Sub-topic 1: Biodiversity and the Distribution of Life

An ecosystem is a natural biological area made up of all living things (community) and their non-living environment.

The variety of things which can live in an ecosystem (biodiversity), and how they are spread out (distributed) can be affected by both biotic and abiotic factors.

Biotic factors involve living organisms e.g.

- Space
- Water supply
- Predators
- Food supply
- Disease
- Build up of toxic waste in the environment

Abiotic factors are non-living variables in the environment that affects the organisms living there e.g.

- Light intensity
- Soil/water pH
- Temperature
- Soil moisture
- Flow rate
- Slope
- Weather
- Climate
- Depth of Soil
- Underlying rock
Over-fishing

- This can lead to destruction of stocks and local extinction.
- This is usually controlled by restricting the numbers of fish that can be caught (quotas)
- Public are encouraged to eat less well known fish to preserve stocks of cod and herring.

Untreated sewage is a source of fresh water pollution

- Micro-organisms in the sewage use the sewage as an energy source (food)
- They multiply rapidly
- They use up the oxygen in the water for their respiration
- Organisms that require oxygen cannot survive.
- Organisms that don’t require oxygen increase in number.
- Further downstream the food in the sewage is used up and gradually the river returns to normal.
- In highly polluted conditions, there is a reduction in the number of species that can survive.
**Acid rain**
- Coal and oil produce oxides of sulphur and nitrogen when burned.
- The oxides of sulphur and nitrogen dissolve in the moisture in clouds.
- This produces acid which falls as rain.
- Fish and trees are killed.

**Climate change** can be caused by two pollutants:
- **Domestic** (household) e.g. sewage, litter, car exhaust fumes and smoke.
- **Industrial** e.g. smoke, carbon dioxide and poisonous chemicals.
  - Fossil fuels (coal, oil & gas) cause pollution when burned.
  - Coal is the worst, gas is the least damaging.
  - All fossil fuels release carbon dioxide when burned.
  - This prevents heat escaping and results in the *greenhouse effect*.
    - Heat is trapped in the atmosphere instead of passing out to space overnight.
    - The world warms up.
    - Ice caps melt, sea levels rise and weather patterns are disrupted.
    - Alternative energy sources such as wind, wave, hydroelectric, and solar (sunlight) can reduce the volume of $CO_2$ produced.
**Intensive agriculture** (farming) 
e.g. fertilisers, pesticides and slurry (see sub-topic 5 for more information).

**Over-Grazing**

- too many cattle on poor land
  - Plants are killed right down to the roots
  - The soil isn’t held together
  - Erosion of the soil occurs
  - Leading to desertification

**Deforestation**

- Rainforests are destroyed to grow cash crops, e.g. coffee or tobacco.
- This results in loss of species through habitat destruction
- May disturb the climate
- To improve the situation farmers may be given money to prevent growth of cash crops
- Native hardwood trees, e.g. teak and mahogany, can be replanted
- Rainforest can be protected by law.
- **Oil and Chemical spills**
  Can destroy habitats and damage wildlife on land and sea.

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**Organisms and the role they play in their ecosystem**

The natural world is filled with plants and animals, each with their own special job or **niche**. A niche is the role played by an organism in the natural world. Animals and plants all have a special role in making natural communities work and stay healthy.

Some animals, like the pileated woodpecker, are insect eaters. They control insect populations in a community. The **pileated woodpecker** eats carpenter ants. It chisels them out of trees with its beak. Without animals like the woodpecker, insect populations could grow out of control.
Biomes

There are large areas (often in different parts of the world), which have similar animal (fauna) and plant life (flora) living there. These geographical areas will experience similar temperatures and rainfall, and are referred to as Biomes.

For further information, visit the link below

http://www.blueplanetbiomes.org/world_biomes.htm
Sub-Topic 2: Energy in Ecosystems

When an organism is removed from a food web all other organisms are affected, you should be able to explain particular examples. The more links in a food web the more stable it is – that is, a change in the population of one organism has less effect on the others.

As energy is transferred from one level to the next in a food web, 90% of the available energy is lost. This is because the energy is being used up by the organism keeping themselves warm, moving and producing body parts (such as bone) which cannot be digested.

Only 10% of the energy is passed on. This 10% comes from the growth and repair of new body tissue, which is then eaten.
Food chains and pyramids.

A **pyramid of numbers** can be constructed from a food chain.

- The purpose is to represent the number of organisms present at each stage in the food chain.
- By counting the organisms and representing the number as the area of a box you get:

  ![](image)

- Some food chains begin with a large producer (such as an oak tree or a rosebush), this would give an odd shape if presented as a pyramid of numbers:

  ![](image)

- A better way of representing this food chain is in a **pyramid of biomass**.

  - Biomass is the total mass of the organisms at each level in the food chain.
  - A pyramid of biomass for the above example would look like this:

    ![](image)
• A 3rd way of presenting the same food chain is to use a *pyramid of energy*. This would look similar to the pyramid of energy, but would be measured in Kilojoules, as it demonstrates the *total energy* available at each level in the food chain.

**Population size**

The *number of organisms* in a population depends on:

• Birth rate
• Death rate

In any population where there are no limits on the size of the population the birth rate will exceed the death rate and population numbers will increase.

![Growth curve](image)

The *number of organisms* in a population is *limited* (controlled/stopped from getting any bigger) by any of several biotic factors e.g.:

• Space
• Food supply
• Water supply
• Disease
• Predators
• Build up of toxic waste in the environment
No population can continue growing forever. At present global growth of the human population is not severely restricted by any of these factors however lack of food, fresh water and/or disease can increase the death rate on a local basis.

- Eventually one or more limiting factors will stop the increase in numbers.
- This produces the *ideal growth curve*

![Ideal Growth Curve Diagram](image)

- In the first part from day 1 to 6 organism is settling in and beginning to reproduce.
- In the middle from day 6 to day 12 the population is reproducing rapidly
- At the end from day 12 to day 19 the population is being limited by one of the factors above.
Nutrient Recycling

Some resources are in short supply for all organisms e.g. carbon and nitrogen.

These need to be recycled. Dead organisms, both animals and plants, are broken down by decomposers (bacteria and fungi) and the chemicals bound up in their remains are released for reuse.

- Nitrogen gas is common in the air but is chemically inert (unreactive and useless to most organisms)
- Some species of bacteria can fix nitrogen into useful chemical nitrates
- Some plants called legumes e.g. peas and beans have nitrogen fixing bacteria living in root nodules (swellings on the roots)
- Plants can absorb nitrates through their roots to make protein
- Animals eating the plants can convert this protein into their own protein
- When protein is excreted or the animals die decomposers (bacteria and fungi) change the protein into ammonia in the soil
- Soil bacteria convert the ammonia into nitrites which is then converted into nitrates in the soil
- Some soil bacteria called denitrifying bacteria change soil nitrates into nitrogen gas
- The system can be summarised as shown on the next page:
Food Chains and Food Webs

Every ecosystem is made up of various populations of organisms, all depending on each other in order to survive.

There is certain vocabulary used to describe the relationships which these organisms have with one another:

- **Population**  The number of organisms of the same species which live in a particular habitat.
- **Producers**  *Green plants* that produce their own food by photosynthesis.
- **Consumers**  Animals which have to eat other organisms to live.
- **Herbivore**  Animals which eat only plants.
- **Carnivore**  Animals which eat only meat.
- **Omnivore**  Animals which eat both plants and animals.
**Competition**

When two organisms or populations of organisms need the same, or similar, resources there will be **competition**

Competition can be for:

- Water
- Light
- Space
- Food
- Mates (Sexual Partners)

Usually the less successful population will become extinct (but only within that ecosystem).
There are different types of competition:

**Inter-specific competition** is where individuals of different species are competing for the same (or similar) resources e.g.
- Red and grey squirrel
- Brown and rainbow trout

**Intra-specific competition** is where individuals of the same species compete for exactly the same resources e.g.
- Feeding in grasshoppers
- Territorial behaviour in pigeons
- Growth of cress seedlings

Experiment to illustrate competition within a plant species.

Beaker A produced seedlings that were longer with larger leaves. This is because each seedling had more space, light and water available to it.

***INTRASPECIFIC COMPETITION IS MUCH MORE INTENSE, THIS IS BECAUSE MEMBERS OF THE SAME SPECIES ARE COMPETING IN EXACTLY THE SAME WAY, FOR EXACTLY THE SAME RESOURCES.***
Sub-Topic 3: Sampling Techniques

There are various ways of measuring and investigating an ecosystem.

**Sampling Techniques**

Ecosystems are usually large and complex.

- It is impossible to count every organism and habitat in the ecosystem.
- We sample the ecosystem to estimate numbers.

- **Quadrats**
  - A wire or wooden square (usually with 0.5m sides), divided into small 5 cm squares, is placed at random and the plants in each square counted.

- **Traps**
  - Pitfall traps are placed at random, small invertebrates fall in.
  - Small, baited animal traps are hidden in undergrowth, small animals are caught.

- **Tree beating**
  - A tray or net is held under a branch.
  - The branch is shaken
  - Insects fall into the tray or net.

- **Kick sampling**
  - A net is held in a stream while the stones upstream are kicked, organisms are swept into it.
Sweep netting
- A big net is swept back and forth through, e.g. long grass, to sample invertebrates.

All sampling techniques are subject to error:

Quadrats
- Not enough coverage of the area, lack of random placement.
- Prevent this by doing as many quadrats as possible to increase reliability, cover eyes to throw or place at random mathematically.

Trapping.
- Creatures climb out of pitfall trap or are eaten by predators.
- Prevent this by putting lethal chemical in trap.

Tree beating
- Some creatures cling on to the surface and aren't knocked off and some can fly away.
- Prevent this by covering the whole branch with a net, examine the branch after beating and pick off remaining insects.

Kick sampling
- Creatures swim around or out of the net
- Prevent this by holding the net close to the kick and then twist the mouth of the net over to prevent escape.
Paired statement keys can be used to identify organisms. At each stage a choice is given which leads to the next choice. If the organism is present, the organism should be identified.

1. Single leaf
   Several leaflets  go to 2
   go to 6

2. Leaf with prickles
   Leaf with no prickles  HOLLY
   go to 3

3. Leaf edge with lobes
   Leaf edge with no lobes  go to 4
   go to 5

4. Lobes sharp pointed
   Lobes rounded  SYCAMORE
   OAK

5. Leaf with smooth edge
   Leaf with serrated edge  BEECH
   ELM

6. Leaflets in fan shape
   Leaflets in pairs  HORSE CHESTNUT
   go to 7

7. Leaf edge serrated
   Leaf edge plain  ROWAN
   ASH
Measuring abiotic factors:

- **Light intensity**
  - Use a light meter
  - Point it at the source of the light
  - Read the result off the scale

- **Moisture**
  - Use a moisture meter
  - Insert the probe into the ground
  - Read the result off the scale

- **pH**
  - Use a pH meter
  - Insert the probe into the ground
  - Read the result off the scale

- **Flow rate**
  - Drop a ball or an orange into the river
  - Measure how long it takes (in seconds) to travel one metre.

There are sources of error on all these methods:

- **Light intensity**
  - Shadow of users falls over sensor
  - Prevent by ensuring users are well back from the sensor

- **Moisture**
  - Moisture from a previous reading affects the probe
  - Prevent by wiping the probe clean and dry after each reading

- **pH**
  - The pH from a previous reading affects the probe
  - Prevent by wiping the probe clean and dry after each reading

- **Flow rate**
  - The river flows at different rates across its width
  - Prevent by taking several readings across the width and calculate the average.
Abiotic factors affect the distribution of organisms e.g.

- Some plants grow well in bright sunlight (trees) others grow better in shade (bluebells)
- Some fish are found in faster flowing water (salmon) others are found in still water (pike)
- Some plants grow well in damp soil (reeds) others grow better in well drained soil (marram grass)
- Some plants thrive in acid soils (heather) others thrive in alkaline soils (primrose).

Given information, you should be able to explain ways in which abiotic factors can influence the distribution of organisms, e.g. cacti cannot grow in low temperatures because their enzymes do not work effectively at these temperatures.
Sub-Topic 4: Adaptation, Natural Selection and Evolution

Variation within a species makes it possible for a population to evolve over time. Mutations are the only source of new variation (because of new alleles being formed) within a population.

Mutations

A mutation is a sudden random change in the structure or quantity of an organism’s genetic material. i.e. in the structure or number of the chromosomes or the structures of the genes.

Mutations are usually of low frequency but the rate of mutation can be increased by mutagenic agents such as:

- Irradiation – gamma rays, X-rays and UV light.
- Chemicals – Colchicines, nicotine and mustard gas.
- High temperature

Harmful mutations produce brand new forms of genes that will decrease an organism’s chances of survival and often lead to death of the organism before it can reproduce and pass on the genetic mutation.

Beneficial mutations can produce brand new forms of genes that may improve an organism’s chances of survival in a particular environment.

Neutral mutations give neither an advantage nor disadvantage to an organism.

Adaptations

New alleles being produced by mutation allow plants and animals to adapt to their environment. These adaptations can either be structural or behavioural.

E.g. Structural – Cactus Spines

Behavioural – Worms Burrowing
Natural Selection.

Every species is capable of producing far more offspring (young) than the environment can support.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average number of offspring per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fox</td>
<td>5</td>
</tr>
<tr>
<td>Rabbit</td>
<td>24</td>
</tr>
<tr>
<td>trout</td>
<td>800</td>
</tr>
<tr>
<td>cod</td>
<td>4000000</td>
</tr>
</tbody>
</table>

I.e. If there are more individuals than can be supported by the available food etc there will be competition for the resources. The organisms compete with each other for survival. There is a **struggle for survival**.

Many of the offspring die before they reach reproductive age. What factors might cause this?

E.g.

- Disease
- Predators
- overcrowding

As not all the members of the species are identical to each other, there are variations among them, some of these variations will allow some to be more successful competing for resources or surviving diseases. The strongest will survive - this is called **survival of the fittest**. Those organisms with characteristics **best suited to the environment** survive and pass on their genes to their young.
Natural selection can be summarised as follows:-

- Most organisms produce many offspring.
- Offspring struggle to survive owing to competition for limited resources.
- The individual members of a species exhibit variation. (Mutations are the only source of new variation)
- Some individuals are better adapted to the environment, have a better chance of survival i.e. they have a selective advantage
- Offspring that survive will reproduce and pass on their favourable features to their offspring (the next generation).

Natural selection:-

- Produces organisms ideally suited for their habitat in a stable environment.
- Favours the emergence of new forms in a changing environment.

Examples of Natural selection

Peppered (Speckled) Moth

Peppered Moths are normally white with black speckles across the wings. The moths settle on tree trunks during the day. The speckles make it well camouflaged against lichen-covered tree trunks.
There is also a naturally occurring mutation which causes some moths to have almost black wings.

These black forms, *Melanic* moth, are not as well camouflaged on the lichen as normal 'peppered' forms and so they are more likely to be eaten by birds and other predators. This means that fewer black forms survive to breed and are less common in the population than the peppered forms.

During the industrial revolution factories produced lots of soot which landed on tree trunks, making them darker. The speckled form was now more visible and the melanic form was camouflaged. They now had an advantage. More light forms were eaten by predators. The number of black moths in these areas increased. The speckled variety decreased.

Other examples include

- Bacteria resistant to antibiotics
- Insects resistant to insecticides e.g. DDT
Evolution and the Red Queen hypothesis

Species, whilst improving and evolving to be more successful must face some sort of pressure from parasites or predators in order to evolve.

The Red Queen Hypothesis is taken from 'Alice in Wonderland' in which Alice cannot catch up with the Red Queen no matter how much she speeds up.

Predators and their prey are in a sort of evolutionary 'arms race' where both have to keep changing to adapt to the changes in the other species.

Parasites, pathogens and their hosts also do the same. E.g. We have to keep changing to adapt to viruses which keep changing to outsmart our immune systems.

Evolutionary change may be required to stay in the same place. Cessation of change may result in extinction.

A bird predator will need to evolve improved methods of detecting a prey, such as a moth, that becomes better camouflaged through natural selection. An organism has to adapt to the changes in the environment. When these changes are biological, the Red Queen effect comes into play, one species evolving and adapting to the changes of an inter-actor, or becoming extinct.
**Speciation**

A species is a group of organisms able to interbreed and produce fertile offspring.

The individuals in a species normally breed freely so that the genes are continually mixed. Sometimes the members of a population can be cut off from the others by an isolation barrier. This barrier stops genes being mixed between the two groups.

Isolation barriers can be

- **Geographical**: mountains, seas or movement of land masses.
- **Ecological**: groups may be isolated by such things as occupying different habitats or breeding areas, pH, salinity.
- **Reproductive**: Breeding between groups within a population may not be possible because of differences in courtship behaviour, physical differences which prevent mating, or failure of gametes to fuse.

Conditions in the environments may be different for both groups. Variations which are favoured are random. Eventually both groups can become so different that they become different species.

As long as a population has the opportunity to interbreed and exchange genes, they remain one species. A population of one species can only evolve into more than one species if groups within the population become isolated from each other by barriers that prevent exchange of genes.
The diagram illustrates what could happen to populations of animals, which become geographically isolated. Once two groups are isolated different mutations occur in each group. If the environments differ, different adaptations are favoured by natural selection. This leads to different characteristics evolving in each group as time passes. Eventually the groups become so different that if they come together again they are unable to interbreed and are now separate species.
Examples of speciation

Darwin’s Finches.

Charles Darwin visited the Galapagos Islands in 1835. He found them to be inhabited by many unique life forms, including 13 different species of finch which all arose from the one species. They share the same habits and characteristics except for one: All 13 have different beaks.

This process in which one species gives rise to multiple species that exploit different niches is called adaptive radiation. The ecological niches exert the selection pressures that push the populations in various directions.

On various islands, finch species have become adapted for different diets: seeds, insects, flowers, the blood of seabirds, and leaves. The ancestral finch was a ground-dwelling, seed-eating finch. Scientists have spent many years in the Galapagos, seeing changing climatic conditions from year to year dramatically altering the food supply. As a result, certain of the finches have lived or died depending on which species' beak structure was best adapted for the most abundant food.
5. Human Impact on the Environment

As the human population continues to increase, there is more demand for an increase in food yield.

When crops are harvested in agriculture, nitrogen is taken out of the cycle so needs to be replaced (think back to the nitrogen cycle).

Nitrogen can be added to the soil in the form of nitrate fertilisers, manure, compost or growing legumes and ploughing them back into the field.

If nitrogen from fertilisers leeches into fresh water it increases algal growth, blocking out the light. This causes death of aquatic plants as well as the death of some of the algae. Bacteria then feed on the dead organisms, using up large quantities of oxygen and means less life can be supported as there is less oxygen availability.

Genetically modified crops may be an alternative to the use of fertilisers.
Bioaccumulation

Pesticides are used in agriculture to control pest populations. The use of pesticides can result in bioaccumulation. Bioaccumulation is the increase in concentration of a substance in an organism over time. If the pesticides are sprayed onto crops which then make their way into the food chain, the pesticides are carried with the crops and as they pass up the food chain their toxicity increases.

Eventually, over a period of time, they can reach fatal levels.

Biological Control

Biological control could be an alternative to the use of pesticides, as a way of reducing the effects of intensive farming on the environment e.g.

- Using a virus (Myxomatosis) to kill rabbits
- Using ladybirds to kill aphids
- Using caterpillar moth to kill cacti
Monitoring pollution

- Organisms that - by their presence or absence - indicate the level of some environmental factor are called indicator species.
- All the organisms in the diagram below are indicator species for oxygen levels in water.

Other indicator species include lichens which indicate levels of sulphur dioxide in the atmosphere.