GCSE
Biology 1
Revision Guide
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Variety of Life, Adaptation and Competition

### Classification - Descriptive Groups

Living organisms show a range of sizes, features and complexity. They can be divided into broad descriptive groups.

![Classification Diagram](image)

- **Plants**
  - Flowering plants
  - Non-flowering plants

- **Animals**
  - Vertebrates
  - Invertebrates

- **Microorganisms (microbes)**
  - Algae
  - Fungi
  - Bacteria

### Why and how should organisms be classified?

The names which we use everyday for animals and plants e.g. dog, cat, seagull, daisy are called **common names**. Common names are usually based on appearances which can be misleading.

### What does classification mean?

Classification means putting things into groups. The smallest group that an organism belongs to is normally the species. Related species are then placed in the same genus. Similar genera can then be placed into larger groups, and these groups can be lumped together into even larger groups. If we go on doing this, we finish up with **kingdoms** or **Domains**.

### What is a Kingdom or Domain?

This depends on the evidence we use to classify. We can use:

1. **Morphological features, e.g. structure or appearance**
   - This method of classification uses **5 kingdoms**:
     - Bacteria
     - Single celled organisms
     - Plants
     - Fungi
     - Animals

2. **DNA analysis**
   - This method of classification uses **3 Domains**:
     - Viruses
     - Bacteria
     - All organisms with a nucleus
How are organisms named?
International committees decide the scientific names of organisms, e.g. International Committee on Zoological Nomenclature (animal names).

Biologists use the binomial system devised by Carl Linnaeus which is in Latin.

All organisms are given two names, e.g. Homo sapiens for humans or Erinaeceus europaeus for the hedgehog.
The first name refers to the genus which the organism shares with other closely related organisms.
The second name refers to the species; no other organism in the genus has this name.

What is the advantage of using the scientific / Latin name?
- The name is always the same all over the world.
- The name is the same in all languages.

These are the type of answers examiners will look for.

An example of classification

<table>
<thead>
<tr>
<th>Scientific classification</th>
<th>Domestic dog</th>
<th>Coyote</th>
<th>Fox</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingdom</td>
<td>Animalia</td>
<td>Animalia</td>
<td>Animalia</td>
</tr>
<tr>
<td>Phylum</td>
<td>Chordata</td>
<td>Chordata</td>
<td>Chordata</td>
</tr>
<tr>
<td>Class</td>
<td>Mammalia</td>
<td>Mammalia</td>
<td>Mammalia</td>
</tr>
<tr>
<td>Order</td>
<td>Carnivora</td>
<td>Carnivora</td>
<td>Carnivora</td>
</tr>
<tr>
<td>Family</td>
<td>Canidae</td>
<td>Canidae</td>
<td>Canidae</td>
</tr>
<tr>
<td>Genus</td>
<td>Canis</td>
<td>Canis</td>
<td>Vulpes</td>
</tr>
<tr>
<td>Species</td>
<td>lupus</td>
<td>latrans</td>
<td>vulpes</td>
</tr>
</tbody>
</table>

Classification helps us to understand how related organisms are to each other. The Latin name of the domestic dog is Canis lupus. The genus shows us that the coyote is more closely related to the domestic dog than the fox.
Variety of Life, Adaptation and Competition

Adaptations
Organisms have **morphological** (the shape of an organism) and **behavioural** adaptations that enable them to survive in their environment.

Case study - Foxes
The arctic fox is found throughout the arctic and sub-arctic tundra whilst the Fennec fox is found in the Sahara and Arabian deserts.

<table>
<thead>
<tr>
<th>Profiles</th>
<th>Arctic fox</th>
<th>Fennec fox</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass / kg</td>
<td>6.5 – 17.0</td>
<td>10.0 – 1.5</td>
</tr>
<tr>
<td>Ear length / cm</td>
<td>4.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Coat colour</td>
<td>White (winter)</td>
<td>Sandy cream</td>
</tr>
</tbody>
</table>

1. Morphological adaptations
   - **Ear length**
     Animals with small ears lose less heat because they have a smaller surface area.
     Animals with big ears lose more heat because they have a larger surface area.
   - **Coat Colour**
     A white coat is camouflage against predators or prey in the snow.
     A sandy cream coat is camouflage against predators or prey in the desert.
   - **Body mass**
     Less heat is lost through the surface of an animal with large body mass.
     More heat is lost through the surface of an animal with a small body mass.

2. Behavioural adaptations
   The fennec fox is nocturnal (goes out during the night). This is to avoid the heat of the desert during the day. It hunts at night because it is cooler.

Don’t always assume that animals are nocturnal to avoid predators or prey.

**Tips**
- Questions on adaptation usually contain information about a plant or an animal and their habitat.
- Use this information to help you!
Variety of Life, Adaptation and Competition

**Population Size**
Population size means how many of **one type of plant or animal** (species) there is in a given ecosystem.

<table>
<thead>
<tr>
<th>The size of an animal population may be affected by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Competition for <strong>food</strong> and <strong>water</strong>,</td>
</tr>
<tr>
<td>• Number of predators,</td>
</tr>
<tr>
<td>• Disease,</td>
</tr>
<tr>
<td>• Pollution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The size of a plant population may be affected by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Competition for <strong>light</strong>, <strong>water</strong> or <strong>minerals</strong>,</td>
</tr>
<tr>
<td>• Number of herbivores,</td>
</tr>
<tr>
<td>• Disease,</td>
</tr>
<tr>
<td>• Pollution</td>
</tr>
</tbody>
</table>

Organisms that are better adapted to the environment are more successful and usually reproduce more and have more offspring (a new organism).

**Predator and Prey Cycles**
Predators are animals that kill and eat other animals while the animals that are eaten are called prey.
Within a natural environment there is a delicate balance between the population of the predator and prey.

**A classic example – Lynx and Hare**

In an exam you may be asked to **explain** the changes in the population.
To answer you must **describe** what is happening, and say **why**?
E.g. At 1 the number of prey is increasing because the number of predators is low. At 3 the number of prey is decreasing because the number of predators is increasing.
What effects do humans have on the environment?

When the human population was less, the effect of human activity on the environment was lower and localised. As populations have increased, the effects on the environment have increased also.

These days more and more species are vanishing because man is destroying their habitats.

Habitats are being destroyed because of increases in the use of land for:

- Building
- Quarrying
- Dumping rubbish
- Agriculture

Assessing Environmental Effects

During the planning process, developers must carry out an environmental impact assessment for each development to show the local authority before starting work. There can be a large fine for failing to do this.

The purpose of the environmental impact assessment is:

1. ensure the timing of any development has the least possible impact on wildlife;
2. show if any rare or endangered species are present;
3. show if it is possible to reduce the environmental effects through adapting the plans to suit the habitat’s needs;
4. monitor long term changes that might develop.

It is the job of Natural Resources Wales to monitor, protect and improve the environment, as well as to promote sustainable development.
In order to feed the growing world population we need get as much \textbf{yield} (from plants or animals) from \textbf{less land}.
We can do this by using \textbf{intensive farming methods}.

<table>
<thead>
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<th>Methods</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilisers</td>
<td>Increase plant yield.</td>
<td>Can wash out of soils and pollute rivers and streams.</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Increases yield by stopping pests from eating or competing with crop plants.</td>
<td>Can destroy non-pest species. Can lead to bioaccumulation.</td>
</tr>
<tr>
<td>Disease control</td>
<td>Prevents losses of plants and animals.</td>
<td>Antibiotics given to animals may still be found in meat form treated animals.</td>
</tr>
<tr>
<td>Battery methods</td>
<td>Less room to move. Less energy wasted. Less food needed. Reduced costs.</td>
<td>Poor quality of life for animal.</td>
</tr>
</tbody>
</table>

\textbf{TB infection in cattle and badgers}
Bovine tuberculosis (bTB) is a very serious disease of cattle in Britain. There is very strong evidence of a link between bTB in cattle and bTB in badgers.

<table>
<thead>
<tr>
<th>Arguments supporting a cull</th>
<th>Arguments against a cull</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badgers carry bTB and pass it on to cattle.</td>
<td>Badger culls have not always been effective.</td>
</tr>
<tr>
<td>Many cattle die each year.</td>
<td>Badgers that survive can move to other areas spreading the disease.</td>
</tr>
<tr>
<td></td>
<td>Vaccination may be more effective.</td>
</tr>
</tbody>
</table>
Measuring pollution in rivers and streams

Populations can be upset by the introduction of harmful materials into the environment, which results in pollution.

Pollution in rivers and streams can be measured using:
- Changes in pH levels
- Changes in oxygen levels
- Indicator species

Changes in pH
Acidification of rivers and streams is due to acid rain and run-off from surrounding land. Below pH 4.5-5 aluminium is released from rocks. This is toxic to fish.

Changes in oxygen levels
The change in oxygen concentration shows how much bacteria there is in the water. The more bacteria there are, the more polluted the water is.

Indicator species
You can estimate the amount of pollution by recording the presence or absence of certain indicator species.

Carrying out a survey
A survey should be a fair test. Therefore only one factor should change (the independent variable). Everything else should stay the same.

Example of an annual survey
- The independent variable is the year.

The variables that should stay the same:
- Time of year the survey is carried out,
- Same locations sampled,
- Time of day the survey is carried out,
- Volume of water sampled,
- Method of sampling,
- Same water conditions, e.g. temperature, flow rate, turbidity.
Lichen can be used as indicator species for air pollution. Lichens are sensitive to **sulphur dioxide** gas (produced from burning fossil fuels). Some species are so sensitive that a very low concentration of the gas will kill them. Lichen found growing on trees or rocks could be used to indicate the concentration of sulphur dioxide in the air.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
<th>Sulphur dioxide content of the air (ug/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Heavy Pollution</td>
<td>High sulphur dioxide concentration</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Clean Air</td>
<td>Low sulphur dioxide concentration</td>
</tr>
</tbody>
</table>

Note, some of the species found in more polluted air can also be found in purer air. Always look for the lichen giving the highest zone reading on the scale.
Monitoring the Environment, Energy Flow and Nutrient Transfer

**Pesticides in Food Chains**

These are chemicals that farmers use to control pests and diseases on crop plants.

- **Insecticides** kill insect pests feeding on plants.
- **Herbicides** (weed killers) reduce competition for water and light between pest plants and crops.
- **Fungicides** kill fungi that cause plant diseases.

**Environmental Effects of Pesticides - Bioaccumulation**

Pesticides can be sprayed on crops. Pesticides from crops may be washed into lakes, rivers and natural underground water stores and so contaminate drinking water.

Some chemicals are not broken down by the cells of living organisms and therefore enter the food chain. The further along a food chain an organism is, the more chemicals accumulate in its tissues. The scientific name for this is bioaccumulation. The organism at the end of a food chain will receive a toxic dose that has harmful effects, e.g. reducing fertility or death.

**DDT – A Case Study for Bioaccumulation**

Between 1960 and 1970 seeds were often treated with pesticides, such as DDT to try and stop insects from eating them. Before long, the numbers of birds of prey, such as the Sparrowhawk were decreasing. Many were found dead with high levels of pesticides in their bodies.

Scientific evidence has shown that DDT stays in the environment for a long time. DDT has been banned in the USA since 1972 and in the UK since 1984.
In the year 2000 new laws were passed to reduce the level of pollution by industry. Many industries (oil refineries, chemical works, steel plants and paper mills) used to release chemicals into rivers and the sea. These chemicals included heavy metals such as lead, mercury, cadmium and tin.

A well-known case of industrial pollution is the tragedy of Minamata, a fishing village in Japan.

52 people died from mercury poisoning. Others were paralysed and babies were born with brain damage. Mercury affects the nervous system.

Explanation

- A plastics factory released mercury compounds into the sea.
- Plant plankton (microscopic plants) absorbed mercury.
- Animal plankton (microscopic animals) ate a lot of the plant plankton, and mercury built up inside them.
- Fish ate a lot of the animal plankton. Because they could not excrete the mercury (get rid of it from their bodies), the concentration increased inside them.
- When people ate a lot of the fish they received a very high concentration of mercury.
- This toxic or poisonous dose was enough to kill them or make them very ill.
Effect of Fertilisers and Sewage on the Environment

Fertilisers contain the minerals that crop plants need to grow, e.g. nitrates and phosphates. Chemical fertilisers are important in intensive farming, but they must be used carefully especially near streams, rivers and ponds.

Fertiliser being washed into the river.

Some plants start dying because of competition for light.

Algal bloom

Fish die because decomposing bacteria have used up all the oxygen for respiration

Explanation - (QWC question model answer)

- Fertilisers containing nitrates and phosphates are washed into streams, rivers, ponds and the sea.
- Nitrates and phosphates cause an increase in the growth of water plants or algal blooms.
- Some plants start dying because there is increased competition for light.
- Decomposing bacteria decompose (rot) the dead plants.
- The number of decomposing bacteria increases.
- The decomposing bacteria use up the oxygen in the water for respiration.
- There is less oxygen in the water.
- Animals, such as fish, die because there is not enough oxygen in the water.

What about sewage?

- Untreated sewage causes an increase in the growth of water plants. (It has the same effect as fertilisers).
- Bacteria in the water also feed on untreated sewage, using up the oxygen in the water for respiration.
Light energy from the sun is the source of all energy for all living things on the planet. Green plants absorb only a small percentage of this energy (about 1%), using the chlorophyll in their chloroplasts. The rest of the light is either reflected or is at the wrong wavelength.

The absorbed energy is used for photosynthesis to produce substances that become part of the cells. These increase the biomass of the plant.

**Biomass** is the mass of living material in plants and animals.

**Food Chains - Glossary of terms**

There are many terms to describe the organisms in a food chain. Some organisms can be described using more than one label. E.g. an herbivore can also be described as a first stage consumer.

- Producer
- Herbivore
- Carnivore
- Carnivore

- Oak leaves → Slug → Thrush → Sparrowhawk

  - First stage consumer
  - Second stage consumer
  - Third stage consumer

- **The arrows** in a food chain show energy being passed from one living thing to the next. (This is sometimes described as a flow of energy).

**Producer**  Makes its own food by photosynthesis.
**Consumer**  An organism that eats other organisms.
**First stage consumer**  The first organism that is ‘eating’ in a food chain.
**Second stage consumer**  The second organism that is ‘eating’ in a food chain.
**Third stage consumer**  The third organism that is ‘eating’ in a food chain.
**Herbivore**  An organism that only eats plants.
**Carnivore**  An organism that only eats animals.
**Omnivore**  An organism that eats both animals and plants.
Food Webs

Food webs are made from a number of different food chains linked together.

In the exam, you may be asked to explain what happens if an animal is removed from the chain.

Example
All the rabbits die from a disease.
1. What effect would this have on the foxes?
   • The number of foxes would decrease.
   b) Why?
   • There is less food for the foxes to eat.

2. a) What effect would this have on lettuce production?
   • The number of lettuce would increase.
   b) Why?
   • There are less rabbits eating the lettuce.

3. Explain in full the effect on the mice. (Notice, the mouse is not part of the same food chain).
   • The number of mice would decrease because the foxes have less rabbits to eat therefore they eat more mice.

Remember to think carefully
• who eats who,
• which animals will have less food,
• what will be the effect on other animals.
**Energy Flow Through a Food Chain**

There is energy lost at each step of a food chain, so there’s less available for the next animal. This is why the numbers of organisms in a food chain is limited. The more energy lost every step, the shorter the food chain.

Energy is also ‘lost’ from the food chain for the repair of animal or plant cells.

**Some things to consider about energy lost as heat during respiration.**
- Animals lose more heat than plants because their metabolism is higher (the amount of chemical activity in cells).
- Animals lose more heat than plants because they move around; plants don’t.
- Warm-blooded animals (mammals and birds) lose more heat than cold-blooded animals (all the others) because they need to keep their body temperature constant. (See homeostasis).
- Land animals lose more energy than animals in water, because they have to support their bodies. E.g. we humans have to stand, a jellyfish just floats!

**Efficient Food Production**

More food can be produced from an area of land if it is used for growing crops rather than grazing animals. **Less energy is lost if people eat plants, because the food chain is shorter.**

However, potatoes wouldn’t grow on a mountain, but sheep can graze there, so no need to stop all animal production.
# Food Pyramids

**Pyramids of number** show the **number of organisms in a given area** or volume for every feeding level.

Rules for pyramids of number:
1. The producer is always at the bottom.
2. The size of every block (area or volume) shows the **number** of plants or animals in the food chain.

Pyramids of numbers can be misleading. The pyramid on the left represents grassland and the one on the right woodland. Their shapes are different even though they show the number of individual organisms. A tree can support thousands of animals; therefore the base of the pyramid is smaller than the levels above.

**Pyramids of biomass** shows the **dry mass of organisms in a given area** or volume for every feeding level.

Rules for pyramids of biomass:
1. The producer is always at the bottom.
2. The size of every block (area or volume) shows the **dry mass of the** of plants or animals in the food chain.

The shape of a pyramid of biomass can change during the year, depending on the time a survey is carried out.

The pyramid on the right has been drawn from grassland during May.

If a survey were carried out in December the mass of grass would be less. During the winter it is colder and there is less sunlight, therefore the grass would be producing less biomass by photosynthesis.

**Remember**
A pyramid of biomass will always be pyramid shaped.
Building Food Pyramids
Organisms are represented as small squares on graph paper. Drawing a line around all the small squares will give a box that represents the numbers or biomass of an organism.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Number in the food chain</th>
<th>Mass of each organism (g)</th>
<th>Total biomass of organisms (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rose plants</td>
<td>1</td>
<td>640</td>
<td>640</td>
</tr>
<tr>
<td>Aphids</td>
<td>7000</td>
<td>0.05</td>
<td>350</td>
</tr>
<tr>
<td>Ladybirds</td>
<td>400</td>
<td>0.25</td>
<td>100</td>
</tr>
<tr>
<td>Chaffinch</td>
<td>1</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

Natural Recycling
Not every animal or plant gets eaten!

- **Decomposers** are bacteria and fungi.
- Decomposers digest and use animal and plant waste for growth and respiration.
- Minerals such as nitrates are released to the soil, and are then used by plants for growth.

Factors that affect the activity of decomposers (bacteria and fungi):
- Temperature
- Oxygen
- pH
- Heavy metals
Monitoring the Environment, Energy Flow and Nutrient Transfer

The Carbon Cycle

• Carbon enters the food chain via **photosynthesis**.
• Some of this carbon then becomes carbohydrates, fats and proteins in plants.
• The carbohydrates, fats and proteins are passed along the food chain when animals are **feeding** (consuming).
• Some carbon is converted to carbon dioxide during **respiration** by plants and animals.
• Carbon is returned to the environment when living things die or produce waste material, e.g. faeces.
• **Decomposers** (micro-organisms such as bacteria or fungi) feed on dead organisms and the waste material for growth and other life processes. This is called decomposition or decay.
• Carbon is released to the atmosphere as carbon dioxide when decomposers respire.
• When decay is prevented substances such as peat, coal, oil and gas are formed and these store energy in carbon compounds.
• Energy and carbon dioxide are released when these fossil fuels are burnt.

**Human effects on the carbon cycle**

• **Combustion** (burning) of fossil fuels has increased the concentration of carbon dioxide in the environment.
• **Combustion** of fossil fuels also releases sulphur dioxide that leads to acid rain.
Monitoring the Environment, Energy Flow and Nutrient Transfer

The Nitrogen Cycle

- Living organisms need nitrogen to make **proteins**.
- 79% of the air is nitrogen, but plants and animals can't use nitrogen gas.
- Nitrogen must be changed into **nitrates** before plants can use it.

Nitrates can be absorbed by plant roots and used to make proteins. This protein then becomes food for animals as it is passed on along food chains.

How does the nitrogen cycle work?

- When a plant or animal dies,
- Soil bacteria and fungi act as decomposers,
- They convert protein (and urea from urine) into ammonia,
- The ammonia is then converted to nitrates in a process called nitrification.
- Nitrifying bacteria carry out nitrification.
- The nitrates are then absorbed (taken up) by plant roots.
- The nitrates are used to make amino acids.
- The amino acids are then used to make new proteins.
Inheritance

Genetic Information

The genetic information to build your body is inside the **nucleus** of each cell.

**In humans** there are 23 pairs of chromosomes.

Chromosomes are arranged by **size** and **shape**.

In humans, pair 23 is called the sex chromosomes.

- **Male** = \( XY \)
- **Female** = \( XX \)

A single chromosome has lots of information on how to build your body. Each bit of information is called a **gene**.

In body cells, chromosomes are found in pairs. Genes are therefore found in pairs.

Pairs of genes are found opposite each other at the same position.

Different genes control different characteristics.
Inheritance

**DNA**

- Chromosomes are strands of DNA and genes are sections of DNA molecules.
- DNA contains coded information which determines the sequence of amino acids which make up the different types of proteins produced in the cell.
- Some proteins are enzymes which control processes within the cell. These enzymes in turn affect the functioning of the cell and so the organism’s inherited characteristics.

![DNA molecule with amino acids](image)

This section of the DNA molecule contains a code to put amino acids into the following order.

This chain of amino acids helps to form a molecule of insulin.

- If a mutation happens in the DNA then the sequence of amino acids will change:

![Mutation diagram](image)

- The protein will then be different which will affect the functioning or characteristics of the organism.
Inheritance

Genetic Profiling

Genetic profiling is the analysis of an organism’s DNA.

(This is commonly referred to as genetic fingerprinting – but this term should not be used in an exam).

DNA profiling involves cutting the DNA into short pieces that are then separated into bands.

The pattern of the bands can be compared to show the similarity between two DNA samples.

DNA profiling is used:
• To identify suspects from evidence at crime scenes
• In paternity cases
• In comparisons between species for classification.

It is very unlikely that two organisms have exactly the same genetic profile.

DNA profiling can be used to identify the presence of certain genes that may be associated with a particular disease. The likelihood that these genes may be linked to a particular disease is based on statistical probability. For example, you may have a gene linked to Type 2 diabetes, but if you live a healthy life style you may never suffer from this problem.

DNA profiling raises several ethical issues:
• Who owns the DNA sample involved and who owns the information after analysis?
• Should information on an individual’s DNA be kept on record?
• Should third parties, e.g. insurance companies be informed of the presence of a particular gene?)
Inheritance

Inheritance and Chromosomes

This is how genetic information is passed from parents to offspring.

- Human body cells contain 46 chromosomes.
- Human sex cells, the sperm and eggs, contain 23 chromosomes. (Sex cells are also called gametes – both terms are correct).
- Different organisms have different numbers of chromosomes. An onion has 16 chromosomes. A dog has 78 chromosomes.

Example - Inheritance in a fruit fly. (Chromosome number = 8)

- The number of chromosomes in the egg and sperm are half the number in a normal cell.
- This is so that when they join together in fertilisation the offspring will have the correct number of chromosomes.
Inheritance of Sex

Equal numbers of X sperms and Y sperms are produced. So the probability of the baby being a boy or a girl is 50%.

We can show this using a Punnett square.

The Punnett square shows all the possible combinations from mixing the sperm and eggs.
Inheritance

Genetics

Genetics is the study of heredity.

It is the genes that you have that decide everything about your body!
You have **two** genes for every characteristic.

Chromosome from father

Chromosome from mother

There are lots of terms you have to use and learn in genetics.

- **Alleles** - two forms of the same gene, and we use letters to represent them.
- **Genotype** – the genetic make-up, i.e. your alleles.
  (This is always a **pair** of letters).
- **Phenotype** – the characteristic that is shown because of your genotype.
- A **dominant** allele will always ‘show’ in the phenotype when present.
  (This is shown with a CAPITAL letter).
- A **recessive** allele will be ‘hidden’ when a dominant allele is present.
  (This is represented with a small case letter).
- **Homozygous** – if the two alleles for a gene are identical.
- **Heterozygous** – if the two alleles for a gene are different.

---

**Example – tongue rolling.**

<table>
<thead>
<tr>
<th>Alleles</th>
<th>Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>R = allele to roll the tongue</td>
<td>Can roll tongue</td>
</tr>
<tr>
<td>r = allele can’t roll the tongue</td>
<td>Can’t roll tongue</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR</td>
<td>Homozygous</td>
</tr>
<tr>
<td>Rr</td>
<td>Heterozygous</td>
</tr>
<tr>
<td>rr</td>
<td>Homozygous</td>
</tr>
</tbody>
</table>
Inheritance

**Gregor Mendel**

Mendel began the study of genetics. He investigated the inheritance of height in pea plants.

Starting in 1856, Mendel carried out a series of experiments in the garden of his monastery. By counting the offspring, Mendel collected the following data from crosses between two ‘pure’ strains of pea plants:

Tall pea plants X Short pea plants

1st generation (F1) = All tall plants.

F1 X F1

2nd generation (F2) = 787 tall plants 277 short plants

Notice that Mendel carried out a large number of experiments (repeats). Doing this made his results and therefore his conclusions more valid.

Mendel crossed a tall plant with a short plant.

Mendel found that all the offspring were tall. He called these the F1 (the first generation in a genetic cross).

Mendel crossed two F1 plants to get the F2 (second generation in a genetic cross).

Mendel found that the F2 generation had the ratio: 3 tall : 1 short

All the F1 plants were tall because they carry one dominant gene.

Mendel said that each plant had ‘factors’ for height. We now call these ‘factors’ genes.
Inheritance

Genetics Problems

We can use Punnett squares to explain genetic crosses.

Example - Mendel’s Peas

Let $T =$ tall allele
Let $t =$ short allele

Parent phenotype
Tall $\times$ Short

Parent genotype
$T T \times t t$

Gametes
$T \text{ and } T$
$\text{ and } t$

| F1 cross
| --- |
| $T \times t$
| $T t$
| $T t$
| $t t$

All F1 offspring have the genotype $T t$. They are heterozygous. The recessive allele (short) is hidden by the dominant allele (tall.).

| F2 cross
| --- |
| $T \text{ and } T$
| $t$
| $T t$
| $T t$
| $t t$

The probability of a tall plant = 75% The probability of a short plant = 25%

The ratio of tall to short plants = 3 tall : 1 short

Remember, Mendel’s work was ignored to begin with because no one knew about the existence of DNA and Genes at the time!
This page contains information on Genetically Modified (GM) Crops and a case study on herbicide resistance in Soya beans. The advantages of GM crops include increased yields due to reduced competition for space and nutrients. The disadvantages include concerns about the health effects of eating them, the escape of transferred genes into other plant species, the creation of super weeds resistant to herbicides, and unknown long-term effects. Extensive field trials are important to understand the possible effects on the environment, identify any possible health problems, and check for possible transfer of genes to other species.
Variation

Variation means the differences between individuals of the same species.

Variations are the result of
- Genetic information (genes)
- The environment,

- Some variations are the result of genes only, but most variations are caused by a combination of genes and the environment.

Plant growth is more affected by the environment.
Some of these environmental factors are:
- Availability or competition for water,
- Competition for light,
- Air or soil temperature,
- Aspect of slope, e.g. a south facing slope gets more sunlight,

Types of variation:
- Continuous variation is controlled by more than one set of genes. When described using a graph it shows a normal distribution, e.g. height.
- Discontinuous variation is usually controlled by one set of genes. When graphed it shows distinct groups, e.g. blood groups.
Reproduction - production of new organisms (offspring)

Asexual Reproduction

In this type of reproduction
- There is only one parent.
- The offspring are genetically identical to the parent.
- There is no variation between the offspring.

Genetically identical organisms are called clones.

Sexual reproduction

In this type of reproduction
- There are two parents.
- The offspring are genetically different because they have genetic information (chromosomes / DNA) from both parents.
- There is variation between the offspring.

Comparison of sexual and asexual reproduction:

<table>
<thead>
<tr>
<th>Asexual reproduction</th>
<th>Sexual reproduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>No variation between offspring</td>
<td>Variation between offspring</td>
</tr>
<tr>
<td>Offspring genetically identical (clones)</td>
<td>Offspring genetically different</td>
</tr>
<tr>
<td>Offspring develop from one parent</td>
<td>Offspring develop from two parents</td>
</tr>
</tbody>
</table>
## Mutations

A mutation is a change in the DNA molecule resulting in a new gene. This can result in a new characteristic that **may** be passed onto the next generation.

Mutations happen naturally at random or in response to natural background radiation. The **probability** of a mutation happening is **increased** if you are exposed to:

- Ionising radiation,
- X-rays
- Ultra violet radiation from the sun,
- Some toxic chemicals (mutagens).

**The greater the dose, the greater the chance of a mutation in genes.**

Most mutations are not noticed, either because the mutant cell is just one amongst millions of ordinary cells, or because it is destroyed by the white blood cells. **Mutations are only passed on if they are in a gamete** (sex cell).

### Harmful mutations
- In reproductive cells, mutations can cause **abnormalities or death** in the young.
- Mutations in body cells can cause them to divide uncontrollably – **cancer**.

### Neutral mutations
- These do not affect the survival rate of an organism, e.g. appearance of blue budgies.

### Beneficial mutations
- These mutations give an organism an advantage that allows it to survive and breed, e.g. bacteria that are resistant to antibiotics are able to survive and create an antibiotic resistant strain of bacteria.
  *(This is an example of natural selection and evolution).*

## Genes and Health

Some diseases are caused by changes in genes (mutations). These diseases can be inherited. Modern medical research has led to the development of **genetic screening** and **gene therapy**.

Tests are available to find out if you are a carrier for some disorders such as **cystic fibrosis**. **Prenatal genetic tests** are also available to test foetuses during pregnancy. Small samples of cells from the membranes surrounding the foetuses are taken. The DNA from these cells is analysed.
**Inherited Diseases – Cystic Fibrosis**

Genetic information can contain a ‘fault’ or a damaged code in the DNA. If this fault is inherited it can cause a disease that can’t be cured because the faulty information is inside every cell.

**Cystic Fibrosis** is an inherited disease. A person with cystic fibrosis produces very thick mucus in their lungs. The mucus slows down exchange of gasses in the lungs; it’s also a breeding ground for bacteria. At least once a day a person with cystic fibrosis must have physiotherapy to move this thick mucus out of the lungs.

**Genetic explanation.**
In humans there are two kinds of alleles that code for mucus.

- One allele codes for normal mucus (C)
- The other codes for thick mucus (c)

There are three possible combinations of these alleles:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CC</td>
<td>Normal mucus</td>
<td>Cc</td>
</tr>
</tbody>
</table>

The inheritance of genetic diseases can be shown using family trees.

- The **genotype** causing cystic fibrosis is **cc**, e.g. Anne, male 5 and female 9.
- An individual with genotype **Cc** produces normal mucus. They do not have Cystic Fibrosis because they carry one copy of the dominant gene.
- Individuals with the genotype **Cc** are called **carriers** because they don’t suffer from the disease but may pass it on to any children, e.g. Kirsty, John, individuals 1, 2, 3 and 4.
Variation

Gene therapy

Gene therapy may offer a solution to the problem of genetic disorders.

Doctors are trying to use gene therapy to treat cystic fibrosis.
  - Genes for normal mucus are **inhaled** into the lungs using an inhaler, like an asthma inhaler.

• Some cells that make mucus take in the gene and produce normal mucus for a few days.

• However, new cells produced by the body will not contain the gene for normal mucus.
• The inhaler will need to be used every few days so that the person has a healthier life.
Evolution

Biologists believe that life began on earth 4000 million years ago. The animals and plants we see around us have developed slowly over time. **Evolution** is the **gradual change** in species **over time**, resulting in the formation of new species, and the extinction of others.

The mechanism for evolution is **natural selection**

**Natural selection - an example:**

1. There is **variation** in a population. (New variation appears because of mutations that can be inherited)

2. There is **competition** for survival.

3. Some individuals have a **characteristic** that gives them an **advantage**. (E.g. ability to run faster).

4. The individuals that survive are more likely to **reproduce** and **pass the gene** (that controls the characteristic giving them the advantage) **on to their offspring**.

5. Over a long period of time the advantageous gene will become more common in the population, (provided the environment does not change).

Species that have a lot of variation carry many versions of the same genes. They are more likely to be able to survive if the environment changes suddenly. Species that don’t have much variation are less likely to adapt quickly when the environment changes and will become **extinct**.
Humans have 5 sense organs connected to the nervous system.

Each sense organ is made up of special cells called **receptors**. The receptors can respond to a certain **stimulus**.

The receptors collect information from the surroundings and **pass the information as electrical impulses along nerves to the central nervous system**.

The central nervous system (the **brain** or **spinal cord**) can then store the information or decide on a reaction.

<table>
<thead>
<tr>
<th>Sense organ</th>
<th>Stimulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye</td>
<td>Light</td>
</tr>
<tr>
<td>Ear</td>
<td>Sound</td>
</tr>
<tr>
<td>Nose</td>
<td>Chemicals (in the air)</td>
</tr>
<tr>
<td>Tongue</td>
<td>Chemicals (in food)</td>
</tr>
<tr>
<td>Skin</td>
<td>Touch / Temperature / Pressure</td>
</tr>
</tbody>
</table>
Plants can sense light, and the pull of gravity and water. They respond to these things by growing slowly in certain directions. A tropism is the growth of a plant towards a light source or in response to a source of gravity.

**Phototropism: response to light**
Plants need light to make food. So they respond to light by growing towards it - positive phototropism. They also turn their leaves to face the light. This makes sure leaves get as much light as possible for photosynthesis.

**Gravitropism: response to gravity**
Roots grow down in response to gravity positive gravitropism. This makes sure they find soil and water.
Shoots always grow up - negative gravitropism. This makes sure they reach light.

Plant hormones regulate growth and other functions in plant cells. A hormone controls a plant's responses to light and gravity. The hormone is made at the tips of stems and roots. It speeds up growth in stems. It slows down growth in roots.
Homeostasis

Body cells work efficiently when they are at the appropriate temperature, pH and are supplied with the correct concentration of nutrients and water.

Homeostasis means keeping the internal environment constant

Conditions inside the body must be kept stable.

Examples to learn:
- Water content of the body must be kept constant,
- Waste chemicals must be removed from the body,
- Body temperature must remain constant.
- Glucose levels must remain constant.

Hormones are chemical messengers that control many body functions. They are produced by glands and carried by the blood. Hormones are proteins.

Insulin is a hormone that controls blood glucose levels.

Controlling Blood Glucose Levels - An Example of Negative Feedback

Eating carbohydrate foods, e.g. bread and rice puts a lot of glucose into the blood when they are digested.
**Diabetes**

**Diabetes is a condition where the level of glucose in the blood can’t be controlled.**

The diabetic can’t store glucose and the level in the blood can rise to a level that is very dangerous. The normal level of glucose in the blood is 0.1g per 100cm³. Above this level the glucose is excreted in the urine by the kidneys.

**Symptoms of diabetes**

1. **Glucose** excreted in the urine.
2. Lots of urine produced as the glucose is diluted with lots of water.
3. Feeling **thirsty**, because a lot of water has been lost in the urine.
4. **Loss of weight** and feeling **weak** because glucose isn’t stored and used by the body.
5. Diabetic **coma** in extreme cases.

**Diagnosis of diabetes**

1. Test urine for glucose.
2. Test blood for higher than normal glucose levels.

**Treatment of diabetes**

1. Regular injections of insulin into the body.
2. Controlling the carbohydrate and fat content of a diet.
3. Possible transplant of pancreatic tissue.

**Diabetes (type 1)** is a condition in which a person’s blood glucose may rise to a fatally high level because the body does not produce insulin.

**Diabetes (type 2)** develops when the body can still make some insulin, but not enough, or when the insulin that is produced does not work properly (known as insulin resistance). In most cases this is linked with being overweight (because of too much carbohydrate and fat in the diet and a lack of exercise). This type of diabetes usually appears in people over the age of 40, though in South Asian and African-Caribbean people, it often appears after the age of 25. Type 2 diabetes accounts for around 90 per cent of people with diabetes.
The skin plays an important part in controlling body temperature.

**Hair**
The hair can insulate the body by trapping a layer of warm air next to the skin.

**Erector Muscle**
This muscle can contract to raise the hair when cold and relax to lower the hair when hot.

**Sweat Pore**
Sweat is released onto the skin through the pore, as the sweat evaporates it cools the skin and body.

**Sweat Gland**
This gland removes water and salt from the blood, producing sweat.

**Sweat Duct**
Carries sweat to the surface of the skin.

**Blood capillaries**
The flow of blood through the capillaries can be changed to help control heat loss from the skin.
Response and Regulation

When the body is cold

1. The diameter of blood vessels in the skin decrease (they become narrow); less blood flows through them; less heat is lost from the skin surface.

Skin appears white

2. Hair erector muscles contract; hair stands up; layer of warm air trapped next to the skin helps insulate heat in the body.

3. Heat is released as muscles in the body contract causing shivering.

When the body is too hot

1. The diameter of blood vessels in the skin increases (get wider); more blood flows through them; more heat is lost from the skin surface.

Skin appears red

3. Sweat is released from the sweat pores; body heat is used to evaporate the sweat.

2. Hair erector muscle relax; hair lies flat; less air is trapped next to the skin so more heat is lost.

Health Balanced Diet

A balanced diet involves eating the right amounts of the essential food groups. Overeating can lead to serious dietary diseases.

We can think of a person as taking in energy (energy intake) and giving out energy (energy output).

The energy content in food eaten must be balanced with the energy used, obesity is caused by a person’s energy intake being greater than the energy output. Excess (too much) energy is stored as fat. The most fattening foods are therefore those that provide most energy.

Carbohydrate foods contain a lot of energy. Foods that contain fat contain a lot of energy because 1g of fat has twice as much energy than 1 g of carbohydrate.

Eating too much

You are eating too much if the energy value of the food you eat each day is more than the amount of energy you use in that time. Eating too much can lead to weight increase and obesity.

Obesity can contribute to heart disease, high blood pressure, diabetes (type 2), gall bladder disease, cancer of the bowel and also breast and womb cancer.
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You are eating too much if the energy value of the food you eat each day is more than the amount of energy you use in that time. Eating too much can lead to **weight increase** and **obesity**. |
| **Obesity can contribute** to **heart disease, high blood pressure, diabetes** (type 2), **gall bladder disease, cancer of the bowel** and also **breast** and **womb cancer**. |
Nutrition information on labels is provided ‘per 100g’ (or ‘per 100ml’ for liquids) and usually per serving too. **Looking at the nutrients ‘per 100g’ helps you compare the levels of nutrients in different products.**

**Too much sugar** can lead to an **increased chance** of developing **type 2 diabetes**.

**Saturated fat** tends to be from animal fat. It is high in cholesterol and **increases the chances** of developing **heart disease**.

**A high salt diet** can **increase blood pressure**. High blood pressure is linked to an **increased chance** of a **heart attack, stroke** or **kidney disease**.

- Knowing how much energy is in food helps people control their diet, especially if they want to lose weight.
- Information of food additives helps inform people with food allergies.
Health

Lifestyle diseases – Drugs

A drug is any substance that alters your physical or physiological state.

Alcohol

Alcohol changes chemical processes in the body.

Short-term effects
Alcohol affects your nervous system by slowing down your reactions (this means that your reaction time is increased).

Long-term effects
- Some people may become dependent on, or addicted to alcohol.
- Alcohol can also cause long-term physical damage
  - E.g. liver disease
  - Circulatory and heart diseases.

What does addiction mean?
- An addiction is when people become dependent on a drug.
- A characteristic of addiction is that people will suffer withdrawal symptoms without the drug.
### Health

Health is not just the absence of illness. It is a positive and enjoyable feeling of well-being resulting from efforts to maintain an all-round state of physical and mental fitness.

**Health** is affected by a variety of factors:
- Diet,
- Living conditions,
- Contact with infections,
- Your genes,
- Lifestyle.

**Poor health** can be prevented by:
- Good hygiene,
- Clean water,
- Improved diet,
- Vaccination.

### Keeping Healthy

Keeping fit helps our bodies to function better. Sustained regular exercise improves our blood circulation and reduces our heart rate. It also makes the breathing system more efficient.

Some conditions can be treated by:
- Drugs such as antibiotics,
- Organ transplants,
- Chemotherapy,
- Radiotherapy,
- Gene therapy.

It is important to remember that science and technology may provide the answer to some health problems but not all.

### Use of Animals for Testing Drugs.

All drugs may have side effects. New drugs may cause side effects that do not show up until lots of people use them. Large scale testing is required before new drugs are released on the market. Part of this testing involves using animals.

The reasons **animal-rights groups** oppose testing drugs on animals
- Laboratory animals are so different from humans that they do not react to drugs in the same way as humans do.
- Humans do not have the right to subject animals to any form of experimentation.

**Scientists** use these reasons to justify their work on animals:
- Humans should never have their lives threatened by experimental procedures.
- Testing on individual cells from tissues does not reflect the complexity of living organisms.
- Computer simulation are not accurate enough to model all the biological processes that take place in living organisms.