

Using Stored Energy

Chapter 5 of 29 • Energy and Matter in Ecosystems

*Lesson 5: How do living things get usable
energy and building materials out of food?*

Angela's Wand • Bring Science Alive! 7th Grade Integrated



PHENOMENON

Seeds that grow in the dark

Soaked peas are sealed in a jar with a cup of blue indicator and a thermometer, then left in a dark cupboard. A day later: roots have pushed out, the jar is a few degrees warmer, and the indicator has turned yellow, its carbon dioxide color. A jar of dry peas shows no change. A jar of soaked peas that were boiled first stays blue and cool. No light reached any jar.

- Notice: which jar changed, and in how many ways?
- Wonder: where did the energy to warm the jar and grow a root come from?
- Predict: what would happen if the living seeds' jar had no air in it?





LEARNING TARGETS

What you will be able to do

- 1 Tell producers from consumers by where they get matter and energy, and show both run on sugar.
- 2 Model cellular respiration with a word equation and atom counts: atoms rearranged, energy released.
- 3 Use evidence to argue that plants respire too, and tell breathing apart from cellular respiration.
- 4 Describe how digested food becomes fuel or building blocks for carbohydrates, fats and proteins.
- 5 Compare photosynthesis and cellular respiration and trace matter and energy through both.

Who makes food, and who has to find it

- Every organism needs two things from food: matter to build with and energy to do work.
- Producers make their own food. Most build sugar from carbon dioxide and water using light.
- Consumers cannot make food. They eat or absorb other organisms to get matter and energy.
- A squirrel, a dolphin, a mushroom and a one-celled amoeba are all consumers.
- A consumer is not always a predator: a squirrel eating an acorn is eating a plant part.



Same fuel, different sources

Model: Where producers and consumers get what they need

The middle column is the surprise: a root cell and a muscle cell use the same reaction to release energy.



Producers (oak tree, kelp, grass)

Consumers (squirrel, dolphin, amoeba, mushroom)

Capture light energy and store it in sugar they build

Get sugar and other molecules from the organisms they eat or soak up

Get carbon for their bodies from carbon dioxide in the air

Get every carbon-containing building molecule from food

Get hydrogen for their bodies from water taken up by the roots

Use water they drink as a large part of their bodies

Take small amounts of minerals from soil or water

Cannot build sugar from carbon dioxide and water

Three words for where food and energy come from

producer: An organism that makes its own food, most often by building sugar from carbon dioxide and water with light energy. *A redwood, a pond alga and a blade of grass are producers.*

consumer: An organism that cannot make its own food and must take matter and energy from other living things, by eating them or by soaking up their molecules. *A mushroom on a log, a dolphin and an amoeba are all consumers.*

chemical energy: Energy held in the arrangement of atoms in a molecule; reactions can store it or release it. *An acorn holds enough chemical energy to power a squirrel for hours.*



CHECK FOR UNDERSTANDING

Quick check: producer or consumer?

Which organism is a consumer?

- A. A bacterium at a deep-sea vent that builds sugar from chemicals, with no light
- B. A mushroom absorbing molecules from a rotting log
- C. A green alga drifting near the surface of a lake
- D. A pea seedling that has just unfolded its first leaves in sunlight





Food is fuel, and every cell needs it

- A dry seed can sit for years. Add water and it warms, breathes out a gas, and grows, all in the dark.
- The seed stored starch, a chain of sugar units, when its parent plant made it.
- Once awake, the seed's cells take sugar apart to release that stored energy.
- A root cell, a muscle cell and an amoeba all release energy from sugar the same way.
- The name for this process is cellular respiration.

Cellular respiration: one trip through a cell

Model

Model: How a cell releases the energy stored in sugar

Sugar (from food or from stored starch) and oxygen enter the cell →

(take in) Reactions in the cell fluid and, mostly, in mitochondria regroup the atoms with oxygen →

(give off) Carbon dioxide and water leave the cell →

(use) Released energy powers the cell's work; the rest becomes heat

Word equation: sugar + oxygen → carbon dioxide + water + energy. Energy is written with the products because the reaction gives it off.



Count the atoms: nothing is lost

- One sugar molecule: 6 carbon, 12 hydrogen, 6 oxygen atoms ($\text{C}_6\text{H}_{12}\text{O}_6$).
- Six oxygen molecules add 12 more oxygen atoms (6 O_2).
- In: 6 C, 12 H, 18 O. That is 36 atoms.
- Out: six CO_2 (6 C, 12 O) and six H_2O (12 H, 6 O). Also 36 atoms: 6 C, 12 H, 18 O.
- Every atom that went in comes out in a new partner. Mass in equals mass out.





VOCABULARY IN CONTEXT

The words of the reaction

cellular respiration: The chain of reactions in cells that combines sugar with oxygen, making carbon dioxide and water and releasing usable energy. *A sprouting pea, a sprinting cheetah and a yeast cell all carry out cellular respiration.*

mitochondrion: A structure inside a cell where most of cellular respiration happens (plural: mitochondria). *Heart muscle cells hold thousands of mitochondria because they never rest.*

reactant and product: A reactant goes into a reaction and is changed; a product is what the reaction makes. *In respiration the reactants are sugar and oxygen; the products are carbon dioxide and water.*

CHECK FOR UNDERSTANDING

Quick check: where do the atoms go?

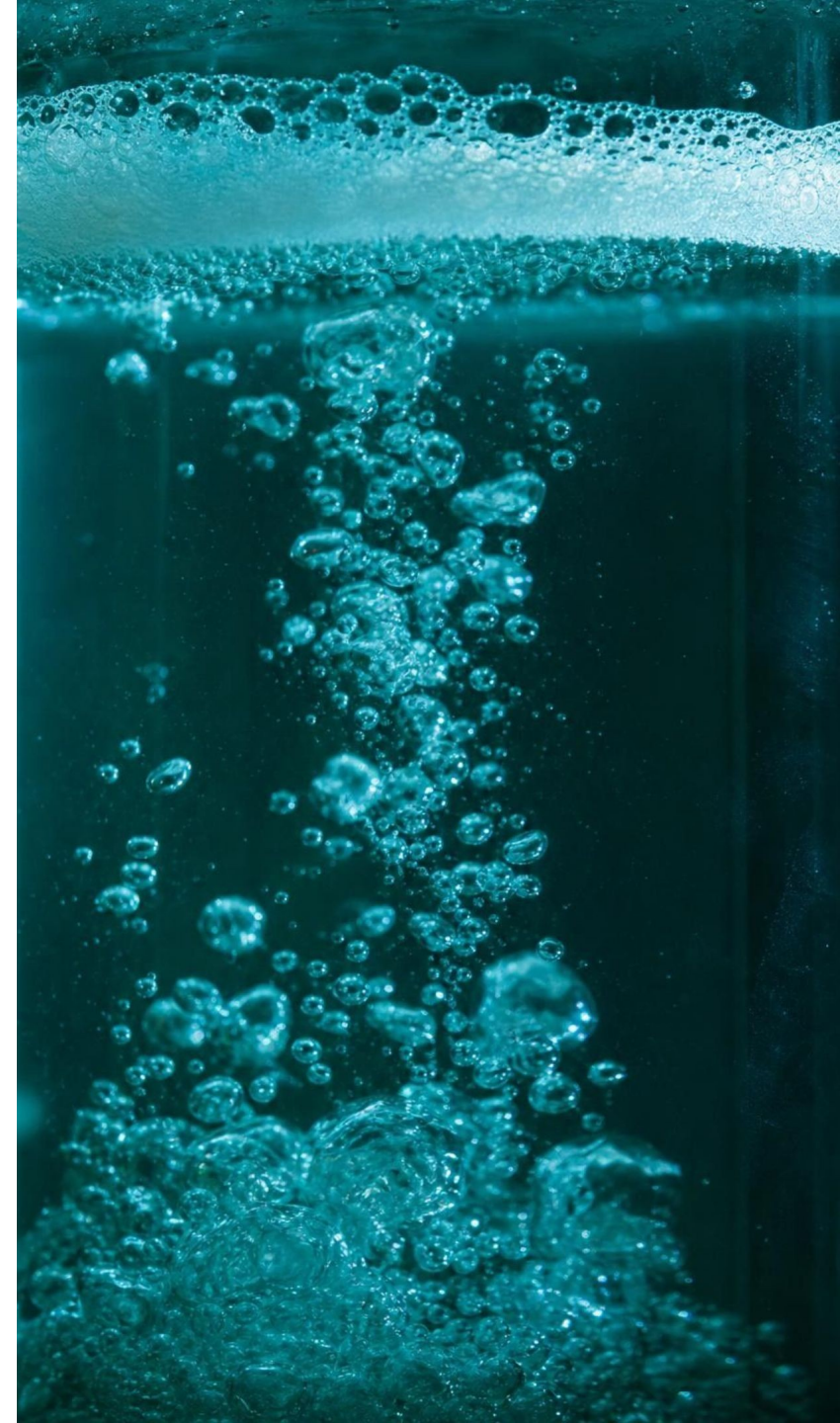
A cell takes apart two sugar molecules by cellular respiration. How many carbon dioxide molecules leave, and how many oxygen molecules were needed?

A. 6 carbon dioxide; 6 oxygen

B. 12 carbon dioxide; 12 oxygen

C. 12 carbon dioxide; 6 oxygen

D. 2 carbon dioxide; 2 oxygen



Where does the energy really come from?

- Sugar and oxygen together hold more chemical energy than carbon dioxide and water do.
- Taking molecules apart always costs energy; forming the new, stronger bonds gives energy back.
- The reaction comes out ahead, so energy is released overall. Nothing created it.
- Cells capture part of that energy for their work; the rest leaves as heat.
- That heat is what warmed the seed jar and what warms you when you run.





Think, pair, share

Discuss: do plants breathe?

- Sprouting seeds in a dark jar give off carbon dioxide and warm up with no light at all.
- A root in waterlogged soil cannot get oxygen and dies, even in full sun.
- A leaf at night makes no oxygen, yet its cells keep working.
- Plants have no lungs, but gases pass in and out through tiny pores and through root surfaces.

A classmate says plants do not need oxygen because photosynthesis makes all the oxygen they need. Use the seed jars and a flooded garden to argue for or against.

Where a plant respire: everywhere, all the time

Model: Four places in one plant

Leaf in sunlight: Photosynthesis makes sugar and oxygen; respiration runs at the same time, using some of each.

Leaf at night: No photosynthesis. Respiration continues; the leaf takes in oxygen and gives off carbon dioxide.

Root in soil: No light ever. Lives on sugar sent down from the leaves; takes oxygen from air spaces in the soil.

Sprouting seed: No leaves yet. Runs on stored starch and oxygen from the air until its first leaves open.

Ripening fruit: Keeps respiring after picking, which is why harvested produce warms and spoils.



Photosynthesis happens only in green cells with light. Cellular respiration happens in every living cell, day and night.

REAL-WORLD CONNECTION

California connection: lettuce that must be cooled fast

The Salinas Valley grows a large share of the lettuce eaten in the United States. A head of lettuce keeps respiring after it is cut: its cells go on using stored sugar and oxygen and giving off carbon dioxide and heat. Left in a warm field, the crop warms itself and spoils in days. So growers rush it into vacuum coolers that chill it within an hour, slowing respiration so the leaves stay crisp for the trip to stores.





CHECK FOR UNDERSTANDING

Quick check: breathing or cellular respiration?

- 1 Air moves into the lungs and back out.
- 2 Sugar and oxygen are rearranged into carbon dioxide and water inside a cell.
- 3 A yeast cell in bread dough releases energy from sugar and gives off a gas.
- 4 A root cell takes oxygen from the soil and uses it to release energy.
- 5 A dolphin surfaces and takes a gulp of air through its blowhole.

Decide for each statement: is it about breathing (B) or about cellular respiration (R)?

From lunch to your cells

- Chewing breaks food into pieces; saliva starts breaking starch into sugar.
- The stomach churns food and begins breaking down proteins.
- The small intestine finishes digestion and absorbs the small molecules into the blood.
- Blood carries sugar, amino acids, fat pieces and water to every cell.
- Each cell then decides: use a molecule as fuel, or use it as a building block.



MODEL

What a meal can become

Model: Two jobs for the molecules from food

CENTER: SMALL MOLECULES ABSORBED FROM DIGESTED FOOD



Fuel: cellular respiration: Sugar reacts with oxygen; energy is released; carbon dioxide and water leave the body.

Glycogen: Spare sugar linked into chains in the liver and muscles; broken back into sugar when needed.

Body fat: Built from fat pieces, and from extra sugar, for long-term energy storage and for membranes.

Proteins: Amino acids from food proteins are reassembled into muscle, enzymes and transport molecules.

Water: From drink and from respiration itself; part of every cell.

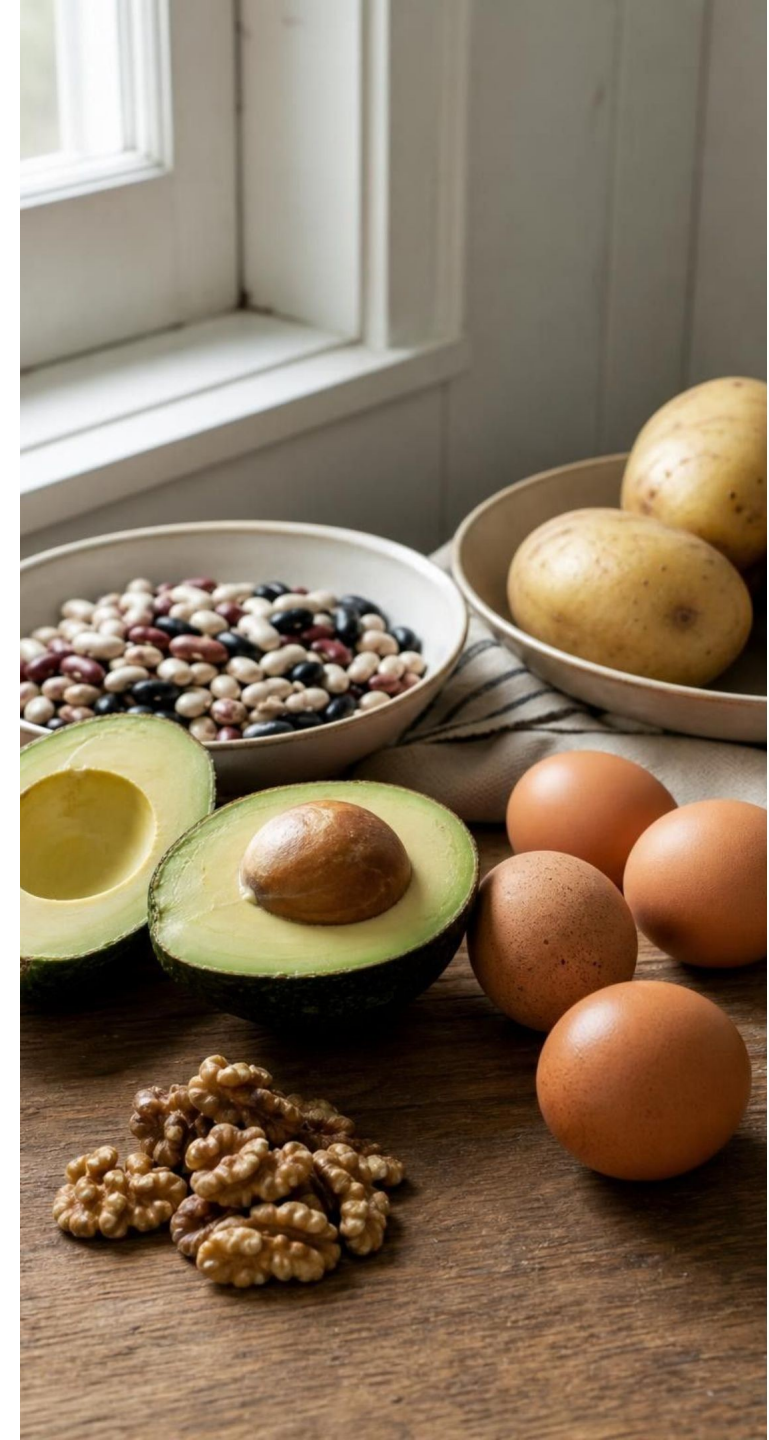
Growth means atoms from food becoming part of you. Energy means atoms from food leaving as carbon dioxide and water.

Three kinds of food molecules

carbohydrate: A molecule of carbon, hydrogen and oxygen that stores energy or builds structure; sugars are single units, starch, glycogen and cellulose are long chains. *A potato stores starch; a plant cell wall is built of cellulose; your liver stores glycogen.*

fat: An energy-rich molecule for long-term storage and, with its relatives, for building cell membranes; liquid fats are called oils. *Avocados, nuts and salmon are rich in fats; a bear stores fat before winter.*

protein: A large molecule built from amino acid units that forms structures, moves materials and speeds reactions. *Beans, eggs and fish supply proteins that your body takes apart and rebuilds as its own.*



Apply it

Task: where did the seed's mass go?

Simulated data for practice.

A class sprouted 100 pea seeds in the dark, dried a sample every two days and weighed it, and collected the gas the seeds released. Use the data to explain where the missing mass went and why the sprouts still grew.



Day	Dry mass of 100 seeds or sprouts (g)	Root plus shoot length (mm)	Carbon dioxide released since last reading (g)
0	24.0	0	0.0
2	23.1	6	1.2
4	21.8	18	1.7
6	20.4	35	1.9
8	19.2	52	1.6

Two processes, one loop of matter



Photosynthesis: carbon dioxide + water + light energy → sugar + oxygen.

Cellular respiration: sugar + oxygen → carbon dioxide + water + energy released.

- The products of each are the reactants of the other, so atoms go round and round.
- The atom counts match: 6 C, 12 H and 18 O on every side of both summaries.
- Only energy differs: it enters as light and leaves as heat and work.

Matter loops, energy passes through

Model: The carbon dioxide to sugar loop between the two processes

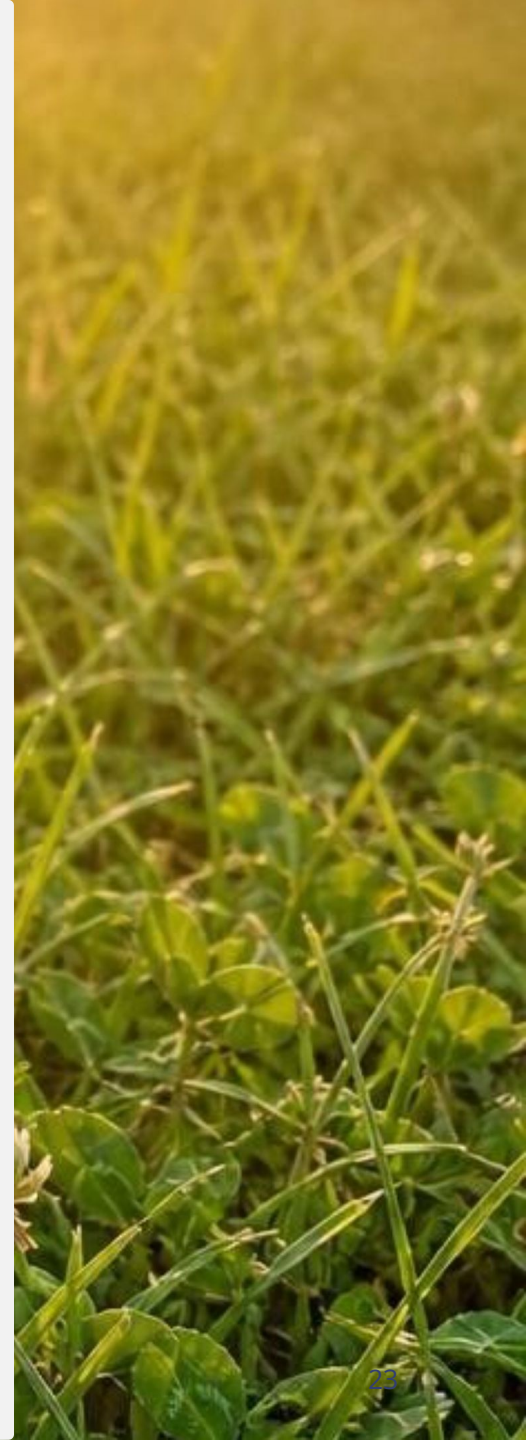
Carbon dioxide and water in air, soil and water →

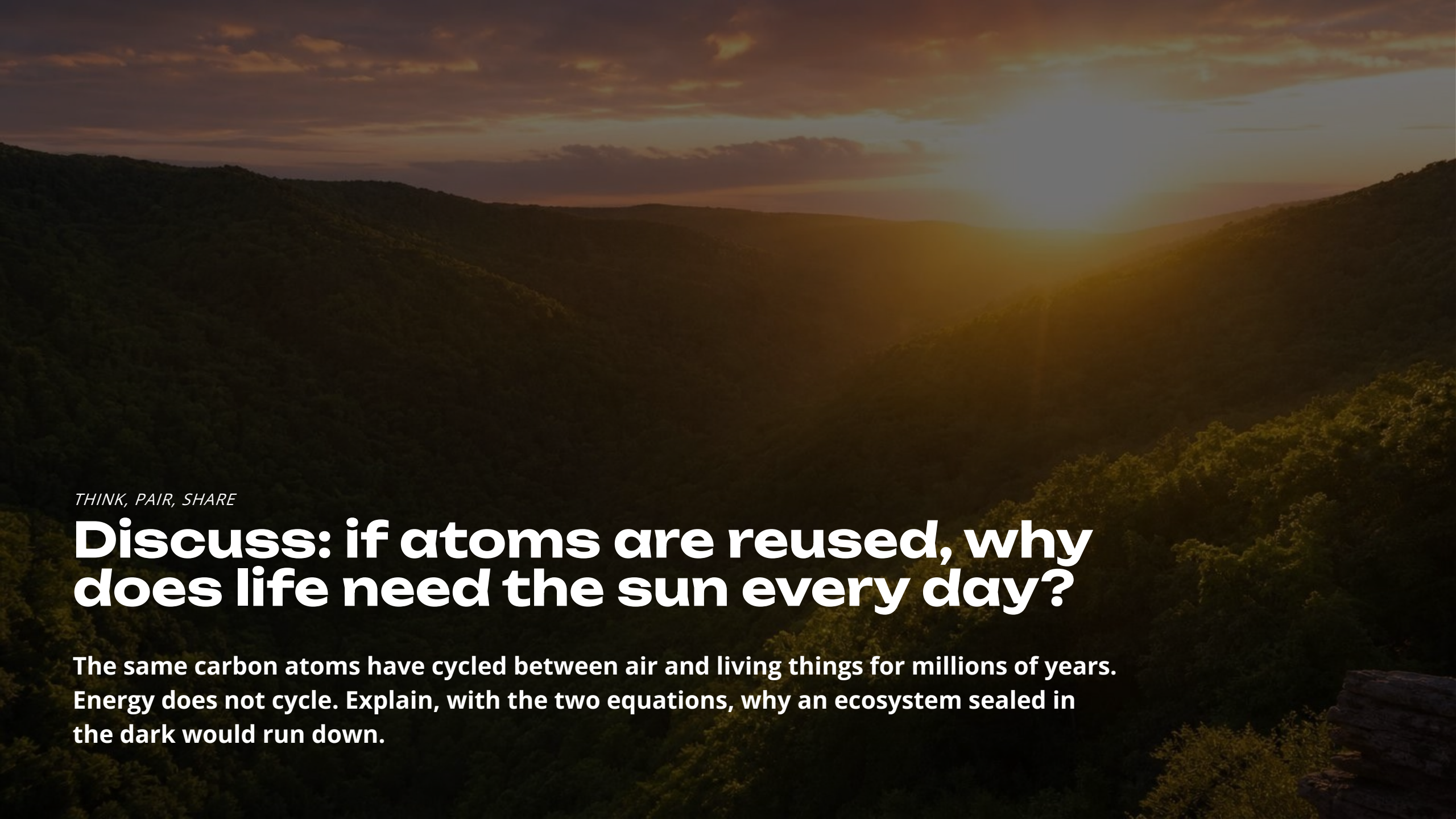
(light energy in) Photosynthesis in green cells with light: stores light energy as chemical energy →

(eaten or used in place) Cellular respiration in every living cell: releases the stored energy → **(energy out as work and heat)** (back to the start)

(sugar made, oxygen released) Sugar and oxygen, in plants and in whatever eats them →

The same atoms circle for years. The energy makes one trip: sunlight in, heat out, with living work done in between.





THINK, PAIR, SHARE

Discuss: if atoms are reused, why does life need the sun every day?

The same carbon atoms have cycled between air and living things for millions of years. Energy does not cycle. Explain, with the two equations, why an ecosystem sealed in the dark would run down.

MISCONCEPTION CHECK

True or false? Only animals do cellular respiration

"Plants get their energy from the sun, so they do not carry out cellular respiration and do not need oxygen. Animals get energy from food and are the only organisms that respire."

True or false? Explain your reasoning.





PUTTING IT TOGETHER

Putting it together

- Producers make sugar; consumers eat it. Every cell then runs on sugar the same way.
- Cellular respiration: sugar + oxygen → carbon dioxide + water + energy; 36 atoms in, 36 atoms out.
- Plants respire in every living cell, all the time. Breathing is not respiration.
- Digested food is fuel or building material: carbohydrates, fats and proteins are taken apart and rebuilt.
- Matter cycles between the two processes; energy enters as light and leaves as heat.

EXIT TICKET

Exit ticket

- Write the word equation for cellular respiration and circle the reactants.
- A seed sprouts in a dark drawer and the drawer gets warm. In one sentence, where did the energy come from?
- Name one way plants get oxygen when they are not making it, and one place in a plant where that happens.
- A sugar molecule has six carbon atoms. After respiration, where are those six atoms?
- Give one molecule from food that your body uses as a building block rather than as fuel.

