Bacteria multiply by **binary fission** as often as once every 20 minutes if they have enough nutrients and a suitable temperature.

Bacteria can be grown in a **nutrient broth solution** or as **colonies** on an agar gel plate.

B1+

Plant diseases can be detected by:
• stunted growth • spots on leaves • areas of decay (rot) • growths • malformed stems or leaves • discolouration • the presence of pests.
Identification can be made by: • reference to a gardening manual or website • taking infected plants to a laboratory • using testing kits that contain monoclonal antibodies.

To stop contamination:
1. Petri dishes and culture media must be sterilised before use
2. Inoculating loops used to transfer microorganisms to the media must be sterilised by passing them through a flame
3. The lid of the Petri dish should be secured with adhesive tape and stored upside down

To prevent harmful bacteria being growth in school laboratories, cultures should be incubated at 25°C.

Tobacco mosaic virus as a viral disease, **black spot** as a fungal disease and **aphids** are insects.

Plants can be damaged by a range of **ion deficiency** conditions:

• stunted growth caused by **nitrate deficiency.** Nitrate ions are needed for protein synthesis and therefore growth

• **chlorosis** caused by **magnesium deficiency.** Magnesium ions needed to make chlorophyll → Photosynthesis stops

Physical defence responses to resist invasion of microorganisms.
• Cellulose cell walls.
• Tough waxy cuticle on leaves.
• Layers of dead cells around stems (bark on trees) which fall off.

Chemical plant defence responses.
• Antibacterial chemicals.
• Poisons to deter herbivores.

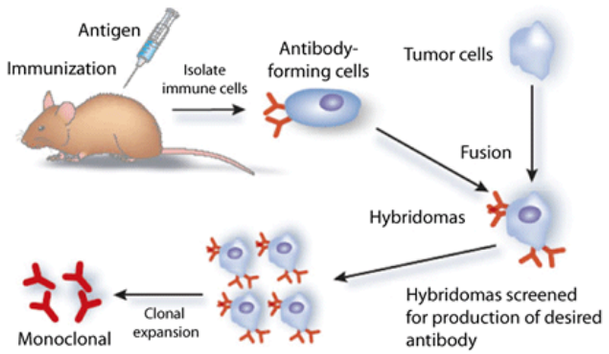
Mechanical adaptations.
• Thorns and hairs deter animals.
• Leaves which droop or curl when touched.
• Mimicry to trick animals.

B2+

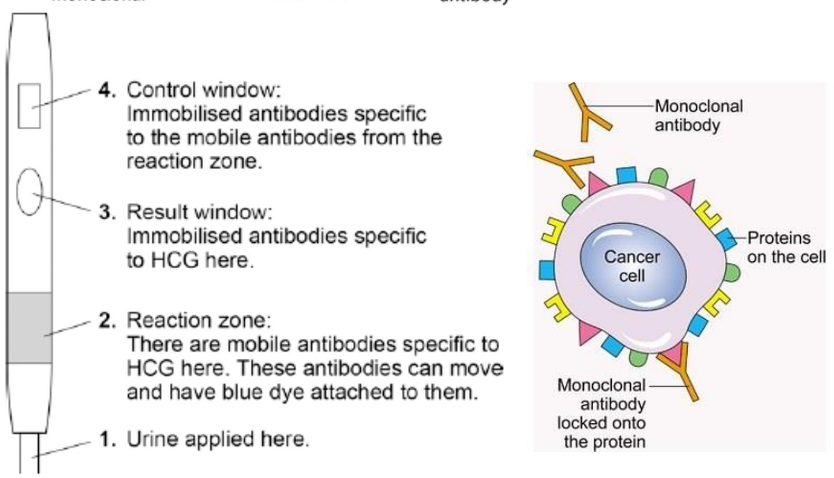
RP: investigate the effect of antiseptics or antibiotics on bacterial growth using agar plates and measuring zones of inhibition. IV = Antibiotic type or antiseptic DV = Area of Inhibition πr^2

Monoclonal antibodies are produced from a **single clone of cells**. The antibodies are **specific** to one binding site on one **protein antigen** and so are able to target a specific chemical or specific cells in the body.

They are produced by stimulating **mouse lymphocytes** to make a particular antibody. The lymphocytes are combined with a tumour cell to make a cell called a **hybridoma cell**.
Single hybridoma cells are **cloned** to produce many identical cells that all produce the same antibody. A large amount of the antibody can be collected and purified.

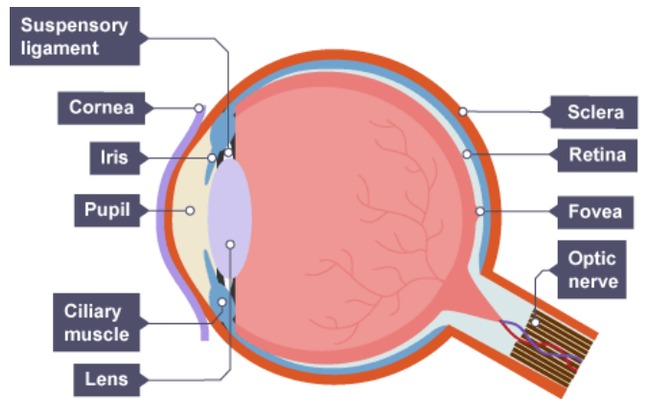


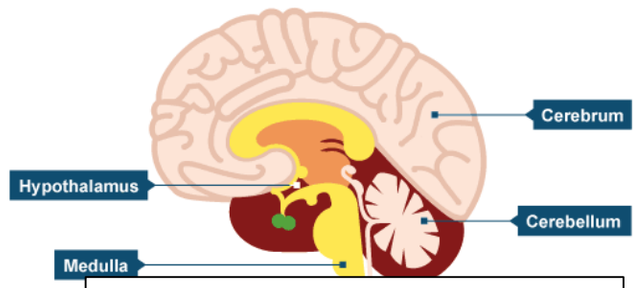
Evaluation
+ Can be used for pregnancy tests, detect hormones, pathogens or drugs in blood. Identify molecules in cells and tissue. To treat diseases such as cancer
- Monoclonal antibodies create more side effects than expected. They are not yet as widely used as everyone hoped when they were first developed.

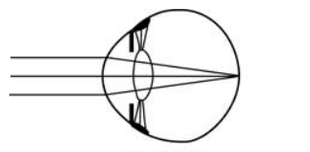


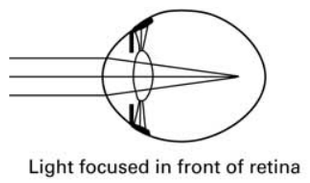
1. urine passes through reaction zone
2. HCG hormone binds to the mobile HCG antibody
3. HCG hormone binds to the immobilised HCG antibodies in the results zone
4. (the other) antibodies which do not attach to HCG bind to antibodies in control zone
5. blue dye appears in both control and results zones (to show positive result)

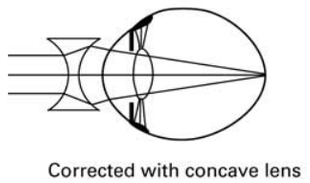
The **brain** controls complex behaviour and is made of **billions of interconnected neurones** Neuroscientists have been able to map the regions of the brain to particular functions by studying patients with brain damage, electrically stimulating different parts of the brain and using MRI scanning techniques.
The complexity and delicacy of the brain makes investigating and treating brain disorders very difficult.











The **eye** is a sense organ containing receptors sensitive to light intensity and colour. **Impulses** travel from the retina to the brain via the **optic nerve**

If the light is dim the pupil dilates to allow more light to reach the retina

Accommodation is the process of changing the shape of the lens to focus on near or distant objects.
To focus on a near object: • the ciliary muscles contract • the suspensory ligaments loosen • the lens is then thicker and refracts light rays strongly.
To focus on a distant object: • the ciliary muscles relax • the suspensory ligaments are pulled tight • the lens is then pulled thin and only slightly refracts light rays.

Two common defects of the eyes are **myopia** (short sightedness) and **hyperopia** (long sightedness) in which rays of light do not focus on the retina - treated with spectacle lenses which refract the light rays so that they do focus on the retina. • New technologies now include hard and soft contact lenses, laser surgery to change the shape of the **cornea** and a **replacement lens** in the eye.

Body temperature is monitored and controlled by the **thermoregulatory centre** in the brain – the skin and brain contain temperature receptors.
If the body temperature is too high, blood vessels dilate (**vasodilation**) and **sweat** is produced from the sweat glands. **Energy transferred** from the skin to the environment.
If the body temperature is too low, blood vessels constrict (**vasoconstriction**), sweating stops and skeletal muscles contract (**shiver**).

Water leaves the body via the lungs during exhalation. **Water, ions and urea** are lost from the skin in sweat. There is no control over water, ion or urea loss by the lungs or skin.
If body cells lose or gain too much water by **osmosis** they do not function efficiently.

The **digestion of proteins** from the diet results in excess **amino acids** which need to be excreted safely. In the liver these amino acids are **deaminated** to form toxic **ammonia.** It is converted to urea.

Excess water, ions and urea are removed via the **kidneys** in the urine.
The kidneys produce urine by **filtration** of the blood and **selective reabsorption** of useful substances such as **glucose, some ions and water**.
ADH is released by the **pituitary gland** when the blood is too concentrated and it causes more water to be reabsorbed back into the blood from the kidney tubules. This is controlled by **negative feedback.** People who suffer from kidney failure may be treated by organ transplant or by using kidney dialysis.
Dialysis fluid has 'ideal' concentrations of solutes . The machine has a partially permeable membrane.

Plants produce hormones to coordinate and control growth and responses to light (**phototropism**) and gravity (**gravitropism or geotropism**). Unequal distributions of **auxin** cause unequal growth rates in plant roots and shoots . Auxin is produced in the tip or shoot or root, diffuses to the shady side, or drops to the underside. In the shoot high concentration of auxin causes elongation. In the root elongation is inhibited. Auxins are used as weed killers, rooting powders and for promoting growth in tissue culture.
Gibberellins are important in initiating seed germination - used to end seed dormancy, promote flowering and increase fruit size. **Ethene** controls cell division and ripening of fruits - used to control ripening of fruit during storage and transport.
RP: investigate the effect of light or gravity on the growth of newly germinated seedlings.

Advantages of sexual reproduction: • produces variation in the offspring • if the environment changes variation gives a survival advantage by natural selection • natural selection can be speeded up by humans in selective breeding to increase food production.
Advantages of asexual reproduction: • only one parent needed • more time and energy efficient as do not need to find a mate • faster than sexual reproduction • many identical offspring can be produced when conditions are favourable.

• Malarial parasites reproduce asexually in the human host, but sexually in the mosquito. • Many fungi reproduce asexually by spores but also reproduce sexually to give variation. • Many plants produce seeds sexually, but also reproduce asexually by runners such as strawberry plants, or bulb division such as daffodils.

Darwin published his ideas in On the **Origin of Species** (1859). The theory of evolution by natural selection was only gradually accepted because: • the theory challenged the idea that God made all the animals and plants that live on Earth • there was insufficient evidence at the time the theory was published to convince many scientists • the mechanism of inheritance and variation was not known until 50 years after the theory was published.

B2+

Jean-Baptiste Lamarck -changes that occur in an organism during its lifetime can be inherited.

Alfred Russel Wallace independently proposed the theory of evolution by natural selection. He published joint writings with Darwin in 1858 which prompted Darwin to publish the Origin of Species (1859) the following year. He is best known for his work on **warning colouration** in animals and his theory of **speciation**.

Geographical isolation – variations caused by mutations, different environmental pressures, natural selection, survival of the fittest, genes passed on

Gregor Mendel carried out breeding experiments on plants (mid 19th century) One of his observations was that the inheritance of each characteristic is determined by 'units' that are passed on to descendants unchanged. In the late 19th century behaviour of chromosomes during cell division was observed.

In the **early 20th century** it was observed that chromosomes and Mendel's 'units' behaved in similar ways. This led to the idea that the 'units', now called genes, were located on chromosomes.
In the **mid-20th** century the structure of **DNA** was determined and gene theory developed by many scientists

Temperature, water and availability of oxygen affect the rate of **decay** of biological material. Gardeners and farmers try to provide **optimum conditions** for rapid decay of waste biological material. The compost produced is used as a natural fertiliser for growing garden plants or crops. **Anaerobic decay** produces methane gas. **Biogas** generators can be used to produce methane gas as a fuel.

RP: investigate the effect of temperature on the rate of decay of fresh milk by measuring pH change.

Environmental changes [temperature, water availability, atmospheric gas composition) affect the **distribution of species** in an ecosystem. The changes may be seasonal, geographic or caused by human interaction.

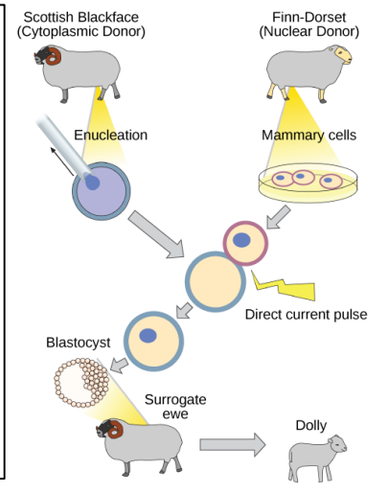
DNA is a **polymer** made from four different **nucleotides**. Each nucleotide consists of a common sugar and phosphate group with one of four **different bases** attached to the sugar. DNA contains four bases, A, C, G and T. A sequence of **three bases** is the code for a particular **amino acid**. The order of bases controls the order in which amino acids are assembled to produce a particular **protein**. A=T, G=C

Proteins are synthesised on **ribosomes**, according to a template. **Carrier molecules** bring specific amino acids to add to the growing protein chain in the correct order. The protein chain is complete it folds up to form a unique shape. This unique shape enables the proteins to do their job as enzymes, hormones or forming structures in the body such as collagen.
Mutations occur continuously. Most do not alter the protein, or only alter it slightly so that its appearance or function is not changed. An enzyme may no longer fit the substrate binding site or a structural protein may lose its strength. Not all parts of DNA code for proteins. **Non-coding** parts of DNA can **switch genes on and off**, so variations in these areas of DNA may affect how genes are expressed.

Trophic levels can be represented by numbers or biomass. Level 1: Plants and algae make their own food and are called **producers.** Level 2: Herbivores eat plants/algae and are called **primary consumers**. Level 3: Carnivores that eat herbivores are called **secondary consumers.** Level 4: Carnivores that eat other carnivores are called **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.

Producers are mostly plants and algae which transfer about 1% of the **incident energy** from light for photosynthesis. Only approximately **10% of the biomass** from each trophic level is transferred to the level above it. Losses of biomass are due to: • not all the ingested material is absorbed, some is egested as faeces • some absorbed material is lost as waste, such as carbon dioxide and water in respiration and water and urea in urine. Large amounts of glucose are used in respiration.

Tissue culture: using small groups of cells from part of a plant to grow identical new plants. This is important for preserving rare plant species or commercially in nurseries.
Cuttings: an older, but simple, method used by gardeners to produce many identical new plants from a parent plant. **Embryo transplants**: splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers.
Adult cell cloning: • The nucleus is removed from an unfertilised egg cell.
• The nucleus from an adult body cell, such as a skin cell, is inserted into the egg cell.
• An electric shock stimulates the egg cell to divide to form an embryo.
• These embryo cells contain the same genetic information as the adult skin cell.
• When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female



Food security is having enough food to feed a population. This is threatened by the increasing birth rate, high food miles, new pests and pathogens that affect farming, drought and conflicts.

The efficiency of food production can be improved by restricting energy transfer from food animals to the environment by limiting their movement and by controlling the temperature of their surroundings. Some animals are fed high protein foods to increase growth.

Fish stocks in the oceans are declining. Control of net size and the introduction of fishing quotas play important roles in conservation of fish stocks at a sustainable level.

The fungus **Fusarium** is useful for producing mycoprotein, a protein-rich food suitable for vegetarians. The fungus is grown on glucose syrup, in **aerobic** conditions, and the biomass is harvested and purified. A **GM** bacterium produces human insulin. When harvested and purified this is used to treat people with diabetes. **GM crops** could provide more food or food with an improved nutritional value such as golden rice.