Organisms and the Environment

Energy flow, food chains and webs, pyramids, the carbon and nitrogen cycles, populations, communities and ecosystems, the effects of humans, and conservation.

19.1 Energy flow

The **Sun** is the **principal source of energy** input to most biological systems. **Plants** (and other producers) capture light energy in **photosynthesis** and store it as chemical energy in glucose and other molecules. **Most forms of life depend completely on photosynthesis**, because it is the way that energy and food enter living things.

Terms

Term	Meaning
producer	an organism that makes its own food by photosynthesis (green plants)
consumer	an organism that gets energy by eating other organisms
herbivore	an animal that eats plants
carnivore	an animal that eats other animals
decomposer	an organism (bacteria and fungi) that breaks down dead organisms and waste

Food chains and food webs

A **food chain** shows the **flow of energy** from one organism to the next; the arrows mean "is eaten by" (the direction of energy flow).

grass → rabbit → fox

A **food web** is a **network of interconnected food chains**, which gives a more realistic picture because most animals eat more than one thing.

NOTE

In a food web question, if one population changes, think about what it eats (its food falls or rises) and what eats it, and what happens to the other organisms that share its food.

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Energy transfer

Energy is **lost** at each **trophic level** (feeding level). Only about **10%** passes on to the next level. Energy is lost:

- as **heat** from **respiration** (and used for movement and keeping warm);
- in **waste** (faeces and urine);
- in parts that are **not eaten** (such as bones, roots and fur), and in parts that are not digested.

> **The transfer of energy from one trophic level to the next is inefficient. This is why food chains usually have fewer than five trophic levels: there is too little energy left to support another level.**

Eating crops or livestock. It is **more energy efficient for humans to eat crop plants** than to eat livestock fed on crop plants, because energy is **lost at each stage**. Eating the plants directly means fewer energy-loss steps, so the same area of land feeds **more people**.

Pyramids

Pyramid	What it shows
pyramid of numbers	the number of organisms at each trophic level (can be an odd shape, for example one tree feeding many insects)
pyramid of biomass	the **dry mass** of living material at each level; always a pyramid shape
pyramid of energy	the energy at each level over a period; always narrows upwards

19.3 Nutrient cycles

The carbon cycle

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Process	Effect on carbon dioxide in the air
photosynthesis	**removes** carbon dioxide (carbon goes into plants as carbohydrates)
feeding	carbon passes from plants to animals in food
respiration (plants, animals and decomposers)	**adds** carbon dioxide
decomposition	decomposers break down dead organisms and release carbon dioxide by respiration
formation of fossil fuels	dead organisms buried over millions of years form coal, oil and gas: a store of carbon
combustion	burning wood and fossil fuels **adds** carbon dioxide

The nitrogen cycle

Plants and animals need nitrogen to make **amino acids** and **proteins**, but they cannot use the nitrogen gas in the air (78%) directly.

1. **Nitrogen fixation:** nitrogen gas is converted to **nitrates** (or ammonium) by **lightning**, and by **nitrogen-fixing bacteria** (in the soil and in root nodules).
2. **Absorption:** plants take up **nitrate ions** through their roots, and use them to make **amino acids and proteins**.
3. **Feeding and digestion:** animals eat the plants, and digest the protein.
4. **Decomposition:** when plants and animals die (and in animal waste), **decomposers** break down the proteins to **ammonium ions**.
5. **Nitrification: nitrifying bacteria** convert ammonium ions to **nitrates**.
6. **Denitrification: denitrifying bacteria** in waterlogged soil convert nitrates back to **nitrogen gas**, which returns to the air.

Decomposers

Fungi and bacteria are **decomposers**. They secrete **enzymes** onto dead organisms and waste to digest them, and absorb the products. This **recycles** nutrients (carbon, nitrogen and minerals) back into the soil and air, so that producers can use them again.

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19.4 Ecosystems and biodiversity

Term	Meaning
population	a group of organisms of **one species**, living in the **same area** at the **same time**
community	**all the populations** of different species in an ecosystem
ecosystem	a unit containing the **community of organisms** and their **environment**, interacting together
biodiversity	the **number of different species** that live in an area

Population growth

The factors that affect the rate of growth of a population are:

- **food supply** (more food means faster growth);
- **competition** (for food, water, light, mates and space) slows growth;
- **predation** (being eaten) reduces numbers;
- **disease** reduces numbers.

The **growth of the human population** increases the **demand for global resources** (food, water, energy and land), and so the pressure on ecosystems.

20.1 Effects of humans on ecosystems

Deforestation

Causes: clearing land for **farming** (crops and cattle), for **timber**, for **building** and **roads**, and for mining.

Consequences:

- loss of **biodiversity**, and **extinction** of species that lose their habitat;
- **loss of soil** (without roots the soil is washed or blown away);
- **flooding** (fewer trees to absorb and slow the water);
- a higher concentration of **carbon dioxide** in the atmosphere (fewer trees for photosynthesis, and the burning or decaying of the trees releases carbon dioxide), which contributes to global warming.

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Other impacts

- **Over-harvesting** of plant and animal species (for example fish and hunted animals) reduces their numbers and can lead to extinction.
- **Introducing a non-native species** can harm native species by **competing** with them, preying on them or bringing disease.

Pollution

Pollutant	Effect
untreated sewage and **nitrogen-containing fertilisers** in water	cause **eutrophication** (below)
greenhouse gases (carbon dioxide and methane)	cause **global warming**: melting ice and rising sea levels, changing weather and climate, and loss of habitats
insecticides and herbicides	harm other organisms (including those that are not pests); can build up in food chains
non-biodegradable plastics	do not rot; harm and kill wildlife that eat them or get trapped in them, in water and on land

Eutrophication.

1. Sewage and fertilisers add **nitrate and other ions** to the water.
2. **Producers** (algae and water plants) **grow faster**.
3. The producers die, and their **decomposition increases**.
4. The **decomposers**, which are bacteria, multiply and respire **aerobically**, using up dissolved oxygen.
5. There is a **reduction in dissolved oxygen**.
6. Organisms that need dissolved oxygen, such as fish, **die**.

20.4 Conservation

Reasons for **conserving species** and habitats:

- to maintain **biodiversity** (every species is part of food webs, and a source of foods, medicines and materials);
- to **reduce extinction** (extinct species cannot be replaced);
- to **protect vulnerable environments** (rainforests, coral reefs and wetlands).

Conserving forests: education (so people understand why forests are important), **protected areas** (national parks), **quotas** on how much timber can be cut, and **replanting** trees.

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Conserving fish stocks: education, **closed seasons** (no fishing while fish breed), **protected areas**, **controlled net types and mesh sizes** (so that young fish escape), **quotas** (limits on the catch) and **monitoring** of numbers.

> **A sustainable resource is one that is produced as rapidly as it is removed from the environment, so that it does not run out.**

> TRY IT
>
> Why is it more efficient for people to eat grain than to eat beef from cattle fed on grain?

Energy is **lost at each trophic level** (by respiration, heat and waste). Eating grain directly has **one fewer energy transfer**, so more of the energy from the crop reaches people, and the same land can feed more.

19.4 Population growth

A **population** is a group of organisms of one species living in the same area at the same time.

A population grows in **phases** when it is introduced to a new habitat:

1. **Lag phase**: slow growth because there are few individuals to reproduce.
2. **Exponential (log) phase**: rapid growth because food and space are plentiful and birth rate is higher than death rate.
3. **Stationary phase**: growth stops because birth rate equals death rate.
4. **Death phase**: the population falls because resources run out or waste builds up.

> **Growth is limited by food supply, competition, predation, disease and the build-up of waste.**

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