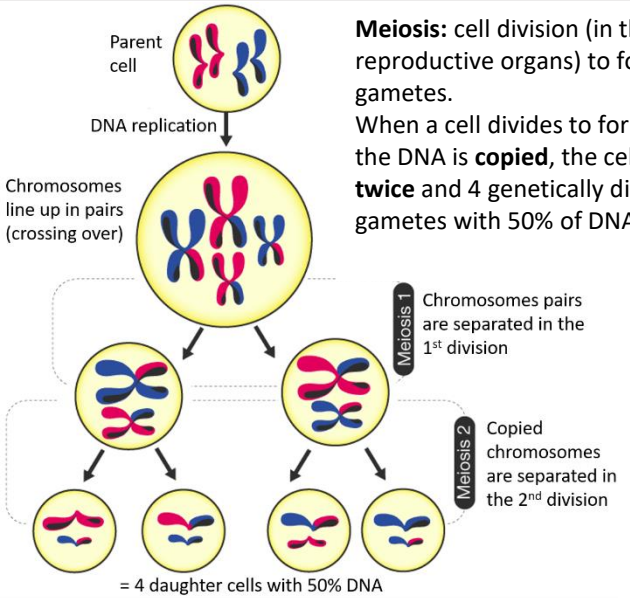
science biology

GCSE B6 – Inheritance, variation & evolution 1

Reproduction:

Asexual reproduction: only one parent, no fusion of gametes, no mixing of genetic information = genetically identical offspring (clones). Only mitosis is involved.

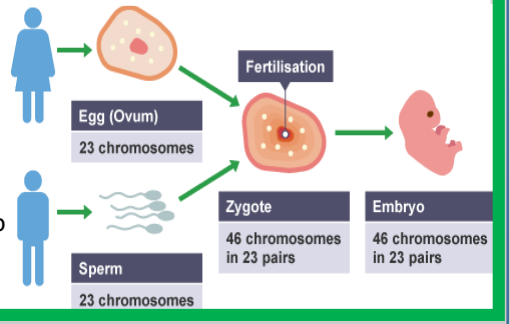
Sexual reproduction: 2 parents, fusion of male and female **gametes** (sperm & eggs in animals, pollen & ovum in plants), mixing of genetic information = variation in offspring.



Meiosis: cell division (in the reproductive organs) to form gametes.

When a cell divides to form gametes, the DNA is **copied**, the cell divides **twice** and 4 genetically different gametes with 50% of DNA are made

Gametes join at **fertilisation** to restore the normal number of chromosomes. The new cell divides by **mitosis**. The number of cells increases. As the embryo develops, cells **differentiate**.



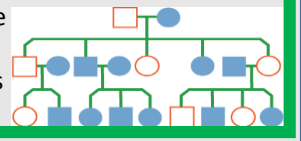
Gender Determination:

XX = female XY = male

During meiosis, 1 sex chromosome goes into one gamete, and the other goes into a second gamete. The **punnet square** shows there is a **50%** chance of having a boy or a girl each time.

	X	Y
X	XX	XY
X	XX	XY

Allele – different form of a gene
Dominant allele – always expressed, even if only one copy is inherited
Recessive allele – only expressed if two copies are inherited
Homozygous – 2 of the same allele
Heterozygous – 2 different alleles (1 of each)
Genotype – the genetics of an individual
Phenotype – the expression of the genes as physical features
Most characteristics result from **multiple genes interacting**.
Punnet square – shows the possible outcome of a genetic cross
Family tree – shows the inheritance of alleles through generations



Genetic Crosses: e.g. A heterozygous brown eyed dog mates with a homozygous blue eyed dog. The Brown allele is dominant.

1. Write genotype of parents **Bb x bb**
2. Draw punnet square, write parents' gamete alleles on top and side and fill in the boxes
3. Write out the possible phenotypes of the offspring:

2x brown eyed Bb (50%)
2x blue eyed bb (50%)
or a 1:1 chance of brown:blue

	b	b
B	Bb	Bb
b	bb	bb

Disorders caused by the inheritance of certain alleles:
- **Polydactyly** (extra fingers or toes) caused by **dominant** allele.
- **Cystic fibrosis** (excess mucus on lungs) caused by **recessive** allele.

Embryo screening involves checking the DNA of early embryos for inherited disorders. Often embryos are destroyed = economic, social and ethical issues.

DNA: the genetic material in the **nucleus**
- DNA is a polymer made up of two strands forming a **double helix**.
- The DNA is contained in structures called **chromosomes**.
- A **gene** is a small section of DNA on a chromosome.
- Each gene codes for a particular sequence of **amino acids**, to make a specific protein.
- **A Mutation** is a change in the DNA sequence.
- The **genome** of an organism is their entire genetic material

The whole **human genome** has now been studied and this will have great importance for medicine in the future:
- search for genes linked to different **types of disease**
- understanding and treatment of **inherited disorders**
- use in tracing **human migration** patterns from the past.

Genetic Engineering – adding characteristics to organisms

HT ONLY e.g. Making Insulin:

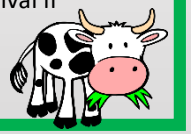
1. *Extract human insulin gene from DNA using **enzymes***
2. *Take a **plasmid** from a bacterium (vector)*
3. *Open plasmid and **insert** insulin gene with **DNA ligase***
4. *Put plasmid back in bacterium*
5. ***Incubate** to allow bacteria to **replicate** and make insulin.*

GM Crops eg. Golden Rice

+	-
Resistant to insects, viruses, fungi	Unknown long term effects
Grow bigger, taste better, more nutritious	Reduced biodiversity
Crops can be grown all over the World	Allergies could develop
Increased crop yield	Herbicide resistant gene could spread to weeds making superweeds!

Selective Breeding: Humans breed animals/plants to gain desirable characteristics in offspring (takes many generations). e.g. disease resistance, increased milk production, behaviour, scented flowers etc.

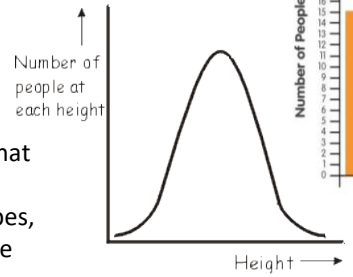
Downsides – Reduces variation limiting success of survival if conditions change, new diseases might wipe out every member of the same species, inbreeding in animals leads to defects.

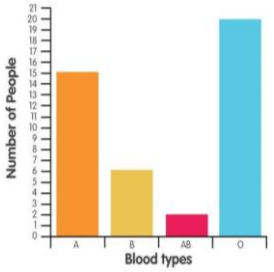


Differences in the **characteristics** of individuals in a population is called **variation** and may be due to differences in:
- the genes they have inherited (**genetic causes**)
- the conditions in which they developed (**environmental causes**)
- a **combination** of genes and the environment.

Continuous variation = data that is measurable eg. height, weight, tail length

Discontinuous variation = data that is categorised eg. colour, spots/stripes, gender, blood type





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GCSE B6 – Inheritance, variation & evolution 2

Evolution: is the change in the **inherited characteristics of a population over time** through a process of **natural selection** which may result in the **formation of a new species**.

There is usually extensive genetic variation within a population of a species and all variants arise from mutations which:

- most have no effect on the phenotype
- some influence phenotype;
- very few determine phenotype

Mutations in DNA occur continuously. Very rarely a mutation will lead to a new phenotype. If the new phenotype is suited to an environmental change it can lead to a relatively rapid change in the species.

Natural Selection:

The theory of evolution by natural selection states that all species of living things have evolved from simple life forms that first developed more than three billion years ago:

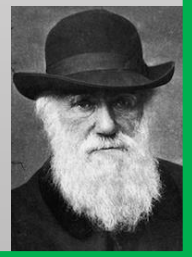
1. Variation occurs naturally within a species due to mutations
2. Some individuals have beneficial adaptations increasing their chances of survival
3. These individuals are more likely to reproduce
4. The genes responsible for the adaptation are passed on to their offspring.

If two populations of one species become so different in phenotype that they can no longer **interbreed** to produce **fertile offspring** they have formed **two new species.**

The theory of evolution by natural selection is now **widely accepted**. Evidence for Darwin's theory is now available as it has been shown that characteristics are passed on to offspring in genes. There is further evidence in the fossil record and the knowledge of how resistance to antibiotics evolves in bacteria.

Reasons why people didn't believe Darwin at first:

- Against religious beliefs
- They didn't know about genes or mutations at the time so Darwin couldn't explain why some organisms had more useful characteristics
- Not enough evidence (fossils)



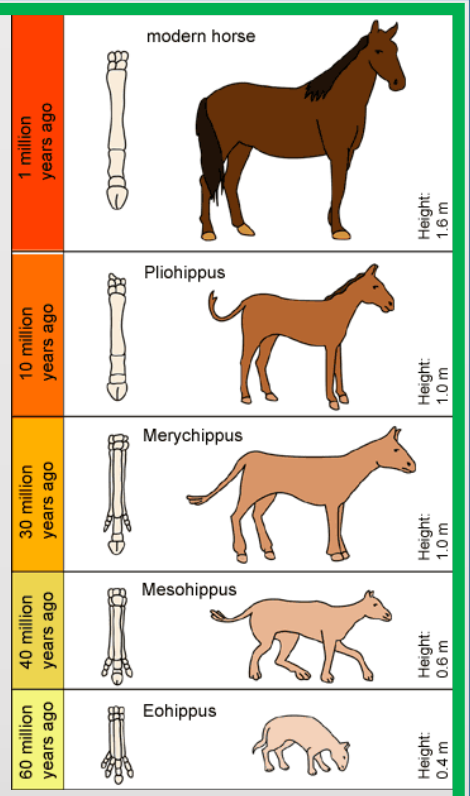
Evidence for Evolution:

1. **Fossils** – mineralised remains of bones, teeth, shells; imprints of tracks, roots, feathers, burrows; organisms trapped in ice or amber

Fossil record = a collection of fossils that show evolutionary history of an organism over many years.

Usually **incomplete** as…

- most organisms don't become fossils
- softer bodies **decay**
- fossils **destroyed** underground due to Earth movement
- **rare** to find



2. **Antibiotic resistant bacteria** – Bacteria **evolve rapidly** because they reproduce at a fast rate and mutations produce new strains.

Some bacteria in the human body are resistant to antibiotics

Antibiotics kill bacteria but not the resistant individuals

Resistant bacteria have more space and resources to multiply and so becomes the most common strain

MRSA is resistant to antibiotics.

To reduce the rate of development of antibiotic resistant strains:

- doctors should not prescribe antibiotics inappropriately
- patients should complete their course of antibiotics so all bacteria are killed and none survive to mutate and form resistant strains
- the agricultural use of antibiotics should be restricted

The development of new antibiotics is **costly** and **slow**. It is unlikely to keep up with the emergence of new resistant strains.

Extinction: no remaining individuals of a species still alive.

Living things become extinct because:

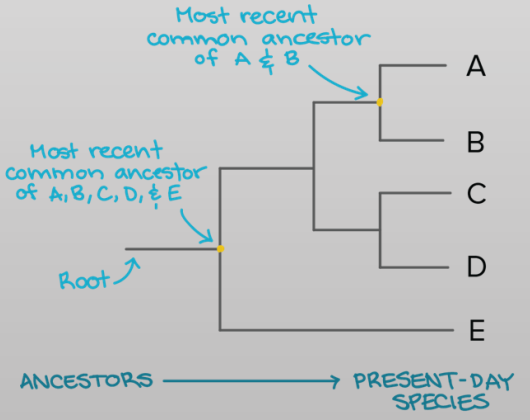
- Habitat changes – not adapted to survive
- New predator – not adapted to get away or hide
- New disease – lack of immunity
- New, more successful competitor – better adapted species will get food, space, water etc.

Classification: organising living organisms into groups of 'relatedness'

TRADITIONAL SYSTEM: Carl Linnaeus	NEW SYSTEM: Carl Woese
• Grouping based on similarities in organisms' characteristics and structures • All living things classified into **Kingdom**, **Phylum**, **Class**, **Order**, **Family**, **Genus** and **Species**. • Organisms are named by the **binomial system** of genus and species eg ***Homo sapiens***	• Grouping based on new evidence from **chemical analysis techniques** that prove some species aren't as closely related as once thought. • **Three-domain** system: 1. **Archaea** – primitive bacteria (extremophiles) 2. **Bacteria** – true bacteria 3. **Eukaryota** – fungi, animals, plants, protists • Domains are sub-divided into groups (KPCOFGS)

Evolutionary trees: show how **closely related** organisms are. They use current **classification data** for living organisms and **fossil data** for extinct organisms.

Common ancestor: the past species that gave rise to the more recent species (can be found at each branching point). The **more recent the common ancestor**, the **more closely related** the species are.



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GCSE B6 – Inheritance, variation & evolution (+triple)

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.

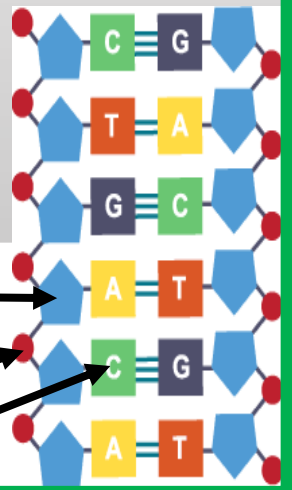
Some organisms reproduce by **both methods** depending on the circumstances:
- **Malarial parasites** reproduce asexually in the human host, but sexually in the mosquito.
- Many **fungi** reproduce asexually by spores but also reproduce sexually to give variation.
- Many **plants** produce seeds sexually, but also reproduce asexually by runners eg. strawberry plants, or bulb division eg. daffodils.

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.

Genetic variants may influence phenotype:
a) in coding DNA by altering the activity of a protein
b) in non-coding DNA by altering how genes are expressed

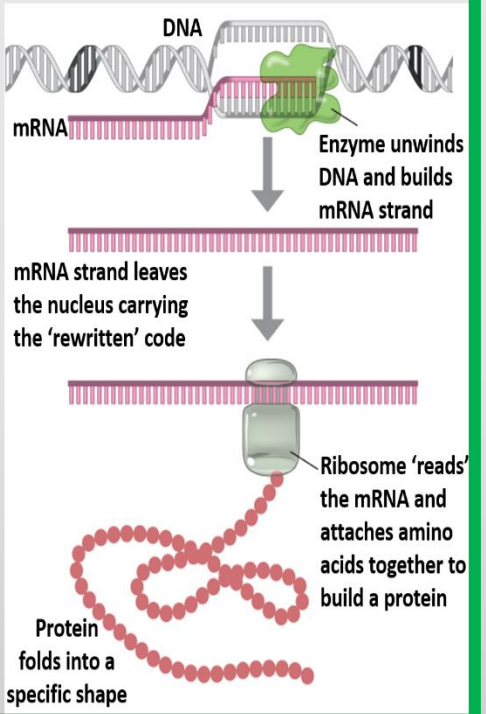
(HT only)

Complementary base pairing:
C** always links to **G
T** always links to **A



(HT only) Protein synthesis:
Making proteins using the instructions in the DNA
1. *DNA double helix **unwinds***
2. *mRNA makes a **corresponding** code using the DNA template*
3. *mRNA leaves the nucleus and binds to a **ribosome***
4. *tRNA '**translates**' the code (back to the original) and **amino acids** are attached in **sequence** as dictated by the code.*
5. *When 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.*

- *DNA mutations occur continuously. Most do not alter the protein, or only alter it slightly so that its appearance or function is not changed.*
- *A few mutations code for an altered protein with a different shape. 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.*



Our current understanding of genetics has developed over time:
* **1850 Gregor Mendel** (a monk) carried out **breeding experiments** on pea plants. Observation = inheritance of each characteristic is determined by 'units' that are passed on, unchanged, through generations. Mendel's discovery was not recognised at the time ☹
* **1879** behaviour of chromosomes during cell division was observed. Led to the idea that the 'units'(genes) were located on chromosomes
* **1953** structure of DNA was determined (**Watson, Crick & Franklin**) and the mechanism of gene function worked out ☺

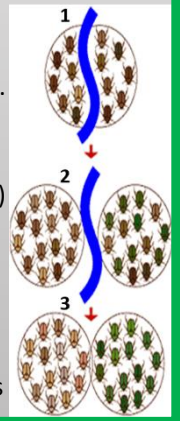
Cloning: making genetically identical copies

PLANT CLONING -
1. **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.
2. **Cuttings:** an older, but simple and cheap, method used by gardeners to produce many identical new plants from a parent plant.

ANIMAL CLONING -
3. **Embryo transplants:** splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers = several copies of identical offspring.
4. **Adult cell cloning:**
- The **nucleus** is removed from an **unfertilised** egg cell.
- The **nucleus** from adult body cell, eg skin cell, is inserted into egg
- An electric shock stimulates the egg cell to divide to form an embryo.
- The 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 to continue its development

Theories of Evolution:
Lamarck – the more a characteristic is used, the more developed it becomes and is then passed on to offspring. (Inheritance of acquired characteristics) e.g. Giraffes stretched their necks to reach higher food and passed on the characteristic to their offspring. ✗
Darwin – evolution by natural selection e.g. mutation caused some giraffes to have longer necks so they would be more likely to reach food, eat, survive and reproduce = offspring will inherit mutation and mutation will become more common. ✓
Wallace - proposed the theory of evolution by natural selection too. He published jointly with Darwin in 1858. He also did lots of work on <u>how</u> new species occur…

Speciation: process by which a new species appears
1. **Geographical isolation** (group split by water /land)
2. **Genetic variation** in both groups = some are more adapted to survive in their own conditions ➔ **Natural selection (**best breed & pass on best genes)
3. **Speciation** – 2 new groups **can't interbreed** with each other means they are now 2 separate species



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GCSE B7 – Ecology

- **Species** – group of similar organisms reproducing to make fertile offspring
- **Habitat** – where an organism lives
  Population – all organisms of a species in a habitat
  Community – all the populations of different species in a habitat
  Ecosystem – the interaction of a community (biotic) with the non-living (abiotic) parts of their environment.
- **Interdependence** - species depend on other species within a community for food, shelter, pollination, seed dispersal etc. If one species is removed it can affect the whole community.
- **A stable community** – all the species and environmental factors are in balance, so population sizes remain fairly constant e.g. tropical rainforests.

Abiotic factors - Non-living factors that affect the ecosystem	**Biotic factors** - Living factors that affect the ecosystem
light, CO_2, temperature, O_2, moisture, soil pH, wind	Competition, food, parasites, predators, disease

Distribution of organisms: where organisms are found in a habitat at a particular time. It is affected by abiotic (eg. temperature) and biotic (eg. food availability) factors.

Adaptations: Organisms have features (adaptations) that enable them to survive in the conditions in which they normally live.

Structural adaptations - the features of an organism's body structure e.g. shape, size or colour.

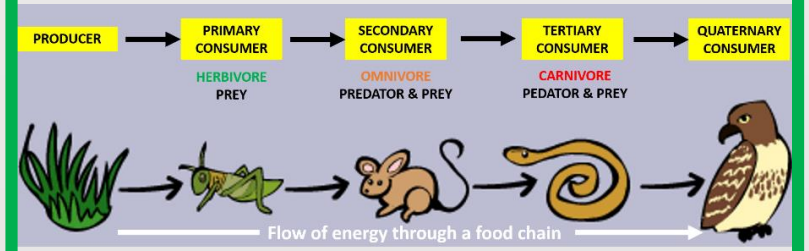
Behavioural adaptations - how an organism behaves e.g. some species migrate to warmer climates during winter months.

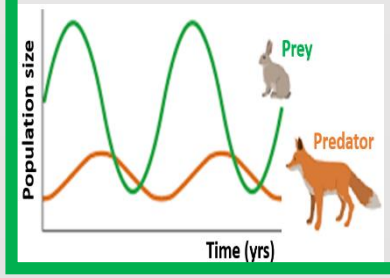
Functional adaptations - internal processes of an organism e.g. desert animals produce little sweat and small amounts of urine to conserve water.

Some organisms live in environments that are very extreme, such as at **high temperature**, **pressure**, or **salt concentration**. They are called **extremophiles** (eg. bacteria living in deep sea vents)

Biodiversity: variety of all the different species of organisms on Earth or within an ecosystem. **High biodiversity** increases the stability of ecosystems. The future of the human species on Earth relies on us maintaining a high level of biodiversity. Many human activities are reducing biodiversity ☹

Food chains: plants are the producers of **biomass** (living tissue) on Earth. All food chains begin with a **producer** which synthesise glucose. Primary **consumers** eat producers, which in turn are eaten by secondary consumers and then tertiary consumers. Consumers that kill and eat other animals are **predators**, and those eaten are **prey**.



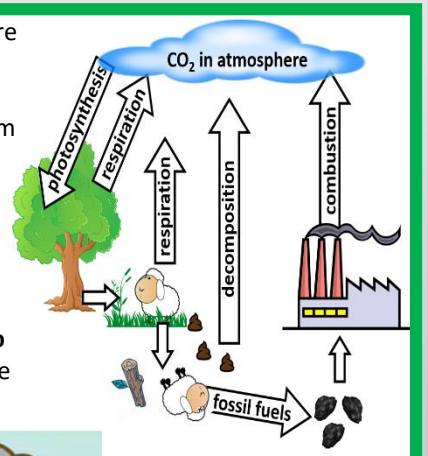


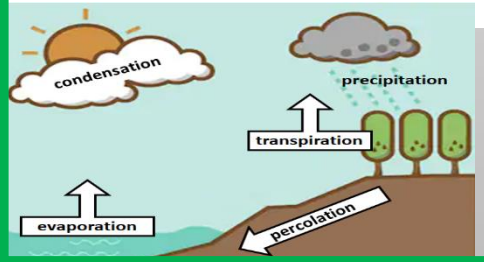
In a stable community the numbers of predators and prey rise and fall in cycles. The amount of food limits the population of a species. If the prey population increases then so will the predator population. As the number of predators increase, the number of prey decrease.

All materials in the living world are recycled to provide the building blocks for future organisms.

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

Microorganisms are responsible for cycling materials through an ecosystem by returning **carbon to the atmosphere** as carbon dioxide and **mineral ions to the soil**.





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

PRACTICAL – USING SAMPLING TECHNIQUES TO DETERMINE THE DISTRIBUTION AND ABUNDANCE OF ORGANISMS.

Quadrats: to estimate population sizes - good for field sampling

1. Grid out the area
2. Use random number generator to place quadrat
3. Use an field ID guide to identify species of plant
4. Count number of organisms /% coverage
5. Repeat & calculate mean number of each species per quadrat
6. Calculate area of habitat and how many quadrats would fit in it
7. Multiply each mean by the total quadrat area

Transect: to see changes in distribution - good for shorelines/woods

1. Lay tape along the length of the area
2. Place quadrat at regular intervals eg. Every 1m
3. Use an field ID guide to identify species of plant
4. Count number of organisms /% coverage
5. Move the transect along and make repeats to calculate a mean

Rapid growth in the human population and an increase in the standard of living mean that more resources are used and more waste and pollution is produced:

- **Water pollution** from sewage/fertiliser eg. **eutrophication** (algae blooms on top of lake →blocks sunlight → lake plants die & decay → O_2 is taken from the water by microbes → fish die)
- **Air pollution** from smoke/SO_2 eg. acid rain (alters pH of soil and water, kills roots and leaves)
- **Land pollution** from landfill/toxic chemicals eg. leaching (chemicals move through soil affecting plant growth)

All pollution reduces biodiversity. Humans reduce the amount of land available for other animals and plants by building, quarrying, farming and dumping waste.

Peat Bogs: destruction of peat bogs to make garden compost reduces the area of this habitat and its variety of different species (biodiversity) Decaying or burning peat releases **carbon dioxide** into the atmosphere

Global Warming: Levels of carbon dioxide and methane in the atmosphere are increasing, trapping more heat energy = melting polar ice caps, sea level rises, extreme weather, migration, extinctions.

Improving biodiversity and protecting environments:

- breeding programmes for endangered species
- protection and regeneration of rare habitats
- reintroduction of field margins and hedgerows in agricultural areas
- reduction of deforestation and carbon dioxide emissions
- recycling resources rather than dumping in landfill

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GCSE B7 – Ecology (+triple)

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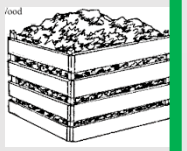
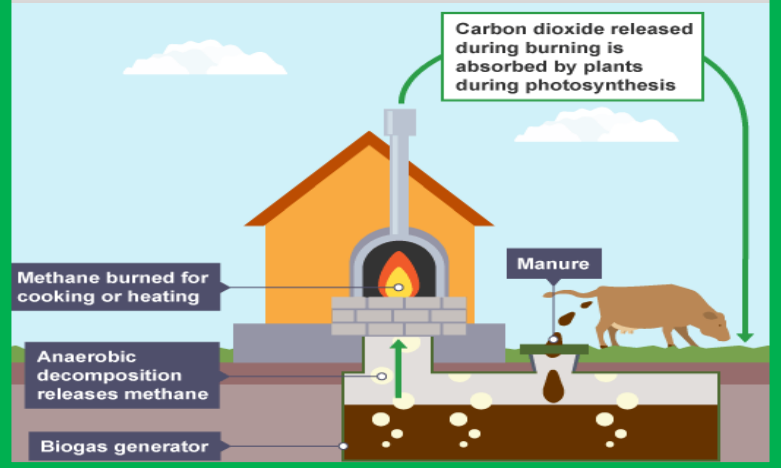
Decomposition: puts nitrates back into the soil and carbon dioxide back into the atmosphere.
Conditions for decay:
Temperature: Decay is controlled by enzymes so too cold = too slow, too hot = denatured.
Moisture: Makes it easier for microorganisms to digest food and prevents drying out.
Oxygen: For aerobic respiration – growth, reproduce etc. Aerobic respiration results in an increase in temperature in a compost heap

- **Compost Heaps** - decay releases nutrients from dead plants and animals to make fertile soil.
- **Air holes** - let oxygen in, regulate temperature.
- **Warmth** - generated by respiring microorganisms.
- Finely shredded waste increases surface area.



Decomposers (fungi and bacteria) break down dead matter by secreting enzymes into the environment. Small soluble food molecules then diffuse into the microorganism.

Biogas: anaerobic respiration in bacteria can produce methane – flammable gas (fuel) Biogas can be produced on a small scale in a **biogas generator**. The carbohydrate-containing materials are fed in, and a range of bacteria anaerobically ferment the carbohydrate into biogas. The remaining solids settle to the base of the digester and can be run off to be used as **fertiliser** for the land. The **optimum** temperature for biogas production is between 32°C and 35°C.
Cooler Countries – slow respiration rate – bury generator with thick walls. **Warmer Countries** – denatures enzymes – bury generator so ground keeps it cool during the day.



Environmental Change:

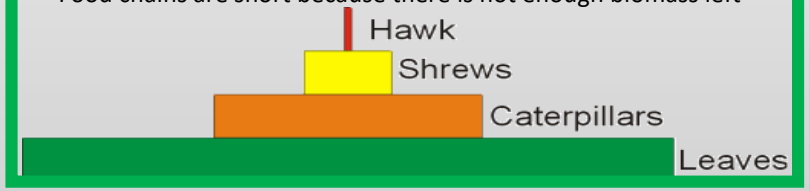
Seasonal Changes	Daylight, amount of rainfall, temperature all change with the seasons. Animals migrate.
Geographical Changes	Changes to soil (structure and pH), altitude, saltiness of water. Organisms have adaptations to survive.
Human Interaction	**Negative**: Global warming, acid rain, pollution **Positive**: Maintaining rainforests, reducing pollution, conservation of hedgerows and woodlands
Living Factors	New predator, diseases, new competitors

Biomass: mass of organism (no water)
Trophic Levels: stages in a food chain eg. producer, primary consumer
Pyramid of Biomass: shows the proportion of organisms at each trophic level. Rules for drawing a good one:

- Producer always at the bottom.
- They always have a pyramid shape

Biomass is lost from the food chain at each level because:

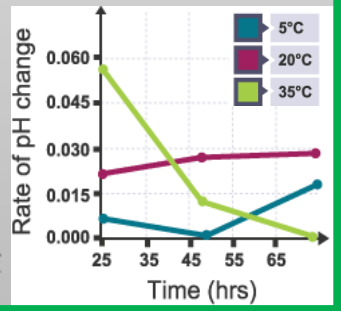
- Not all organisms or parts are eaten e.g. roots, bones.
- Faeces contain biomass (available to decomposers for decay)
- Most biomass consumed is used for respiration not growth
- Food chains are short because there is not enough biomass left



PRACTICAL – RATE OF DECAY
As milk decays its pH reduces because the milk bacteria respire converting lactose sugar to lactic acid.

- 3 beakers of milk
- Measure the pH
- Place at 3 different temperatures
- Measure the pH at 24, 48 & 72 hrs
- Calculate the rate of change of pH
- Faster drop in pH = faster decay

$$rate\ of\ change = \frac{change\ in\ value}{change\ in\ time}$$



Food Security: Having enough food for the population
Biological factors threatening food security:

- the increasing birth rate has threatened food security in some countries
- changing diets in developed countries means scarce food resources are transported around the world
- new pests and pathogens that affect farming
- environmental changes that affect food production, such as widespread famine occurring in some countries if rains fail
- the cost of agricultural inputs
- conflicts that have arisen in some parts of the world which affect the availability of water or food.

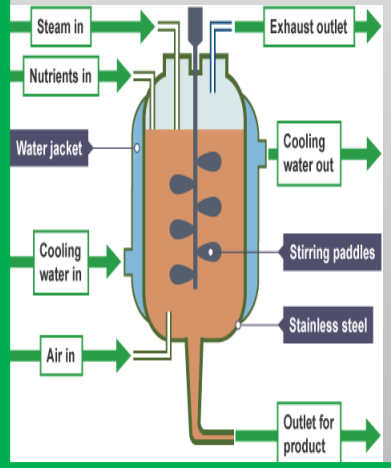
To make food production efficient:

- Shorter food chains so less biomass lost
- Limit movement of farm animals = less respiration = more growth
- Warmer temperature – less respiration more biomass
- Fish bred in cages on high protein diets

Downsides: Ethical concerns over animal cruelty and welfare, Cost for lighting and heating, disease spreads in intensive farms

Sustainable = producing foods in ways that supply the whole human population and can continue for years.
Maintaining fish stocks: breeding must continue or species may become extinct. To prevent overfishing:

- Larger-holed nets to only catch the bigger, older fish
- Ban fishing during breeding season
- Strict fishing quotas to make sure some fishermen only bring in a limited number of specific types of fish.



Modern biotechnology techniques enable large quantities of food to be produced.
The fungus **Fusarium** (grows fast on glucose syrup) in a **fermenter** under **aerobic** conditions. Fungal biomass is harvested, purified and processed to make **mycoprotein**. It can be shaped and flavoured to make a low fat, protein rich food.
GM crops could provide more food or food with improved nutritional value eg. golden rice.

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