Biology 20 full slide deck

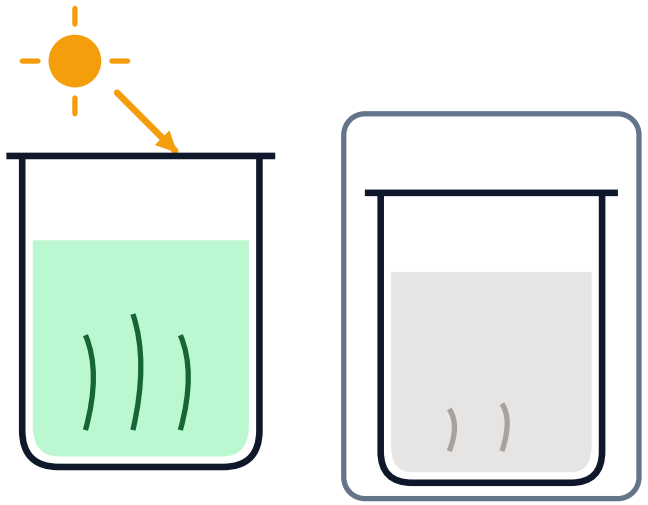
Biology 20

Unit A: Energy and matter in the biosphere

One-way energy through the biosphere

One jar stays green and warm

- A sealed pond jar on a bright windowsill stays green because algae keep growing, and the glass feels slightly warm.
- The matching jar in a dark cupboard cools, and the green algae fade until the water looks brown.



Windowsill jar: green and warm

Cupboard jar: brown and cool

Energy inputs and heat loss

- Sunlight is the energy input for the green algae in the windowsill jar.
- The energy stored in the algae's sugars is the chemical store inside the producers.
- Cellular respiration moves that store into cell work and heat.

Key terms

biosphere

The global system of organisms together with the air, water, and crust they use.

one-way energy flow

Energy enters a living system and leaves that system as heat.

chemosynthesis

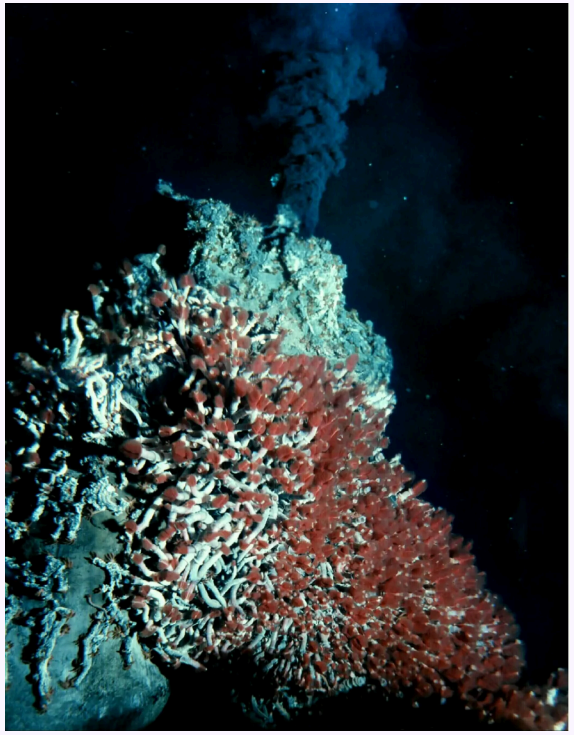
Building organic molecules with energy released by inorganic chemical reactions.

cellular respiration

Transfer of energy from organic molecules into cell work and heat.

Energy enters and heat leaves

- Photosynthetic communities take in light and store a fraction in carbohydrate.
- Chemosynthetic communities at deep-sea vents, hot cracks in the ocean floor with no sunlight, take in energy from inorganic reactions such as hydrogen sulfide.
- Cellular respiration and decomposition release heat in both kinds of community.



Tracking energy in the sunlit jar

- Write the input, the chemical store, and the heat exit on one card.
- Repeat the card for a deep-sea vent community so the exit stays heat in both rows.

A testable question

- A useful question names the light condition and the chemical store you will compare.
- The prediction states how the store changes when the light changes.

Input and exit

- Name the energy input and the heat exit for a sunlit pond and for a deep-sea vent.
- State what the carbon atoms do while the joules leave.

Food chains carry this energy onward

- The next lesson places this same heat exit at every link of a food chain.
- Producers, consumers, and decomposers will share one energy ledger.

Image credits

University of Washington; NOAA/OAR/OER, Tube worms at a hydrothermal vent (NOAA Photo Library, expl2366), public domain

Biology 20

Unit A: Energy and matter in the biosphere

Food chains and food webs

Aspen leaves end up as lynx muscle

- A snowshoe hare spends the evening clipping aspen twigs in parkland snow.
- A lynx later takes that hare, and leaf litter still feeds fungi under the snow.



Links and trophic levels

- A food chain is one path, written so each arrow aims at the receiver.
- A trophic level is the feeding position counted from the producer.
- A food web joins chains where one animal feeds in more than one place.

Key terms

food chain

A single path of energy from a producer through a sequence of consumers.

food web

Linked food chains that show one organism feeding at more than one point.

trophic level

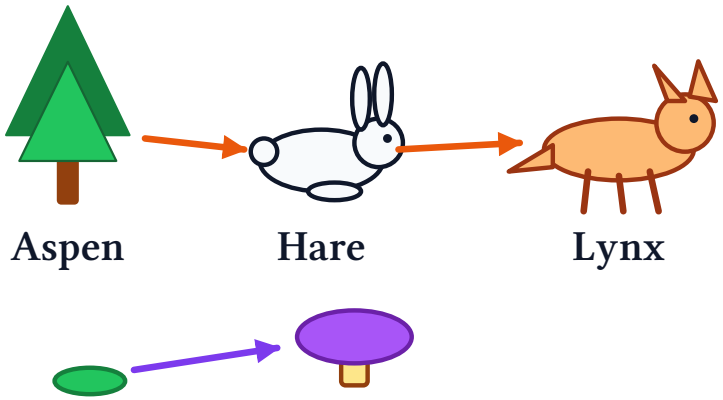
The feeding position of an organism, counted from the producers upward.

decomposer

An organism that releases energy from dead matter and wastes as heat.

Arrows carry energy to the eater

- Producers occupy the first trophic level because they build the organic store.
- Each consumer sits one level above the organism it eats in that path.
- Decomposers take energy from dead matter at every level of the chain.



Arrowheads sit on the eater

Parkland food chain sketch

- Four boxes and three arrows are enough for the first annotated chain.
- Each label names the organism and its trophic level in words.

From chains to a web

- A second producer or a second prey animal forces a branch in the drawing.
- The web still uses arrows that point toward the receiver of energy.

Path and web

- State where the arrow points and how trophic levels are counted.
- Explain when a drawing has become a food web.

Pyramids will count these levels

- The next lesson stacks this chain as pyramids of numbers, biomass, and energy.
- Bring a labelled chain so the stack has organisms to count.

Image credits

kdee64 (Keith Williams), Canadian lynx by Keith Williams, CC BY 2.0

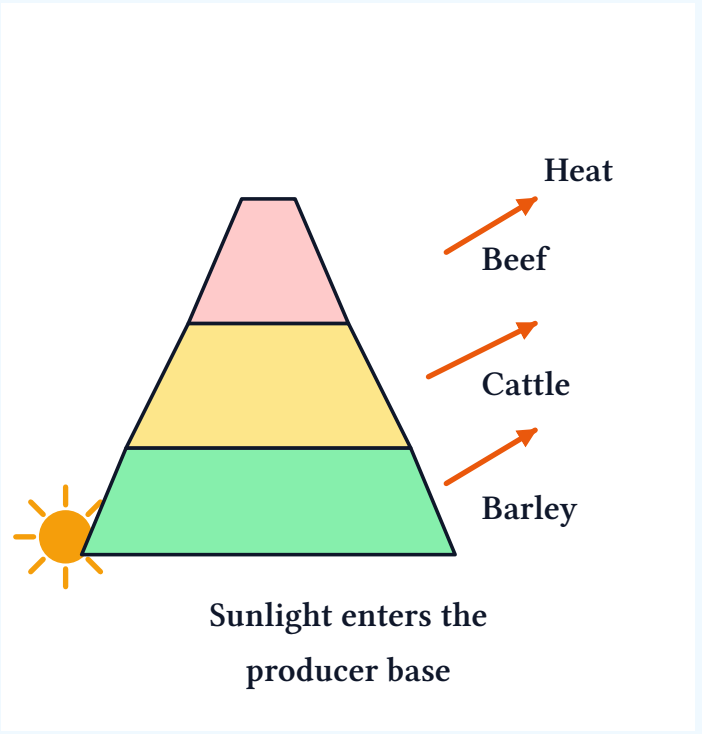
Biology 20

Unit A: Energy and matter in the biosphere

Ecological pyramids

Energy loss along a food chain

- A hectare of barley holds a large store of chemical energy in the grain.
- Cattle that eat that grain keep only a fraction, and people who eat the cattle keep a fraction of that fraction.



Three ways to stack one chain

- Count the organisms when you build a numbers pyramid.
- Weigh the dry matter when you build a biomass pyramid.
- Use kilojoules per square metre per year when you build an energy pyramid.

Key terms

pyramid of energy

A stack of trophic levels drawn by the energy available at each level in a set time. (kJ m^{-2} y^{-1})

pyramid of numbers

A stack of trophic levels drawn by how many organisms sit at each level.

pyramid of biomass

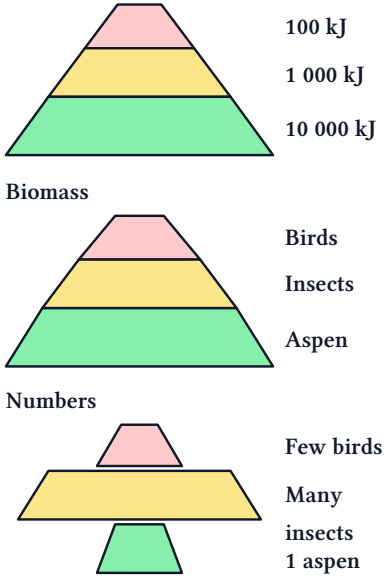
A stack of trophic levels drawn by the dry mass of organisms at each level.

albedo

The fraction of incoming sunlight that a surface reflects.

Energy narrows even when counts invert

- About one tenth of the energy at one level is available at the next.
- One aspen can support thousands of insects, so a numbers pyramid can widen upward.
- Biomass and energy for that tree still narrow because the tree outweighs and out-stores the insects.



Energy pyramid with units

- Write the producer value, then take one tenth twice.
- Keep kJ m^{-2} y^{-1} on every floor and match the digits to the data.

Pyramids and decisions

- Diet, grain storage, ice cover, and wetland loss ask different energy questions.
- Choose the display whose unit can answer the question in front of you.

Which stack

- Give the energy values after two transfers of about one tenth.
- State when a numbers pyramid widens and which human choice the energy pyramid explains.

The atoms stay when the joules leave

- The next lesson follows carbon, oxygen, nitrogen, and phosphorus.
- Those atoms cycle after the energy pyramid has already narrowed.

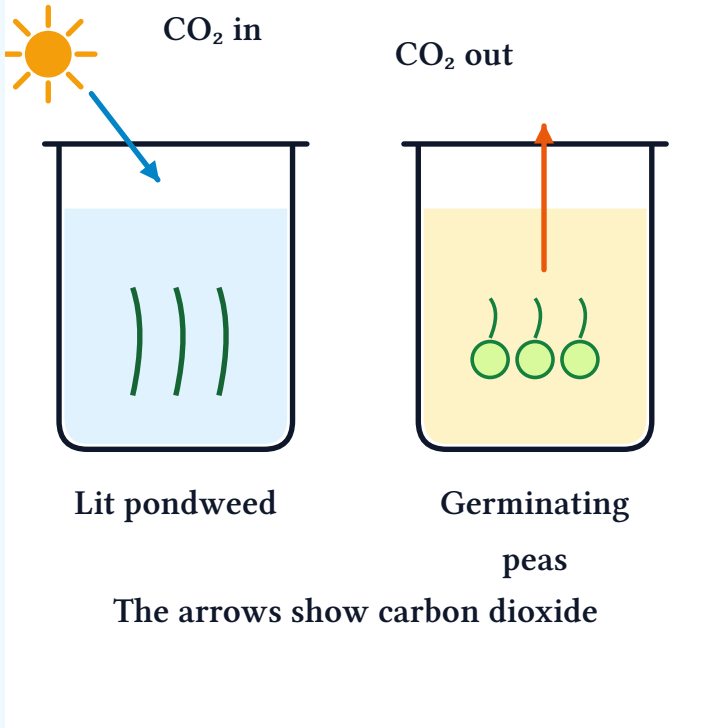
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Unit A: Energy and matter in the biosphere

Biogeochemical cycles

Carbon from leaf to air

- Pond weed in a bright jar builds sugar from carbon dioxide in the water.
- Germinating peas in a dark jar release carbon dioxide as they respire.



Four element routes

- Carbon and oxygen move together through photosynthesis and cellular respiration.
- Nitrogen moves through bacteria that fix, convert, and return N_2.
- Phosphorus moves from rock and soil into organisms and back to sediment.

Key terms

carbon cycle

The movement of carbon atoms among air, water, organisms, and fossil stores.

nitrogen cycle

The movement of nitrogen from N_2 in air through soil bacteria, plants, and animals, and back to N_2.

phosphorus cycle

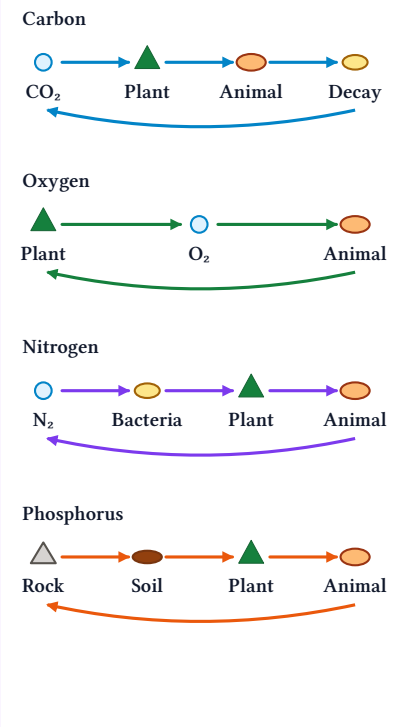
The movement of phosphorus from rock and soil into organisms and back to soil and sediment.

oxygen cycle

The movement of oxygen released by photosynthesis and used in cellular respiration.

Atoms return through each cycle

- Photosynthesis and respiration move carbon and oxygen in opposite directions.
- Bacteria open and close the nitrogen route between air and plants.
- Weathering and burial move phosphorus between rock and living tissue.



Plant and animal carbon test

- The question names pond weed and germinating peas as the two producers of a carbon dioxide record.
- The prediction says which jar raises the indicator faster in the dark.

One human change, several cycles

- Fertilizer adds nitrate and phosphate that crops absorb.
- Extra nutrients in runoff feed algae, and decay then changes oxygen in the water.



Four routes

- State the return path for carbon and for nitrogen.
- State where phosphorus enters living systems and one human change that speeds two cycles.

Water carries the dissolved load

- The next lesson treats water as the solvent that moves these nutrients.
- Hydrogen bonding explains why water holds and transports ions.

Image credits

United States Geological Survey (USGS) and National Aeronautics and Space Administration (NASA), Landsat8 Sep262017 Toledo LakeErie AlgalBloom, public domain

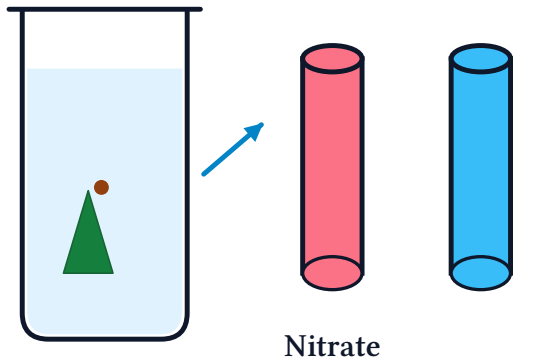
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Unit A: Energy and matter in the biosphere

Water as solvent and carrier

The slough holds more than water

- A clear slough sample still carries dissolved nitrate and phosphate from the fields around it.
- Those ions are invisible until a test changes colour.



Read the WHMIS label before you open a kit

Polar water holds the ions

- A hydrogen bond joins the hydrogen of one water molecule to the oxygen of another.
- Polarity lets water surround positive and negative ions.
- That solvent action moves nutrients through soil, organisms, and rivers.

Key terms

hydrogen bond

The attraction from a hydrogen atom of one water molecule to the oxygen atom of a neighbour.

universal solvent

Water dissolves many ions and polar molecules because the molecule itself is polar.

cohesion

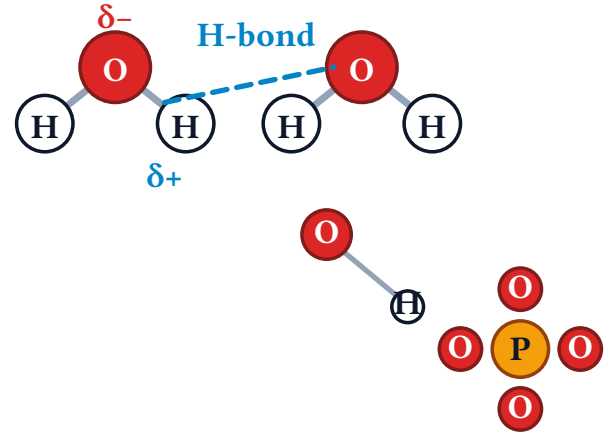
Water molecules staying together through hydrogen bonds, which supports flow in soil and in xylem.

nutrient runoff

Dissolved nitrate, phosphate, or metal ions carried by water from land into a river or slough.

Cycles move in solution

- Hydrogen bonds keep water liquid across the temperatures of Alberta seasons.
- Dissolved nitrate and phosphate are the travelling forms in the nitrogen and phosphorus cycles.
- Heavy metals dissolved in water can pass from algae into the animals that eat them.



That H faces a phosphate oxygen

Opposite charges pull the molecules together

Units and labels in a test

- Record pH and the nutrient with the kit’s unit, such as mg/L.
- Match a high nitrate reading to fertilizer or sewage before you name a fix.

Water use and return

- Households, farms, mines, and processing plants remove large volumes.
- Return flow can carry heat, nutrients, or metals back to the river.



Bonds and budgets

- Explain hydrogen bonds and why water dissolves nitrate.
- Interpret a high phosphate reading and a large industrial withdrawal.

Regions balance these flows

- The next lesson compares productivity and gas balance across whole regions.
- Water and nutrients are two of the limits you will use.

Image credits

Quintin Soloviev, Bassano Dam (Alberta), CC BY 4.0

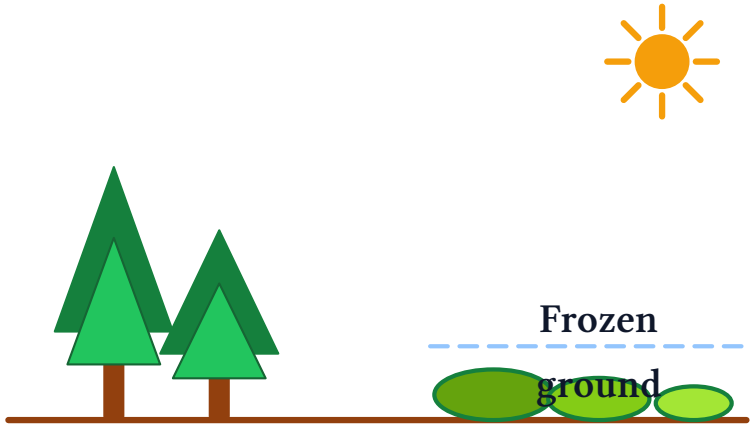
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Unit A: Energy and matter in the biosphere

Productivity and atmospheric balance

Slow growth in the tundra

- Summer sun over tundra is strong, and the plants stay low to the ground.
- A taiga of spruce beside it builds a much larger standing mass of wood.



Same summer sun, different plant height

Limits on the biosphere

- Productivity compares biomass built in two regions under their energy and nutrient limits.
- Atmospheric equilibrium compares photosynthetic gas exchange with respiratory gas exchange.
- Stromatolites record a long rise in oxygen produced by ancient microbes.

Key terms

ecosystem productivity

The biomass producers build in a place over time, set by energy, water, and nutrients.

atmospheric equilibrium

A steady mix of gases when photosynthetic release and respiratory use of oxygen and carbon dioxide balance.

stromatolite

A layered rock formed by microbial mats, evidence that ancient photosynthesis changed the air.

closed ecological system

A habitat that must recycle its matter while still receiving an energy input.

Energy plus nutrients set the biomass

- Tropical rain forest is highly productive because light, water, and rapid recycling coincide.
- Desert productivity stays low where water is scarce, even under strong sun.
- Nutrient-rich polar seas can outproduce nutrient-poor tropical surface water.

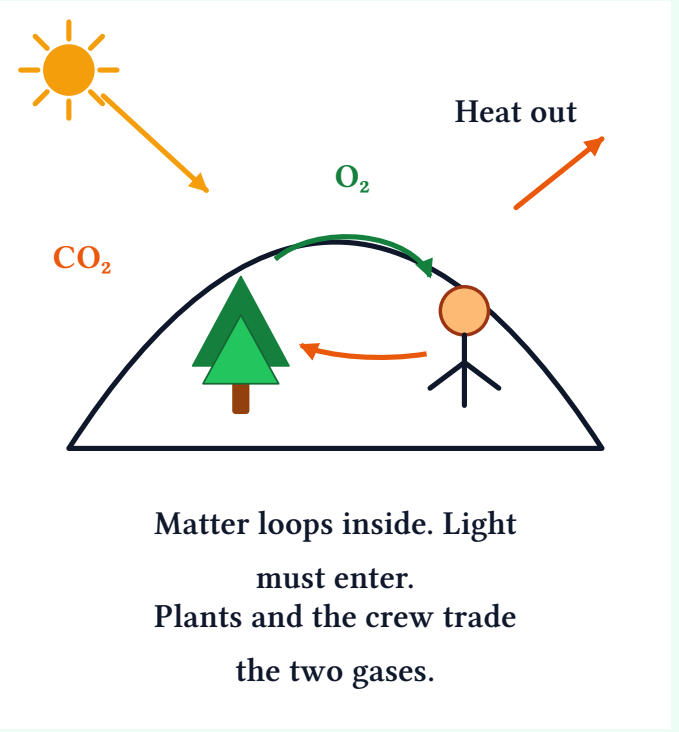


Tracking oxygen and carbon dioxide

- Photosynthesis removes carbon dioxide and releases oxygen.
- Cellular respiration and combustion do the reverse.

Closed habitats and ozone

- In the station drawing, plants and the crew trade oxygen and carbon dioxide.
- Water stays in the loop, and sunlight still has to come in from outside.



Matter loops inside. Light must enter.
Plants and the crew trade the two gases.

Limits and gases

- Explain one productivity pair with energy and a nutrient or water limit.
- State the gas result of forest loss and the role of stromatolites.

Limits become habitats

- Unit B: Ecosystems and population change asks which species can live under the limits you named here.
- Niches and abiotic factors start from productivity, water, and climate.

Image credits

Willem van Aken, CSIRO, CSIRO ScienceImage 3829 Tropical rainforest canopy near Cairns QLD, CC BY 3.0

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Unit B: Ecosystems and population change

Habitats and niches

One lynx, four levels

- A single Canada lynx is one member of a species.
- The hares, spruce, and snow around it belong to a larger system than the lynx alone.



Niches within an ecosystem

- A population is one species in one area.
- A community is the populations living together.
- A niche is the role, and a habitat is the place where that role happens.

Key terms

ecosystem

The community of organisms plus the abiotic surroundings they use in one place.

niche

The role a species plays, including what it eats, where it feeds, and the conditions it tolerates.

habitat

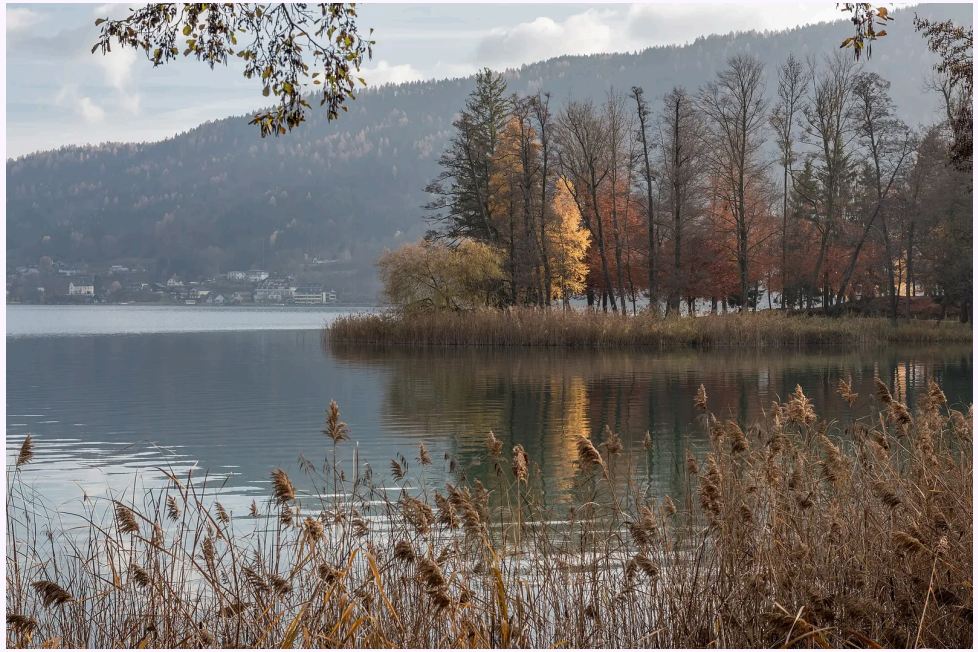
The physical place where a species lives, such as the forest floor or the littoral zone.

population

A group of organisms of one species living in the same area at the same time.

Layers in the forest and the lake

- Terrestrial layers run from canopy to sub-canopy, forest floor, and soil.
- Lake zones run from littoral shallows to limnetic open water, profundal dark water, and benthic bottom.
- Each layer offers habitats, and several niches can share one layer.



Plant and microclimate study

- The question names the dominant plant and one abiotic measure.
- The plan says where the samples sit, under the plant and in the open.

A one-line niche

- A niche line names food, feeding place, and one condition.
- A habitat line names only the layer or zone.

Stack and role

- Define population, community, and ecosystem with one local example.
- Separate habitat from niche for one lake organism.

Limits decide who stays

- The next lesson measures abiotic and biotic limits in a local place.
- A niche can be empty when a limit sits outside what the species tolerates.

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Johann Jaritz, Pörtschach Halbinselpromenade Naturpark im Landschaftsschutzgebiet 18112021 1711, CC BY-SA 4.0

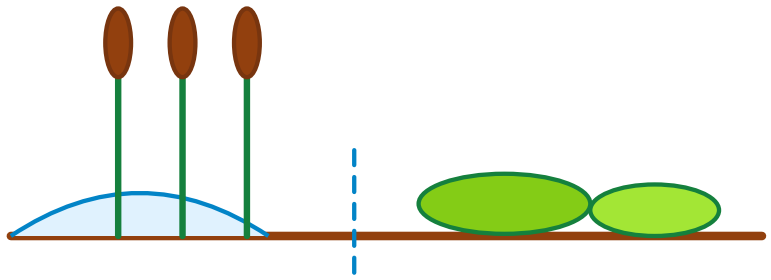
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Unit B: Ecosystems and population change

Local ecosystems and limiting factors

Cattails stop where the water stops

- Cattails ring the slough and fade out within a few metres of dry prairie.
- Grass covers the upland where the cattails are absent from the stand.



The cattail edge is the habitat boundary

Abiotic and biotic limits

- Abiotic factors include moisture, temperature, light, soil, oxygen, and nutrients.
- Biotic factors include competitors, predators, and parasites.
- A limiting factor is the condition that most restricts distribution or population size.

Key terms

limiting factor

An abiotic or biotic condition that restricts where a species lives or how large its population grows.

abiotic factor

A physical or chemical condition, such as temperature, moisture, light, oxygen, or soil nutrients.

biotic factor

A living influence, such as a competitor, a predator, or a parasite.

range

The geographic area where a species is found.

A limiting factor sets the habitat edge

- Cattails require saturated soil, so moisture limits their upland range.
- Trout require cold, oxygen-rich water, so temperature and oxygen limit warm ditches.
- Competitors and predators limit abundance even when the abiotic setting is suitable.



Measurement precision

- Write the reading and the plus-or-minus precision of the tool.
- Compare two sites with the same tool before you claim a difference.

Rebuild a disturbed patch

- A reclamation plan names the limiting factors the disturbance created.
- The plan chooses plants that match the moisture and soil that remain.

Limits and tools

- Give one abiotic and one biotic limiting factor for a local species.
- Explain how tool precision changes a conclusion.

Names make the field list usable

- The next lesson assigns binomial names and kingdom-level nutrition.
- Human changes to biodiversity use the limits you measured.

Image credits

Diane9247, Pond, cattail grass, sunlight (North of Klamath Falls, OR), CC BY-SA 3.0

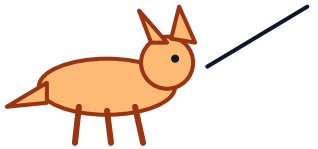
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Unit B: Ecosystems and population change

Scientific names and human impact

Lynx canadensis on a label

- The name card uses two words, and the first word starts with a capital L.
- People in another language can still look up that same lynx.



Lynx canadensis

Genus species

Genus is the group. Species is the kind.
A capital on the second word breaks the name.
Italic in print. Underline when you handwrite.

Feed first, then the two-word name

- Plants build food with light, animals eat other organisms, and fungi absorb digested food.
- The genus is the group. The species epithet picks one member.
- A field list writes the genus with a capital and the species word in lowercase.

Key terms

binomial nomenclature

The two-word scientific name: a genus and a species epithet.

introduced species

A species people bring into an ecosystem where it was absent from the local community.

genus

The first word of a scientific name, shared by closely similar species.

species epithet

The second word of a scientific name, which picks out one species in the genus.

A new arrival can take the space

- Purple loosestrife can crowd out cattails along a marsh edge.
- Tropical fish released in the Banff hot springs live where the water stays warm.
- A drained wetland removes the shallow habitat whole communities use.



Scientific name format

- Capitalize the genus. Keep the species epithet lowercase.
- Add the feeding type when the question asks for the kingdom clue.

Marsh restoration options

- Name the introduced plant and the local plant it crowds.
- Pick one action and say which animals gain nesting space.

Names and change

- Write one binomial with the capital in the right word.
- Explain one introduced species using a local habitat.

A named species still varies

- The next lesson stays with one species and looks at differences inside it.
- Those differences are the raw material for natural selection.

Image credits

U.S. Fish and Wildlife Service, National Conservation Training Center, Purple Loosestrife, public domain

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Unit B: Ecosystems and population change

Variation and natural selection

The lynx sees the brown hare

- On patchy snow, the white hare blends in and the brown hare stands out.
- The lynx catches the hare it can see, and that hare leaves fewer young.



Differences first, then sorting

- A heritable mutation can change a trait the offspring receive.
- Sexual reproduction mixes traits so litters are uneven.
- Natural selection keeps the versions that leave more young.

Key terms

natural selection

Heritable traits that help survival or reproduction become more common in the next generation.

heritable mutation

A change in DNA that can be passed to offspring and may help, harm, or do little in a given place.

sexual reproduction

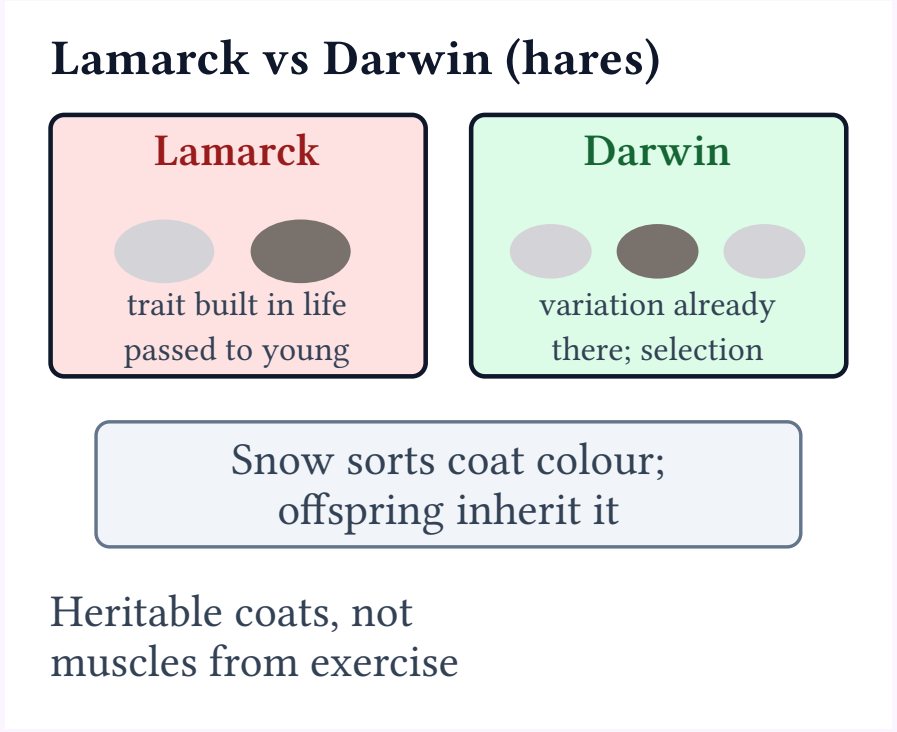
Reproduction that combines genetic material from two parents, so offspring differ.

acquired trait

A feature gained during one lifetime, such as a muscle built by exercise.

Lamarck’s idea and Darwin’s explanation

- Lamarck said a trait built during life is passed to the young.
- Darwin said heritable variation is already present, and some individuals leave more young.
- The hare example sorts coats that the young can inherit.



Measuring inherited variation

- Pick one trait you can measure on many individuals of one species.
- Say how you will know the differences are worth graphing.

Explanations for hare colour

- Point to the coat the young hares can inherit.
- Leave the exercise story on the acquired-trait side.



Sorting and sources

- Explain the hare coats with natural selection.
- Name mutation and sexual reproduction as sources of heritable differences.

The long record of this sorting

- Fossils, limbs, embryos, and DNA are the next evidence.
- Speciation is what this sorting can do when populations are split.

Image credits

Colin Canterbury/USFWS, Snowshoe hare transitioning, public domain

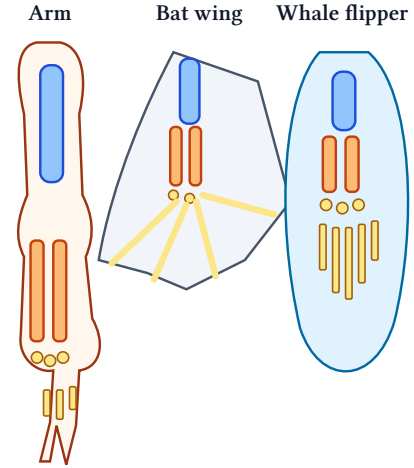
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Unit B: Ecosystems and population change

Evidence for change and speciation

Arm and whale flipper

- Each outline shows one humerus, then a radius and an ulna, then carpals and pha-langes.
- The arm holds, the bat wing flies, and the whale flipper swims, and the bones stay in that same order.



Blue: humerus (one upper bone)
Orange: radius and ulna
(two lower bones)
Yellow: carpals and phalanges
(wrist and fingers)

Several lines, one conclusion

- Fossils show earlier forms and the order of change.
- Homologous limbs share a plan. Analogous wings share a job.
- DNA similarities line up with the groups the bones suggest.

Key terms

homologous structure

A body part with the same underlying bones or plan in different species, used for different jobs.

analogous structure

A body part with a similar job and a different underlying plan, such as an insect wing and a bird wing.

speciation

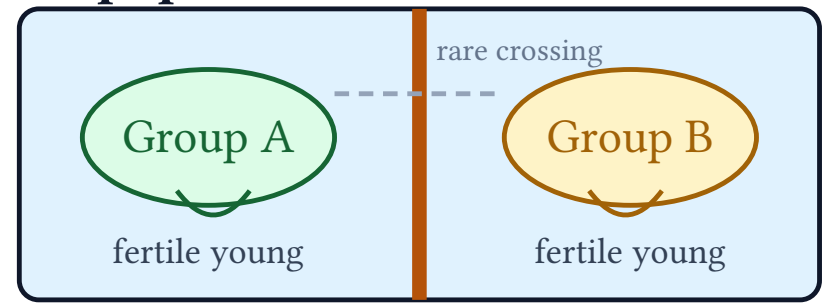
The splitting of one population into two species that produce fertile young within their own group.

reproductive isolation

A barrier that keeps two groups from producing fertile young together.

What has to happen for two species

- A barrier splits one population into two groups.
- Each group faces its own food, climate, or mates.
- Fertile young are produced within each group, and cross-group matings become rare.



Each group faces its own food, climate, or mates

A small data set

- A table of beak depth can show a shift after a dry year.
- A DNA match can show which finches are closer.



Homologous and analogous structures

- Same bone plan means homologous, even when the job differs.
- Same job with a different plan means analogous.

Bones and splits

- Define a homologous structure with the limb example.
- List the conditions for finch speciation.

Pace is the remaining question

- Gradualism and punctuated equilibrium describe tempo.
- The Burgess Shale will sit in that argument as evidence.

Image credits

Andrew Katsis, Medium ground finch on Floreana Island in the Galápagos Islands, CC BY 4.0

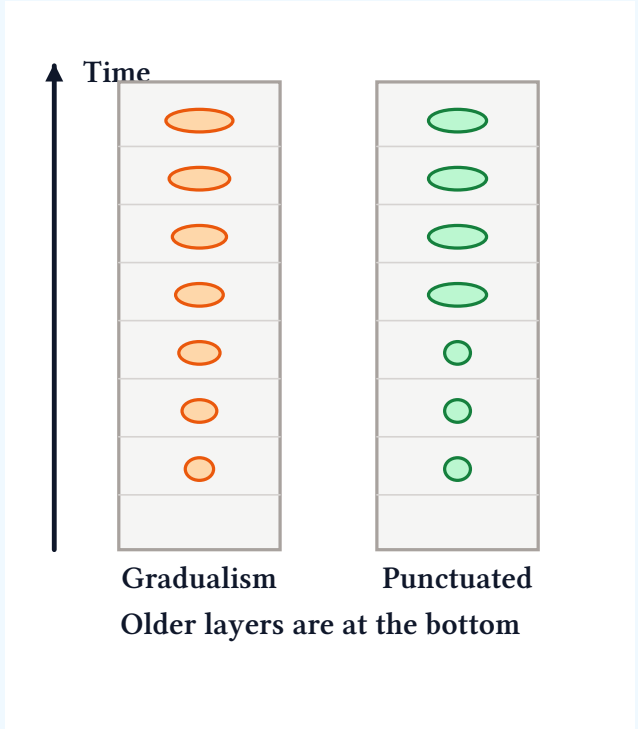
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Unit B: Ecosystems and population change

Gradualism and punctuated equilibrium

Gradual change and long stable stretches

- One sketch rises smoothly from older layers to younger layers.
- The other stays flat, jumps, and stays flat again.



Fossil layers show the tempo of change

- Gradualism means steady change through the layers.
- Punctuated equilibrium means long stability and shorter bursts.
- A mass extinction clears many species and opens space for later bursts.

Key terms

punctuated equilibrium

A pattern of long stable stretches in the fossil record with shorter bursts of change.

gradualism

A pattern of steady change in form across the fossil record.

fossil record

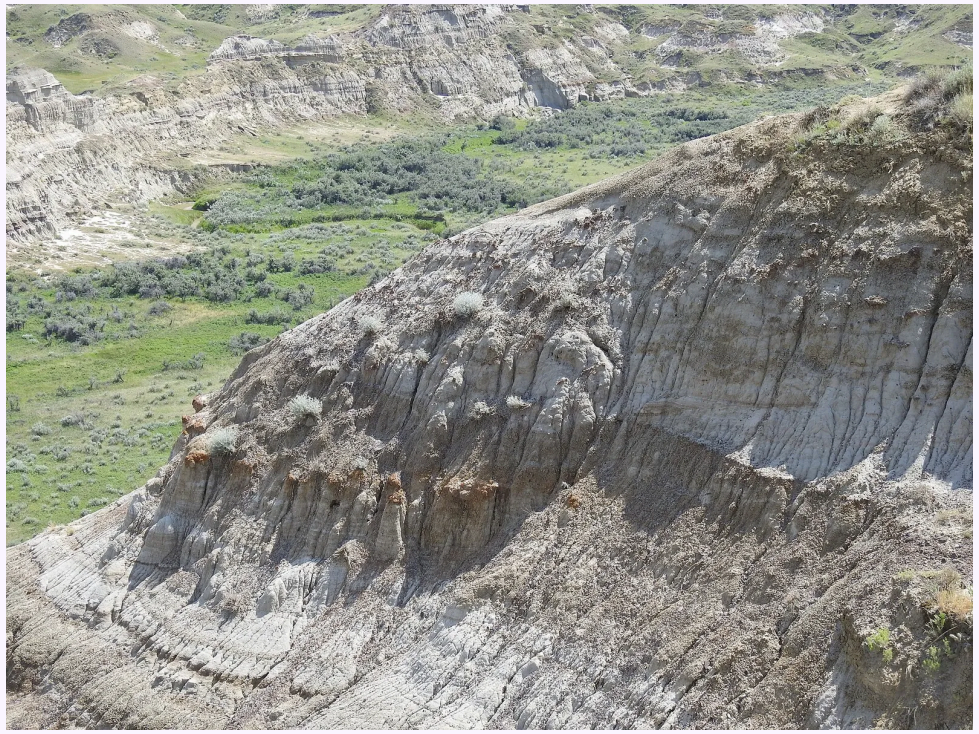
The ordered remains of past life that show when forms lived.

mass extinction

A time when many species disappear from the fossil record together.

Sketches and claims

- A steady series of intermediate fossils supports gradualism.
- Long stretches of the same form, then a new form, support punctuated equilibrium.
- Say when the rock layers are too incomplete to choose.



Plotting a small series

- The axis needs a unit and even spacing.
- The sentence you choose has to match the shape you plotted.

Evidence that changes a conclusion

- A new intermediate fossil can turn a jump into a slope.
- A long stable stack can turn a slope hypothesis into a staircase.

Two tempos

- Describe gradualism and punctuated equilibrium from the sketches.
- Say how a fossil gap can affect the choice.

Producers store the energy

- Unit C: Photosynthesis and cellular respiration opens the chloroplast and asks how light becomes sugar.
- The species in this unit depend on that stored energy.

Image credits

Hirgax, Badlands in Dinosaur Provincial Park, Alberta, CC BY-SA 4.0

Biology 20

Unit C: Photosynthesis and cellular respiration

Light reactions in the thylakoid

Oxygen from pondweed in light

- Pondweed under a bright lamp releases a string of bubbles.
- Move the lamp away and the string slows.



Light, then two chemical products

- Chlorophyll and other pigments absorb light in the thylakoid.
- NADP is reduced to NADPH.
- Chemiosmosis at the membrane stores energy in ATP.

Key terms

thylakoid

The membrane sac inside a chloroplast where the light reactions occur.

chemiosmosis

ATP formation as hydrogen ions flow through ATP synthase in a membrane. ($NADP^+ + H^+$ becomes NADPH)

NADPH

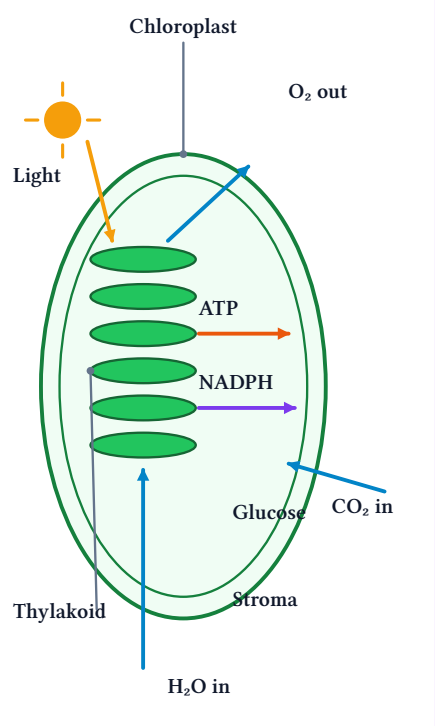
The reduced form of NADP, carrying chemical reducing power from the light reactions.

pigment

A molecule, such as chlorophyll, that absorbs visible light.

Light reactions happen in the thylakoid

- Light hits the stack of green thylakoid discs.
- Water enters the thylakoid and oxygen leaves. ATP and NADPH move into the stroma.
- The fluid around the stack is the stroma. Carbon dioxide enters it, and glucose is made there.



Factor and prediction

- Name light distance or brightness as the factor you change.
- Predict the bubble count in one minute.

Where each product forms

- Point to the thylakoid for NADPH and ATP.
- Save glucose for the stroma lesson.

Light reactions

- Place the light reactions in the chloroplast.
- Name NADPH, ATP, and oxygen.

The stroma uses NADPH and ATP

- NADPH and ATP are ready for carbon dioxide.
- Glucose is the product of that next set of reactions.

Image credits

Krzysztof Ziarnek, Kenraiz, Elodea canadensis kz03, CC BY-SA 4.0

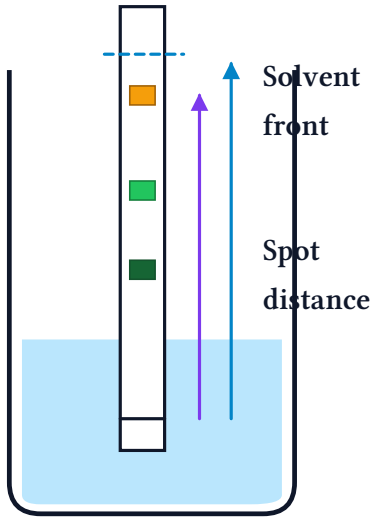
Biology 20

Unit C: Photosynthesis and cellular respiration

Carbon fixation in the stroma

The yellow band travelled farthest

- The paper strip shows a yellow carotene band above two green bands.
- The caption says Rf is the spot distance divided by the solvent distance.



Rf = spot distance / solvent distance

The stroma uses NADPH and ATP

- NADPH and ATP move from the thylakoid into the stroma.
- Carbon dioxide enters that same fluid.
- Glucose is the sugar that leaves the reactions.

Key terms

stroma

The fluid in a chloroplast, around the thylakoids, where glucose is assembled.

Rf value

How far a pigment spot travels, divided by how far the solvent travels.

carbon fixation

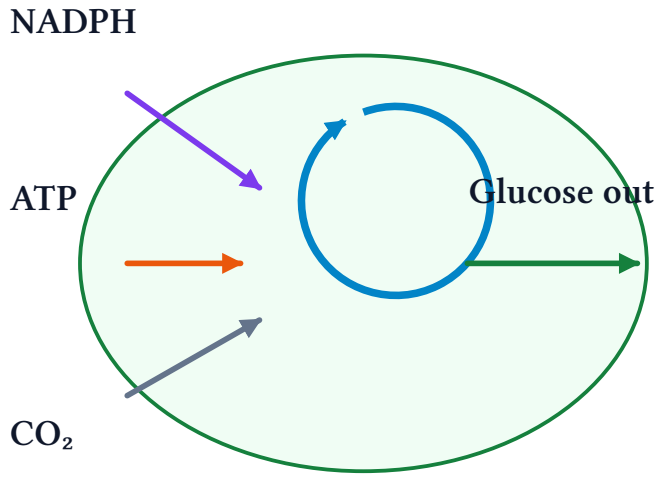
The set of reactions that attaches carbon dioxide into a sugar.

iodine test

A stain that turns blue-black where starch is present in a leaf.

The Calvin cycle in the stroma

- NADPH, ATP, and carbon dioxide point into the cycle.
- The cycle sits in the stroma.
- Glucose leaves along the green arrow.



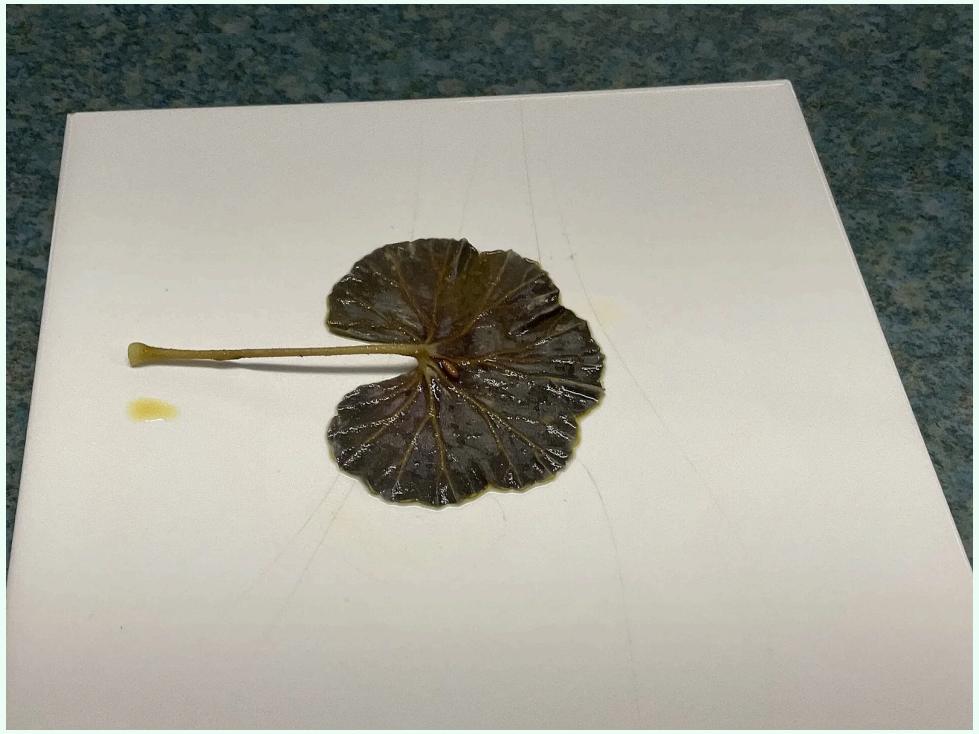
The cycle turns in the stroma

Divide the two distances

- Measure from the start line to the middle of the spot.
- Measure from the start line to the solvent front, then divide.

Stains and light

- The lit half of the leaf goes dark with iodine where starch formed.
- The covered half stays pale on the same leaf.



Stroma and strip

- Place glucose-building in the chloroplast.
- Show one Rf value with both distances.

Fields store and use this sugar

- Crops store the glucose this stroma path builds.
- The next lesson follows that sugar into farming and water loss.

Image credits

DariaWi, GinkgoLeaf1, CC BY 4.0

Biology 20

Unit C: Photosynthesis and cellular respiration

Photosynthesis in fields and labs

Grain holds sugar made in sunlight

- A barley field turns a summer of light into grain you can harvest.
- The same open leaves are losing water while they take in carbon dioxide.

Three field facts from one leaf path

- Agriculture and forestry harvest carbon that photosynthesis stored.
- Evapotranspiration rises when stomata stay open in sun and wind.
- A herbicide can block the electron path that makes NADPH and ATP.

Key terms

evapotranspiration

Water evaporating from soil and from leaves, including the water lost through open stomata.

herbicide

A chemical used to kill or stunt plants, sometimes by blocking the light reactions.

C4 photosynthesis

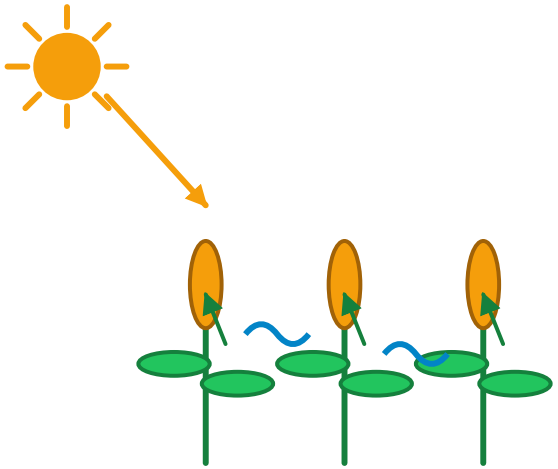
A leaf path, used by corn, that concentrates carbon dioxide for the sugar-building enzyme.

stomata

Pores in a leaf that let carbon dioxide in and water vapour out.

What the barley drawing shows

- The top bar says sunlight on the crop.
- Green arrows carry sugar into the grain head.
- Blue waves are water leaving the leaves.



Sugar arrow into the head

Waves are water leaving the leaf

Covered soil and pot mass

- Cover the soil so the loss is from the leaves.
- Compare one sunny hour with one shady hour.

One herbicide, one blocked step

- Name the crop and the product in the first sentence.
- Say whether the brief claims a block in the light reactions.

Field and lab

- Connect grain to photosynthesis.
- Explain a water-loss comparison and a herbicide block.

Respiration releases the energy in sugar

- Cells can release the energy stored in that glucose.
- The next lesson starts in the cytosol with glycolysis.

Biology 20

Unit C: Photosynthesis and cellular respiration

Glycolysis and the Krebs cycle

The sugar splits before the loop

- A glucose hexagon in the cytosol leads to two pyruvate circles.
- NADH is marked in the cytosol and again by the matrix loop.

Cytosol first, matrix second

- Glycolysis in the cytosol forms pyruvate and NADH.
- The Krebs cycle turns in the mitochondrial matrix.
- That loop releases carbon dioxide and forms NADH and FADH.

Key terms

glycolysis

The cytosol pathway that splits glucose into pyruvate and forms NADH.

Krebs cycle

The loop in the mitochondrial matrix that releases carbon dioxide and forms NADH and FADH.

pyruvate

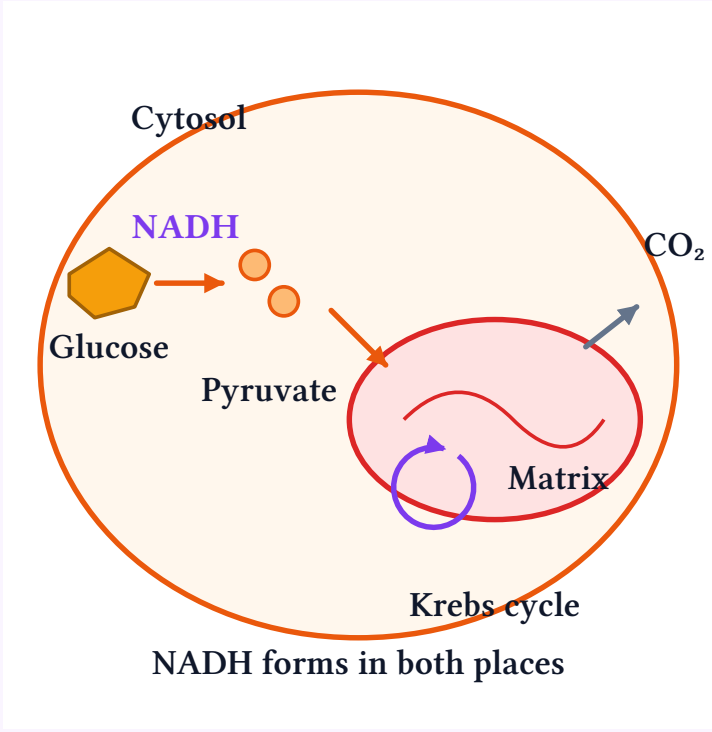
The three-carbon product that leaves glycolysis and can enter the mitochondrion.

FADH

A carrier, formed in the Krebs cycle, that holds reducing power for later ATP production.

Into the matrix

- Pyruvate moves from the cytosol into the mitochondrion.
- The loop drawn in the matrix is the Krebs cycle.
- The caption marks NADH in both places.



NADH forms in both places

Products from one glucose

- One glucose in glycolysis yields two pyruvate molecules.
- The matrix loop then forms NADH and FADH and releases carbon dioxide.

Pea flask comparison

- Germinating peas are the flask expected to warm.
- Dry dormant peas are the matched flask.



Two stages

- Place glycolysis and name its products.
- Place the Krebs cycle and name NADH, FADH, and carbon dioxide.

NADH and $FADH_2$ still lead to ATP

- NADH and FADH are holding reducing power.
- The inner membrane is where that power becomes ATP.

Image credits

pics pd, Mung bean sprouts, close-up, CC0 1.0

Biology 20

Unit C: Photosynthesis and cellular respiration

ATP at the inner membrane

Hydrogen ions return through ATP synthase

- Hydrogen ions sit above the inner membrane bar.
- They flow down through ATP synthase, and ATP leaves into the matrix.

Reducing power becomes ATP

- NADH and FADH supply reducing power at the inner membrane.
- Chemiosmosis is the hydrogen-ion flow through ATP synthase.
- ATP forms in the matrix and can leave to do cell work.

Key terms

chemiosmosis

The flow of hydrogen ions through ATP synthase that stores energy in ATP.

ATP

The molecule that carries usable chemical energy for cell work such as contraction and active transport.

inner membrane

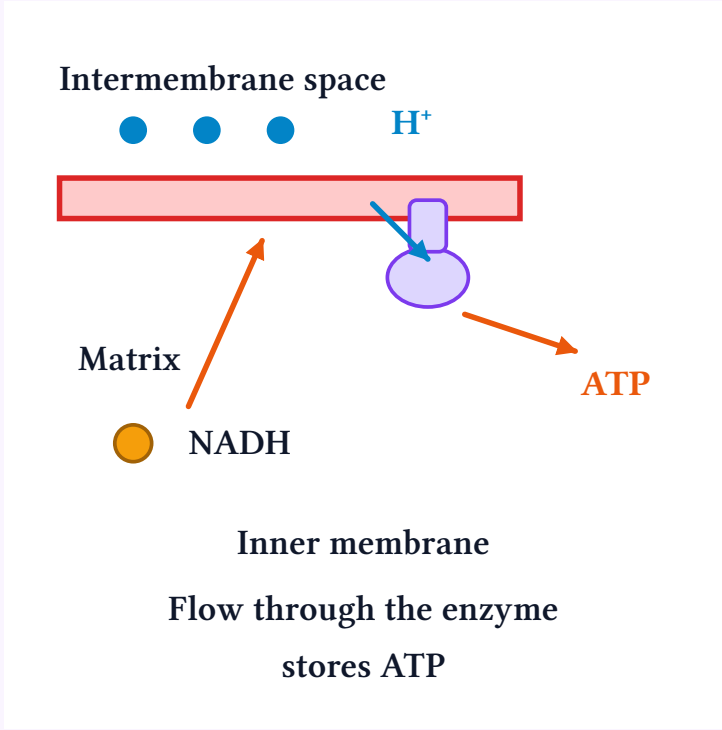
The mitochondrial membrane that holds the electron carriers and ATP synthase.

ATP synthase

The enzyme in the inner membrane that lets hydrogen ions flow back and forms ATP.

ATP forms at the inner membrane

- NADH is in the matrix, donating upward.
- The ion arrow points back through the enzyme.
- The caption says that flow stores ATP.



Send each element to its exit

- Carbon atoms from glucose leave as carbon dioxide.
- Hydrogen from glucose and inhaled oxygen meet in water.

Jobs that use ATP

- Contraction in the heart spends ATP.
- Active transport in the gut spends ATP too.

Ions and atoms

- Describe chemiosmosis at the inner membrane.
- Send glucose carbon and inhaled oxygen to their products.

Oxygen makes the larger ATP yield possible

- This membrane path needs oxygen to keep accepting electrons.
- Cells have shorter routes when oxygen is scarce.

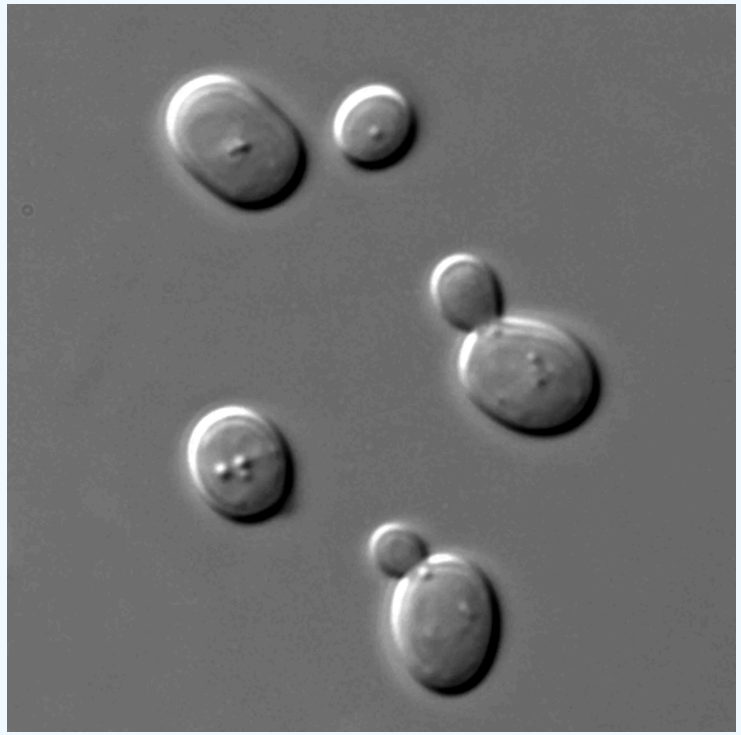
Biology 20

Unit C: Photosynthesis and cellular respiration

Routes when oxygen is scarce

Three branches from pyruvate

- The oxygen branch shows a mitochondrion and a tall ATP stack.
- Muscle shows lactic acid and a short stack. Yeast shows alcohol, carbon dioxide, and a short stack.



Oxygen and ATP yield

- Aerobic respiration uses the mitochondrion and builds many ATP.
- Fermentation in muscle yields lactic acid and a short ATP count.
- Fermentation in yeast yields alcohol and carbon dioxide, also with a short count.

Key terms

fermentation

An anaerobic route that recycles pyruvate into lactic acid or into alcohol and carbon dioxide, with a small ATP yield.

metabolic toxin

A substance such as cyanide or hydrogen sulfide that blocks the aerobic path in the mitochondrion.

aerobic respiration

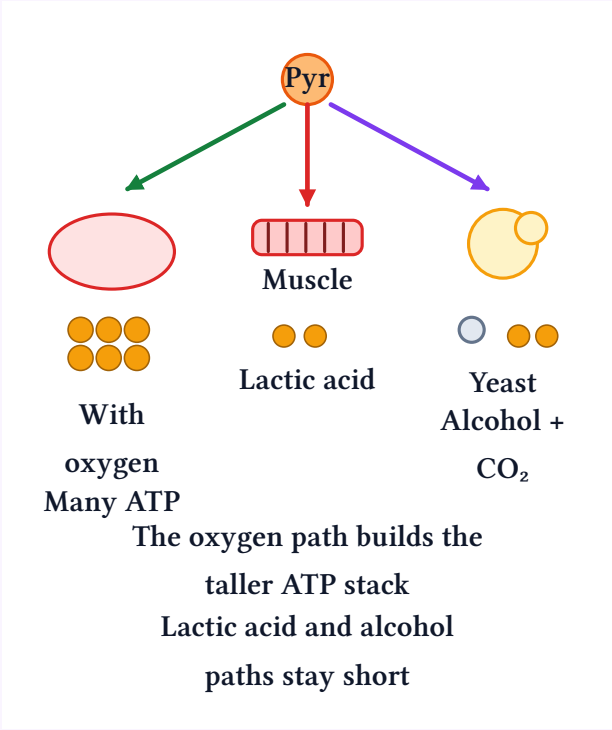
The oxygen-using path through the mitochondrion that builds the larger ATP yield.

lactic acid

The product muscle cells form from pyruvate when oxygen delivery lags behind a sprint.

Each route matches one kind of cell

- The tall stack sits on the branch labelled with oxygen.
- The striped fibre is the lactic acid branch.
- The budding cell is the alcohol and carbon dioxide branch.



Pea respiration data

- Germinating peas consume more oxygen and warm more.
- Dry dormant peas stay cooler and use less oxygen.

Checking a source on toxins

- A toxicology report names the chemical and the evidence.
- An advertisement is a weaker source for a health claim.

Three branches

- Compare ATP yield for oxygen, lactic acid, and alcohol.
- Name one industrial toxin that blocks the aerobic path.

The body has organs for these exchanges

- Cells still depend on food in and gases exchanged.
- Human organs are the next place those exchanges are organized.

Image credits

Masur, S cerevisiae under DIC microscopy, public domain

Biology 20

Unit D: Human body systems

The food tube and the airway

Food and air travel in separate tubes

- Food travels from the mouth through the stomach to the intestines.
- Air travels from the nose and pharynx through the trachea to the lungs.

Organs on each tube

- The digestive tract includes mouth, esophagus, stomach, and intestines.
- Liver, pancreas, and gall bladder add secretions to that tube.
- The airway runs from the nose and pharynx through the larynx and trachea to the bronchi and alveoli.

Key terms

digestive tract

The food tube from the mouth through the esophagus, stomach, and intestines.

absorption

The movement of digested nutrients from the small intestine into the blood.

peristalsis

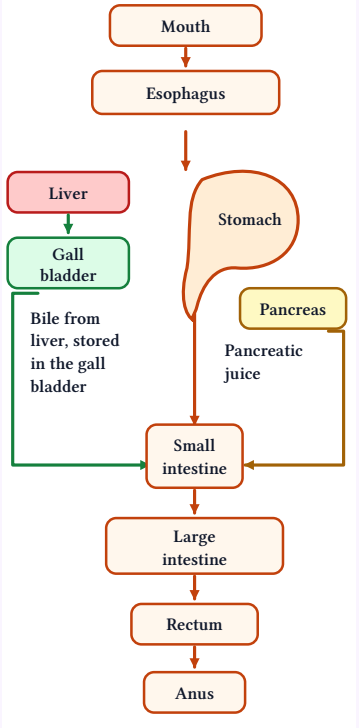
Waves of muscle that push food along the digestive tract.

trachea

The ringed tube that carries air from the throat toward the bronchi and lungs.

A meal moves through the digestive tract

- Chewing in the mouth is a physical breakup of the bite.
- Liver and pancreas join the intestine with secretions.
- Absorption moves nutrients from the intestine into the blood.

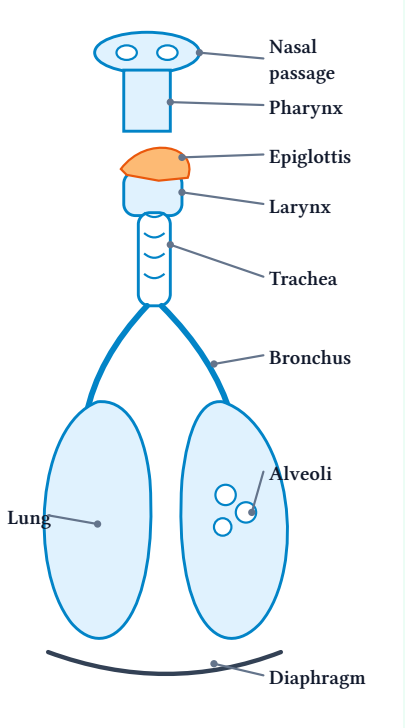


Physical and chemical digestion

- Chewing and stomach churning are physical.
- Enzyme action and bile are chemical, and absorption fills the blood.

Swallowing and the epiglottis

- The epiglottis covers the air-way during a swallow.
- Air returns through the tra-chea once the swallow passes.



Tubes and a meal

- List the food-tube organs and the airway organs.
- Mark one physical step and one chemical step, then name absorption.

The chemical steps have names

- Enzymes finish the splits that absorption depends on.
- The next lesson tests foods and watches an enzyme cleft.

Biology 20

Unit D: Human body systems

Enzymes and food tests

The chain fits the cleft

- Starch is drawn as a chain heading into the enzyme cleft.
- Sugar pieces leave on the far side of that cleft.

Three foods, three enzyme families

- Carbohydrases cut carbohydrates such as starch.
- Lipases cut lipids, and proteases cut proteins.
- Temperature, pH, and the amount of substrate change the rate.

Key terms

enzyme

A protein that speeds a reaction because the substrate fits its shape.

competitive inhibition

A slowdown that happens when a different molecule occupies the enzyme's cleft.

carbohydrase

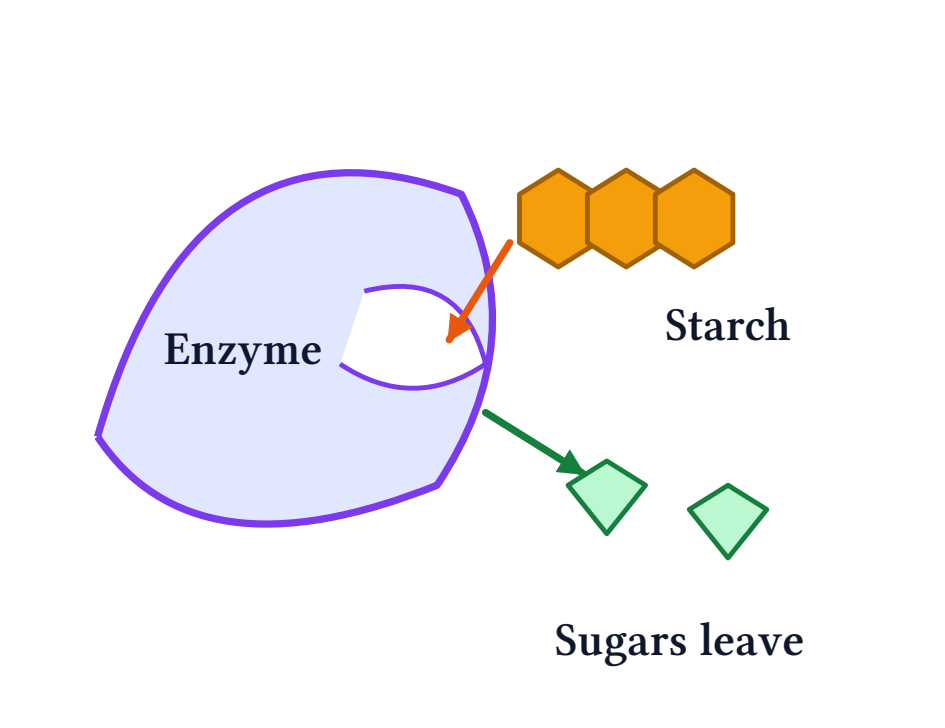
An enzyme that cuts carbohydrates such as starch into sugars.

protease

An enzyme that cuts proteins into smaller peptides and amino acids.

An enzyme at work

- The enzyme shape has a cleft that starch can enter.
- Sugars leave after the bond breaks.
- A molecule parked in the cleft blocks starch.



Pepsin at two pH values

- Pepsin in acid cuts egg-white protein.
- The same protease in a basic tube leaves the cube firmer.

A calorimetry change

- A larger water-temperature rise means more energy left the food.
- Matched mass and matched water make the comparison fair.

Fit and factors

- Match the three enzyme families to starch, fat, and protein.
- Say how pH and competitive inhibition change the cleft.

The airway moves the gases

- Digested food still needs oxygen for the tall ATP path.
- The alveolus is the next exchange surface.

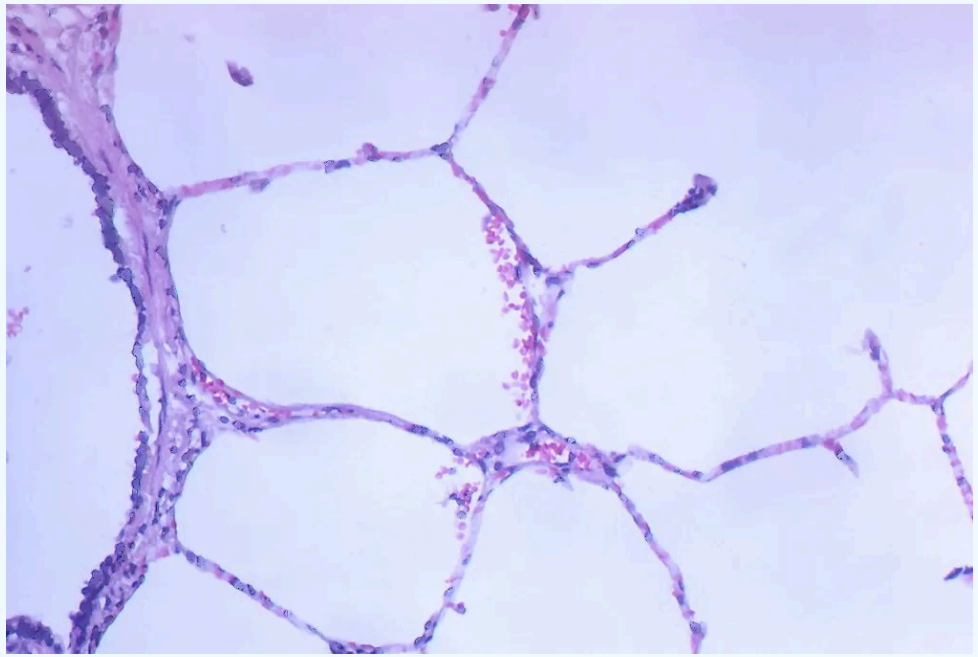
Biology 20

Unit D: Human body systems

Breathing and lung health

Two arrows at a thin wall

- A green oxygen arrow runs from the air sac into the blood.
- An orange carbon dioxide arrow runs from the blood into the air sac.



Breathing and gas exchange

- The diaphragm and rib muscles change the chest size.
- Gas exchange at the alveolus loads oxygen and unloads carbon dioxide.
- Breathing also helps heat leave and helps clear foreign material.

Key terms

alveolus

A thin air sac in the lung where oxygen and carbon dioxide cross with the blood.

gas exchange

The swap of oxygen into blood and carbon dioxide out of blood at the alveolus.

diaphragm

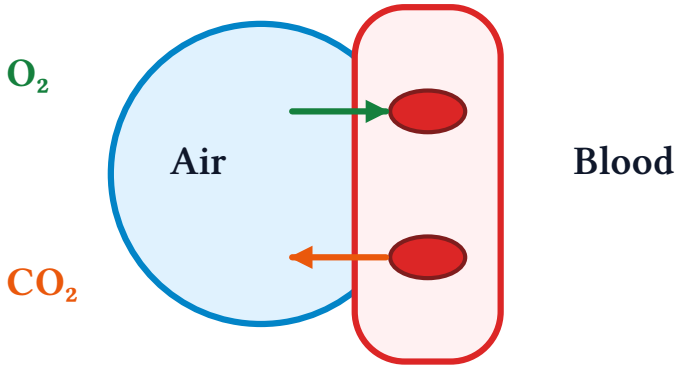
The muscle sheet under the lungs that contracts to enlarge the chest during a breath in.

irradiation

A food treatment that uses radiation to slow spoilage by microbes.

Gases cross at the alveolus

- Oxygen is the arrow aimed at the red blood cells.
- Carbon dioxide is the arrow aimed at the air.
- The caption says the gases cross the shared thin wall.



Gases cross the shared thin wall

Smoking data and technology

- Smoke damages cilia and the walls of alveoli.
- Second-hand smoke exposes people who share the air.

Trusted community sources

- Ranchers and Indigenous hunters have read animal droppings for health clues.
- A respiratory remedy needs a named nation and a community-approved source.

Lungs and sources

- Describe gas exchange and one breathing muscle.
- State one limit of smoking technology and one source rule.

The blood has to move next

- Oxygen that entered the blood still needs a pump.
- The heart circuits are the next map.

Image credits

Yale Rosen from USA, Normal lung, CC BY-SA 2.0

Biology 20

Unit D: Human body systems

The heart and its circuits

Image left is the person’s right

- The blue side of the drawing is labelled person’s right.
- That side sends blood toward the lungs, and the red side sends blood toward the body.

Two pumps in one organ

- The right ventricle feeds the pulmonary circuit to the lungs.
- The left ventricle feeds the systemic circuit to the body.
- Arteries leave the heart, and veins return blood to it.

Key terms

pulmonary circuit

The path that carries blood from the right ventricle to the lungs and back to the left atrium.

systemic circuit

The path that carries blood from the left ventricle through the body and back to the right atrium.

artery

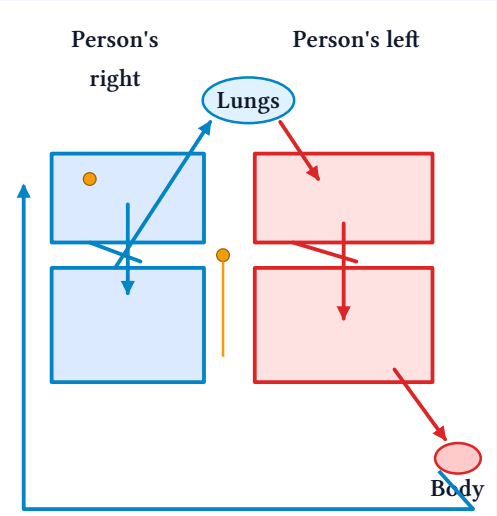
A vessel that carries blood away from the heart, usually under higher pressure.

sinoatrial node

The patch of tissue in the right atrium that starts each heartbeat.

Blood travels two circuits

- Body blood enters the right atrium on the image-left side.
- The right ventricle sends that blood up to the lungs.
- The left ventricle sends high-oxygen blood out to the body.



Blue: low oxygen, toward the lungs

Red: high oxygen, toward the body

Vessel names by direction

- The aorta is an artery leaving the left ventricle.
- The venae cavae are veins entering the right atrium.

Pulse after exercise

- Heart rate rises during the climb.
- The recovery minutes show it settling toward the quiet value.

Two circuits

- Trace the pulmonary circuit from the right ventricle.
- Name the systemic exit and one artery-versus-vein difference.

The fluid in the vessels has parts

- Plasma and cells do the carrying inside these circuits.
- Capillaries are where the exchange with organs happens.

Biology 20

Unit D: Human body systems

Blood and lymph

Three shapes in one liquid

- The red cell is a pale disc, and the white cell shows a nucleus.
- Tiny platelets sit nearby in the same plasma.

Capillaries exchange materials with tissues

- Erythrocytes carry oxygen, and plasma carries dissolved loads.
- Capillaries serve the gut, lungs, kidneys, and muscles.
- The lymphatic system returns fluid that capillaries leave in the tissues.

Key terms

erythrocyte

A red blood cell, shaped like a biconcave disc, that carries oxygen.

lymphatic system

The vessels that collect leftover fluid from tissues and return it toward the blood.

plasma

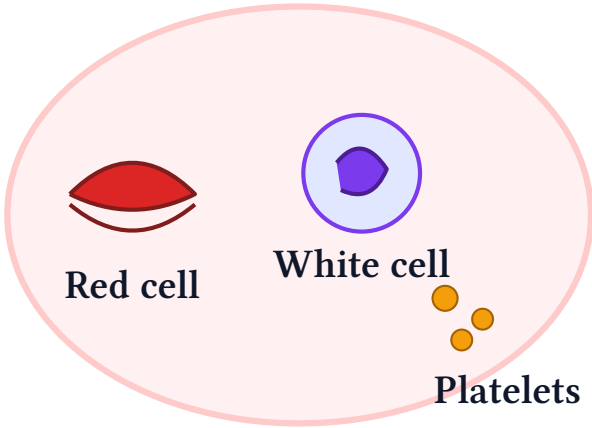
The pale liquid of blood that carries cells, nutrients, wastes, and heat.

platelet

A cell fragment that helps blood clot at a break in a vessel.

Cell shapes and jobs

- The disc is the erythrocyte that carries oxygen.
- The cell with a nucleus is a leucocyte.
- The fragments are platelets, and the liquid is plasma.



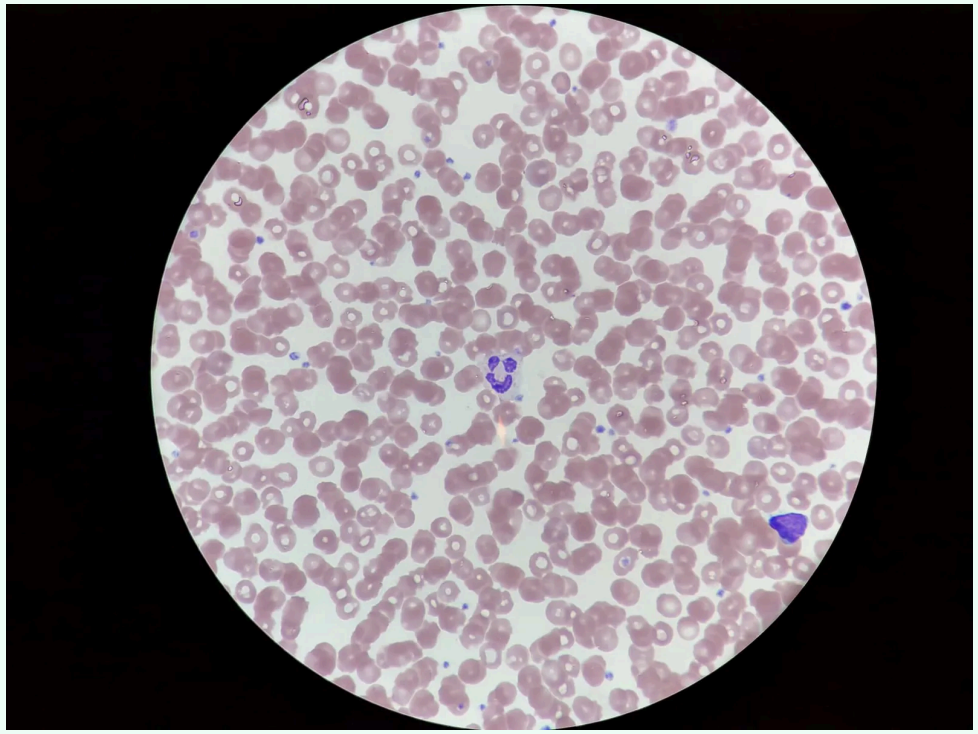
The pale liquid around them is plasma

Four organs, four exchanges

- The lung capillary loads oxygen and unloads carbon dioxide.
- The gut capillary loads nutrients from absorption.

A blood smear

- Red discs should far outnumber white cells on a typical smear.
- A field of mostly white cells is a reason to check the slide region.



Cells and exchange

- Name the four main parts of blood and one job each.
- Describe one capillary exchange and the lymph return.

White cells have specialties

- The nucleated cell in the smear is the start of a larger defence team.
- Blood types are a label on the red cells.

Image credits

Markgirton, Happy neutrophil, CC BY 4.0

Biology 20

Unit D: Human body systems

Defence and blood types

A bacterial infection

- Skin stops most of the bacteria drawn on the surface.
- A macrophage engulfs the one that crossed, and Y shapes leave the B cell.

Cells, then the labels on red cells

- Helper T cells activate B cells and killer T cells.
- Antibodies from B cells match a specific antigen.
- ABO and Rh types are antigens on erythrocytes plus antibodies in plasma.

Key terms

antibody

A Y-shaped protein, released by a B cell, that attaches to a matching antigen.

antigen

A molecule on a cell surface that antibodies or immune cells can recognize.

macrophage

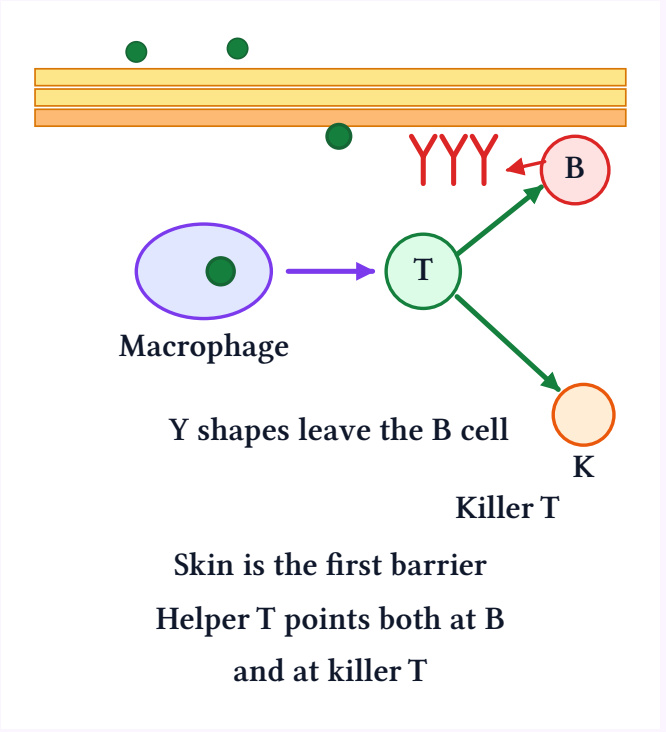
A large white cell that engulfs a pathogen and helps alert helper T cells.

helper T cell

A lymphocyte that coordinates the defence by activating B cells and killer T cells.

Helper and killer T cells

- The macrophage is the cell that engulfs the bacterium.
- The helper T cell points at the B cell and the killer T cell.
- Antibodies are the Y shapes leaving the B cell.



ABO cards before donation

- Write the antigen that sits on the red cell.
- Write the antibody that sits in that type's plasma.

Benefits and limits of a technology

- A vaccine builds memory against an antigen.
- An artificial heart supports pumping and brings surgical risk.

Cells and types

- Order skin, macrophage, helper T, B cell, and killer T.
- Give the antigen and antibody for one ABO type.

Plasma is cleaned downstream

- The kidney keeps the plasma's water and salts in range.
- The nephron is the next structure.

Biology 20

Unit D: Human body systems

The nephron filters plasma

Wide vessel in, narrow vessel out

- The incoming vessel at the capsule is wider than the vessel leaving it.
- Green arrows marked to the blood leave the tubule, and the tube ends at urine.

Steps in kidney function

- The glomerulus filters plasma into Bowman’s capsule.
- Reabsorption along the tubule returns water, glucose, and salts.
- Urine leaves the kidney through the ureter, bladder, and urethra.

Key terms

nephron

The kidney tubule, with its capsule and loop, that filters blood and forms urine.

reabsorption

The return of useful water and solutes from the tubule back into the blood.

glomerulus

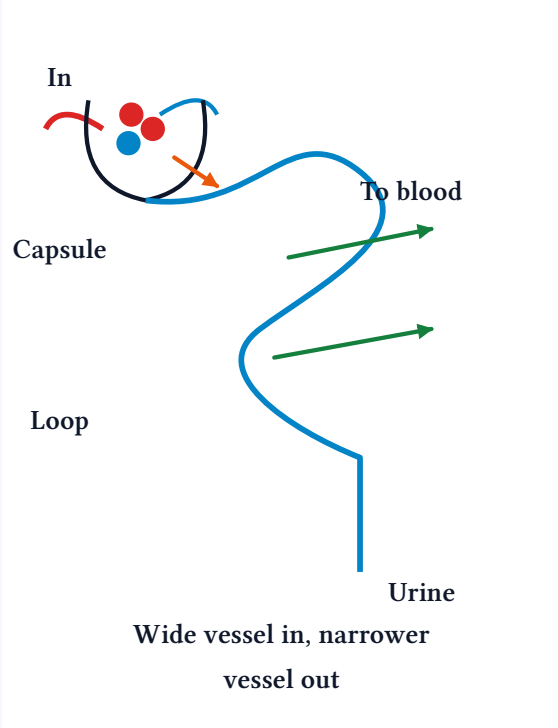
The knot of capillaries inside Bowman’s capsule where filtration begins.

ureter

The tube that carries urine from a kidney to the urinary bladder.

Arrows on the nephron

- Filtration is the step inside the capsule.
- The green arrows are reab-sorption to the blood.
- The end of the tube is urine.



A daily flowchart

- Extra drinking water leads to a larger urine volume.
- Heavy sweat leads the nephron to return more water.

Organs on a diagram

- The kidney sits above the ureter on each side.
- The bladder stores urine before the urethra expels it.

Filter and return

- Place filtration and reabsorption on the nephron.
- Name the organs that store and expel urine.

Hormones change the last duct

- The collecting duct can return more water or let it stay in the urine.
- ADH is the signal the next lesson adds.

Biology 20

Unit D: Human body systems

Kidney regulation and dialysis

Pores appear when ADH arrives

- The left duct is marked little ADH, and its water arrow stays inside.
- The right duct has green pores, and water arrows leave when ADH is present.

Two hormones, two saved materials

- Antidiuretic hormone saves water at the collecting duct.
- Aldosterone saves sodium and supports blood pressure.
- Caffeine and alcohol lead to a larger urine volume.

Key terms

antidiuretic hormone

The hormone, also called ADH, that adds water channels to the collecting duct.

dialysis

A treatment that lets wastes and extra water leave the blood across a membrane when kidneys fail.

aldosterone

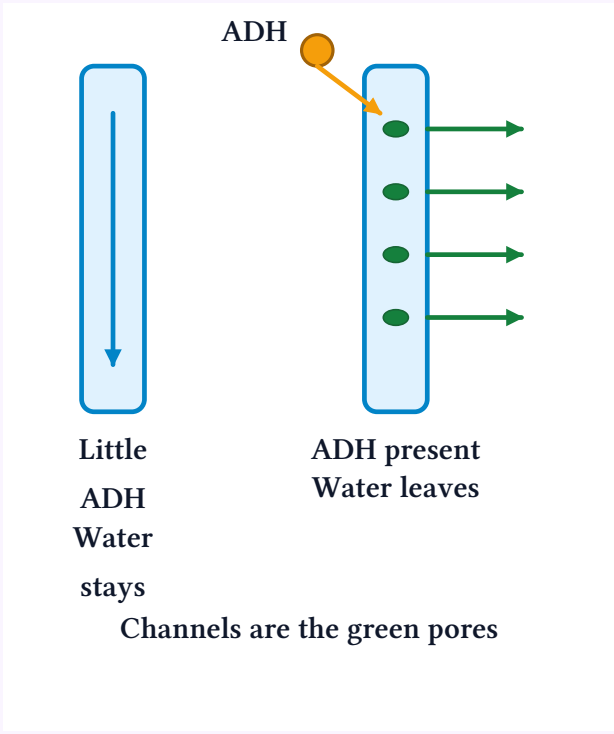
The hormone that increases sodium reabsorption and helps support blood pressure.

collecting duct

The last channel of the nephron, where ADH decides how much water returns to the blood.

ADH changes how much water returns

- Green pores mean antidiuretic hormone is present.
- Water leaving the duct returns to the blood.
- A duct with little hormone keeps the water in the lumen.

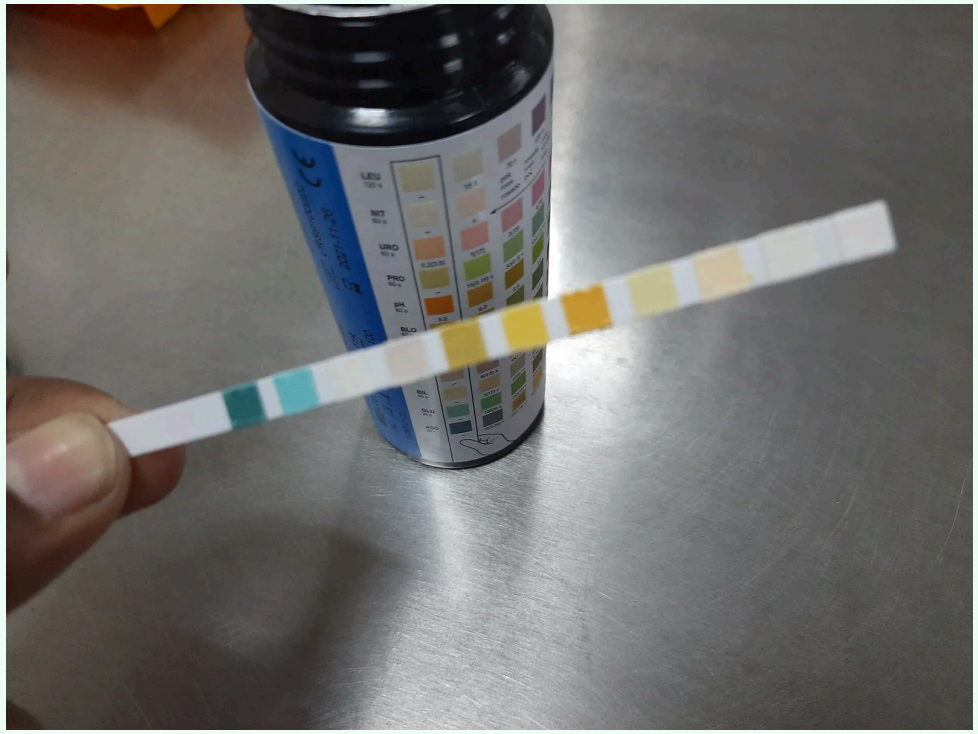


Urine and fluid intake

- A large water intake lowers antidiuretic hormone.
- The duct then keeps water in the urine.

Urine test strips and their limits

- Compare each simulated result with the expected range.
- A single strip is a class model, and a clinical lab uses a tighter method.



Pores and machines

- Compare the duct when antidiuretic hormone is present and when it is scarce.
- Say what dialysis moves out of the blood.

Muscles move the rest of the body

- Smooth, cardiac, and skeletal muscle support these organs.
- The sliding filament is the next mechanism.

Image credits

Ajay Kumar Chaurasiya, Special urine test during urine analysis, CC BY-SA 4.0

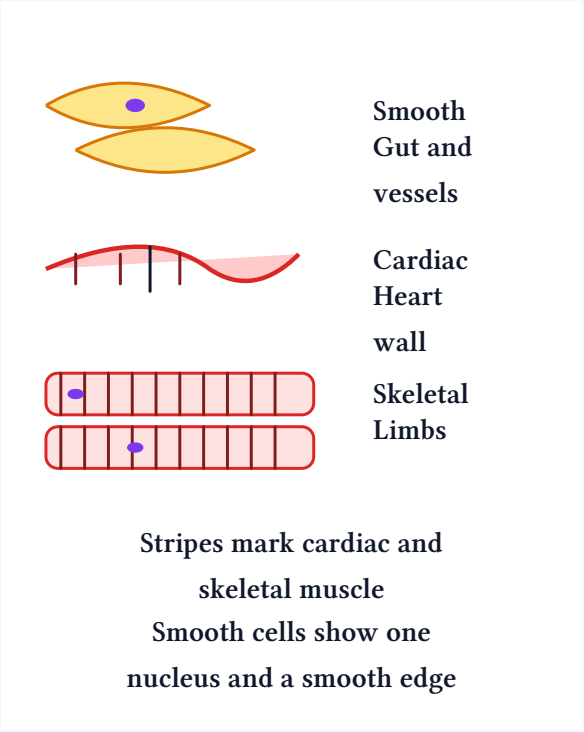
Biology 20

Unit D: Human body systems

Three muscles and the sliding filament

Three shapes under the lens

- Smooth cells taper, with one nucleus, and they serve gut and vessels.
- Cardiac cells branch in the heart wall, and skeletal fibres are long and striped in the limbs.



Each tissue holds up other systems

- Smooth muscle moves food and changes vessel width.
- Cardiac muscle pumps blood through both circuits.
- Skeletal muscle breathes, stands, and walks, and it makes heat.

Key terms

cardiac muscle

The striped, branching muscle of the heart wall that pumps blood.

sarcomere

The repeating unit of a striped muscle fibre, from one Z line to the next.

actin

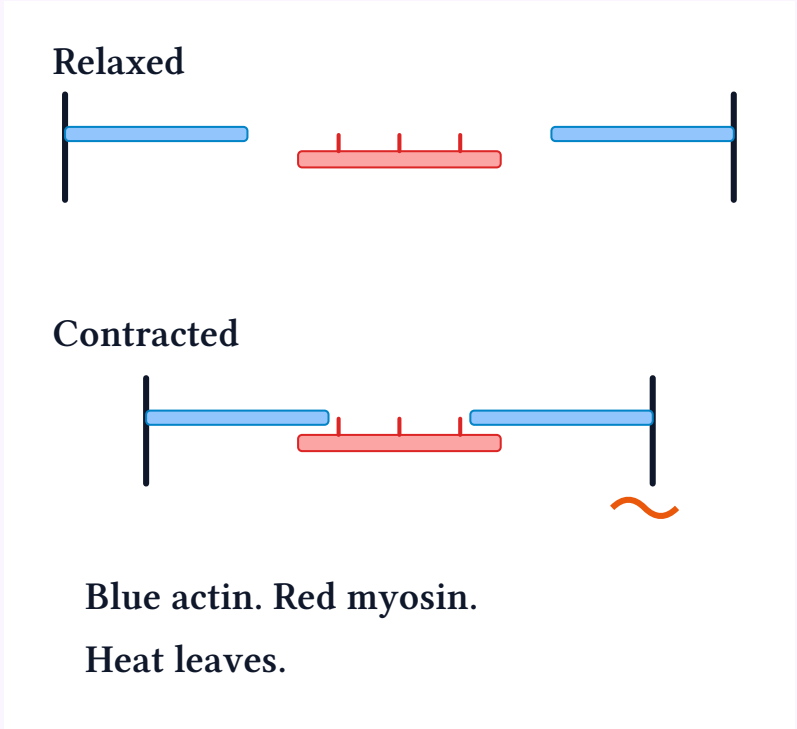
The thin filament, drawn in blue, that slides inward over myosin.

myosin

The thick filament, drawn in red, that pulls on actin during contraction.

The filaments slide and stay long

- Blue actin and red myosin keep their length in both drawings.
- The contracted sarcomere has closer Z lines and more overlap.
- A small heat mark leaves the working sarcomere.



A paper sarcomere

- Record actin length and myosin length before the slide.
- After the Z lines move closer, those lengths read the same.

Tissues and organ jobs

- Peristalsis in the intestine is smooth muscle.
- The heartbeat is cardiac muscle, and a step is skeletal muscle.

Tissue and slide

- Tell the three muscle tissues apart with one visual clue each.
- Describe the sliding filament and the heat that leaves.

More lifts, more heat

- The heat mark on the contracted sarcomere can be measured.
- The next lesson compares one lift with many lifts.

Biology 20

Unit D: Human body systems

Muscle fatigue and care

ATP use in repeated lifts

- The single curl shows one gold ATP circle and one heat wave.
- The repeated curls show a stack of ATP circles and several heat waves.

Muscle force and fatigue

- Each contraction spends ATP and releases some energy as heat.
- Muscle fatigue shows up as a drop in force during repeated work.
- Creatine phosphate can rebuild ATP for a brief burst.

Key terms

muscle fatigue

The drop in force that appears when a muscle's ATP supply lags behind repeated work.

creatine phosphate

A small energy store in muscle that can quickly rebuild ATP for a short burst.

anabolic steroid

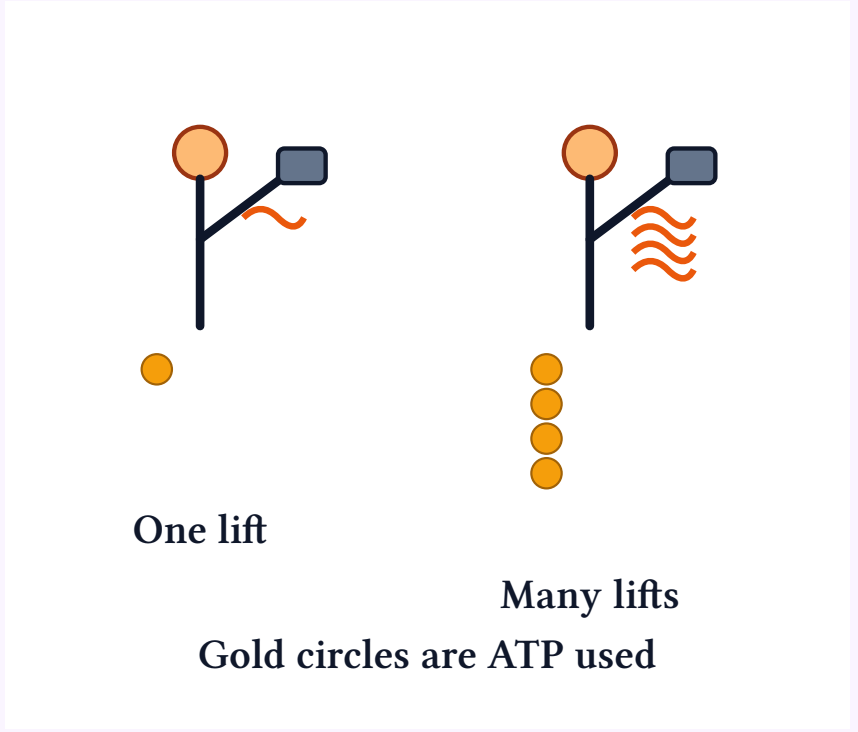
A drug related to testosterone that can increase muscle size and also harm other body systems.

tendonitis

Inflammation of a tendon, often after repeated overload where muscle meets bone.

More ATP use releases more heat

- Gold circles count ATP used, and they stack on the busy side.
- Heat waves increase on that same side.
- The muscle is the same arm in both drawings.



A small heat table

- Ten curls raise skin temperature more than two curls.
- The unit on the table is degrees Celsius.

Injury words and drug limits

- Atrophy is muscle loss from disuse, strain is a tear from over-load, and tendonitis is an irritated tendon.
- An anabolic steroid can enlarge muscle and harm the heart, liver, and hormone balance.

Heat and care

- Relate ATP use and heat to repeated lifts.
- Define muscle fatigue and one injury, and name a steroid harm.

Heat still leaves the living system

- The heat waves on the busy arm are energy leaving the body.
- That same idea opened the course in the biosphere.