Energy and matter in the biosphere slide deck

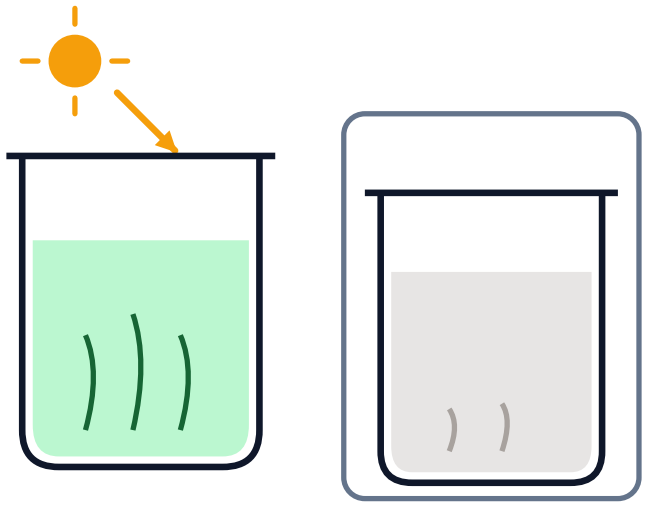
Biology 20

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

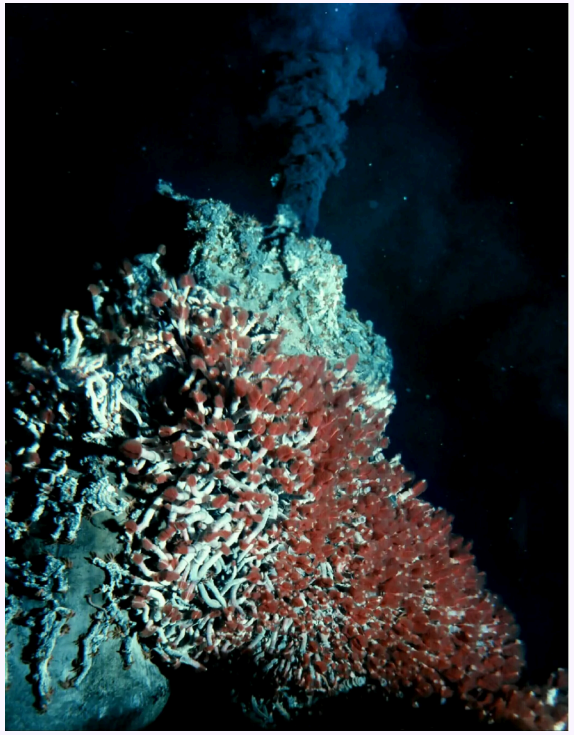
Building organic molecules with energy released by inorganic chemical reactions.

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

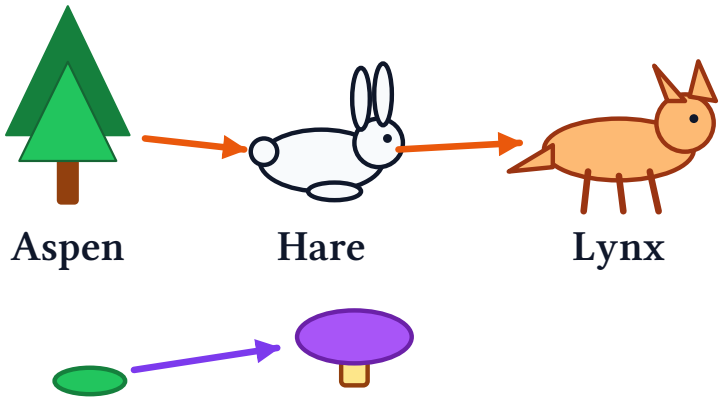
The feeding position of an organism, counted from the producers upward.

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

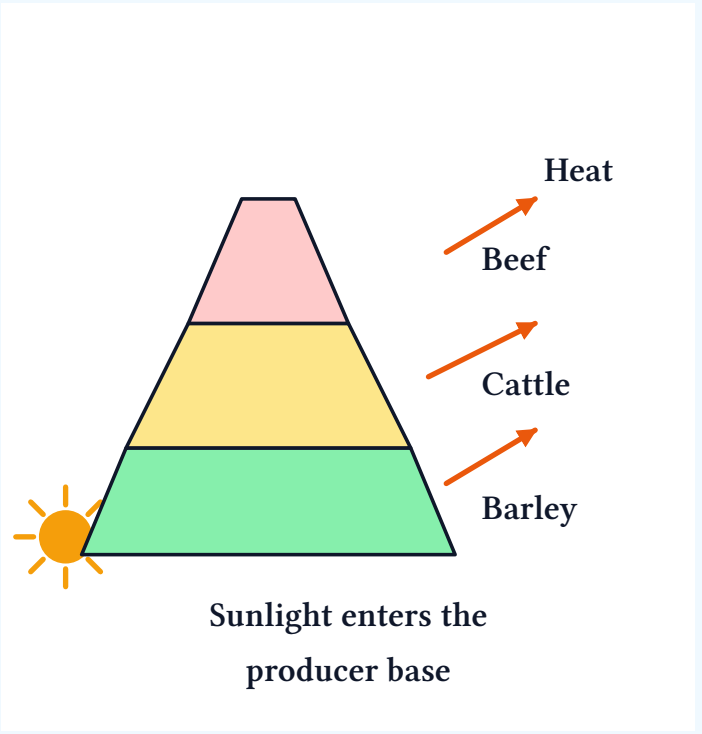
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Ecological pyramids

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

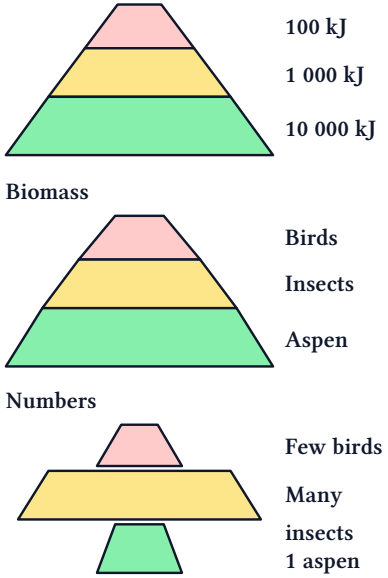
A stack of trophic levels drawn by the dry mass of organisms at each level.

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.

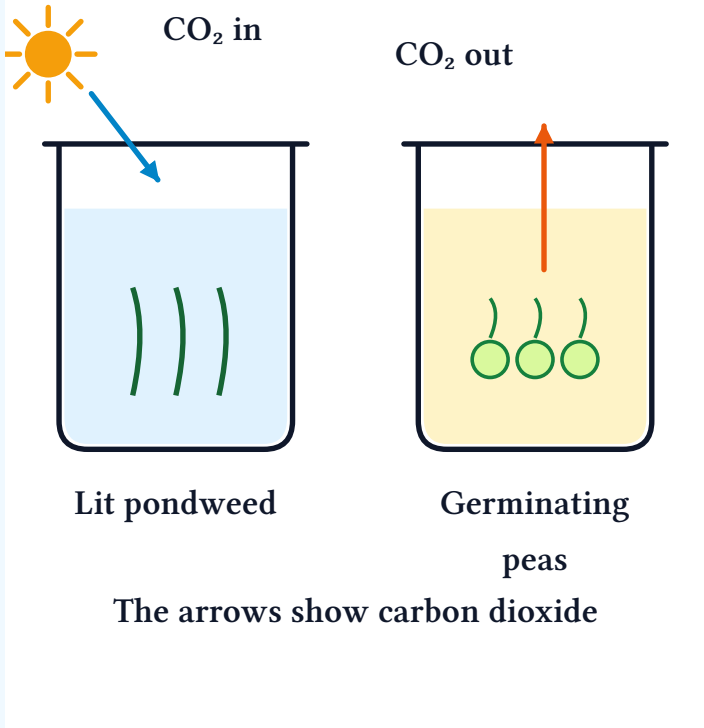
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Unit A: Energy and matter in the biosphere

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

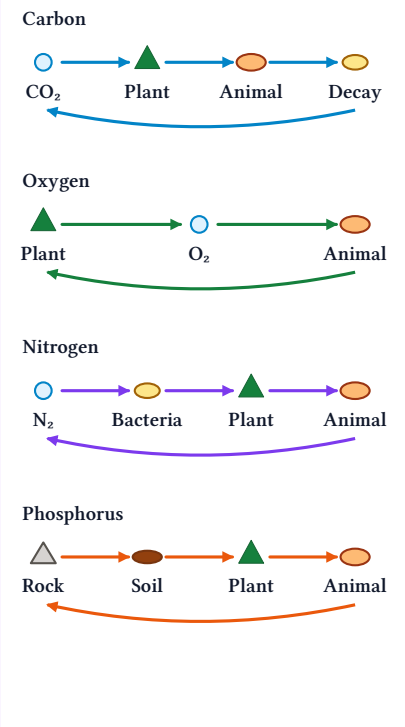
The movement of phosphorus from rock and soil into organisms and back to soil and sediment.

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

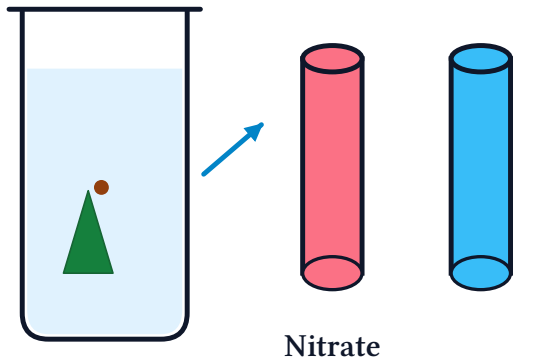
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Unit A: Energy and matter in the biosphere

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

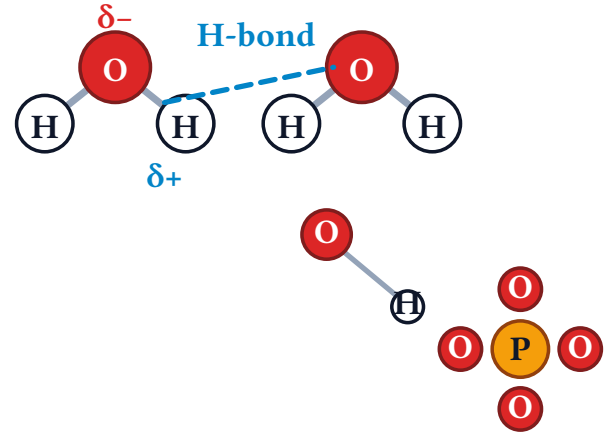
Water molecules staying together through hydrogen bonds, which supports flow in soil and in xylem.

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

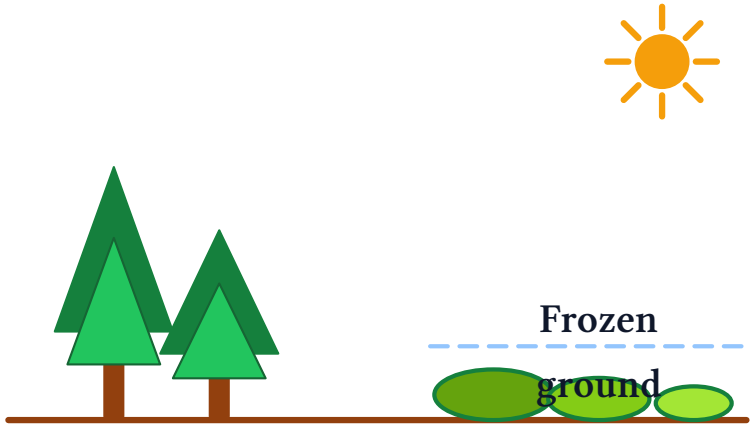
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Unit A: Energy and matter in the biosphere

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.

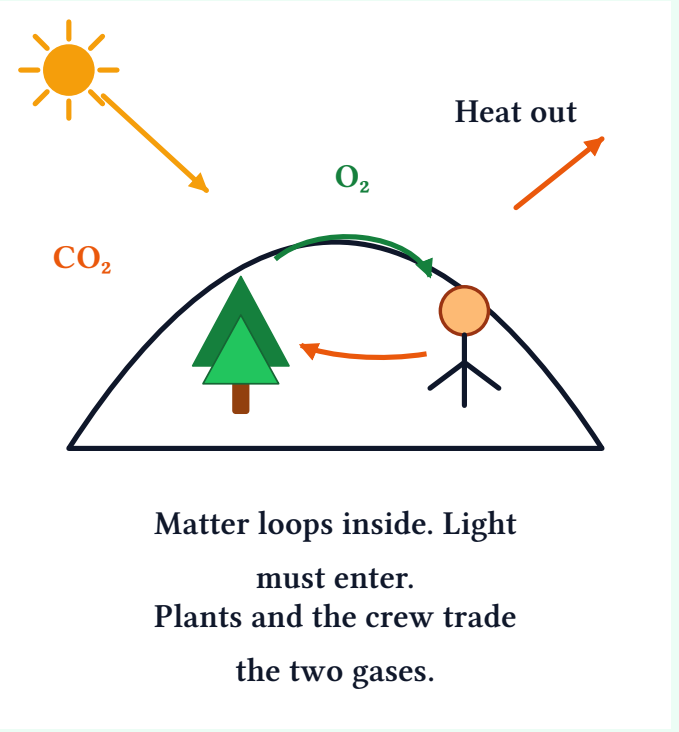


Tracking oxygen and carbon dioxide

- 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