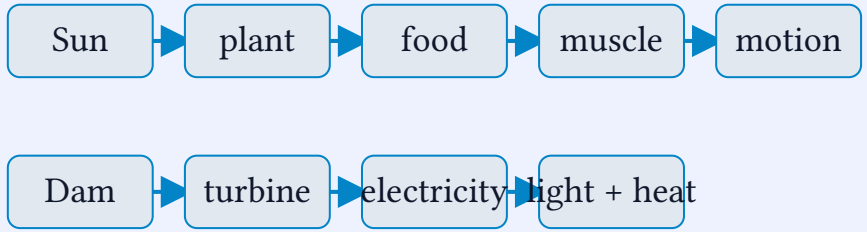
- At each station, name the dominant energy form and the evidence you can observe.
- Include at least one technology and one example from outside a machine.



· transforms between forms: total energy is conserved in a closed

Alberta energy contexts

- Hydro, natural gas, wind, and solar installations transform energy for communities.
- Discuss why naming the form matters for engineers and environmental stewards.

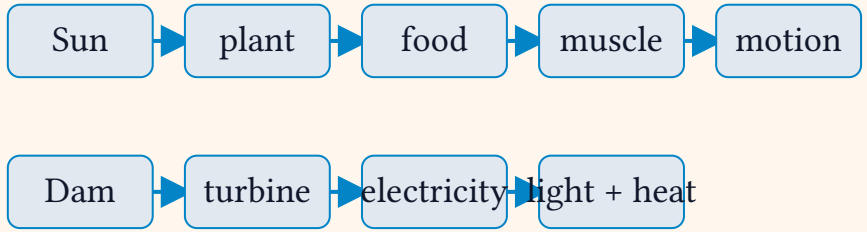


Each step: measurable changes in temperature, motion, or light

Alberta examples: hydro, oil sands upgrading, wind, solar farms

Traditional technologies

- Indigenous tool making, structures, and heating use the same thermodynamic ideas.
- Efficient use of locally available materials reflects deep knowledge of energy transfer.



Each step: measurable changes in temperature, motion, or light

Alberta examples: hydro, oil sands upgrading, wind, solar farms

Form classification sort

- Teams sort examples into mechanical, chemical, thermal, nuclear, solar; defend one card.
- A complete answer gives evidence of transfer, such as motion, a temperature change, or light.

Energy-form retrieval check

- Trace energy from sunlight to wheat, food, a moving cyclist, and the surroundings.
- Classify the dominant energy evidence in a raised ball, a burning fuel, and warm water.
- Explain why a generator transforms energy from one form to another.

Image credits

USFWS Mountain-Prairie, Sunset Storm with Lightning Over Seedskadee National Wildlife Refuge, public domain

Science 10

Unit B: Energy flow in technological systems

Energy transformation technologies

A hand crank lights a lamp

- Turning the crank produces electrical energy that makes the lamp emit light and thermal energy.
- The crank becomes harder to turn when the generator supplies more electrical power.

Function of a generator

- A generator transforms mechanical energy into electrical energy; total energy is conserved.
- Mechanical energy enters; electrical energy carries the transfer; light and thermal energy leave.
- Trace energy transformations in technologies and identify measurable evidence at each step.

Key terms

energy transformation

A change from one energy form to another within a system.

energy transfer

Movement of energy across a system boundary.

generator

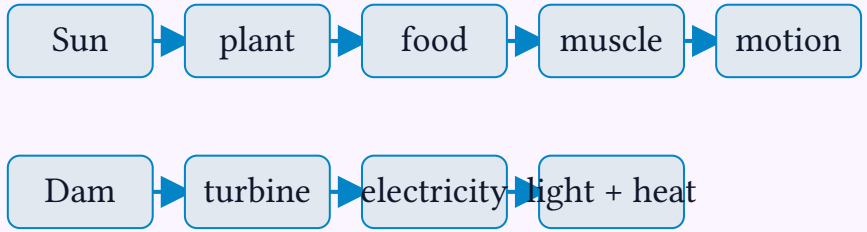
A device that transforms mechanical energy into electrical energy.

turbine

A rotating device driven by moving fluid, such as water, steam, or air.

Transformation technologies

- Hydroelectric and coal generators; solar panels; windmills; fuel cells.
- Transfers produce observable changes in motion, shape, or temperature.

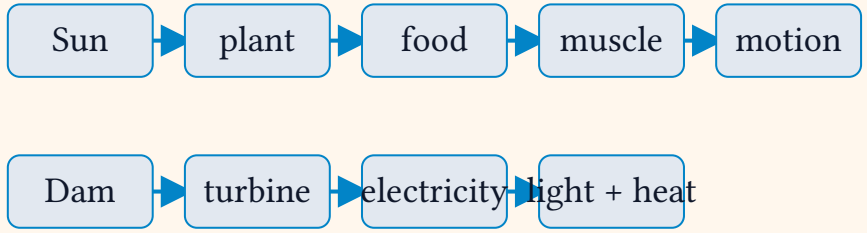


Each step: measurable changes in temperature, motion, or light

Alberta examples: hydro, oil sands upgrading, wind, solar farms

Indigenous technologies

- Tool making, building design, and heating all apply thermodynamic principles.
- Technology and trial-and-error precede formal laws.
- A scraper, a winter dwelling, and a fire each move energy in a way you can describe from the materials.



Each step: measurable changes in temperature, motion, or light

Alberta examples: hydro, oil sands upgrading, wind, solar farms

Technology and society

- Hydro and wind start with a moving fluid and end with electrical energy from a generator.
- A natural-gas plant starts with chemical energy, then combustion, motion, and generation.
- A region may use more than one system because fuel, water, and wind are found in different places.
- The local site changes. The energy accounting stays the same.



Energy chain of a technology

- Draw the energy chain for one technology and label one observable change at each transfer.
- A complete answer names the energy forms in order and cites evidence such as motion, a temperature change, or light.

Image credits

Royalbroil, Pincher Creek Summerview Wind Farm August 2013, CC BY-SA 4.0

Science 10

Unit B: Energy flow in technological systems

Engines and the idea of energy

Fuel use in Watt's engine

- Early steam engines repeatedly heated and cooled the same cylinder.
- Watt's separate condenser kept the working cylinder hotter and reduced wasted thermal transfer.



fficiency improvements drove industrial and transportation chang

Engines before the laws

- Practical engines came first; repeated observations and measurements helped scientists formulate the laws later.
- Less energy is used to reheat the cylinder during each cycle, so more input supports useful mechanical work.
- Connect trial-and-error engine improvements to the later formulation of thermodynamic laws.

Key terms

heat engine

A device that transforms thermal energy into mechanical work through a repeating cycle.

steam engine

A heat engine that uses steam pressure to drive mechanical motion.

efficiency

Useful energy output divided by total energy input, usually expressed as a percentage.

thermodynamics

The study of energy transfer, thermal processes, and work.

Invention of the engine

- Early heat engines improved when builders tried a change and measured whether it worked.
- Watt redesigned the engine so less heat was wasted reheating the cylinder each cycle.



fficiency improvements drove industrial and transportation chang

Concept of energy

- Rumford and Joule showed that mechanical work and heating are connected.
- First Nations and Inuit technologies using thermal energy transfer.
- People were already moving thermal energy with tools long before the laws were written down.



fficiency improvements drove industrial and transportation chang

Design change and evidence

- Explain one Watt design change and connect it to a reduced thermal-energy loss.
- A complete answer names one design change, compares before and after, and gives a physical reason the efficiency improved.

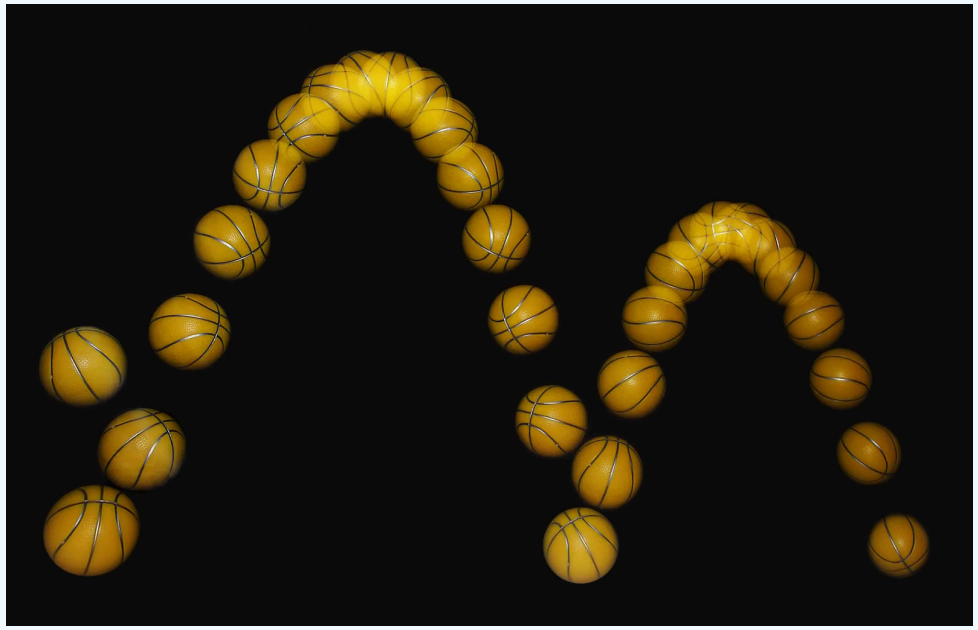
Science 10

Unit B: Energy flow in technological systems

Kinetic and potential energy

A ball at rest and in motion

- A ball held still above the floor has gravitational potential energy.
- After release, its speed increases as gravitational potential energy is transformed into kinetic energy.



Energy definitions

- In the opening case, the held ball has gravitational potential energy because of its height, even while it sits still.
- As the ball falls, gravitational potential energy decreases and kinetic energy increases.
- Above the floor, the moving ball has both.
- Food, batteries, and gasoline store chemical energy because reactions can change their particle arrangements.

Key terms

kinetic energy

Energy associated with an object's motion. (KE or E_k)

potential energy

Energy associated with position, arrangement, or condition. (PE or E_p)

chemical energy

Potential energy associated with the arrangement of atoms and bonds.

system

The object or group of objects chosen for an energy analysis.

Evidence of energy

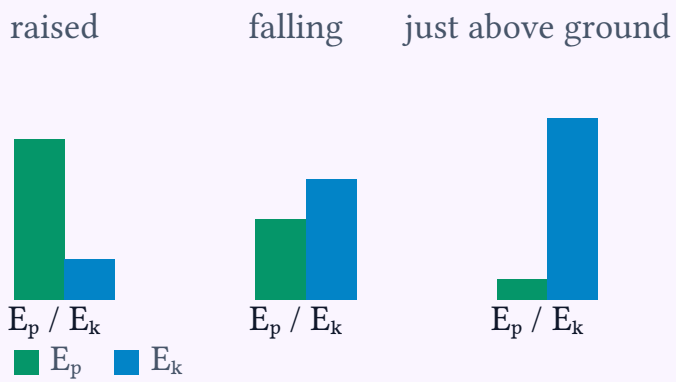
- You infer energy from a change you can measure.
- A change in speed supports a kinetic-energy description. A change in height or shape supports potential energy.
- Temperature, light, sound, or a new substance can show that energy moved or changed form.
- The evidence comes from what you observe. A battery might be charged, flat, or disconnected.



Energy is inferred from observable changes, not seen directly

Applying the energy definitions

- A rolling cart has kinetic energy (KE or E_k) because it is moving.
- A raised cart has gravitational potential energy (a form of PE or E_p) because of its height relative to the floor.
- Food, batteries, and gasoline have chemical energy because their particle arrangements can change during reactions.



Classifying with reasons

- Classify four scenarios and cite the observation or condition that supports each choice.
- A complete answer uses motion for kinetic energy, position or condition for potential energy, and chemical change for chemical energy.

Image credits

MichaelMaggs Edit by Richard Bartz, Bouncing ball strobe edit, CC BY-SA 3.0

Science 10

Unit B: Energy flow in technological systems

Scalars and vectors in motion

Distance and displacement on a lap

- A runner completes 400 m around a track and returns to the starting point.
- The distance is 400 m, but the displacement is 0 m because start and finish positions match.



Speed and velocity

- Speed is a scalar; velocity includes both speed and direction.
- Distance measures path length; displacement compares final and initial position and includes direction.
- Distinguish scalar and vector quantities and calculate displacement, velocity, and acceleration.

Key terms

scalar

A quantity described by magnitude and unit only.

vector

A quantity described by magnitude, unit, and direction.

displacement

Change in position from initial point to final point, including direction. (Δd)

velocity

Rate of change of displacement, including direction. (v)

Key terms

acceleration

Rate of change of velocity. (a)

Scalars and vectors

- Speed tells you how fast. Velocity tells you how fast and which way.
- A full lap can be a long distance with a displacement of zero.
- For a vector, write the size, the unit, and the direction.



ectors need magnitude and direction (displacement, velocity, force

Acceleration

- Acceleration is the change in velocity divided by the time that change takes: $a = \Delta v/\Delta t$.
- Speeding up, slowing down, or turning each count as an acceleration.
- With no friction or drag, an object already moving at constant velocity keeps moving without any push.

Acceleration

$a = \Delta v / \Delta t$



Speed up, slow down, or turn all change velocity

Displacement and velocity

- Calculate distance and displacement for a path, then state an average velocity with direction.
- A complete answer states the reference points, the direction, the units, and the difference between path length and change in position.

Image credits

Santeri Viinamäki, Athletics track start line numbers 1, 2, 3, CC BY-SA 4.0

Science 10

Unit B: Energy flow in technological systems

Work and the joule

Work in joules

- You do work when you speed something up or move it against an opposing force.
- Energy change on a system equals work done on it: $\Delta E = W$.

$$W = F \times d$$

work (J) = force (N) × displacement (m) in direction of force

$\Delta E = W$ on system · $E_p = mgh$ · $E_k = \frac{1}{2}mv^2$

push ⟶ box moves

Force and distance

- Force, work, and energy share equations, and the units have to match before the numbers do.
- Work uses $W = Fd$, and the answer is in joules only when the units already match.
- The check $mgh = \frac{1}{2}mv^2$ asks whether height lost shows up as speed gained.

Key terms

force

A push or pull that can change an object's motion or shape. (F)

work

Energy transferred when a force moves an object ($W = Fd \cos \theta$). (W)

gravitational potential energy

Energy associated with an object's position relative to a chosen reference level in a gravitational field. (E_p)

kinetic energy

Energy associated with an object's motion. (KE or E_k)

Key terms

joule

SI unit of energy and work (J).

Work and gravitational potential energy

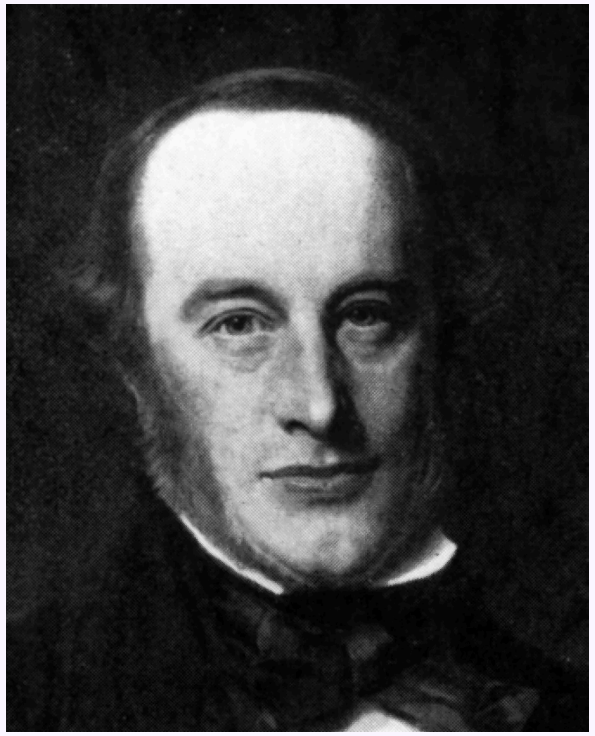
- Gravitational potential energy (E_p) is work done against gravity and is calculated with $E_p = mgh$.
- Mechanical work: $W = Fd$ when force and displacement align.
- Change in energy of a system equals work done on it.

Falling object

- From rest, gravitational potential energy lost over height h becomes kinetic energy gained when air resistance is ignored.
- The relationship $mgh = \frac{1}{2}mv^2$ asks whether height lost accounts for the speed gained.

The joule

- One joule is one newton-metre, which is also one kilogram metre squared per second squared.
- Energy and work use that same unit, so a work calculation can be compared with an energy change.



Practice set

- Calculate the gravitational potential energy of a 5 kg object on a 2 m shelf.
- Calculate the kinetic energy of a 3 kg object moving at 4 m/s.
- How much work is required to double the speed of an object that starts at rest?

Safety

Lab safety

- Keep feet and hands out of the path of a cart on a ramp.
- Clamp or brace the ramp before you measure its height.
- A rolling cart takes some of the energy as its own motion, which throws off the measurement.
- Stop the apparatus before you lean in to read a scale.

Work calculation

- Calculate work for 20 N over 3 m; compare to mgh for 2 kg raised 3 m (g ≈ 9.8 N/kg).
- A complete answer uses W = Fd with matching units and states the result in joules.

Work and energy retrieval check

- Calculate the work done by a constant 12 N force over 3.0 m in the force direction.
- Calculate gravitational potential energy gained by a 2.0 kg object raised 1.5 m.
- Explain why carrying a box horizontally at constant speed does no mechanical work on the box by the upward support force.

Image credits

Unknown photographer; ETH-Bibliothek Zürich, Image Archive, Joule, James Prescott (1818-1889), portrait, public domain

Science 10

Unit B: Energy flow in technological systems

Mechanical energy transformations

Height and speed on a ramp

- A cart released from a higher point reaches the bottom of a ramp at a greater speed.
- With small friction, decreasing gravitational potential energy corresponds to increasing kinetic energy.



Energy transformation with friction

- Potential energy is transformed mainly into kinetic energy and partly into thermal energy when friction acts.
- Measure release height and final speed while keeping the cart and ramp the same.
- Keep the cart and the ramp the same, link release height to final speed, and account for friction.

Key terms

mechanical energy

The sum of kinetic and potential energy in a mechanical system.

gravitational potential energy

Energy associated with position in a gravitational field. (E_p)

kinetic energy

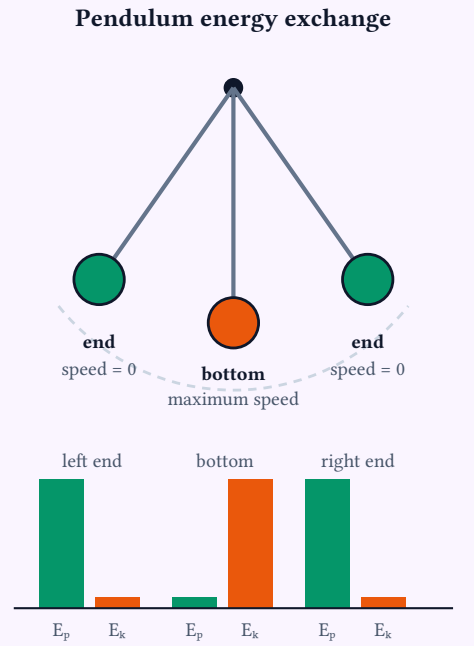
Energy associated with motion. (KE or E_k)

energy conservation

The principle that total energy stays constant as it transfers and transforms.

One-dimensional scalar motion

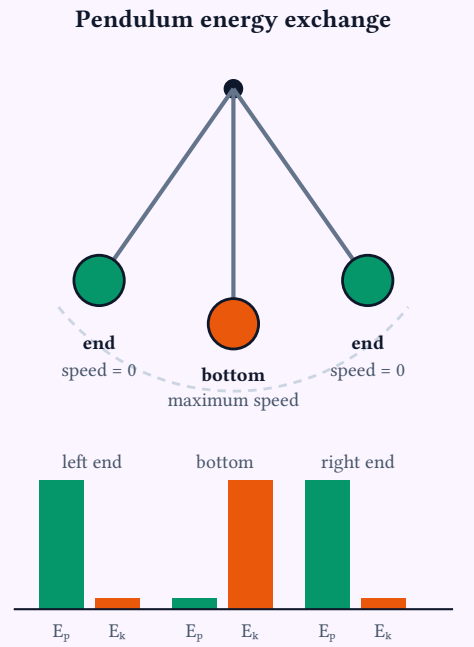
- In one dimension, distance, elapsed time, and velocity describe the motion.
- Work on that system is the force along the motion times the distance moved.



Ideal model: $E_p + E_k$ stays constant when friction is ignored.

Conservation in transformations

- In an ideal system, mechanical energy trades between kinetic energy and potential energy.
- In a real system, friction turns some of that energy into thermal energy.



Ideal model: $E_p + E_k$ stays constant when friction is ignored.

Ramp evidence

- Predict and compare final speed from two release heights, then explain differences using energy transformations.
- A complete answer keeps the variables controlled, links height to speed, and accounts for friction.

Image credits

Airtime Thrills Raw Footage, The drop of the roller coaster Orion, at Kings Island, CC BY 4.0

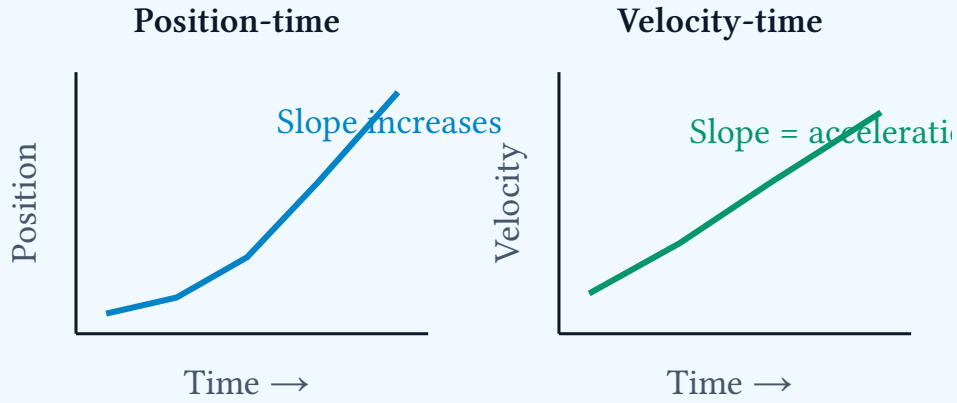
Science 10

Unit B: Energy flow in technological systems

Motion graphs and work

Motion graphs

- A steeper position-time line represents a greater speed.
- The area under a force-distance graph represents energy transferred as work.
- Read the axis labels before you decide whether a steep line means speed or acceleration.



Slope and area

- Meaning depends on the axes; on a position-time graph, the slope gives speed and the height of the line only gives location.
- Slope answers the speed question; area under the force-distance graph answers the work question.
- Interpret graph slope and area to describe motion, acceleration, and mechanical work.

Key terms

slope

Vertical change divided by horizontal change on a graph.

position-time graph

A graph showing position as a function of time.

velocity-time graph

A graph showing velocity as a function of time.

work

Energy transferred when a force acts through a displacement in its direction. (W)

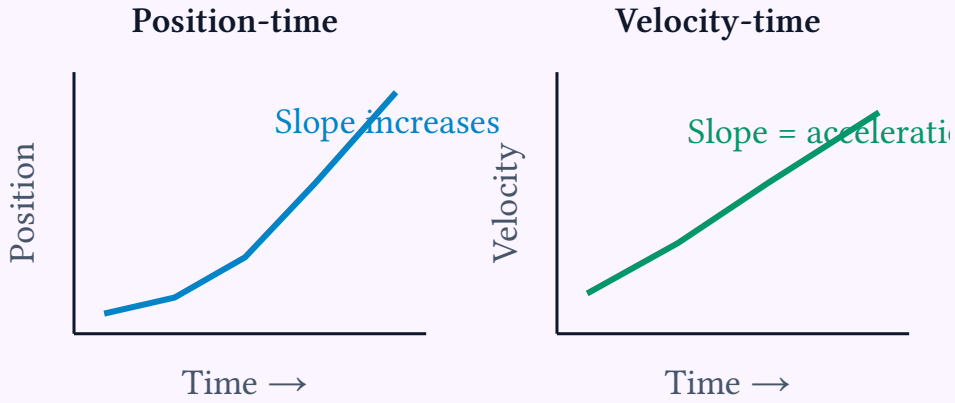
Key terms

area under a curve

The region between a graph line and the horizontal axis over an interval.

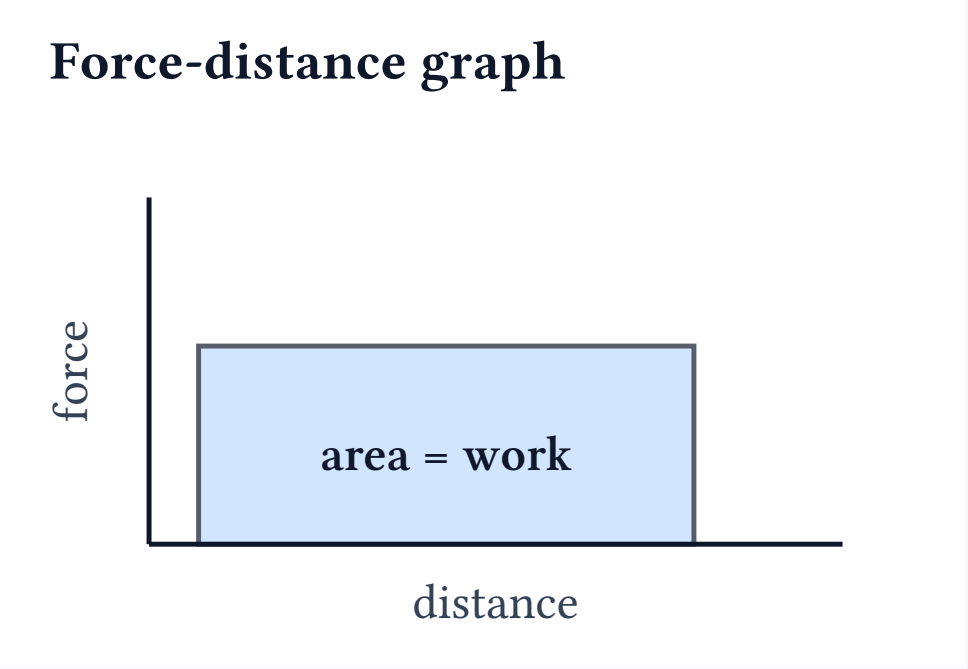
Velocity-time graphs

- On a velocity-time graph, the slope tells how quickly the velocity is changing.
- That change is the acceleration, and its sign depends on the direction you chose as positive.
- A horizontal line means the velocity is steady.



Force-distance graphs

- The area under a force-distance graph is the work done along that distance.
- A rectangle is a steady force. A triangle is a force that grows steadily from zero.
- Report that area in joules, and say which way the displacement points.



Practice

- Plot the points before you calculate.
- On a velocity-time graph, slope is acceleration and the area is displacement.
- On a force-distance graph, the area is work in joules.
- Check the axis labels before treating a slope as speed.

Slope and area

- Calculate one graph slope and one rectangular or triangular area, including units.
- A complete answer shows the rise over the run, the geometric area, and what that quantity means for motion or for joules.

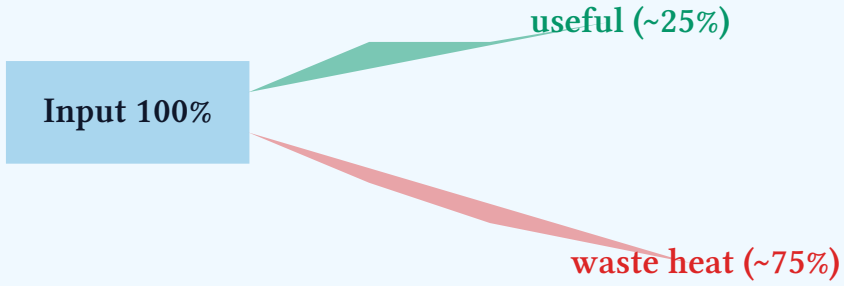
Science 10

Unit B: Energy flow in technological systems

Thermodynamic laws and useful energy

Purpose of a radiator

- Only part of the fuel energy becomes vehicle motion.
- The radiator and exhaust transfer thermal energy to the surroundings.
- Hidden energy, such as heat spread into the surroundings, still counts. It left through the radiator and the exhaust.



ıd law: some energy always spreads to surroundings as thermal eı

Conserved but less useful energy

- Inefficient devices conserve energy but transfer a larger fraction to non-useful outputs, often thermal energy.
- Total energy is conserved, but some spreads to the surroundings and is less available for useful work.
- Outputs sum to input and the second law is explained without saying energy vanished.

Key terms

first law of thermodynamics

Energy is conserved; it changes form or crosses system boundaries.

second law of thermodynamics

Energy transfers spread energy and reduce how much is available for useful work.

useful energy

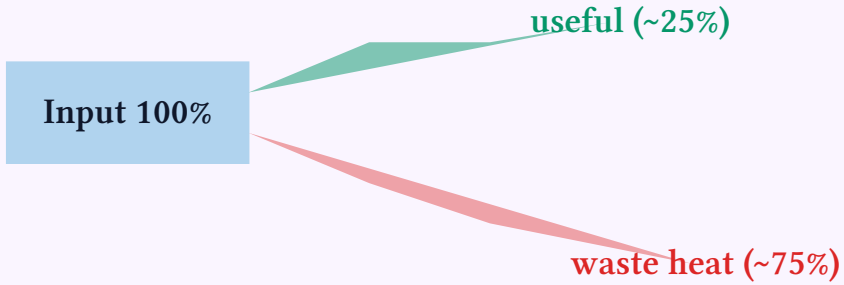
Energy delivered in the form intended for the device's purpose.

thermal transfer

Energy transferred because of a temperature difference.

Transformations in systems

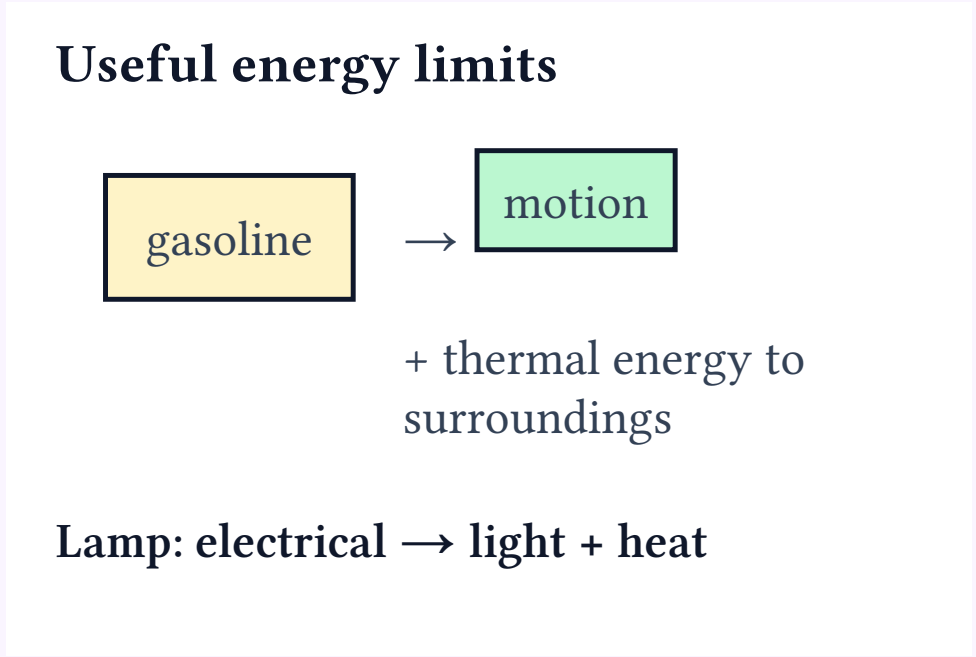
- A car, a refrigerator, a heat pump, and a food chain all move energy, and none of them is pure useful output.
- The first law is a balance of energy in and energy out. The second law says real transfers leave some energy less useful.



ıd law: some energy always spreads to surroundings as thermal eı

Useful energy limits

- The chemical energy in gasoline becomes the car's motion and thermal energy dumped to the surroundings.
- A lamp turns electrical energy into visible light and into thermal energy you can feel at the bulb.



Accounting for 100 joules

- Divide a 100 J input among useful output and thermal or sound transfers, then check the total.
- A complete answer makes the outputs add up to the input and explains the second law without saying the energy vanished.

Science 10

Unit B: Energy flow in technological systems

Efficiency and Alberta energy systems

Energy losses in a device

- A device receives 100 J and delivers 35 J as useful output.
- Its efficiency is 35%; the remaining 65 J is transferred in other forms, often thermal energy.



Useful and wasted output

- Report efficiency as a ratio and as a percentage.
- Then name the evidence you used to judge whether that system is a good choice here.

efficiency = useful out ÷ total in × 100%

Coal plant: ~35%	Gas combined-cycle: ~50%
Hydro: ~90%	Wind: ~40 to 50%

Approximate values vary by design and operating conditions

Key terms

efficiency

Useful energy output divided by total energy input, multiplied by 100%.

useful output

The energy output that serves the intended purpose.

energy input

The total energy supplied to a system.

system boundary

The chosen limit that determines which inputs and outputs are counted.

Efficiency

- Efficiency is the useful output divided by the total energy input.
- Use that ratio when you compare a heat pump, a furnace, and an engine.
- Say which output you counted as useful before you compare the percentages.

efficiency = useful out ÷ total in × 100%

Coal plant: ~35%	Gas combined-cycle: ~50%
Hydro: ~90%	Wind: ~40 to 50%

Approximate values vary by design and operating conditions

Alberta context

- Compare fuels for thermal plants on cost, what you gain, efficiency, and whether the supply can last.
- First Nations, Métis and Inuit perspectives on judicious use of resources.
- Name the system boundary before you treat two efficiency numbers as a fair comparison.

efficiency = useful out ÷ total in × 100%

Coal plant: ~35%	Gas combined-cycle: ~50%
Hydro: ~90%	Wind: ~40 to 50%

Approximate values vary by design and operating conditions

Efficiency and decision

- Calculate one efficiency and name one additional criterion needed for a technology decision.
- A complete answer gives the ratio and the percentage, then names one more piece of evidence for the decision.

Image credits

Tonyglen14, ENMAX Shepard Energy Centre, CC BY 2.0

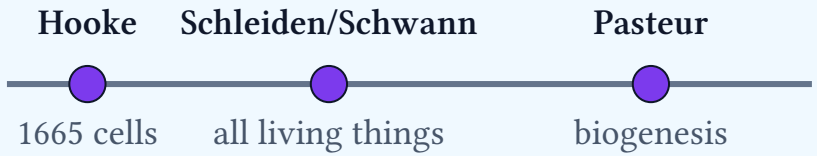
Science 10

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

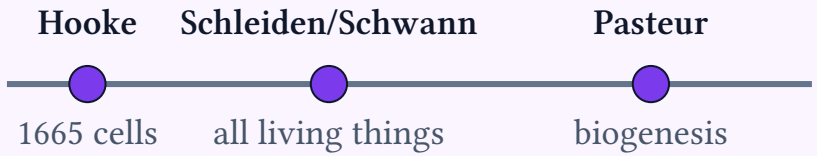
The principle that living cells arise from existing living cells.

controlled experiment

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

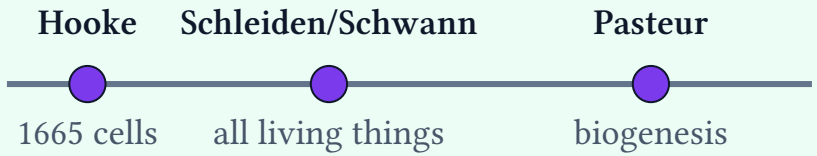
Cell theory timeline

- 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.



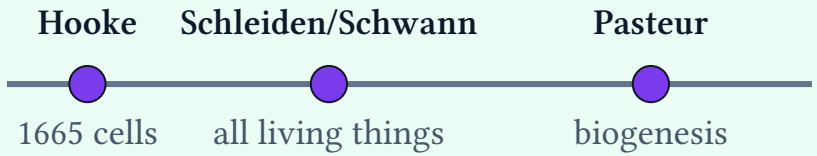
Claim and evidence

- 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.



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.



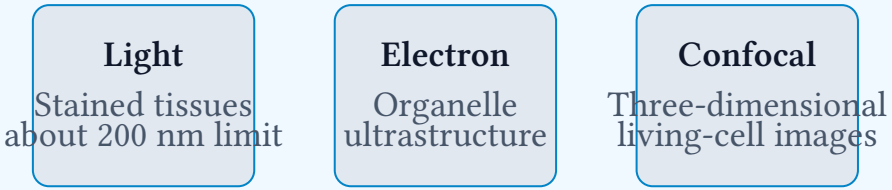
Science 10

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.

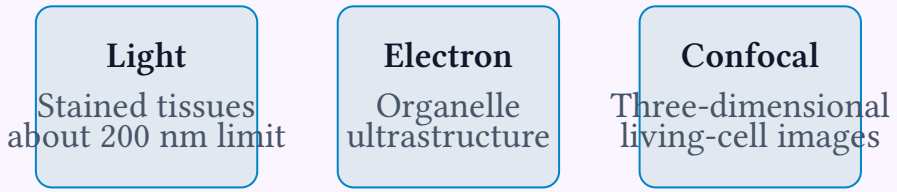
Key terms

stain

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

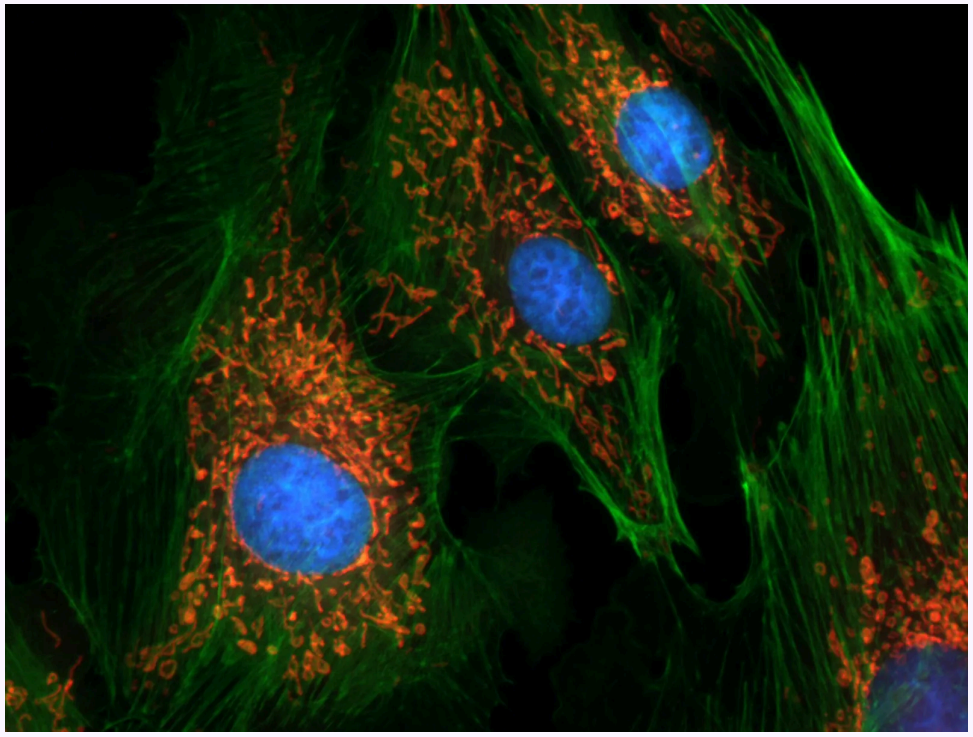
Imaging technology

- 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

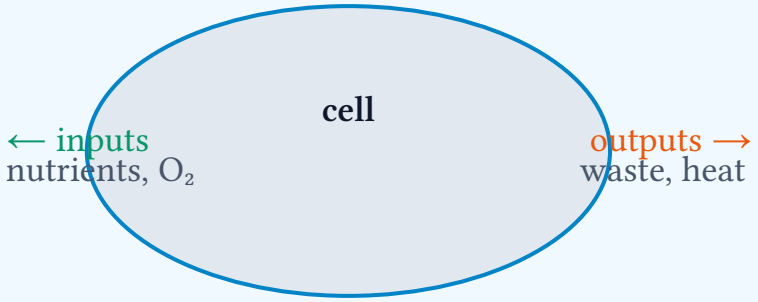
Science 10

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

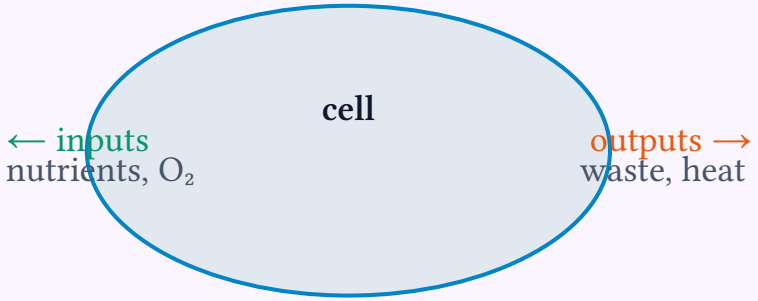
Matter or energy leaving a chosen system.

cell membrane

The selectively permeable boundary that regulates exchange with the environment.

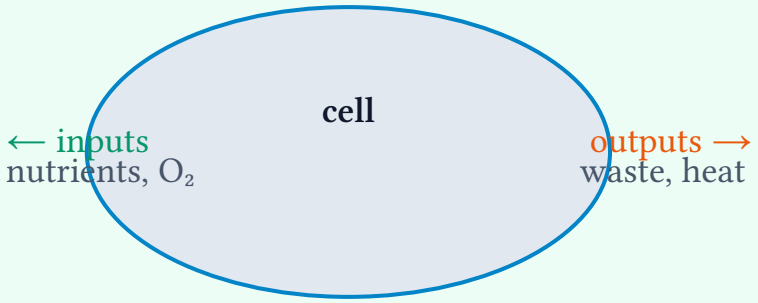
Open systems

- 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.



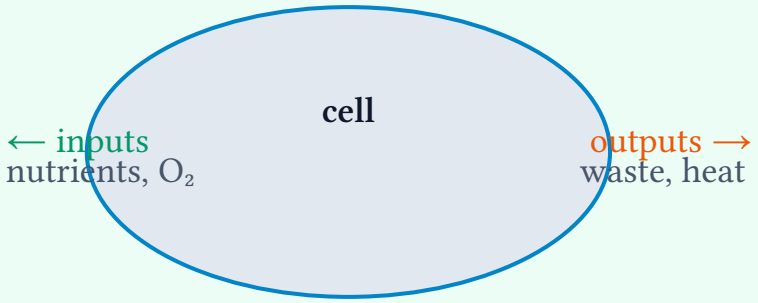
Cell boundary audit

- 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.



Cell boundary audit

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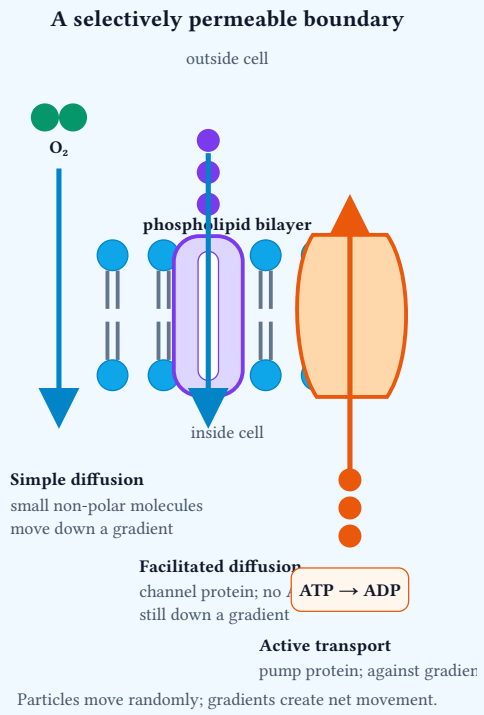
Science 10

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

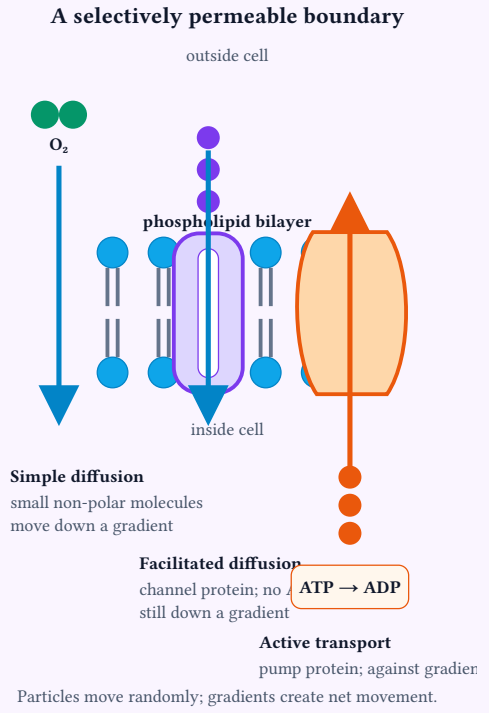
Membrane transport against a concentration gradient using cellular energy.

concentration gradient

A difference in concentration across distance or a membrane.

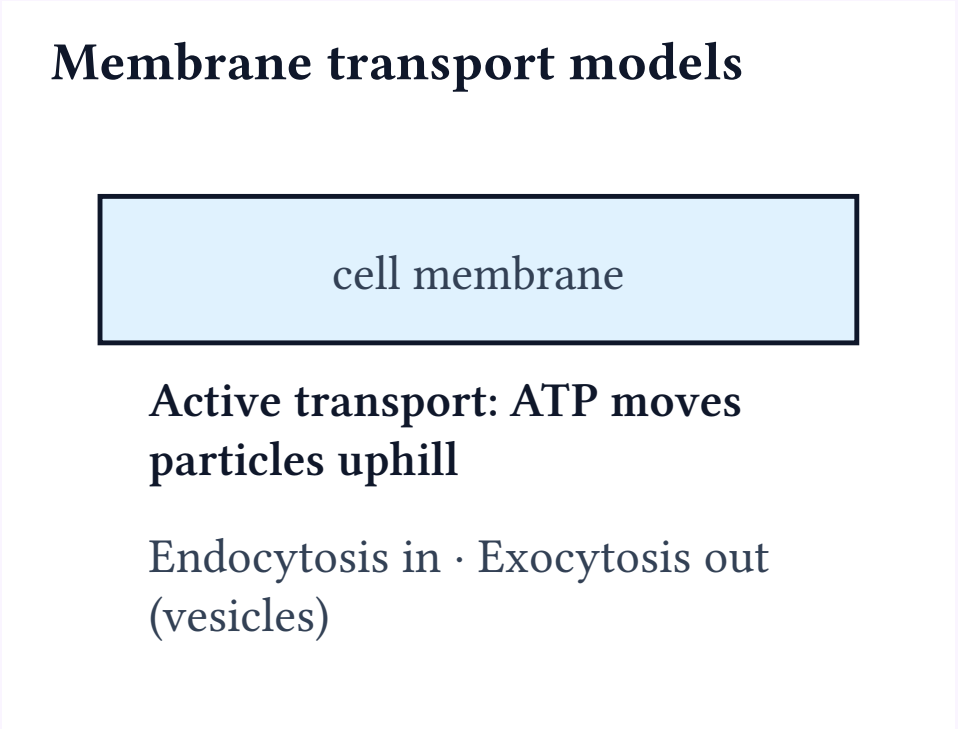
Passive transport

- 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.

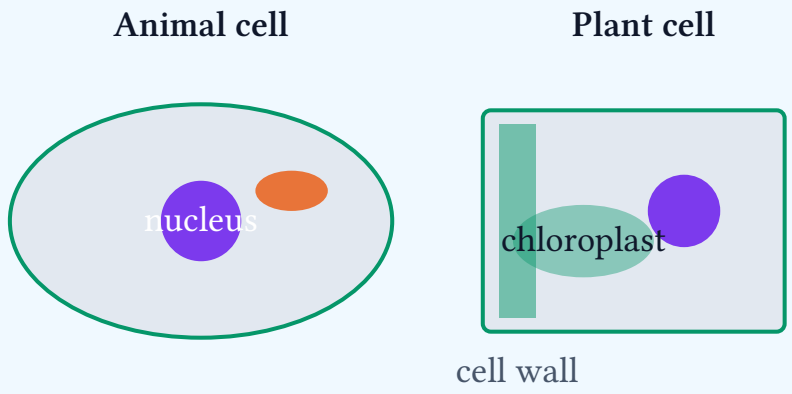
Science 10

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

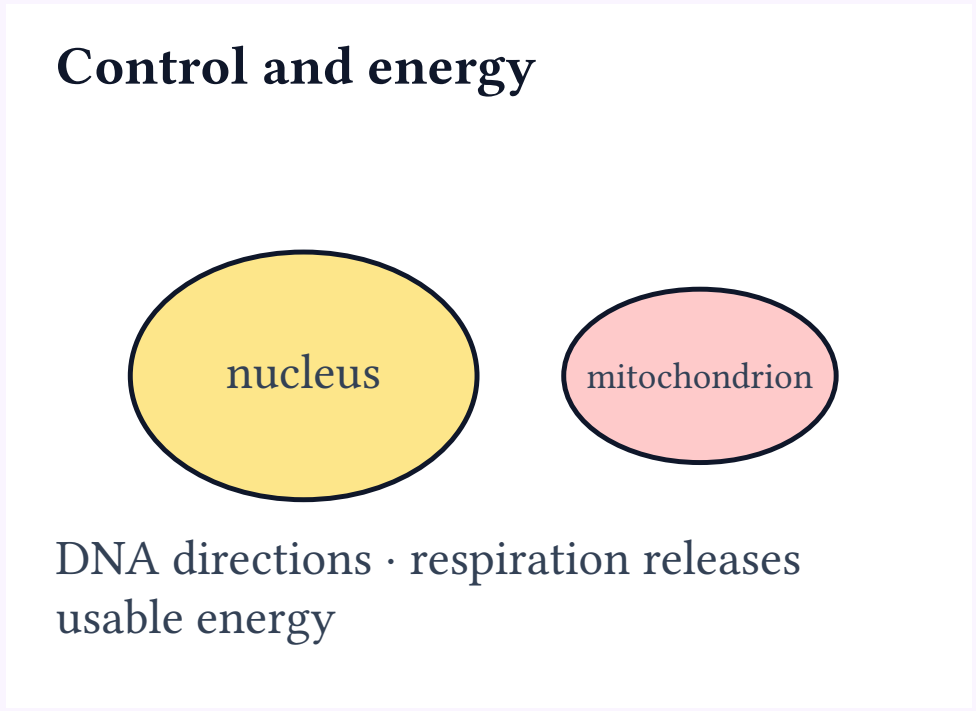
Rigid layer outside the cell membrane that supports and protects plant cells.

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.

Processing and transport

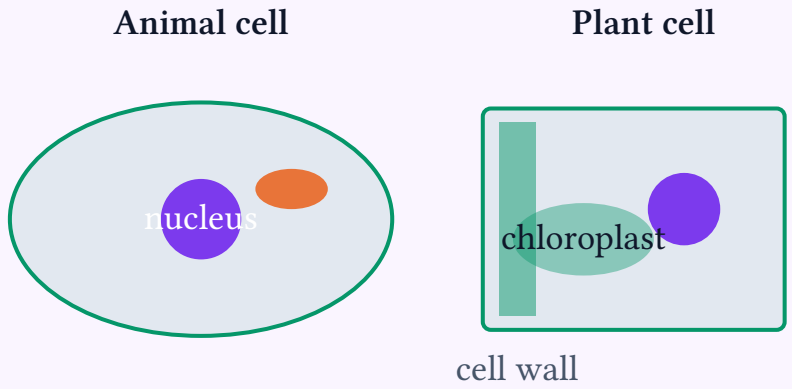


ER builds and moves materials

Golgi modifies and packages

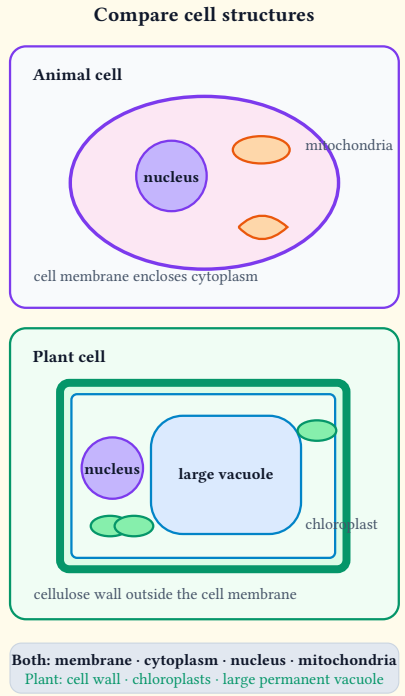
Plant structures

- 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.



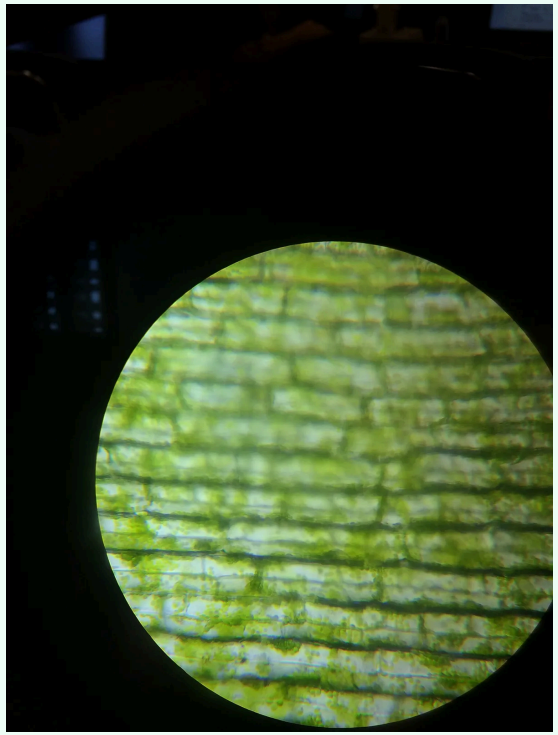
Comparing two cells

- 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.



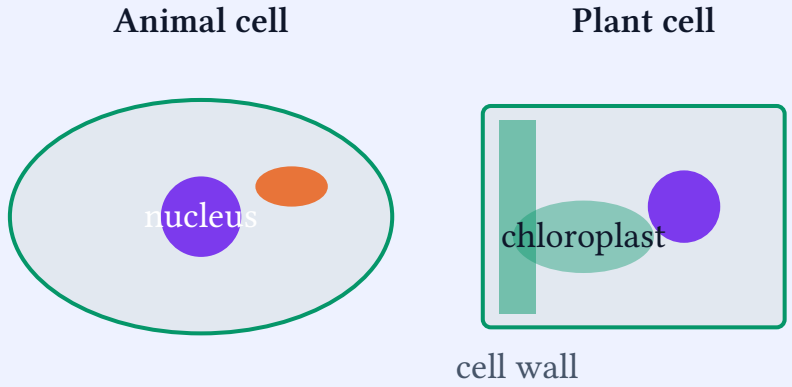
Gallery walk

- 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

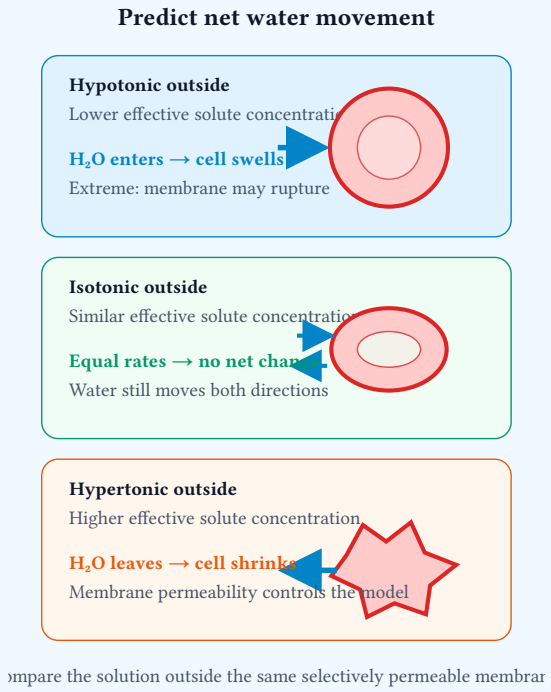
Science 10

Unit C: Cycling of matter in living systems

Membrane equilibrium and applications

Intravenous saline

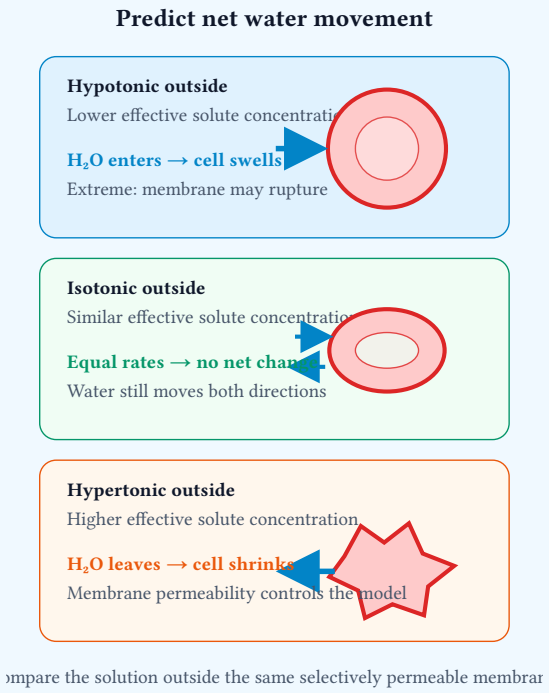
- Red blood cells gain water and may burst in a strongly dilute solution.
- They lose water and shrink in a strongly concentrated solu-tion.



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

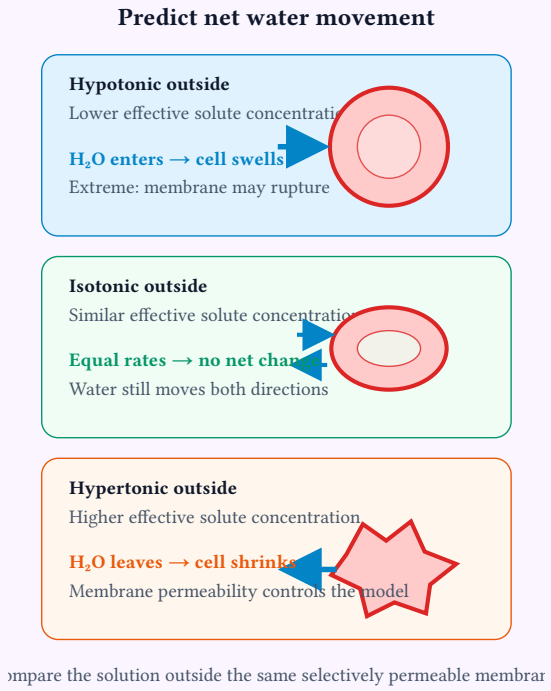
A solution with higher effective solute concentration that drives net water movement out of a cell.

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

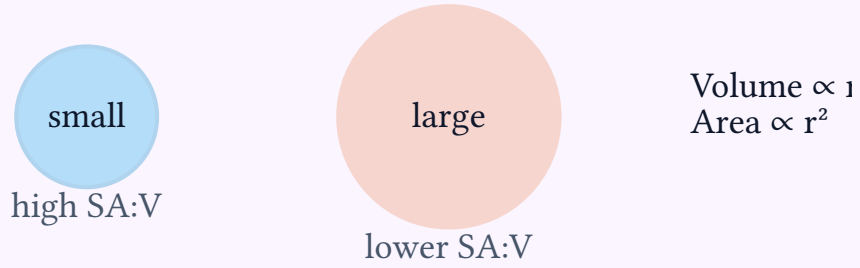
Surface area divided by volume; a measure of exchange area relative to internal demand.

exchange rate

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

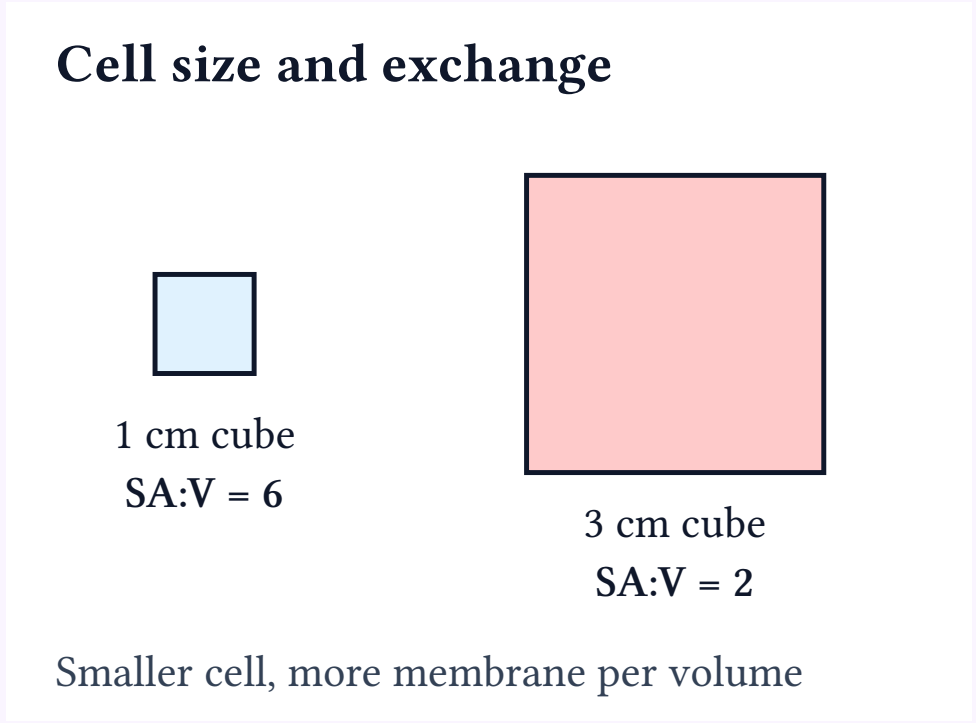
Surface area to volume ratio

- 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.

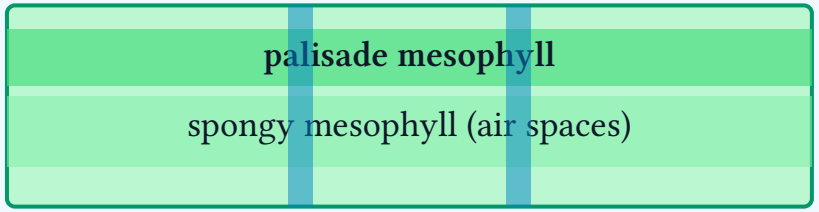
Science 10

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

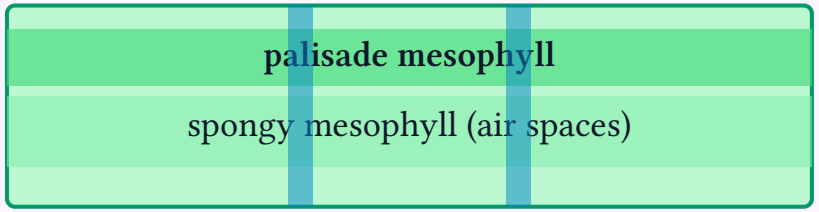
Leaf xylem and phloem that transport water, minerals, and sugars.

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

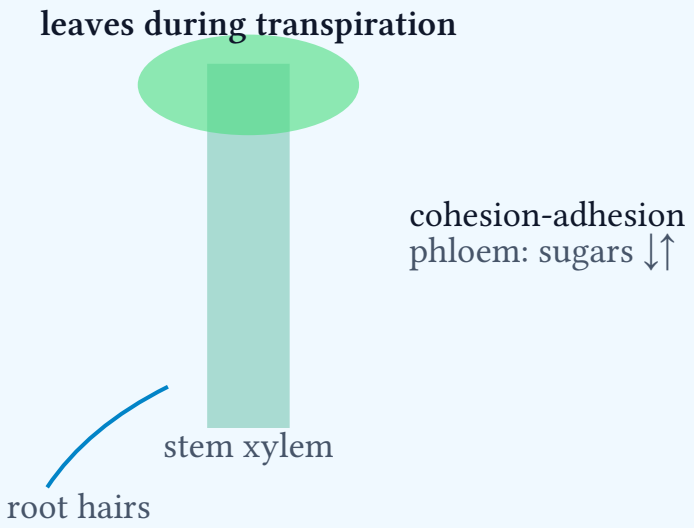
Science 10

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

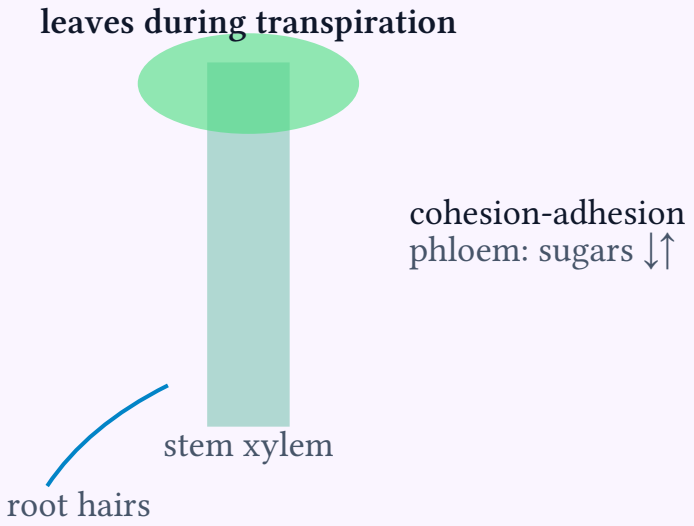
Pressure of cell contents against the cell wall after water enters a plant cell.

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.



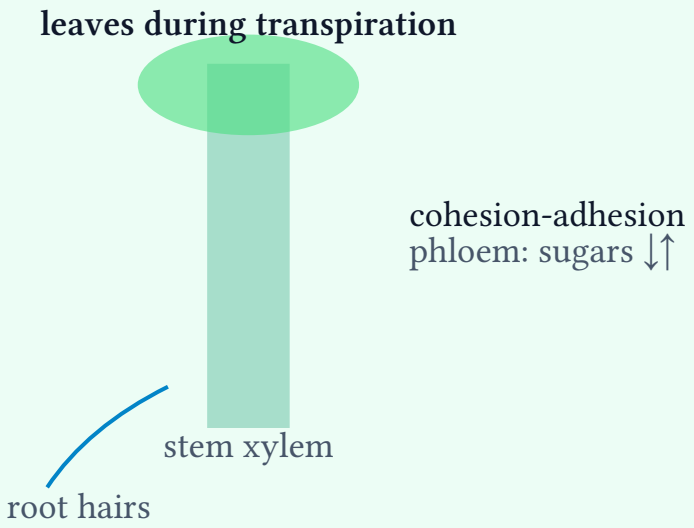
Roots and phloem

- 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.



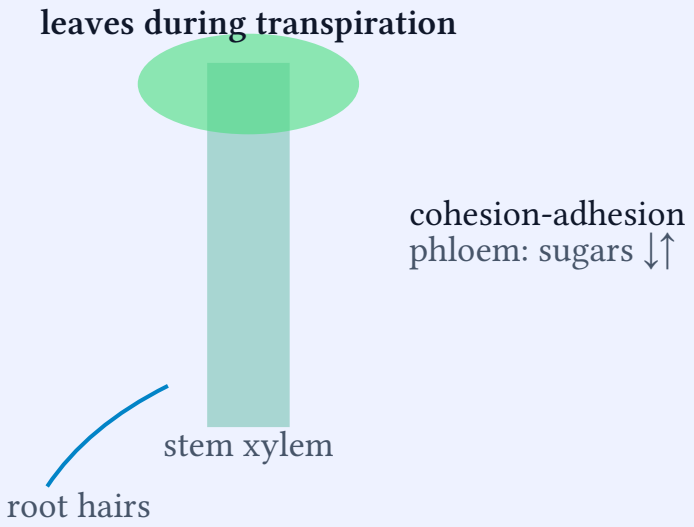
Dye in celery

- 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.

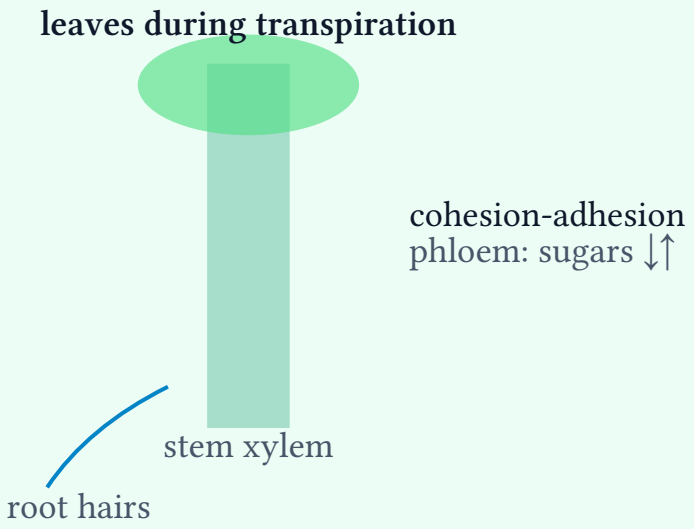


Image credits

Krzysztof Ziarnek, Kenraiz, Carduus nutans kz04, CC BY-SA 4.0

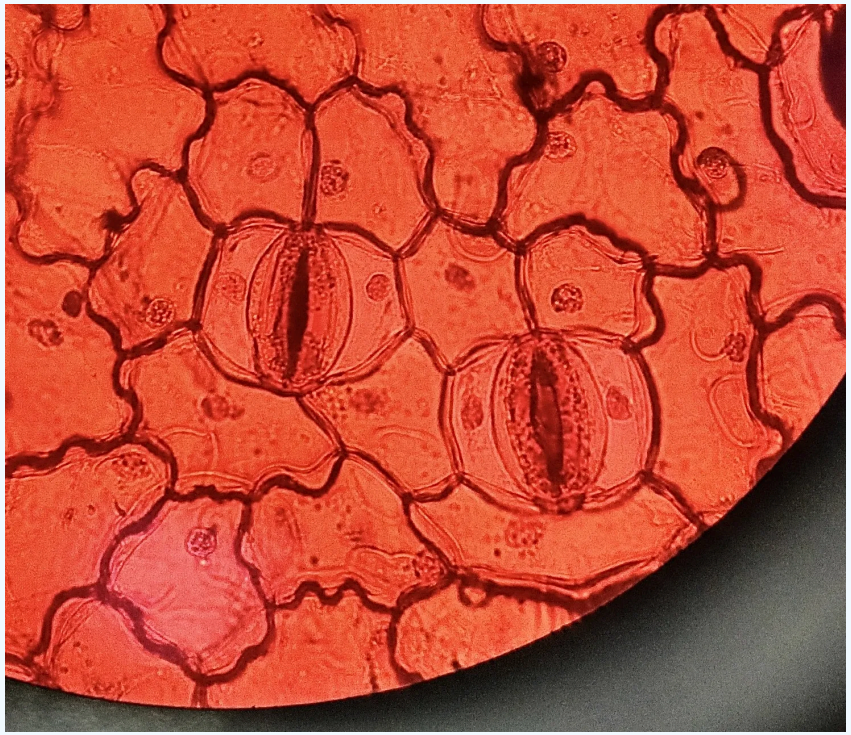
Science 10

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.

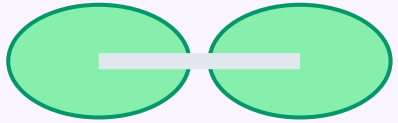
Key terms

gravitropism

Directional plant growth in response to gravity.

Gas exchange

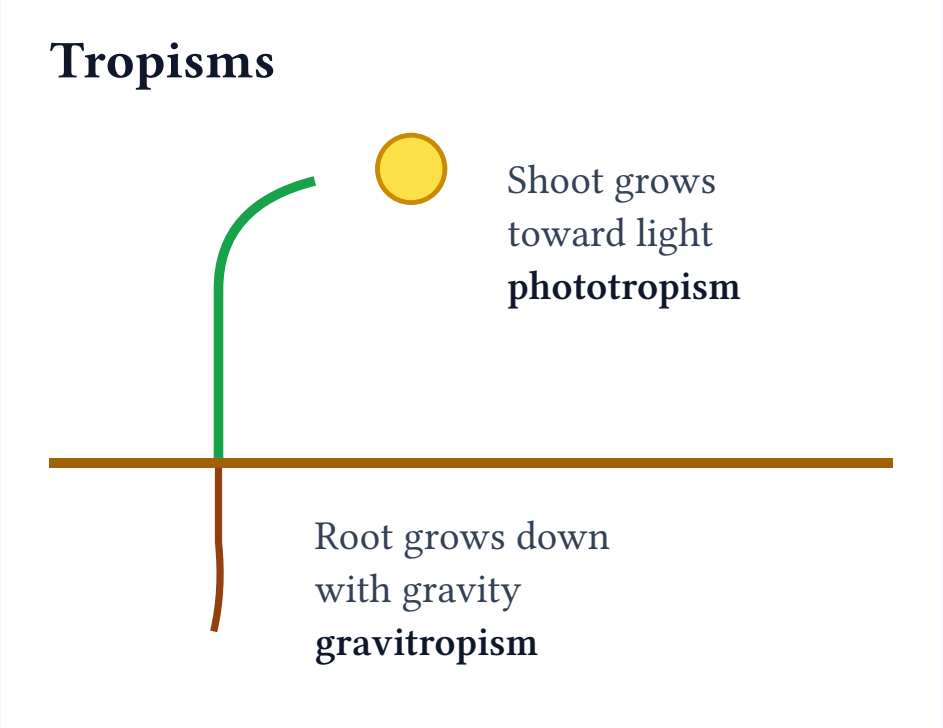
- Carbon dioxide enters a leaf. Oxygen and water vapour can leave.
- Guard cells open or close the stomata by changing their water pressure.
- An open pore gains carbon dioxide and loses water.
- Light, drought, humidity, and temperature all push on that tradeoff.



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.

Image credits

Greeneggplantz, How do plants breathe?, CC BY-SA 4.0

Science 10

Unit D: Energy flow in global systems

Solar energy and life

One energy source for many systems

- Sunlight supplies energy for photosynthesis and heats Earth's surface unevenly.
- Uneven heating drives atmospheric and hydrologic processes that shape climate.



Solar radiation drives photosynthesis, weather, and climate

Two paths from sunlight

- Photosynthesis stores energy from light in chemical compounds.
- The same sunlight can warm the ground, move air, and drive phase changes.
- The Sun powers most surface climate and most food webs. Heat from inside Earth and the tides are the exceptions.

Key terms

solar radiation

Electromagnetic energy emitted by the Sun.

photosynthesis

Process that uses light energy to form energy-rich molecules from carbon dioxide and water.

climate

Long-term patterns and ranges of weather conditions.

adaptation

A heritable structural, physiological, or behavioural trait that improves survival or reproduction.

Climate and life

- Climate is the long-term pattern of weather over decades.
- People and other species meet extremes with shelter, insulation, water storage, or seasonal movement.
- A trait passed on in a population is different from one animal coping for a single week.
- Housing, fur, and behaviour are responses you can point to in a specific climate.



Solar radiation drives photosynthesis, weather, and climate

Solar source

- One afternoon of sunshine can grow grain and also start a breeze.
- Follow chemical energy from a plant to an animal, and follow heating into moving air.
- Sunlight drives most of the climate at Earth's surface and most food webs. Tides and heat from inside Earth are separate sources.
- The carbon in a leaf came from carbon dioxide; light supplied only the energy.



Solar connections

- Trace solar energy through one living system and one climate process.
- A complete answer traces a physically plausible chain and separates energy transfer from matter cycling.



Solar radiation drives photosynthesis, weather, and climate

Image credits

Migco, Village Milo Alberta, public domain

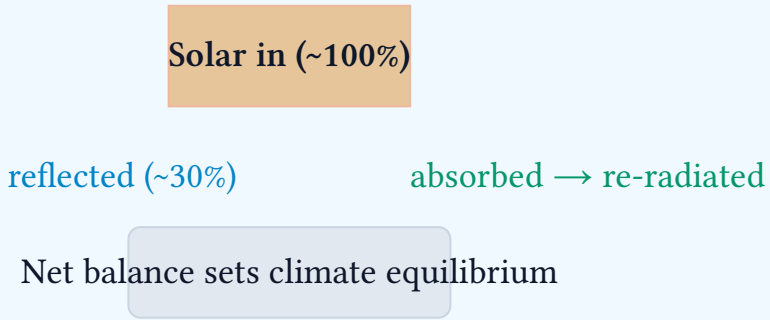
Science 10

Unit D: Energy flow in global systems

Net radiation budget

One hundred units of sunlight

- About 30 of 100 incoming solar-energy units are reflected by clouds, atmosphere, and surfaces.
- The absorbed portion is later transferred and emitted as longwave radiation.



Terms in the energy budget

- Incoming sunlight, reflected sunlight, and outgoing infrared radiation all belong in the budget.
- Reflected radiation bounces straight back to space without warming Earth.
- Use one set of units, or one set of percentages, for the whole calculation.

Key terms

radiation budget

Accounting of incoming, reflected, absorbed, and outgoing radiation.

albedo

Fraction of incoming radiation reflected by a surface.

shortwave radiation

Mostly visible and near-visible solar radiation arriving at Earth.

longwave radiation

Infrared radiation emitted by Earth and its atmosphere.

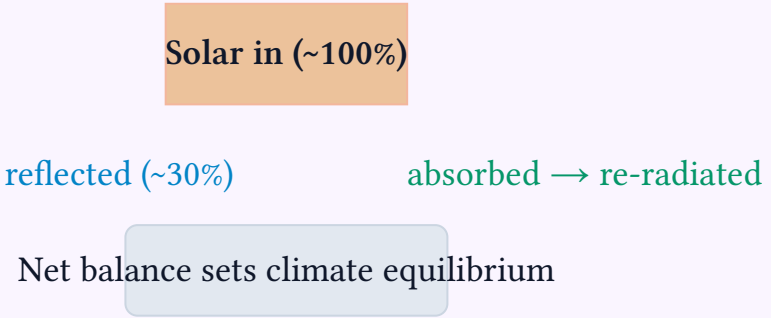
Key terms

net radiation

Incoming absorbed radiation minus outgoing radiation.

Radiation budget

- State incoming radiation, outgoing radiation, and the net as percentages of the same total.
- Shortwave radiation arrives from the Sun. Longwave radiation leaves from Earth.
- The net is what remains after you subtract what leaves.



Closing the budget

- From a simple 100-unit model, calculate the radiation that was absorbed and the net radiation.
- Subtract the reflected portion, keep the percentages consistent, and say whether the system gained or lost energy.



Closing the budget

- Calculate absorbed and net radiation from a simple 100-unit model.
- A complete answer subtracts reflected energy, keeps one set of units or percentages, and interprets the sign of the net.

Image credits

NASA/Apollo 17 crew; taken by either Harrison Schmitt or Ron Evans, The Earth seen from Apollo 17, public domain

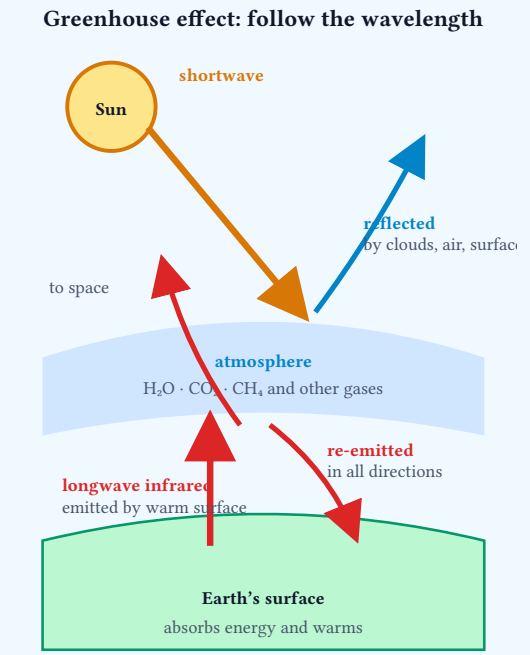
Science 10

Unit D: Energy flow in global systems

Earth systems and the greenhouse effect

Earth’s temperature and the atmosphere

- Earth’s surface absorbs solar radiation and emits infrared radiation.
- Greenhouse gases absorb and re-emit some outgoing in-frared radiation, changing the rate of energy loss to space.



enhouse gases are not a solid lid; they absorb and emit infrared ener

Effects of greenhouse gases

- Greenhouse gases matter because they absorb and emit infrared radiation.
- That changes how fast energy leaves, and therefore the temperature at which incoming and outgoing energy balance.
- On a diagram, label the reservoirs and the arrow directions. Say the energy is slowed on its way out to space.

Key terms

atmosphere

The layer of gases surrounding Earth.

hydrosphere

All water on, under, and above Earth's surface.

biosphere

All living organisms and the regions they inhabit.

greenhouse gas

A gas that absorbs and emits infrared radiation.

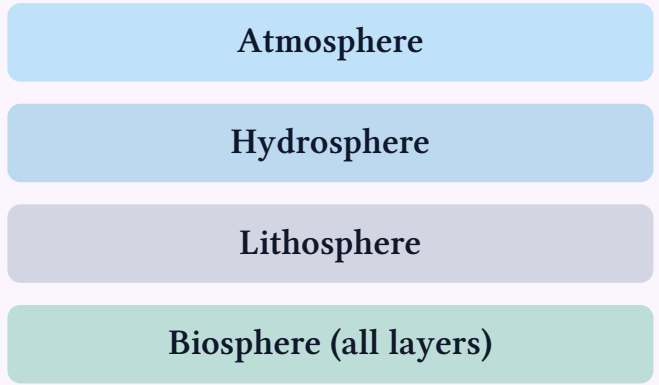
Key terms

greenhouse effect

Atmospheric warming caused by absorption and re-emission of infrared radiation.

Earth spheres

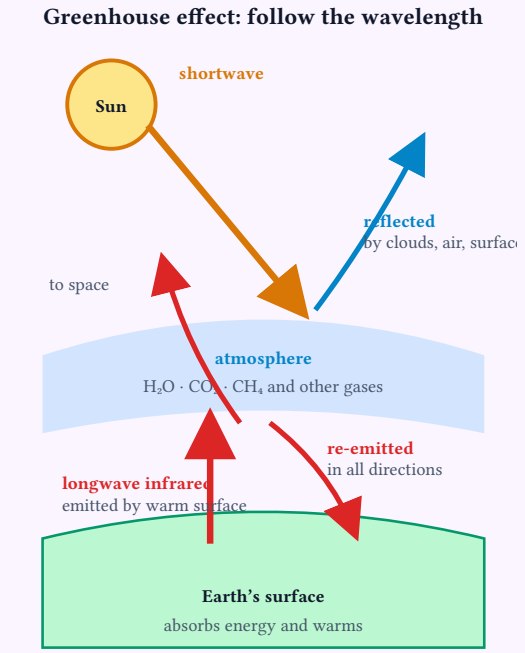
- Air, water, rock, and life trade materials.
- Water leaves a lake as vapour. Rock weathers into soil. Plants take in carbon.
- Draw the reservoirs and the arrows, and say which boundary you are using.
- A missing arrow is a missing transfer, and that matters.



reenhouse gases (H_2O, CO_2, CH_4) trap outgoing longwave radiatic

Greenhouse effect

- The surface absorbs sunlight and gives off infrared radiation.
- Carbon dioxide, methane, and water vapour absorb some of that infrared and emit it again.
- The planet warms until energy leaving matches energy absorbed.
- The effect is wavelength-specific. Calling it a blanket around Earth is only a rough comparison.



enhouse gases are not a solid lid; they absorb and emit infrared ener

An exchange between spheres

- Trace one matter transfer and one energy transfer through at least two Earth systems.
- A complete answer names the reservoirs, points the arrows the right way, and says the energy is slowed on its way out.

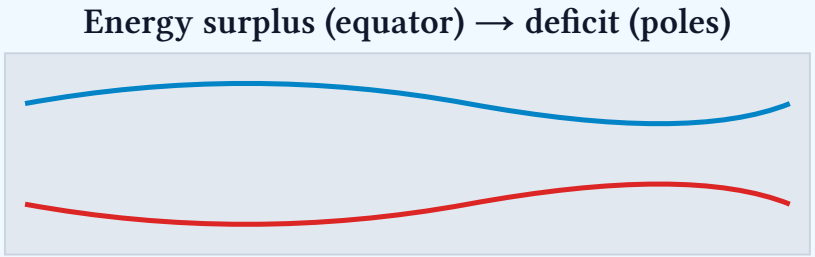
Science 10

Unit D: Energy flow in global systems

Global energy transfer and climate zones

Energy surplus at the equator

- Low latitudes receive more concentrated solar radiation on average than high latitudes.
- Atmospheric circulation and ocean currents move thermal energy toward higher latitudes.



Hadley, Ferrel, and polar cells redistribute heat

Energy transfer toward the poles

- Without air and ocean currents moving energy, the equator would run hotter and the poles colder.
- Moving air and moving water carry thermal energy toward higher latitudes.
- Show both paths on the diagram. Tomorrow's local weather comes from a forecast; a climate zone describes the long-term pattern.

Key terms

latitude

Angular distance north or south of the equator.

atmospheric circulation

Large-scale movement of air driven by heating differences and Earth's rotation.

ocean current

Persistent movement of ocean water that transfers matter and energy.

energy surplus

A region or period where absorbed energy exceeds outgoing energy.

Key terms

energy deficit

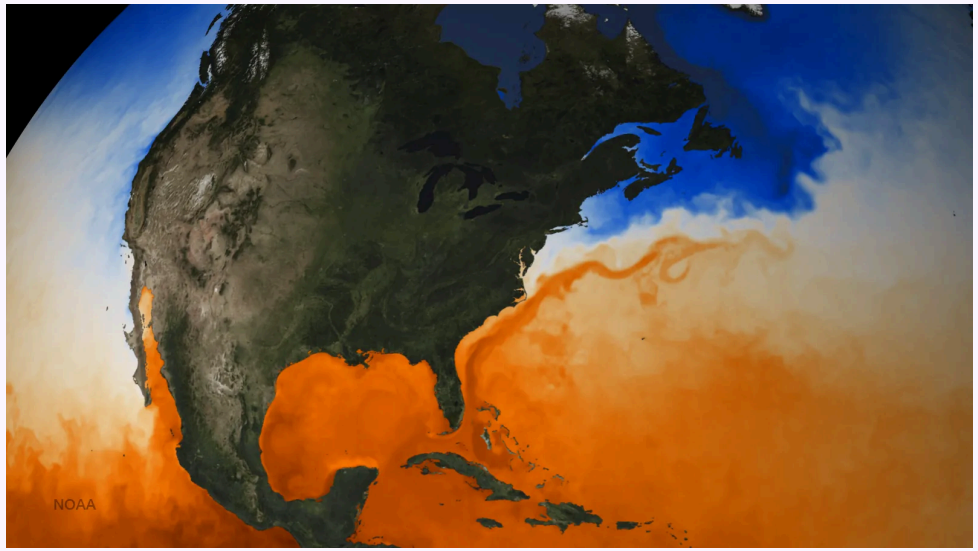
A region or period where outgoing energy exceeds absorbed energy.

Atmospheric transfer

- Low latitudes gain more solar energy than the poles, so air moves to even that difference out.
- Earth's rotation bends large-scale winds and helps set broad climate bands.
- A jet stream and a local storm are both moving air, at different scales.
- One day's weather can still disagree with the climate zone printed on the map.

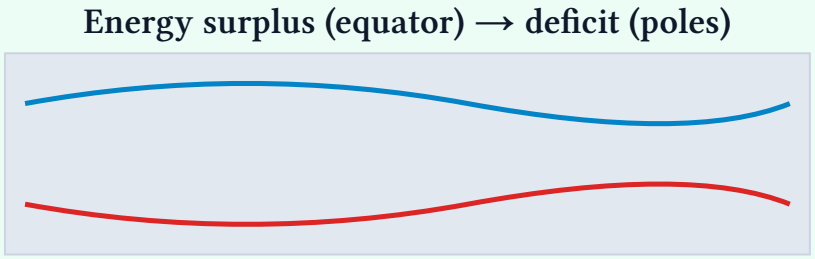
Ocean and climate

- Surface currents carry warm or cold water along coasts.
- Wind drives much of that surface flow. Temperature and saltiness help drive deeper flow.
- A coast can be milder than inland places at the same latitude.
- Currents move energy. The equator still gets extra energy and the poles still get less.



Surplus to deficit

- Annotate a world diagram with energy surplus, deficit, and two transport pathways.
- A complete answer shows the latitude pattern and arrows for both air and ocean transport.



Hadley, Ferrel, and polar cells redistribute heat

Image credits

NOAA, The Gulf Stream Seen Through Sea Surface Temperature (NESDIS 2016-06-03), public domain

Science 10

Unit D: Energy flow in global systems

Factors affecting solar input

Winter shadows

- At a lower solar angle, the same incoming energy spreads over a larger surface area.
- Shorter winter days also reduce the time available for solar-energy input.

Angle of Sun	season, latitude, day length
Albedo	ice/snow reflect more than forest
Clouds and aerosols	scatter and absorb incoming solar radi

Axial tilt and seasons

- Earth’s tilt changes the solar angle and the length of the day.
- Axial tilt is the main cause of the seasons; distance from the Sun plays a minor part.
- A lower Sun spreads the same beam over more ground and sends it through more air.
- Name the mechanism, such as reflection or a longer path through the air.

Key terms

solar angle

Angle at which sunlight strikes a surface.

albedo

Fraction of incoming radiation reflected by a surface.

day length

Time between sunrise and sunset at a location.

aerosol

A small solid particle or liquid droplet suspended in air.

Surface solar energy

- A low Sun spreads the same beam over more ground.
- Longer days mean more hours of input.
- Bright surfaces reflect more. Clouds and particles can scatter or absorb.
- Seasons follow the tilt of Earth's axis. Earth's distance from the Sun barely changes them.

Angle of Sun	season, latitude, day length
Albedo	ice/snow reflect more than forest
Clouds and aerosols	scatter and absorb incoming solar radi

Factor and mechanism

- Match each factor to reflection, absorption, scattering, or how long the energy arrives.
- Name the physical mechanism. ‘It increases’ is a start; an explanation also names the cause.

Angle of Sun	season, latitude, day length
Albedo	ice/snow reflect more than forest
Clouds and aerosols	scatter and absorb incoming solar radi

Factor and mechanism

- Match each factor to reflection, absorption, scattering, or duration of input.
- A complete answer names a physical cause for the change.

Angle of Sun	season, latitude, day length
Albedo	ice/snow reflect more than forest
Clouds and aerosols	scatter and absorb incoming solar radi

Science 10

Unit D: Energy flow in global systems

Uneven heating and phase changes

Sand and lake water cooling

- After sunset, dry land often changes temperature faster than a nearby large body of water.
- Equal energy input can produce different temperature changes because materials have different specific heat capacities.



Temperature and energy

- Temperature measures how fast particles are moving on average. It is only part of the energy change.
- The same mass and the same energy input can still produce different temperature changes in different materials.
- During a phase change, energy can go in while the thermometer stays still.

Key terms

specific heat capacity

Energy required to raise one unit mass of a substance by one degree Celsius.

phase change

A change of state without a change in chemical identity.

heat of fusion

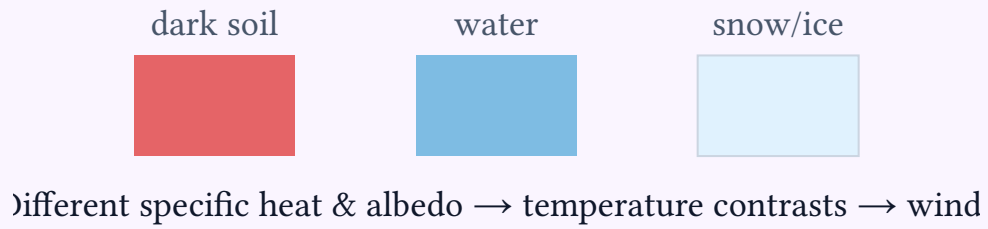
Molar energy required for melting at the melting point.

heat of vaporization

Molar energy required for vaporization at the boiling point.

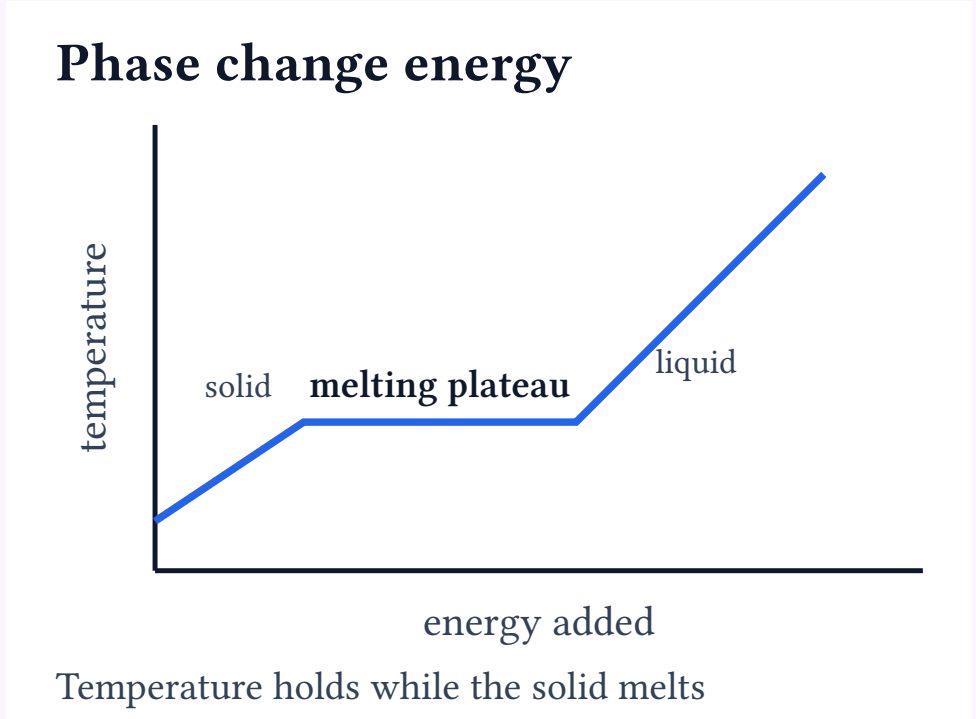
Uneven heating

- Sand and lake water warm by different amounts under the same sunshine.
- A material that warms quickly usually cools quickly too.
- Large lakes change temperature more slowly than nearby dry ground.
- Specific heat capacity is why equal masses can still diverge.



Phase change energy

- Melting ice can absorb energy while the thermometer stays at the melting point.
- Use a temperature-change calculation only while the substance stays in one state.
- Use a fusion or vaporization value when the state itself is changing.
- A full heating path may need both kinds of step, in order.



Temperature holds while the solid melts

Choosing an equation

- Decide whether a scenario uses $Q = mc\Delta t$, molar heat of fusion, or molar heat of vaporization and justify the choice.
- A complete answer names the process, the known quantities, the units, and whether temperature changed or a phase changed.

Image credits

CocoRoux, Sylvan Lake 2014 Beach, CC BY-SA 4.0

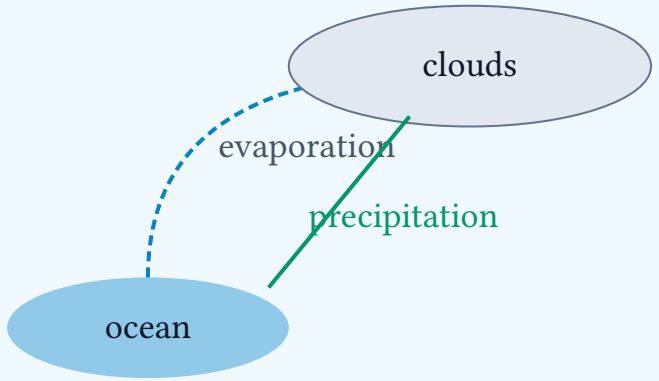
Science 10

Unit D: Energy flow in global systems

Hydrologic cycle and climate

Evaporation and condensation

- Evaporation requires energy and can cool the remaining liquid or surface.
- Condensation transfers energy to the surrounding air as water vapour becomes liquid.



ıanges move thermal energy through atmosphere, hydrosphere, b

Phase changes move energy

- A phase change moves energy as well as water.
- Evaporation takes energy from the surface. Condensation releases energy to the surrounding air.
- Name the phase and the direction of the arrow before you talk about the climate effect.

Key terms

evaporation

Change from liquid to gas at a surface.

condensation

Change from gas to liquid.

precipitation

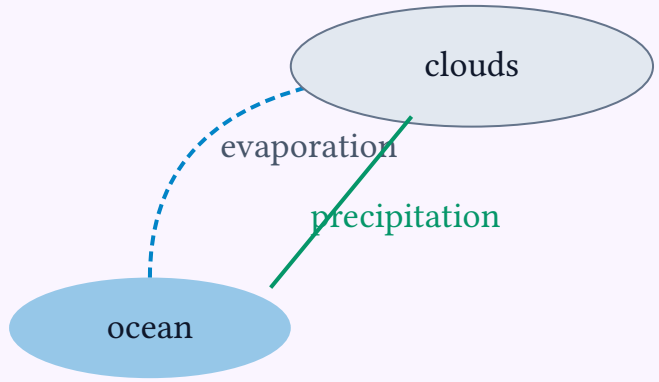
Water that falls from the atmosphere as rain, snow, sleet, or hail.

latent energy transfer

Energy absorbed or released during a phase change without temperature change during the transition.

Hydrologic cycle

- Sunlight evaporates water from oceans, soil, and organisms.
- Vapour travels, then returns as rain or snow.
- Rivers, groundwater, ice, and oceans hold water for very different lengths of time.
- Each change of state moves energy as well as water.



ıanges move thermal energy through atmosphere, hydrosphere, b

Climate link

- Evaporation cools the surface that lost the water.
- Condensation warms the air around the new droplets.
- Vapour can travel a long way before that energy is released.
- The water molecules are matter. The warming and cooling are energy transfer.



Water and energy arrows

- Label a water-cycle diagram with matter movement and energy absorbed or released.
- A complete answer names the phases, points the arrows, and shows energy absorbed at evaporation and released at condensation.

Image credits

Tomascastelazo, Large cloud over Mexican landscape, CC BY-SA 4.0

Science 10

Unit D: Energy flow in global systems

Biomes as open systems

Grassland boundaries

- Sunlight, water, organisms, gases, and nutrients cross any chosen biome boundary.
- Matter cycles within and across the boundary while energy flows through and leaves mainly as thermal energy.



Matter and energy exchange

- A biome includes its climate, soils, living communities, and the materials that cross its boundary.
- Matter and energy move between the biome and its surroundings.
- When you model a biome, name what cycles, what flows through, and what the climate allows to live there.

Key terms

biome

A large ecological region characterized by climate and typical communities.

open system

A system that exchanges matter and energy with its surroundings.

matter cycle

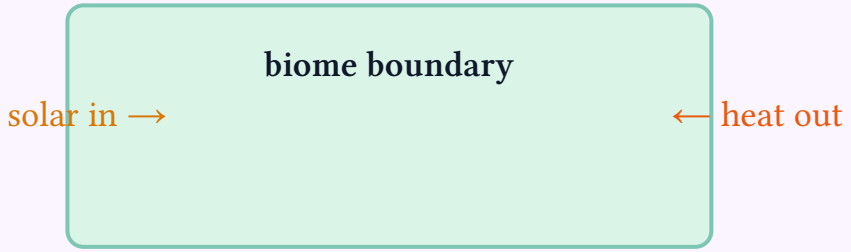
Repeated movement and transformation of matter among reservoirs.

energy flow

One-way transfer and transformation of energy through a system.

Biome inputs and outputs

- A biome boundary is a line people choose for study. Living things cross it freely.
- Light, water, gases, animals, and nutrients cross it.
- Matter can loop among soil, water, air, and organisms.
- Energy arrives mostly as sunlight and leaves mostly as heat.



Matter cycles; energy flows through: compare to cell open system

System inventory

- Choose a biome and draw the boundary you are studying.
- Sort four exchanges into inputs and outputs.
- Say which exchanges are matter, which are energy, and how the climate limits the community.

System inventory

- Choose a biome boundary and classify four exchanges as inputs or outputs.
- A complete answer names the boundary, separates matter from energy, and connects the exchanges to the climate.

Image credits

1brettsnyder, Aspen Parkland in Dry Island Buffalo Jump Provincial Park - panoramio, CC BY-SA 3.0

Science 10

Unit D: Energy flow in global systems

Climatographs and biome comparison

Two annual patterns

- A climatograph combines monthly temperature and precipitation on one set of axes.
- Seasonal range and precipitation timing distinguish locations with similar annual averages.



Pair temperature and precipitation curves to classify biomes

Reading a climatograph

- On a climatograph, temperature is a line and precipitation is a set of bars. They use different units.
- A yearly average hides the coldest month and the month when the rain actually falls.
- Compare biomes using the shape of the whole year.

Key terms

climatograph

A graph of monthly average temperature and precipitation for a location.

temperature range

Difference between the highest and lowest values in a period.

annual precipitation

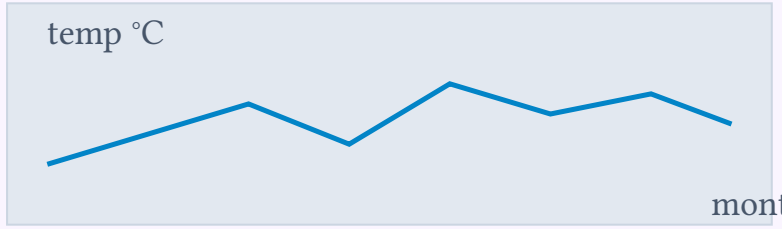
Total precipitation measured over one year.

biome

A large ecological region characterized by climate and typical communities.

Major biomes

- Grassland, desert, tundra, taiga, deciduous forest, and rain forest name broad living regions.
- Give the climate range, then ask what else could move the boundary: soil, fire, or elevation.
- Describe a biome with a range of temperatures and rainfall totals.



Pair temperature and precipitation curves to classify biomes

Climatographs

- Read the temperature line and the precipitation bars before you name a biome.
- A yearly total can hide a dry summer or a harsh winter.
- Compare the coldest month and the wettest months across the whole graph.
- The same biome name can show up where the climate pattern matches, even at another latitude.



Evidence-based biome match

- Compare two climatographs and justify a biome match with temperature and precipitation evidence.
- A complete answer uses values from both axes, describes the seasonal pattern, and rests on more than one measurement.

Image credits

CLS Research Office from Saskatoon, Canada, Quarry of the Ancestors Sep 2009 110, CC BY-SA 2.0

Science 10

Unit D: Energy flow in global systems

Human actions and climate evidence

Climate change in two centuries

- Burning fuels, clearing land, and draining wetlands have changed what the air and the biomes do.
- The scientific question is how much of that change is caused by people and how much is natural variability.

- Fossil fuel combustion → CO_2
- Land-use change → CO_2, CH_4
- Ice cores & tree rings → past CO_2 & temperature

le independent lines of evidence support recent anthropogenic wa

Greenhouse gases and past climates

- Carbon dioxide and methane are greenhouse gases because they absorb and emit outgoing infrared radiation.
- Air bubbles trapped in ice cores preserve samples of past atmospheres, while layer chemistry helps reconstruct paleoclimate.
- Tree-ring width and density can date past growing conditions.
- One proxy is only part of the climate record.

Key terms

greenhouse gas

A gas that absorbs and emits infrared radiation in the atmosphere.

paleoclimate

Climate conditions from before instrumental records, reconstructed from proxy evidence.

ice core

A cylinder of ice whose layers and trapped gases preserve evidence of past atmosphere and climate.

dendrochronology

Study of annual tree rings to date events and infer past environmental conditions.

Human actions that change climate

- Burning fuels, draining wetlands, forest fires, and clearing forests all change how much carbon stays in the air or in the land.
- Tie each action to a measurement, such as emissions, ice loss, or sea level, before you call it a cause.

- Fossil fuel combustion → CO_2
- Land-use change → CO_2, CH_4
- Ice cores & tree rings → past CO_2 & temperature

le independent lines of evidence support recent anthropogenic wa

Paleoclimate archives

- Ice cores hold tiny samples of old air, so past carbon dioxide levels can be compared with temperature over thousands of years.
- Tree rings add a year-by-year record of wet and dry growing seasons from before thermometers existed.



Reading a climate graph

- Describe how atmospheric carbon dioxide has changed since industry expanded.
- Separate one unusual week of weather from a trend that lasts decades.

- Fossil fuel combustion → CO_2
- Land-use change → CO_2, CH_4
- Ice cores & tree rings → past CO_2 & temperature

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Alberta connections

- Forestry, farming, and energy production change land and emissions in different ways.
- A measurement can inform a decision. The decision still depends on what a community values.

- Fossil fuel combustion → CO_2
- Land-use change → CO_2, CH_4
- Ice cores & tree rings → past CO_2 & temperature

le independent lines of evidence support recent anthropogenic wa

Evidence triad

- Name three human actions that change climate, and one kind of evidence scientists use.
- A complete answer names greenhouse-gas emissions and land use, and uses ice cores or tree rings as evidence of past climate.

Climate evidence retrieval check

- Separate weather from climate in the claim: one cold winter disproves global warming.
- Name one direct modern record and two paleoclimate proxies.
- Climate also changed naturally in the past. Explain why human influence can still drive change today.

Image credits

Dargaud, Ice core extracted at Talos Dome showing an ash layer corresponding to the Toba eruption, CC BY-SA 4.0

Science 10

Unit D: Energy flow in global systems

Climate science and decisions

Decisions under uncertainty

- Alberta winters, farming, forestry, and northern communities feel climate variability.
- Science informs choices, and values and perspectives still shape them.



Decisions that cite evidence

- Name the evidence before you recommend a climate action.
- Say what is still uncertain, and who would live with the result.
- A transit proposal, for example, still needs emissions data and a list of people affected.

Key terms

Intergovernmental Panel on Climate Change

A United Nations body that assesses published research about climate change. (IPCC)

model

A simplified representation used to explain evidence, test ideas, or make predictions.

perspective

A viewpoint shaped by evidence, experience, responsibilities, and values.

stewardship

Responsible care and management of land, water, living systems, and resources.

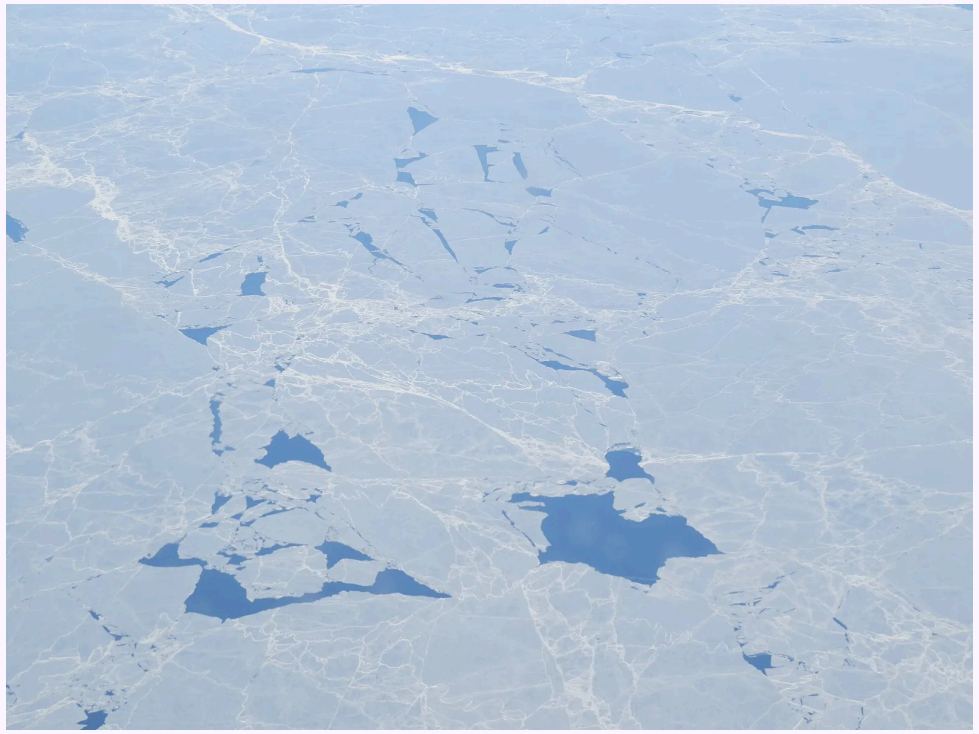
Key terms

biome

A large region with characteristic climate, plants, and animals.

Sensitive biomes and peoples

- Less Arctic ice changes habitats for species and for Indigenous societies that rely on ice for travel and hunting.
- Connect local observations to global energy balance studied earlier in Unit D: Energy flow in global systems.



Global collaboration in science

- Weather agencies, Global Atmosphere Watch, and the IPCC pool measurements and review one another's conclusions.
- Satellites and ground stations record greenhouse gases and changes at Earth's surface.



Limits of knowledge

- Predictions for agriculture, forestry, oceans, and shifting circulation all carry uncertainty.
- Good decisions state assumptions and what would change the conclusion.



Evaluating a proposal

- Take a proposal such as expanding public transit to reduce emissions from transportation.
- List the benefits, the risks, the evidence you still need, and who is affected before you choose.

Multiple perspectives

- Compare the Gaia hypothesis with Indigenous perspectives that see the land as a web of relationships.
- A decision should weigh economic, social, environmental, and cultural consequences together.

Structured debate

- Teams present a course of action to reduce greenhouse gases from goods and people transport.
- The audience should hear the evidence, the limits of the claim, and more than one perspective.

Position with evidence

- Groups defend one transport-emissions reduction strategy using two evidence sources and one limitation.
- A complete answer cites the data, says what is still uncertain, and takes more than one perspective seriously.

Course closure

- Before a final assessment, be ready to read a radiation budget and a biome climatograph again.
- This course connects chemical change, energy technologies, living systems, and the flow of energy across Earth.

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Luke Jones (Accretion Disc on Flickr), Pack Ice in the Beaufort Sea - 2013-05-25, CC BY 2.0