

# Material cycles

Revision notes · How materials cycle through ecosystems, with the carbon, water and nitrogen cycles, decomposers, desalination, fertilisers and crop rotation.

For Edexcel GCSE Biology 1BI0 and Combined Science 1SC0. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

## Material cycles Spec 9.12-9.15

### Cycling of materials Spec 9.12

Materials such as carbon, nitrogen and water are **cycled** through an ecosystem, moving between the abiotic components (air, water and soil) and the biotic components (living organisms).

Plants take up materials from the air, water and soil and build them into their own biomass. The materials pass to animals when they feed. Materials return to the soil and air when organisms excrete waste, and when dead organisms and their waste are broken down by decomposers. The materials can then be used again by new organisms. Cycling is needed because the supply of each material is limited.

### The carbon cycle Spec 9.13

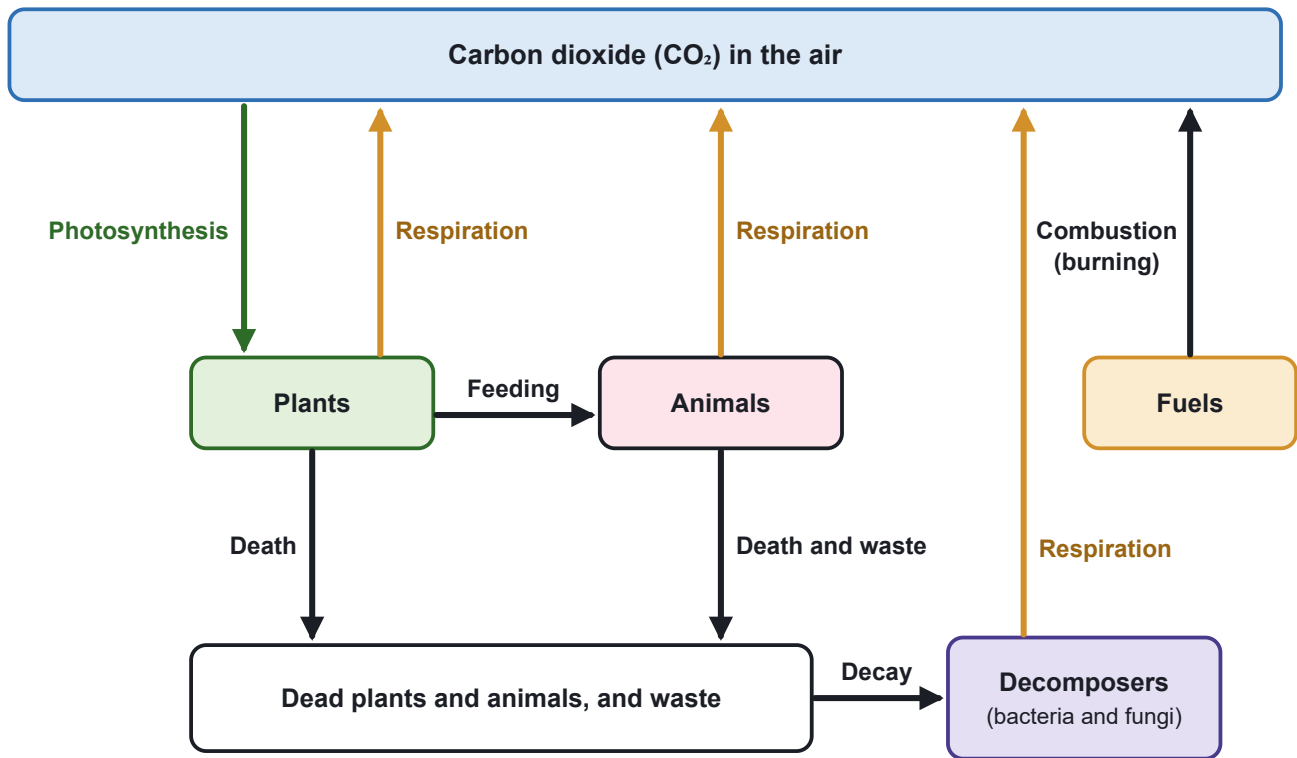
All living things are made of carbon compounds. The **carbon cycle** is important because it returns carbon to the atmosphere as carbon dioxide, so that it is available for plants to use in photosynthesis again.

1. Plants and algae take carbon dioxide from the air and use it in **photosynthesis** to make carbon compounds such as glucose, starch and proteins.
2. The carbon compounds pass along the food chain when animals feed.
3. All organisms (plants, animals and decomposers) release carbon dioxide into the air by **respiration**.
4. When plants and animals die, their bodies and waste are broken down by decomposers, which release carbon dioxide into the air by respiration.
5. Burning of fuels (combustion) also releases carbon dioxide into the air.

### The role of microorganisms as decomposers

**Decomposers** are microorganisms such as bacteria and fungi. They release enzymes to break down dead plants, dead animals and waste, and they respire, releasing carbon dioxide into the air. Without decomposers, dead material would pile up, carbon would be locked in it, and the supply of carbon dioxide for photosynthesis would run out. Decomposers also release mineral ions back into the soil.

*Exam tip: Name the process at each arrow: photosynthesis takes carbon dioxide in, and respiration (including by decomposers) and combustion put it back.*



The carbon cycle: **photosynthesis** takes carbon dioxide in; **respiration** and **combustion** put it back.

## The water cycle and potable water Spec 9.14

All organisms need water to survive, and plants need it for photosynthesis. The **water cycle** is important because it keeps supplying fresh water to the land for plants, animals and humans. The main processes are:

- **Evaporation:** water from seas, lakes and soil changes to water vapour, using heat from the Sun.
- **Transpiration:** water vapour is lost from the leaves of plants.
- **Condensation:** water vapour cools and turns into liquid water droplets, forming clouds.
- **Precipitation:** water falls as rain, snow or hail, and then runs over the land or soaks into the soil and flows into rivers, lakes and the sea.

### Potable water and desalination

**Potable water** is water that is safe to drink. In areas of drought there may not be enough fresh water. Sea water contains too much dissolved salt to drink, but **desalination** removes the salt to produce potable water.

- **Distillation:** sea water is evaporated, leaving the salt behind, and the water vapour is condensed back to pure water.
- **Reverse osmosis:** sea water is forced through a partially permeable membrane that lets water through but not salt.

Desalination needs large amounts of energy, so it is expensive.

## The nitrogen cycle Spec 9.15

Plants need **nitrates** from the soil to make amino acids and proteins. Although 78% of air is nitrogen gas, plants cannot use it directly. Bacteria in the soil have key roles in making nitrates available.

| Bacteria in the nitrogen cycle |                                                                     |                                                                                      |
|--------------------------------|---------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Process                        | Bacteria                                                            | What happens                                                                         |
| <b>Decay</b>                   | Decomposers (bacteria and fungi)                                    | Break down proteins and urea in dead material and waste into ammonia (ammonium ions) |
| <b>Nitrification</b>           | Nitrifying bacteria                                                 | Convert ammonium ions in the soil into nitrates, which plants absorb                 |
| <b>Nitrogen fixation</b>       | Nitrogen-fixing bacteria, in the soil or in root nodules of legumes | Convert nitrogen gas from the air into nitrogen compounds, which become nitrates     |
| <b>Denitrification</b>         | Denitrifying bacteria                                               | Convert nitrates in the soil into nitrogen gas, which reduces soil fertility         |

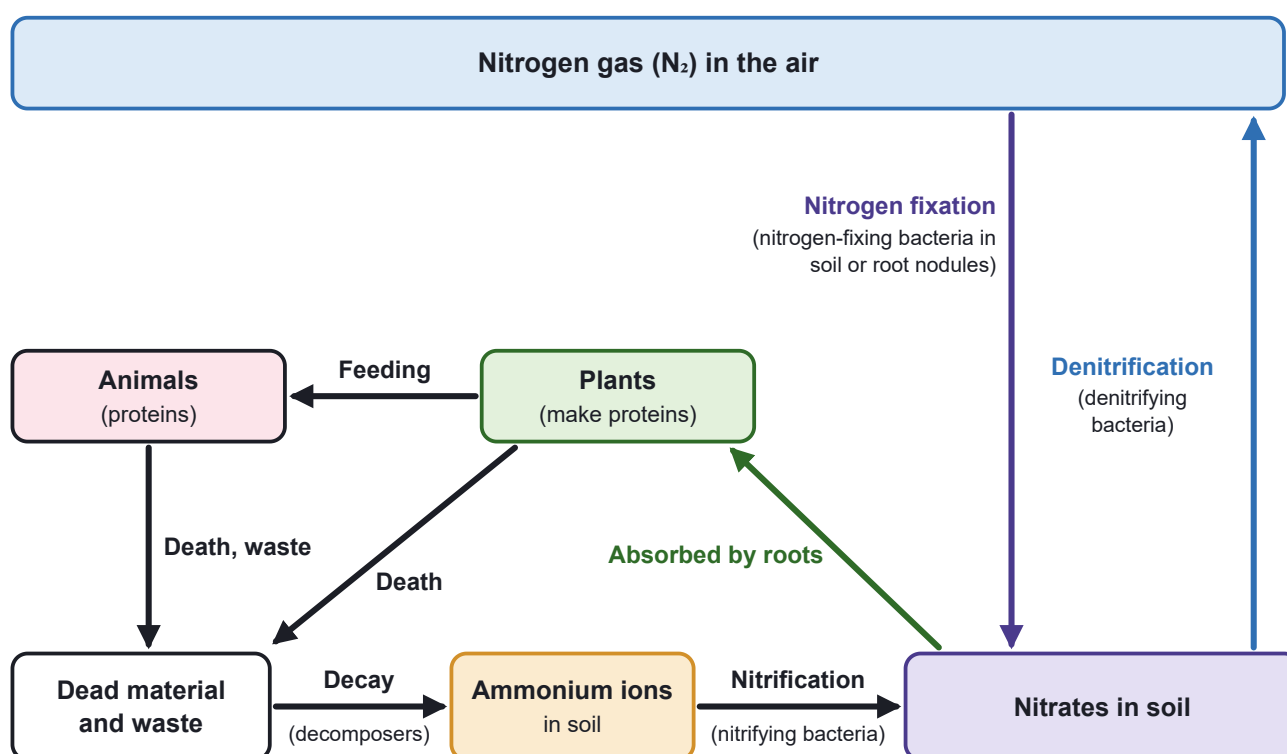
Plants take up nitrates and build them into proteins. Animals get the nitrogen by eating plants or other animals.

### Fertilisers and crop rotation

Farmers remove crops, so nitrates are lost from the soil. They can replace them in two ways:

- **Fertilisers:** add nitrates (and other minerals) to the soil.
- **Crop rotation:** different crops are grown in a field in different years. In some years a legume crop such as clover or peas is grown. Its root nodules contain nitrogen-fixing bacteria, and when its remains are ploughed into the soil they add nitrates. It is then followed by a crop that needs a lot of nitrates.

*Common mistake: Nitrogen-fixing bacteria are not the bacteria that make ammonia from dead material. That is decay. Fixing means turning nitrogen gas into compounds.*



The nitrogen cycle: bacteria carry out **nitrogen fixation**, **nitrification** and **denitrification**; decomposers carry out **decay**.

**Quick check**

- 1 . Which process removes carbon dioxide from the air?
- 2 . What is potable water?
- 3 . Why do plants need nitrates?
- 4 . Which bacteria are found in the root nodules of legumes?
- 5 . Why are decomposers important in the carbon cycle?

## Quick check answers

### Material cycles

1. Photosynthesis.
2. Water that is safe to drink.
3. To make amino acids and proteins.
4. Nitrogen-fixing bacteria.
5. They break down dead material and release carbon dioxide by respiration.