

AQA GCSE Biology — Biology

Topic 7

Ecology

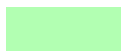
Specification 8461 · AQA

Free edition

Revision notes for one topic, free to download.

These are the summary notes only. The full edition of this booklet also carries the worked examples, the required practicals and the formula sheets, with every topic in one place.

Colour Codes



Definitions



Diagrams



Notes and warnings



Sub-topic headings

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Define Ecosystem

- the interaction of a community of living organisms (biotic) with the non-living (abiotic) parts of their environment.

Define Community

- all the populations of different species in a habitat.

Define Stable community

- one where all species and environmental factors are in balance, so population sizes stay fairly constant.

Define Biotic factor

- a living factor that can affect a community.

Define Extremophile

- an organism living in a very extreme environment (high temperature, pressure or salt).

Define Decomposer

- a microorganism that breaks down dead matter by secreting enzymes into the environment.

Define Trophic level BIOLOGY ONLY

- an organism's position in a food chain, numbered from level 1 (plants and algae).

Define Food security BIOLOGY ONLY

- having enough food to feed a population.

Define Habitat

- the place where an organism lives.

Define Population

- all the organisms of one species in a habitat.

Define Interdependence

- species depend on each other for food, shelter, pollination and seed dispersal.

Define Abiotic factor

- a non-living factor that can affect a community.

Define Adaptation

- a feature enabling an organism to survive in the conditions in which it normally lives.

Define Producer

- a photosynthetic organism that synthesises molecules, making biomass for life on Earth.

Define Biodiversity

- the variety of all the different species of organisms on Earth or within an ecosystem.

Define Apex predator BIOLOGY ONLY

- a carnivore with no predators.

7.1 Adaptations, interdependence and competition

7.1.1 Communities

Levels of organisation, smallest to largest: individual organism → population → community → ecosystem.

An **ecosystem** is the interaction of a community of living organisms (**biotic**) with the non-living (**abiotic**) parts of their environment. To survive and reproduce, organisms need materials from their surroundings and from the other living organisms there.

Competition. Organisms compete for resources in short supply:

ANALOGY

Interdependence is like interlocking cogs in a clock. Every cog is turned by the ones next to it, so pulling out one small cog — a single pollinating insect species, say — does not cost you "one cog's worth" of time. The whole clock stops.

7.1.3 Biotic factors

Biotic (living) factors that can affect a community are:

- availability of food
- new predators arriving
- new pathogens
- one species outcompeting another so the numbers are no longer sufficient to breed.

WATCH OUT

Disease is often wrongly called abiotic. A pathogen is living, so new pathogens are a **biotic** factor — as is food. The mineral ions in soil that plants need are abiotic.

Group	Compete for
Plants	Light and space; water and mineral ions from the soil
Animals	Food, mates and territory

Interdependence. Each species depends on others for food, shelter, pollination, seed dispersal etc, so removing one can affect the whole community. A **stable community** is one where all species and environmental factors are in balance, so population sizes stay fairly constant — for example mature oak woodland.

7.1.2 Abiotic factors

Abiotic (non-living) factors that can affect a community are:

- light intensity
- temperature
- moisture levels
- soil pH and mineral content
- wind intensity and direction
- carbon dioxide levels for plants
- oxygen levels for aquatic animals.

To explain how a change in an abiotic factor affects a community, argue in a chain: *factor changes* → *effect on one species* → *knock-on effect through the food chain*. Less light means less photosynthesis, so producers grow slowly and fewer primary consumers are supported.

7.1.4 Adaptations

Organisms have features (**adaptations**) enabling them to survive in the conditions in which they normally live. These may be:

Type	Meaning	Example
Structural	Body shape or features	Small ears, thick fur of an Arctic fox reduce heat loss
Behavioural	How an organism acts	Migrating to avoid cold seasons
Functional	Body processes	Making very concentrated urine to conserve water in a desert

Organisms living in very extreme environments — high temperature, pressure or salt concentration — are called **extremophiles**. Bacteria living in deep sea vents are extremophiles.

7.2 Organisation of an ecosystem

7.2.1 Levels of organisation

Photosynthetic organisms are the **producers** of biomass for life on Earth. All food chains begin with a producer which synthesises molecules — usually a green plant or alga making glucose by photosynthesis.

producer → **primary consumer** → **secondary consumer** → **tertiary consumer**

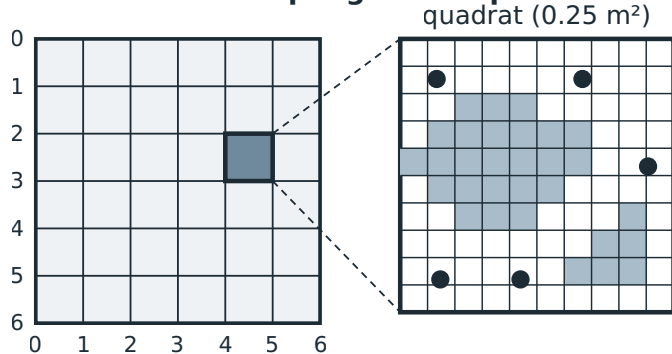
Consumers that kill and eat other animals are **predators**; those eaten are **prey**. In a stable community their numbers rise and fall in cycles: prey rise when predators are few, so predators increase, cutting prey numbers, so predators fall again. On a graph the predator peak comes after the prey peak, and prey are always more numerous.

Sampling. Ecologists use **quadrats** and **transects** to determine distribution and abundance.

- A **quadrat** is a square frame of known area, placed at **random** coordinates to sample abundance without bias.
- A **transect** is a line along which quadrats are placed at regular intervals, showing how distribution *changes* across a gradient (for example from a path into a field).

Sampling with random quadrats and along a transect

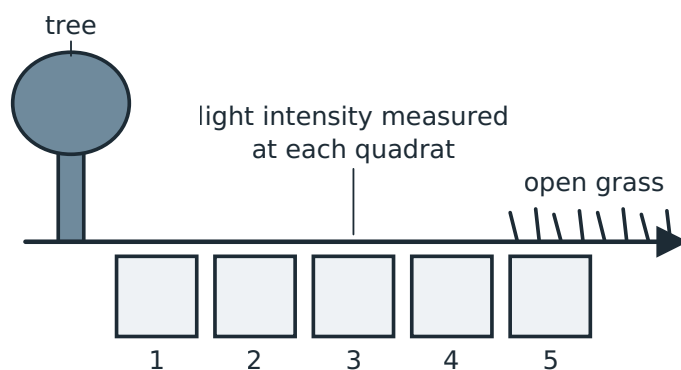
Random sampling with a quadrat



Repeat at several random coordinates and

calculate the mean number per quadrat.

Belt transect from a tree to open grass



quadrat	1	2	3	4	5
light / lux	200	450	900	1500	2000
daisies	2	5	9	14	18

$$\text{estimated population size} = \text{mean number per quadrat} \times \frac{\text{total area of the habitat}}{\text{area of one quadrat}}$$

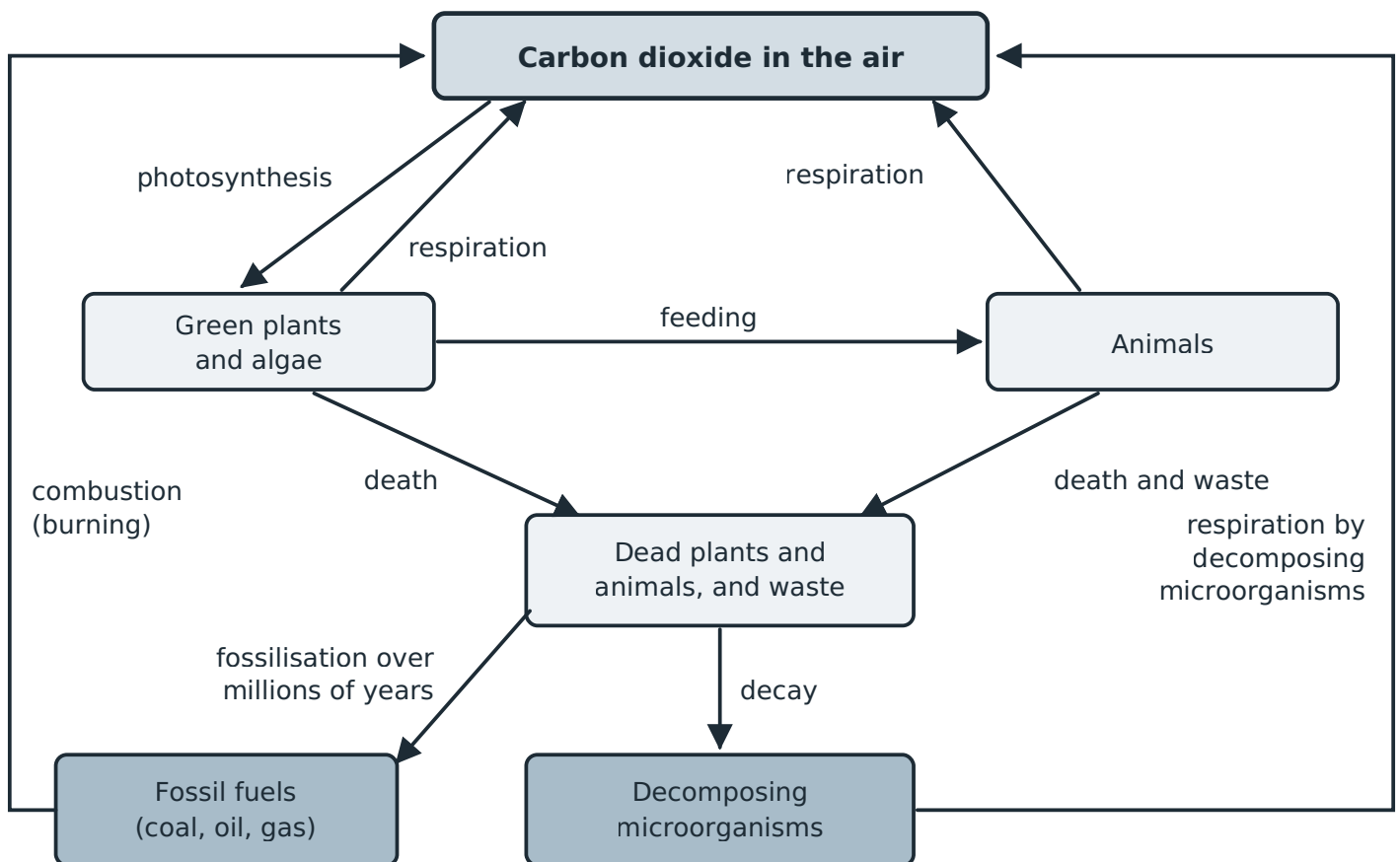
7.2.2 How materials are cycled

Many different materials cycle through the abiotic and biotic components of an ecosystem: all materials in the living world are recycled to provide the building blocks for future organisms.

The carbon cycle returns carbon from organisms to the atmosphere as carbon dioxide, to be used by plants in photosynthesis.

- Carbon dioxide is removed from the air by **photosynthesis** in plants and algae.
- Carbon passes along food chains when organisms are eaten.
- Carbon dioxide is returned to the air by **respiration** of plants, animals and decomposing microorganisms, and by **combustion** of fuels.

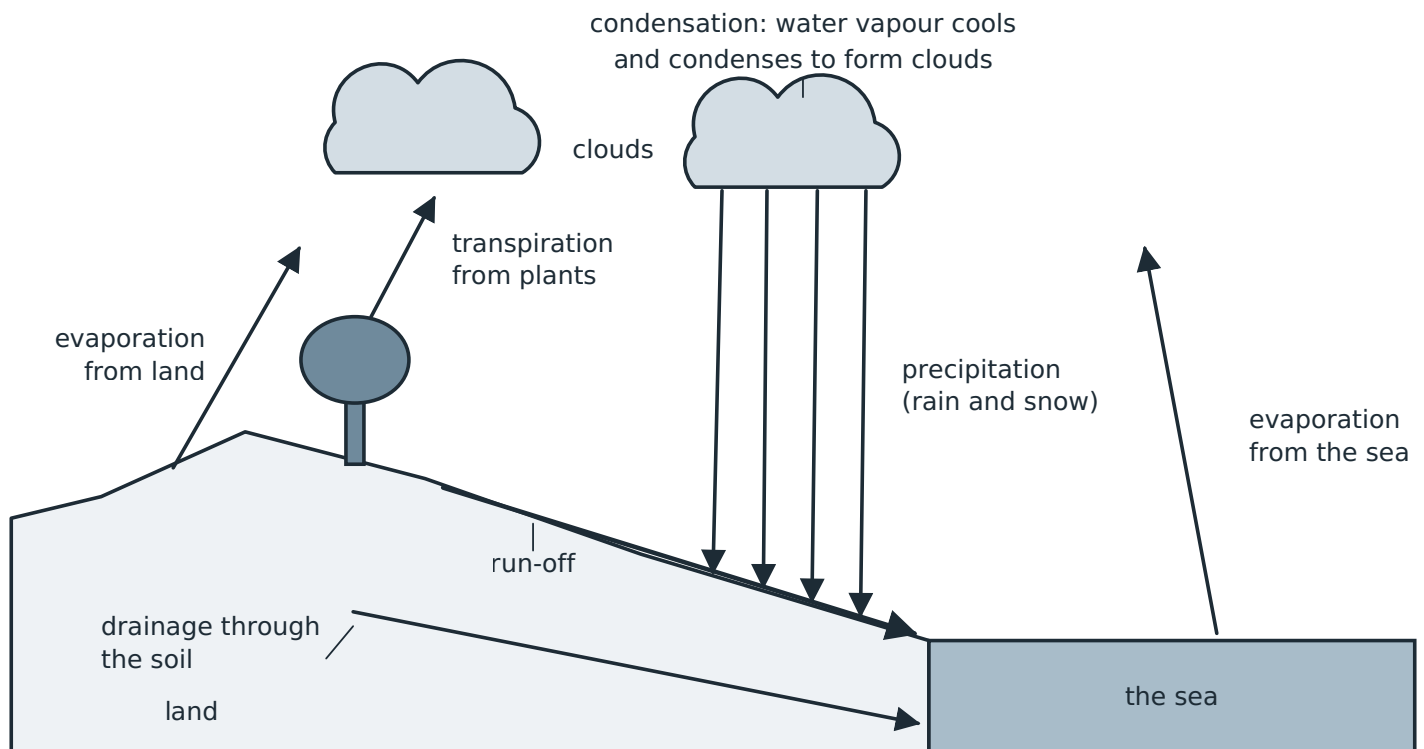
The carbon cycle



The water cycle provides fresh water for plants and animals on land before draining into the seas. Water is continuously **evaporated** and **precipitated**.

- Energy from the Sun evaporates water from seas, lakes and land; plants also lose water by transpiration.
- Water vapour rises, cools and condenses into clouds.
- Water falls as precipitation, providing fresh water on land, then drains through rivers back into the seas.

The water cycle



The water cycle provides fresh water for plants and animals on land before draining into the seas.

Role of microorganisms. They cycle materials through an ecosystem by returning carbon to the atmosphere as carbon dioxide and **mineral ions to the soil**, where plants take them up again.

7.2.3 Decomposition **BIOLOGY ONLY**

BIOLOGY ONLY Three factors affect the **rate of decay** of biological material.

Factor	Effect on rate of decay
Temperature	Warmth speeds decay as decomposers' enzymes work faster; too hot and the enzymes denature; cold slows decay
Water	Moist conditions speed decay — decomposers need water to survive and to secrete enzymes onto the material
Availability of oxygen	Most decomposers respire aerobically, so more oxygen means faster decay

NOTE

The spec states students are not expected to study the nitrogen cycle — carbon and water only.

ANALOGY

The carbon cycle is like canteen crockery: the same finite set of plates is served out (photosynthesis), passed down the queue (feeding), then washed and returned to the stack (respiration, decay, combustion). No new plates are made — burning fossil fuels just unlocks a cupboard shut for millions of years, so more are in circulation at once.

BIOLOGY ONLY Compost. Gardeners and farmers provide optimum conditions for rapid decay of waste biological material — warm, moist, aerobic (heaps are turned to let air in). The compost is used as a **natural fertiliser** for garden plants or crops.

BIOLOGY ONLY Biogas. **Anaerobic decay produces methane gas.** Biogas generators can be used to produce methane gas as a fuel; they are kept warm, moist and without oxygen.

7.2.4 Impact of environmental change **BIOLOGY ONLY**

HT ONLY

BIOLOGY ONLY HT ONLY Environmental changes affect the **distribution** of species in an ecosystem. These changes include:

- temperature
- availability of water
- composition of atmospheric gases.

BIOLOGY ONLY HT ONLY The changes may be **seasonal** (birds migrating in winter), **geographic** (a species found only above a certain altitude) or **caused by human interaction** (pollution, deforestation, global warming). To **evaluate** impact from data, quote figures and state which way the distribution shifts.

7.3 Biodiversity and the effect of human interaction on ecosystems

7.3.1 Biodiversity

Biodiversity is the variety of all the different species of organisms on Earth, or within an ecosystem.

- A great biodiversity ensures the stability of ecosystems by reducing the dependence of one species on another for food, shelter and maintenance of the physical environment.
- The future of the human species relies on maintaining a good level of biodiversity. Many human activities are reducing it, and only recently have measures been taken to try to stop this.

7.3.4 Deforestation

Large-scale deforestation in tropical areas has occurred to:

- provide land for cattle and rice fields
- grow crops for biofuels.

Implications to use when evaluating: habitat loss and so reduced biodiversity, less carbon dioxide removed by photosynthesis, and carbon dioxide released when trees are burned or decay.

7.3.2 Waste management

Rapid growth in the human population and a rising standard of living mean more resources are used and more waste produced. Unless waste and chemical materials are properly handled, more pollution is caused, and it can occur:

- **in water**, from sewage, fertiliser or toxic chemicals
- **in air**, from smoke and acidic gases
- **on land**, from landfill and toxic chemicals.

Pollution kills plants and animals, which reduces biodiversity.

7.3.3 Land use

Humans reduce the land available for other animals and plants by **building, quarrying, farming and dumping waste**.

Peat bogs. Destroying peat bogs and other peat areas to produce garden compost reduces this habitat and so the variety of plant, animal and microorganism species living there (biodiversity). The decay or burning of the peat releases carbon dioxide into the atmosphere. The conflict to evaluate: cheap peat compost increases food production, but peat bogs must be conserved for biodiversity and to reduce carbon dioxide emissions.

7.3.5 Global warming

Levels of **carbon dioxide and methane** in the atmosphere are increasing and contribute to **global warming**. Biological consequences include:

- loss of habitat, for example low-lying areas flooded as ice melts and sea water expands
- changes in the **distribution** of species, migrating polewards or to higher ground as areas warm or dry
- changes in **migration patterns**, for example birds migrating earlier or further north
- reduced biodiversity if species cannot migrate or adapt fast enough and become extinct.

The scientific consensus on global warming is based on systematic reviews of thousands of peer reviewed publications. Evidence can still be uncertain or incomplete because climate is a complex system with many interacting variables.

7.3.6 Maintaining biodiversity

Programmes put in place by scientists and concerned citizens to reduce human damage to ecosystems and biodiversity include:

- breeding programmes for endangered species
- protection and regeneration of rare habitats
- reintroduction of field margins and hedgerows in agricultural areas where farmers grow only one type of crop
- reduction of deforestation and carbon dioxide emissions by some governments
- recycling resources rather than dumping waste in landfill.

Be ready to describe positive and negative human interactions, explain their impact on biodiversity and evaluate the **conflicting pressures** — cost, loss of farmland or jobs, and a growing population's demand for food and housing.

7.4 Trophic levels in an ecosystem BIOLOGY ONLY

7.4.1 Trophic levels **BIOLOGY ONLY**

BIOLOGY ONLY Trophic levels are numbered from level 1 (plants and algae), then subsequently according to how far the organism is along the food chain.

Level	Organisms	Name
1	Plants and algae — make their own food	Producers
2	Herbivores eating plants/algae	Primary consumers
3	Carnivores eating herbivores	Secondary consumers
4	Carnivores eating other carnivores	Tertiary consumers

Apex predators are carnivores with no predators.

Decomposers break down dead plant and animal matter by **secreting enzymes into the environment**; small soluble food molecules then **diffuse into the microorganism**.

7.4.2 Pyramids of biomass BIOLOGY ONLY

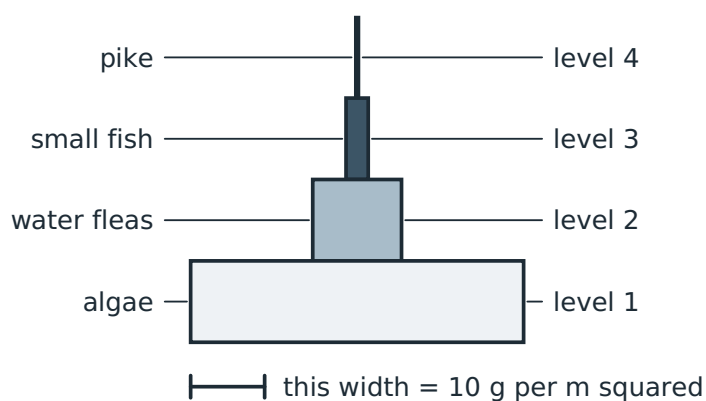
BIOLOGY ONLY Pyramids of biomass represent the relative amount of biomass at each level of a food chain, with **trophic level 1 at the bottom**. To construct one accurately, draw horizontal bars stacked from level 1 upwards, each bar's width **to scale** with the biomass at that level, centred on a common axis and labelled with the organism.

Constructing one accurately — AQA expects you to be able to draw the pyramid, not just describe it. The five steps are always the same:

1. **Put the organisms in trophic order**, level 1 at the bottom, and work out which is which from the food chain.
2. **Find the largest biomass** and decide the **widest bar** the space will allow — usually about 90 mm across a page of graph paper.
3. **Choose the scale**: $\text{scale} = \text{largest biomass} \div \text{widest bar}$. Round it to a convenient number (0.5, 1, 2, 5, 10 units per mm) so the other widths are easy to calculate.
4. **Calculate every bar width** = $\text{biomass} \div \text{scale}$, and check the largest still fits.
5. **Draw the bars**: all the **same height**, centred on a **common vertical line**, each **labelled with the organism**, and write the **scale** beside the pyramid.

Constructing an accurate pyramid of biomass to scale

The pyramid, drawn to scale



Every bar has the same height. Only the width shows the biomass, and every bar is centred on the same vertical line.

Trophic level 1 always goes at the bottom.

How each bar width was found

- 1 The largest biomass is 45 g per m squared, for the algae.
- 2 The widest a bar can be on the grid is 90 mm, so 90 mm must stand for 45 g per m squared.
- 3 $\text{scale} = 45 \text{ divided by } 90$, so 1 mm on the paper stands for 0.5 g per m squared.
- 4 $\text{bar width in mm} = \text{biomass divided by } 0.5$

organism	biomass / g per m sq	bar width / mm
pike	0.6	1
small fish	3.0	6
water fleas	12	24
algae	45	90

WATCH OUT

A pyramid of biomass is **not** a pyramid of numbers. One oak tree feeding thousands of insects gives an upside-down pyramid of *numbers* but a normal pyramid of *biomass*, because the single tree has far more mass than all the insects. Marks are also lost for bars of unequal **height**, bars that are not **centred**, and pyramids with **no scale stated** — the width is the only thing carrying the data.

ANALOGY

The 10% rule is like getting £100 of pocket money a week but only saving £10. Most goes on running costs (respiration, staying warm) and some never reaches your pocket at all (egested as faeces, lost in urine). The next level up can only inherit your savings, not your income — which is why apex predators are so rare.

7.4.3 Transfer of biomass **BIOLOGY ONLY**

BIOLOGY ONLY Producers are mostly plants and algae, which transfer about **1%** of the incident energy from light for photosynthesis. Only approximately **10%** of the biomass at each trophic level is transferred to the level above.

BIOLOGY ONLY Biomass is lost because:

- not all ingested material is absorbed — some is **egested as faeces** some absorbed material is **lost as waste**: carbon dioxide and water in respiration, and water and urea in urine.

Large amounts of glucose are used in **respiration**. Because so little biomass is passed on, food chains are usually only four or five levels long and there are **fewer organisms** at each level going up.

7.5 Food production **BIOLOGY ONLY**

7.5.1 Factors affecting food security **BIOLOGY ONLY**

BIOLOGY ONLY **Food security** is having enough food to feed a population. Biological factors threatening it include:

- the increasing **birth rate** in some countries
- **changing diets** in developed countries, so scarce food resources are transported around the world
- new **pests and pathogens** affecting farming
- **environmental changes** affecting food production, such as widespread famine if the rains fail
- the **cost of agricultural inputs**
- **conflicts** affecting the availability of water or food.

Sustainable methods must be found to feed all people on Earth.

7.5.3 Sustainable fisheries **BIOLOGY ONLY**

BIOLOGY ONLY Fish stocks in the oceans are declining. Stocks must be maintained at a level where **breeding continues**, or certain species may disappear altogether in some areas. Two conservation measures:

- **Control of net size** — larger mesh lets young fish escape so they survive to breed.
- **Fishing quotas** — limits on the mass or type of fish landed from an area, so fewer fish are removed than are replaced by breeding.

7.5.2 Farming techniques **BIOLOGY ONLY**

BIOLOGY ONLY The efficiency of food production can be improved by restricting energy transfer from food animals to the environment:

- **limiting their movement**, so less energy is transferred by muscle contraction in respiration
- **controlling the temperature of their surroundings**, so less energy is used keeping the animal warm.

Some animals are fed **high protein foods** to increase growth. Advantages and disadvantages to weigh up:

Advantages	Disadvantages
More food from the same input, so cheaper food, and less land needed	Some people have ethical objections : animal welfare is poor
Faster growth, so quicker turnover	Crowded conditions spread disease, so antibiotics may be overused; heating costs energy

7.5.4 Role of biotechnology **BIOLOGY ONLY**

BIOLOGY ONLY Modern biotechnology techniques enable large quantities of microorganisms to be cultured for food.

- **Mycoprotein.** The fungus *Fusarium* produces mycoprotein, a protein-rich food suitable for vegetarians. It is grown on **glucose syrup** in **aerobic** conditions, and the **biomass is harvested and purified**.
- **Human insulin.** A **genetically modified bacterium produces human insulin**; harvested and purified, it treats people with diabetes.
- **GM crops.** These could provide more food, or food of improved nutritional value such as **golden rice**, modified to make a precursor of vitamin A.

Key ideas in biology (specification 4.8)

A small number of key ideas of universal application underpin the whole GCSE Biology course.

- Life processes depend on molecules whose structure is related to their function.
- The fundamental units of living organisms are cells, which may be part of highly adapted tissues, organs and organ systems, enabling living processes to be performed effectively.
- Living organisms form populations of single species, communities of many species and ecosystems, interacting with each other, the environment and humans in many ways.
- Living organisms are interdependent and show adaptations to their environment.
- Life on Earth depends on photosynthesis, in which green plants and algae trap light from the Sun to fix carbon dioxide and combine it with hydrogen from water to make organic compounds and oxygen.
- Organic compounds are used as fuels in cellular respiration to allow the other chemical reactions necessary for life.
- The chemicals in ecosystems are continually cycling through the natural world.
- The characteristics of a living organism are influenced by its genome and its interaction with the environment.
- Evolution occurs by natural selection, and accounts both for biodiversity and for how organisms are all related to varying degrees.