

Cambridge OCR GCSE Biology A — Biology

Topic B6

Global challenges

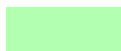
Specification J247 · Cambridge OCR

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 Random sampling

- sampling at coordinates chosen at random, so the sample is unbiased.

Define Capture

- recapture — estimating a mobile animal's population by marking and re-sampling.

Define Food security

- having enough safe, affordable food to feed a population.

Define Genetic engineering

- modifying the genome of an organism to introduce a desirable characteristic.

Define Communicable disease

- a disease caused by a pathogen and passed from one organism to another.

Define Pathogen

- a microorganism that causes disease: a virus, bacterium, protist or fungus.

Define Antibody

- a protein made by lymphocytes that binds one specific antigen.

Define Antibiotic

- a medicine that kills bacteria inside the body; it has no effect on viruses.

Define Biodiversity

- the variety of different species of organisms in an ecosystem, or on Earth.

Define Transect

- a line across a habitat with samples taken at fixed intervals along it.

Define Conservation

- protecting and managing species and habitats so that they survive.

Define Selective breeding

- breeding from the parents with the desired characteristics, over many generations.

Define Health

- a state of physical, mental and social well-being, not merely the absence of disease.

Define Non-communicable disease

- a disease that cannot be passed on, caused by interacting factors.

Define Antigen

- a molecule on a pathogen's surface recognised by the immune system as foreign.

Define Vaccine

- dead or inactive pathogen used to give immunity without causing the disease.

Define Antiseptic

- a chemical that kills microorganisms outside the body, on skin or surfaces.

Define Aseptic technique

- the methods used to stop unwanted microorganisms contaminating a culture.

HIGHER TIER

NOTE

Topic B6 is examined on **Paper 2 (Foundation)** and **Paper 4 (Higher)**, which assess Topics B4–B6 with assumed knowledge of Topics B1–B3 and B7, and which include **synoptic assessment**. Higher- Tier-only statements are **B6.1d, B6.2e, B6.3i, B6.3m and B6.3n**, tagged **HT ONLY**. Ten statements are **biology only**, tagged **BIOLOGY ONLY**: B6.1d, B6.2a, B6.2b, B6.2g, B6.3g, B6.3h, B6.3i, B6.3m, B6.3n and B6.3p.

Define Correlation

- a relationship between two variables; it does not by itself prove cause.

This topic applies biological knowledge to global challenges — using biological information to improve people's lives and to create a sustainable world for future generations.

B6.1 Monitoring and maintaining the environment

Living organisms interact with each other, the environment and with humans in many ways. If the variety of life is to be maintained we must monitor our environment, collecting and interpreting information about the natural world, to identify patterns and relate possible cause and effect.

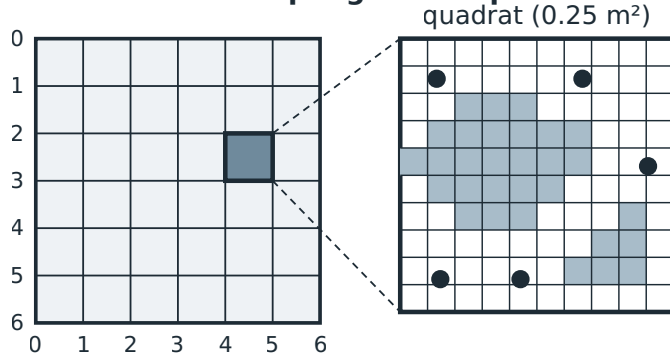
Carrying out a field investigation (B6.1a)

Distribution is *where* organisms are found; **abundance** is *how many*.

- Random sampling** — **quadrats** at random coordinates, across a uniform habitat; **transects** — quadrats at fixed intervals along a line, where conditions **change** across the habitat; **capture– recapture** for **mobile animals**, which cannot be counted in a quadrat.
- Apparatus** — quadrats, **pooters** for small insects, **sweep and pond nets**, pitfall traps, and **keys** to identify what is caught.
- Scaling up** — take the **mean** per quadrat and multiply by the number of quadrat-areas in the habitat.
- Measure **abiotic factors** at each point (light meter, thermometer, pH and moisture probes), take enough samples, place them without bias, and keep quadrat size and observer the same.

Random sampling with a quadrat, and a belt transect across a changing habitat.

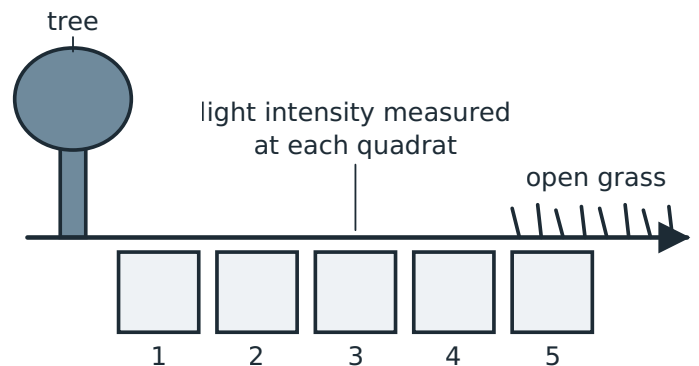
Random sampling with a quadrat



random coordinates (4, 2)

shaded squares = area covered by the plant
percentage cover = 30 of 100 squares = 30%
count = 5 snails (dots) in this 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

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

Human interactions within ecosystems (B6.1b)

- **Negative** — **deforestation**; destruction of **peat bogs**, releasing stored carbon; **land use** for building and quarrying, fragmenting habitats; **over-fishing and hunting**; **invasive species**; and **pollution** — sewage and fertiliser run-off causing **eutrophication**, sulfur dioxide and nitrogen oxides causing **acid rain**, ocean plastics, and pesticides accumulating along food chains.
- **Positive** — **conservation and captive breeding**; **seed banks** as a store of biodiversity; nature reserves and reintroductions; replanting hedgerows, woodland and peat bogs; pollution controls, sewage treatment and recycling; and the **monitoring**, research and education that make the rest possible.

WATCH OUT

Learners assume **every human interaction with an ecosystem is negative**. OCR is explicit that this topic must give the chance to explore **both positive and negative** interactions — conservation schemes, seed banks, replanting, pollution controls and ecotourism all **increase** biodiversity. An "evaluate" question expects both sides before a judgement.

Benefits and challenges of maintaining biodiversity (B6.1c)

- **Benefits** — high biodiversity makes ecosystems stable, because species are interdependent; wild species provide food crops, medicines, pollination, clean water and air, soil and flood protection, and have aesthetic and ethical value. **Ecotourism** gives local people an income from protecting a habitat rather than clearing it, though it adds travel emissions and disturbance unless visitor numbers are controlled.
- **Conservation of individual species** — captive breeding is expensive, needs a habitat to return animals to, and can reduce genetic variation. **Conservation of selected habitats** blocks farming, housing or development that people need, and **land use and hunting** remain threats where enforcement is weak.
- **Gaining agreements is difficult** — conservation is global but decisions are national, and countries differ in wealth and priorities. **Monitoring is difficult** too: schemes are long-term, remote and costly to check, so it is hard to prove an agreement is kept.

HT ONLY **BIOLOGY ONLY** Environmental change and distribution (B6.1d)

HT ONLY **BIOLOGY ONLY** Evaluate the evidence for the impact of environmental changes on the distribution of organisms, **with reference to water and atmospheric gases**.

- **Water** — changed rainfall, drought and drainage shift the range of plants and the animals depending on them; melting sea ice removes the hunting platform of polar species; rising sea level floods coastal habitats.
- **Atmospheric gases** — rising **carbon dioxide** raises temperature, so ranges shift polewards and up mountains, and dissolved CO₂ acidifies oceans, damaging corals; **sulfur dioxide** restricts lichens to cleaner air.
- **Evaluating the evidence** — is the data set long enough to separate a trend from natural variation, and the sample large and representative? Is there only a **correlation**, or a mechanism too? Has it been **peer reviewed**, and do independent data sets agree? State what the data show, give the limitations, then conclude.

B6.2 Feeding the human race

The human population is increasing rapidly and with it the need for more food. There is much debate about gene technology as a solution to the problem of food security.

BIOLOGY ONLY Agricultural solutions (B6.2b)

BIOLOGY ONLY

- **Hydroponics** — roots in a mineral solution instead of soil; minerals, pH and disease precisely controlled and crops grown where soil is poor, but energy and set-up costs are high.
- **Biological control** — a natural predator or parasite instead of a pesticide (ladybirds against aphids): no residues, bioaccumulation or resistance, but slower, never total, and the control species may itself become a pest.
- **Gene technology** — crops modified for pest resistance, herbicide tolerance, drought tolerance or better nutrition (B6.2d–f).
- **Fertilisers** — replace nitrates, phosphates and potassium removed at harvest, raising yields sharply, but run-off causes **eutrophication**. **Pesticides** protect yield but kill non-target species, **accumulate along food chains** and select for **resistant** pests.

BIOLOGY ONLY Biological factors affecting food security (B6.2a)

BIOLOGY ONLY **Food security** is having enough safe, affordable food for a population. It is threatened by:

- the **increasing human population** — more mouths from the same land;
- **changing diets in wealthier populations**, shifting to meat and dairy, which need far more land, water and crop energy per gram of food;
- **new pests and pathogens** spread by trade and warming, destroying yields;
- **environmental change** — drought, flooding and soil erosion reducing farmable land;
- **sustainability and the cost of agricultural inputs** — fertilisers, pesticides, fuel and water are expensive and finite, and heavy use damages soil and water for later years.

Selective breeding (B6.2c)

- Choose the individuals showing the desired characteristic, breed them, choose the best offspring, and repeat over **many generations**. In **food plants**: high yield, disease resistance, drought tolerance, uniform ripening. In **domesticated animals**: milk or meat yield, docile temperament, disease resistance, wool quality.
- **Benefits** — greater yields from the same land, more nutritious food, and less need for pesticides where resistance is bred in.
- **Problems** — it **reduces genetic variation** (inbreeding), so the population is vulnerable to a new disease and has less to select from later; harmful recessive alleles become common; some breeds suffer inherited health problems; and it is **slow**.

Genetic engineering (B6.2d)

- **Genetic engineering is a process which involves modifying the genome of an organism to introduce desirable characteristics.**
- A gene is taken from one organism and inserted into another, which then makes that protein. Because the genetic code is **universal**, a gene works in a different species.
- Examples: bacteria making human **insulin**; crops with genes for **insect resistance** or **herbicide tolerance**; golden rice making beta-carotene. The products are **genetically modified (GM)**.

HIGHER TIER

HT ONLY The main steps in genetic engineering (B6.2e)

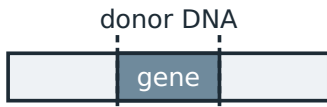
HT ONLY Learn the steps in order, with the correct terms.

1. The desired gene is cut from the donor DNA with a **restriction enzyme**, which cuts at a specific base sequence and leaves single-stranded **sticky ends**.
2. A **vector** — usually a bacterial **plasmid** — is cut with the **same restriction enzyme**, so it has complementary sticky ends.
3. Gene and vector are joined: the sticky ends pair by complementary base pairing and **ligase** seals the backbones.
4. The vector is taken up by **host bacteria**.
5. Only some cells take it up, so the successful ones are picked out by **selection using antibiotic resistance markers** — the plasmid also carries an antibiotic resistance gene, so only modified bacteria survive on agar containing that antibiotic.
6. The modified bacteria are cultured and reproduce rapidly, all expressing the gene.

The main steps in transferring a gene into a bacterium using a plasmid vector.

[HT only]

1 Cut out the gene



cut, leaving sticky ends

A restriction enzyme cuts the donor DNA at a specific base sequence, leaving single-stranded sticky ends.

2 Cut open the vector

bacterial plasmid — the vector



cut with the same enzyme

The same restriction enzyme cuts open the plasmid, so its sticky ends match the gene's.

3 Join gene and vector

recombinant plasmid



joins sealed by ligase

The sticky ends pair by complementary base pairing and ligase seals the joins.

4 Insert into host cells

host bacterium

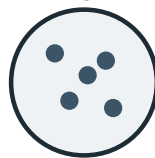


with the plasmid inside

The recombinant plasmid is taken up by host bacteria, but only some cells take it up.

5 Select the modified cells

agar containing the antibiotic



The plasmid also carries an antibiotic resistance gene, so only bacteria that took it up grow on this agar.

6 Culture the bacteria

the bacteria multiply



They reproduce rapidly and every one expresses the gene, making the protein — for example human insulin.

In plants and animals the gene is transferred at an early stage of development.

- In plants and animals the gene is transferred at an **early stage of development**, so every cell of the adult carries it.

ANALOGY

Restriction enzymes and ligase — cut and paste. A restriction enzyme is a pair of scissors that cuts only at one particular phrase, and cuts raggedly. Cut the gene and the plasmid with the **same** scissors and the two torn edges match perfectly; ligase is the glue that makes the join permanent. The antibiotic marker is the receipt proving which cells actually got the paste.

Benefits and risks of gene technology in agriculture (B6.2f)

- **Benefits** — higher yields and better food security; pest resistance without spraying; drought and salt tolerance for poor land; improved nutrition, as with vitamin A in golden rice; longer shelf life and less waste. It is far **faster and more precise** than selective breeding and can move a characteristic between species.
- **Practical risks** — modified genes may spread by pollen to wild relatives; pests may evolve resistance to the inserted toxin; non-target insects may be harmed; long-term health effects are not fully known; and monoculture of a few GM varieties reduces genetic variation.
- **Ethical considerations** — whether it is right to move genes between species and to patent organisms; farmers in poorer countries becoming dependent on a few seed companies; labelling and the consumer's right to choose (WS1.1d, WS1.1f, WS1.1g).

WATCH OUT

OCR reports that learners often think **genetic engineering leads to increased use of pesticides**. Usually the opposite is true: an **insect-resistant** crop needs **less insecticide**, because the plant makes its own protection. What can increase is the use of a specific **herbicide** on herbicide-tolerant crops — a chemical for weeds, not pests. Keep herbicide and insecticide apart in your answers.

BIOLOGY ONLY Biotechnological solutions (B6.2g)

BIOLOGY ONLY Biotechnology uses living organisms, usually microorganisms, on an industrial scale.

- **Mycoprotein** — the fungus *Fusarium* grown in a **fermenter** on glucose syrup with oxygen and controlled pH and temperature; the biomass is harvested as a high-protein, low-fat meat substitute.
- **GM microorganisms** producing insulin, enzymes, vitamins and feed supplements; **fermentation** by yeast for bread, brewing and bioethanol, and by bacteria for yoghurt and cheese.
- **Advantages** — very fast growth, easily controlled conditions, independence from climate and land quality, and waste materials as feedstock. **Considerations** — high energy and equipment costs, strict sterile conditions, and consumer acceptance.

B6.3 Monitoring and maintaining health

Diseases affect the health of populations of both humans and plants. Understanding how disease is spread, how the body defends itself and how immunity is achieved is essential if potentially fatal diseases are to be stopped from spreading through whole populations.

Health, disease and their interactions (B6.3a–c)

Health is physical, mental and social well-being, not just the absence of disease; diet, stress and exercise affect it as well as disease, and physical and mental ill health each make the other more likely (B6.3a).

WATCH OUT

Four errors OCR names here. (1) Learners view **all microorganisms as harmful** — most are harmless or useful: gut bacteria, decomposers, yoghurt cultures, antibiotic-producing fungi. Only **pathogens** cause disease. (2) Learners treat **health as physical only** — the definition includes **mental and social well-being**. (3) Learners **confuse inherited with caught** diseases: a communicable disease comes from a pathogen, an inherited one is passed on in the alleles. (4) Learners **see cancer as an inherited genetic disease**. Cancer comes from changes in cells during life, usually from interacting lifestyle, environmental and genetic risk factors; only a small share of the risk is inherited.

	Communicable	Non-communicable
Cause	A pathogen — virus, bacterium, protist or fungus	An interaction of factors : genetic, lifestyle, environmental
Passed on?	Yes , between organisms	No
Onset, duration	Often rapid, often short	Usually slow and long-term
Treatment	Antibiotics, antivirals, supportive care	Lifestyle change, drugs, surgery
Prevention	Hygiene, vaccination, vector control, isolation	Change the modifiable risk factors
Examples	Influenza, TB, HIV, athlete's foot	Cardiovascular disease, type 2 diabetes, many cancers

Interactions between different types of disease (B6.3c) — a damaged immune system makes infection far more likely, so people with **HIV**, which destroys lymphocytes, are much more likely to develop **tuberculosis**; and some pathogens trigger cancer, as infection with **HPV** causes the cervical cell changes leading to **cervical cancer**.

How communicable diseases spread (B6.3d)

Pathogen	What it is	How it harms	Examples
Virus	Not a cell — genetic material in a protein coat; reproduces inside host cells	Host cell bursts as new viruses are released	Influenza, HIV, TMV
Bacterium	Prokaryotic cell that divides rapidly	Produces toxins damaging cells and tissues	Tuberculosis, crown gall
Protist	Single-celled eukaryote, often carried by a vector	Damages the cells it enters	<i>Plasmodium</i> (malaria)
Fungus	Eukaryote spreading by spores	Digests and damages tissue	Athlete's foot, powdery mildew

- **In animals** — direct contact, including sexual contact and body fluids; **water**, e.g. cholera; **air**, in droplets from coughs and sneezes; contaminated food; and **vectors** such as mosquitoes.
- **In plants** — contact between leaves and roots; **wind-blown spores**; soil and infected debris; water splash; contaminated tools and hands; and insect vectors such as aphids.

Reducing and preventing spread (B6.3e)

- **Animals** — hygiene and handwashing, covering the mouth, safe food preparation, antiseptics; **isolation** and quarantine; **destroying vectors** with insecticides, nets and drainage; safe water and sewage treatment; **barrier contraception** (condoms) against sexually transmitted infections — hormonal methods prevent pregnancy but do **not** reduce STI transmission; **vaccination**.
- **Plants** — destroy infected plants; **crop rotation**; sterilise tools; control insect vectors; grow **resistant varieties**; chemical treatments and polytunnels; inspect imported material.

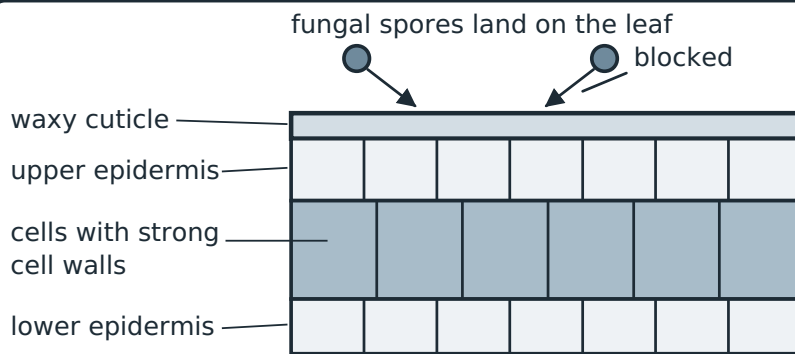
Named diseases (B6.3f)

- **Viral: influenza** — airborne droplets; fever, aching and cough; antibiotics do not work, and annual vaccination protects vulnerable groups.
- **Bacterial: tuberculosis** — droplets; damages the lungs, giving a persistent cough, fever and weight loss; treated with a long antibiotic course, and BCG protects.
- **Fungal: athlete's foot** — contact on damp floors and shared towels; itchy, cracked skin between the toes; antifungal cream.
- **Sexually transmitted infections, including HIV/AIDS** — HIV spreads in body fluids, through unprotected sex, shared needles or mother to baby, and destroys **lymphocytes** so the immune system fails; in late-stage infection (**AIDS**) people die of other infections such as TB, or of cancers.
Antiretroviral drugs control it but do not cure it; prevention is by condoms, testing, clean needles and screened blood.
- **Viral plant disease: tobacco mosaic virus (TMV)** — a **mosaic** of mottled, discoloured leaves, so less chlorophyll, less photosynthesis and stunted growth.
- **Fungal plant disease: *Erysiphe graminis*, barley powdery mildew** — white powdery growth on leaves, spread by airborne spores, cutting photosynthesis and yield.
- **Bacterial plant disease: *Agrobacterium tumefaciens*, crown gall disease** — enters through wounds at the stem base and forms swollen **galls** that disrupt xylem and phloem transport.

BIOLOGY ONLY Plant defence responses (B6.3g–h)

- **BIOLOGY ONLY Physical (B6.3g)** — the **waxy cuticle** is a barrier pathogens cannot penetrate and keeps the leaf surface dry so spores do not germinate; **cellulose cell walls** give a second barrier round every cell; bark and layers of dead cells protect stems.
- **BIOLOGY ONLY Chemical (B6.3h)** — plants make **antimicrobial substances** that kill bacteria and fungi directly, which is why mint, garlic and witch hazel are used as antiseptics and why some medicines come from plants. Poisons and bitter chemicals deter herbivores, so the wounds pathogens enter through are never made.

The physical and chemical defences a plant uses against pathogens and pests.



Waxy cuticle

A waterproof layer over the leaf surface. Pathogens cannot get through it.

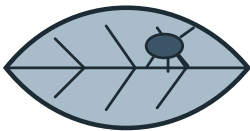
Cell walls

Every plant cell has a strong cellulose cell wall — a second barrier if a pathogen does get past the cuticle.

Other physical barriers

Layers of dead cells (bark) on stems, and thorns or hairy stems, make it harder for pests to reach the plant.

Chemical defences



pest eating a leaf

Many plants make chemicals that kill pathogens or stop pests eating them:

- antibacterial chemicals, e.g. in mint, kill bacteria
- poisons, e.g. in deadly nightshade, stop animals eating the plant

Some are used as human medicines: aspirin from willow bark relieves pain and fever, and quinine from cinchona bark treats malaria.

HIGHER TIER

HT ONLY BIOLOGY ONLY Detecting and identifying plant diseases (B6.3i)

HT ONLY BIOLOGY ONLY

- **In the field — observation and microscopy.** Look at the pattern and distribution of damage: stunted growth, spots, mottled leaves, rotting, galls, malformed stems, visible pests. A hand lens or field microscope shows spores and insects; compare with a diagnostic guide.
- **In the laboratory — detection of the DNA or the antigen of the disease-causing organism.** DNA testing identifies the pathogen's DNA in diseased tissue; antigen testing uses **monoclonal antibodies** that bind a specific antigen and give a colour change.
- Laboratory tests matter because different diseases, and mineral deficiencies, give similar field symptoms; DNA and antigen tests are **specific** and can detect infection before symptoms appear.

Blood cells in defence (B6.3j)

- **Phagocytes** — white blood cells with a **lobed nucleus** and flexible membrane, so they squeeze out of capillaries and change shape to **engulf and digest** pathogens with enzyme-filled vesicles.
- **Lymphocytes** — make **antibodies** shaped **complementary to one antigen**, clumping pathogens for phagocytes to engulf, and **antitoxins** that neutralise bacterial toxins.
- **Platelets** — cell fragments with no nucleus that trigger **clotting**; the fibrous clot stops blood loss and dries to a **scab** that seals out pathogens.

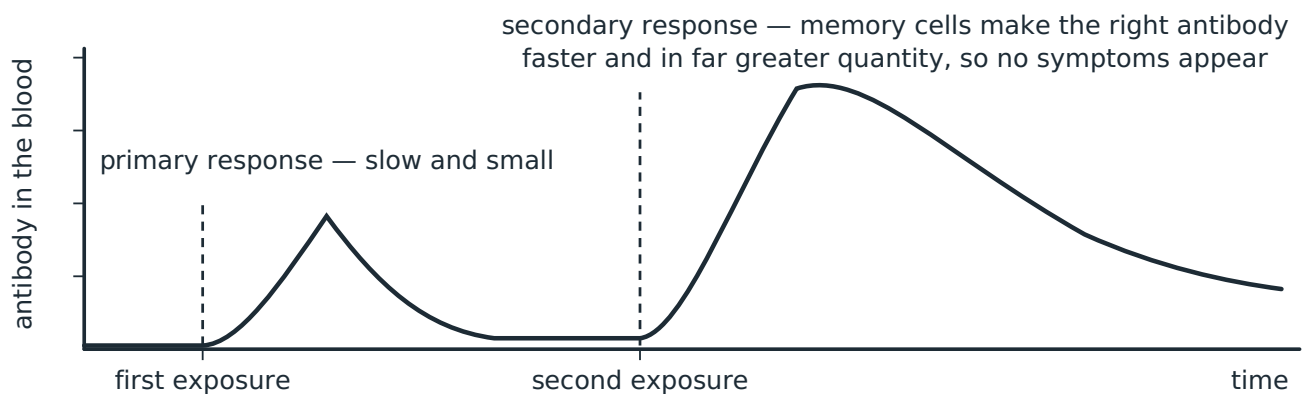
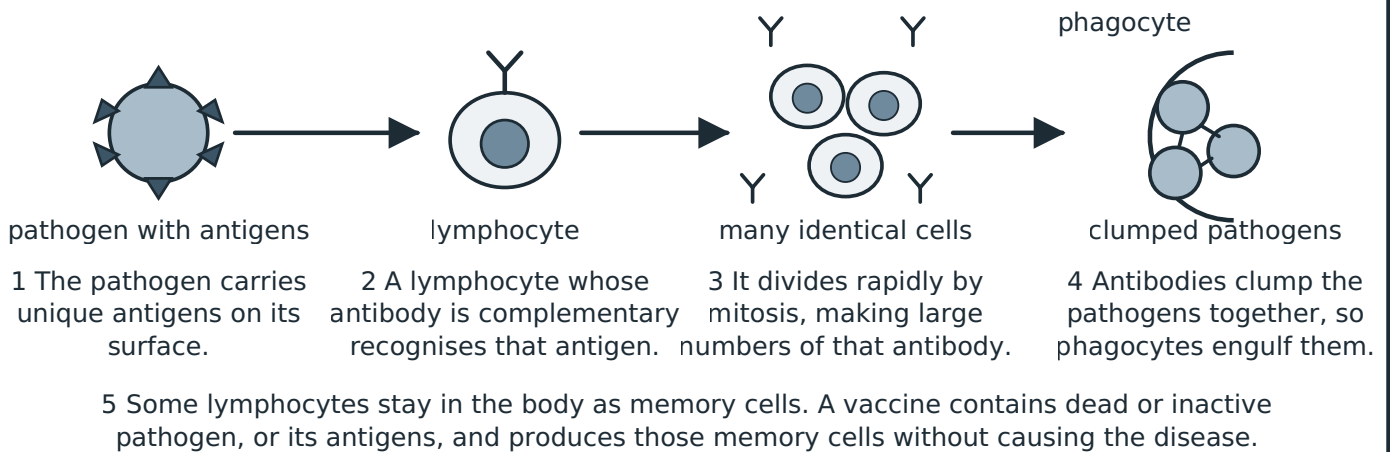
Non-specific defence systems (B6.3k)

These work against **all** pathogens without recognising any of them: the **skin**, a barrier of dead cells with antimicrobial **sebum**, harmless competing bacteria and **scab formation**; **mucus and hairs** in the nose; **mucus and cilia** in the trachea and bronchi, sweeping trapped pathogens up to be swallowed; **hydrochloric acid** in the stomach; and **lysozyme** in tears, which digests bacterial cell walls.

The immune system (B6.3l)

1. The pathogen carries unique **antigens** on its surface.
2. A **lymphocyte** with a complementary antibody recognises the antigen as foreign.
3. That lymphocyte **divides rapidly by mitosis**, producing large numbers of the **specific antibody**.
4. Antibodies bind the antigens, **clumping the pathogens** for **phagocytes** to engulf; antitoxins neutralise toxins.
5. Some lymphocytes remain as **memory cells**, so a second infection by the same pathogen produces the right antibody **faster and in far greater quantity** — the person is **immune**.

The immune response to a pathogen, and why the secondary response is faster and larger.



HT ONLY BIOLOGY ONLY Monoclonal antibodies (B6.3m–n)

HT ONLY BIOLOGY ONLY How they are produced (B6.3m)

1. A **mouse is injected with the antigen**, so its lymphocytes make the required antibody.
2. The **lymphocytes are extracted**; they make the right antibody but do not divide well in culture.
3. Each is **fused with a tumour cell** that divides indefinitely, forming a **hybridoma**.
4. Single hybridomas are **cloned**, then cultured, and the **antibody is collected and purified**. - They are **monoclonal** because all come from one clone of one cell, so every molecule is identical and specific to one antigen.

HT ONLY BIOLOGY ONLY How they are used (B6.3n) — **detecting antigens in pregnancy testing**, where antibodies in the stick bind the hormone **HCG** in urine to give a coloured line; **detecting disease**, such as measuring **prostate specific antigen** for prostate cancer, or locating clots and tumours with antibodies carrying a fluorescent dye; and **potentially treating disease**, where antibodies specific to a **cancer cell** antigen deliver a drug or radioactive substance to the tumour, harming fewer healthy cells than chemotherapy.

BIOLOGY ONLY Aseptic technique (B6.3p)

BIOLOGY ONLY Aseptic technique stops unwanted microorganisms contaminating the culture — and the culture contaminating you.

- **Autoclave** glassware and growth media at 121 °C to kill all microorganisms and spores, or use pre-sterilised plastic.
- **Flame** the inoculating loop until red hot before and after every transfer, and flame the neck of a bottle when opening and closing it.
- Wipe the bench and hands with **70% alcohol** before and after work.
- **Work around a Bunsen burner** on a gentle blue flame: the convection current stops airborne contaminants falling into the medium, and lift the Petri dish lid **only slightly, at an angle**.
- **Tape the lid in two places** — never seal it all round, or anaerobic pathogens could grow — **incubate at 25 °C** in school laboratories, and invert the dish so condensation does not drip on the agar. Autoclave everything before disposal.

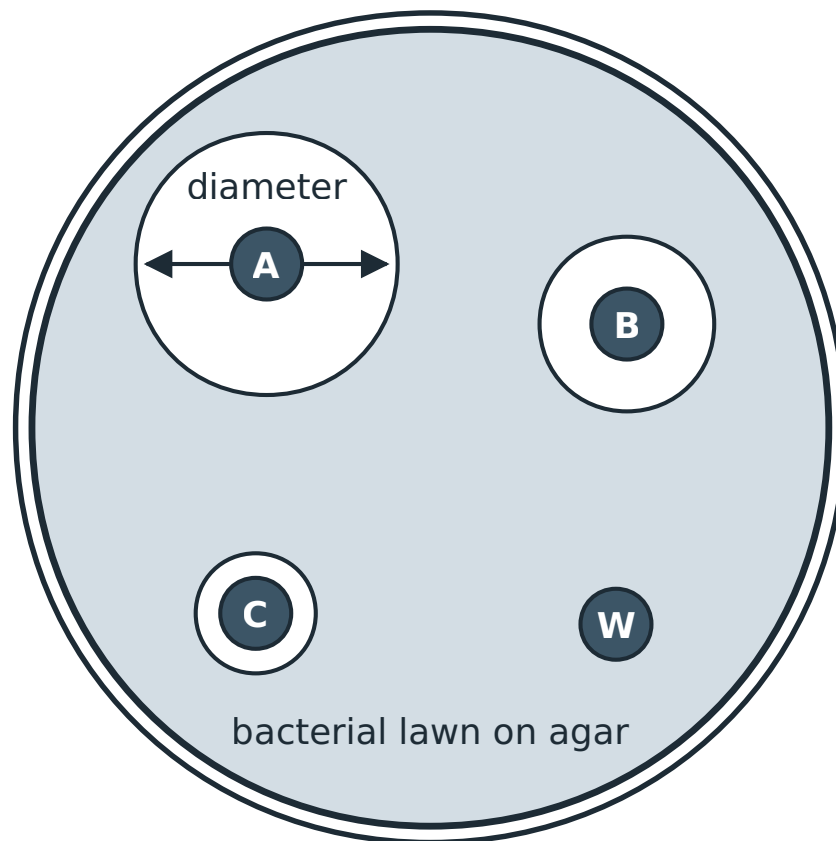
Vaccines and medicines (B6.3o)

- A **vaccine** contains a **small quantity of dead or inactive pathogen**, or its antigens, which stimulate lymphocytes to make the specific antibody and, crucially, **memory cells** — without the person suffering the disease. On real infection the **secondary response** destroys the pathogen before symptoms appear.
- If a **large proportion of the population is vaccinated** the pathogen cannot spread, so even the unvaccinated are protected — **herd immunity**. More infectious diseases need a higher proportion vaccinated.
- **Evaluating vaccination** — it has almost eradicated smallpox and polio and prevents epidemics; against that, no vaccine is 100% effective, a few people suffer side effects, and some cannot be vaccinated for medical reasons (WS1.1h).
- **Antibiotics kill bacteria inside the body but have no effect on viruses, which reproduce inside the host's own cells; specific bacteria need specific antibiotics, and resistance (B5.2e) is why courses must be completed. Antivirals slow viral reproduction rather than killing the virus. Antiseptics kill microorganisms outside the body, on skin and surfaces, so they prevent rather than treat infection. Painkillers treat symptoms only.**

ANALOGY

Herd immunity — the firebreak. A fire spreads tree to tree; vaccinated people are trees already soaked, so it cannot pass through them. Soak enough trees, scattered through the forest, and there is no continuous path, so even the dry trees survive. Leave the dry trees **clustered together** and the fire runs straight through — which is why falling vaccination in one community can restart an outbreak while the national figure still looks safe.

An agar plate testing three antimicrobials against a bacterial lawn, with a water control.



A, B and C — paper discs soaked in three different antimicrobials
W — disc soaked in sterile water, the control: no clear zone forms
clear zone — where bacteria were killed or prevented from growing
area of a clear zone = πr^2 — the larger the zone, the more effective

Discovery and development of new medicines (B6.3q)

- Drugs were traditionally extracted from **plants and microorganisms** — digitalis from foxgloves, aspirin from willow bark, penicillin from *Penicillium* mould; most are now synthesised, often from a natural starting molecule.
- Every medicine is tested for **efficacy, toxicity and dose**. **Preclinical testing** is on cells, tissues and then live animals in the laboratory.
- **Clinical testing** gives very low doses to **healthy volunteers** to check safety, then treats **patients**, raising the dose to find the optimum. In **double-blind trials** patients are randomly given the drug or a **placebo**, and neither patient nor doctor knows which, so neither can bias the result.
- Results are **peer reviewed and published** before a licence is granted; the process takes years and is expensive, which is why medicines cost so much.

Non-communicable disease (B6.3r-u)

Many non-communicable diseases are caused by the **interaction of a number of factors** — genetic, lifestyle and environmental. The spec names **cardiovascular diseases, many forms of cancer, some lung (bronchitis) and liver (cirrhosis)** diseases, and diseases influenced by nutrition, including **type 2 diabetes** (B6.3r). A **risk factor** raises the probability of disease; it does not guarantee it.

Treatments for cardiovascular disease (B6.3s) — you must **evaluate** all three.

Type	Treatment	Advantages	Disadvantages
Lifestyle	Stop smoking, exercise, less saturated fat and salt, lose weight	Cheap, no side effects, treats the cause	Needs long-term commitment; slow; may not be enough alone
Medical	Statins to lower cholesterol; drugs to lower blood pressure	Cut the risk of heart attack and stroke; non-invasive	Taken for life; side effects; do not clear an existing blockage
Surgical	Stents , coronary bypass, valve replacement, heart transplant	Immediate improvement in blood flow; a transplant can be a cure	Infection, clots and rejection; anaesthetic risk; expensive; donors are scarce

Lifestyle factors (B6.3t) — **exercise** reduces obesity, blood pressure, cardiovascular disease and type 2 diabetes; a **diet** high in fat, sugar and salt raises cholesterol, blood pressure and diabetes risk; **alcohol** causes **cirrhosis**, brain damage and some cancers, and harms fetal development; **smoking** causes lung cancer, **bronchitis**, emphysema and cardiovascular disease. Analyse the effect at three levels — *local*, where incidence varies between areas of a city with income and access to services; *national*, where rates differ between social and economic groups; and *global*, where non-communicable disease dominates in wealthier countries and communicable disease in the poorest. Data are given as **incidence per 100 000** so that populations of different sizes can be compared, and plotted on a **scatter diagram** to look for a **correlation** (BM6.3iv) — but **correlation is not proof of cause**, which also needs a mechanism, a dose- response relationship and independent repeats.

Cancer (B6.3u) — cancer is **the result of changes in cells that lead to uncontrolled growth and division**, because mutations disrupt control of the cell cycle. A **benign** tumour stays in one place inside a membrane; a **malignant** tumour invades neighbouring tissue and spreads in the blood to form **secondary tumours**, and malignant tumours are the cancers. Risk factors include smoking, obesity, UV and ionising radiation, carcinogenic chemicals, **HPV** infection and inherited alleles.

Stem cells, gene technology and the human genome (B6.3v–x)

- **Stem cells (B6.3v)** — unspecialised cells could replace damaged tissue in **tissue transplantation**: nerve cells after spinal injury, insulin-producing cells in type 1 diabetes, retinal cells for blindness, and the bone marrow transplants already used for leukaemia. Tissue grown from the patient's own cells avoids **rejection** and the shortage of donors. **Risks**: donor cells may be rejected, needing immunosuppressants; viruses may be transmitted; transplanted cells may divide uncontrollably to form a tumour; techniques are new and expensive. **Ethics**: embryonic stem cells come from embryos, which some believe have a right to life, while others argue that relieving suffering outweighs this — adult and cord-blood cells avoid the objection but are less versatile (WS1.1d).
- **Gene technology in medicine (B6.3w)** — engineered bacteria make **insulin**, growth hormone and vaccines cheaply and in unlimited quantity; **gene therapy** aims to correct a faulty allele; genetic testing identifies carriers and predicts risk. Against this, long-term effects are unknown, an inserted gene may disrupt another, treatments must be repeated, and costs are high and access unequal; and there are ethical questions about altering genes in embryos, and about who may see genetic information — insurers and employers in particular.
- **The human genome (B6.3x)** — understanding it allows the **likelihood of disease to be predicted**, so screening, earlier diagnosis and preventative advice become possible, and allows **drugs targeted to genomes**, matching treatment to an individual's alleles for better results and fewer side effects. Concerns remain over privacy, insurance and employment discrimination, the effect of knowing an untreatable risk, and unequal access.