Edexcel Biology GCSE

Topic 8: **Ecosystems and material cycles**

Notes

(Content in bold is for higher tier only)

CONTENTS

9.1 - Levels of Organisation

An individual is part of a species, but lives in its habitat within a population.
Many different populations interact in the same habitat, creating a community. The populations are often dependent on each other.
An ecosystem is the interaction of a community with non-living (abiotic) parts of the environment. Organisms are adapted to live in the conditions of their environment.

Organisms which need the same resources compete for it.

- There can be competition within a species or between different species.
  - Plants may compete for light, space, water and mineral ions.
  - Animals may compete for space, food, water and mating partners.

9.2 - Abiotic and Biotic Factors affecting Communities

An abiotic factor is a non-living factor. You need to be able to explain the effect of a change in an abiotic factor.

Abiotic factors which can affect a community:

1. Light intensity
   - Light is required for photosynthesis.
   - The rate of photosynthesis affects the rate at which the plant grows.
   - Plants can be food sources or shelter for many organisms.
2. Temperature
   - Temperature affects the rate of photosynthesis.
3. Moisture levels
   - Both plants and animals need water to survive.
4. Soil pH and mineral content
   - Soil pH affects the rate of decay and therefore how fast mineral ions return to soil (which are then taken up by other plants).
   - Different species of plants thrive in different nutrient concentration levels.

5. Wind intensity and direction
   - Wind affects the rate of transpiration (movement of water from root to leaves) in plants.
   - Transpiration affects the temperature of the plant, and the rate of photosynthesis because it transports water and mineral ions to the leaves.
6. Carbon dioxide levels
   - CO_2 affects the rate of photosynthesis in plants.
   - It also affects the distribution of organisms as some thrive in high CO_2 environments.
7. Oxygen levels for aquatic animals
   - Levels in water vary greatly, unlike oxygen levels in air.

- Most fish need a high concentration of oxygen to survive.

Biotic Factors

A biotic factor is a living factor. You need to be able to explain the effect of a change in a biotic factor.
Biotic factors that can affect a community:

1. Food availability: more food means organisms can breed more successfully and therefore the population can increase in numbers
2. New predators
3. New pathogens: when a new pathogen arises the population has no resistance to it so they can be wiped out quickly
4. Competition: if one species is better adapted to the environment than another, then it will outcompete it until the numbers of the lesser adapted species are insufficient to breed.

9.3 - Interdependence

Interdependence describes how organisms in a community depend on other organisms for vital services.

- These include for food, shelter and reproduction (pollination, seed dispersal), e.g. birds take shelter in trees, flowers are pollinated with the help of bees.
- The removal or addition of a species to the community can affect the populations of others greatly, as it changes prey or predator numbers
- A stable community is one where all the biotic (living) and abiotic (non-living) factors are in balance.
    - As a result the population sizes remain roughly constant.
    - When they are lost it is very difficult to replace them.
    - Examples include tropical rainforests, oak woodlands and coral reefs.

9.4 - Parasitism and Mutualism

Some species live together in a symbiotic relationship. There are two types of symbiotic relationship:

If a smaller species lives directly within or on a larger species, and benefits at the expense of the other species, it is known as a parasite.
If it provides some benefit or resource to the other species, for instance providing nutrients, it is known as a mutualistic relationship.

Parasitism involves taking nutrients from another species, to the detriment of the other species. For example, in humans, the tapeworm is a parasite that lives inside the gut. It ‘steals’ nutrients from the host and can lead to malnutrition.

Commensalism is when there is no damage caused to either species, and there is often a mutual benefit. For example, algae and fungi live together to form lichens. Algae can photosynthesise to provide sugars for the fungi, whereas the fungi allows the algae to live in more extreme conditions than those under which it would normally thrive.

9.6 - Fieldwork and Counting Organisms

We can determine the number of organisms in a given area using fieldwork techniques, and tools such as quadrats and transects.

Imagine we wanted to estimate the number of 3-leaf clover in a 10m x 10m field. This might be a useful experiment in determining the biodiversity of an area. We could either:

a) Measure every single 3-leaf clover in the field, or:
b) Take a sample of 3-leaf clover from a small area, and use this to estimate the entire population of clover

Method a) would be time consuming and there would be a high likelihood of error - however b) would take significantly less time and with less risk of error. To carry out this estimate, we can:

- Divide the field into 100 equal 1m x 1m squares.
- Use a random number generator to randomly select a single square.
- Take a 1m x 1m quadrat and place it in the selected square.
- Count the number of clover in the square.
- Repeat with a different square 4 times, and average the 5 results.
- Multiply the average by 100 to estimate the number of clover in the field.

9.7 - Trophic Levels and Pyramids of Biomass and 9.8B - Efficiency of Energy Transfers

Pyramids of biomass show the relative biomass at each trophic level.

- It shows the relative weights of material at each level.
- There is less biomass as you move up the trophic levels.
- Not all the food consumed by an animal is converted into biomass – this means the biomass of the organism in the level above another will always be higher, as not all the organism can be consumed and converted into biomass.

Producers (.e.g plants and algae) transfer about 1% of the incident energy from light for photosynthesis, as not all the light lands on the green (photosynthesising) parts of the plant.

Only approximately 10% of the biomass of each trophic level is transferred to the next.

- Not all biomass can be eaten.
  - Carnivores cannot generally eat bone, hooves, claws and teeth.

- Not all of the biomass eaten is converted into biomass of the animal eating it.
  - Lots of glucose is used in respiration, which produces the waste product carbon dioxide
  - Urea is a waste substance which is released in urine
  - Biomass consumed can be lost as faeces
    - Herbivores do not have all the enzymes to digest all the material they eat, so it is egested instead

You should be able to calculate the efficiency of biomass transfers between levels:

Efficiency of biomass transfers: (Biomass transferred to the next level / Biomass available at the previous level) x 100

Because less biomass is transferred each time, it is common to find less animals in the higher trophic levels.

9.9 - Human Interactions with Ecosystems

Positive human interactions with ecosystems	Negative human interactions with ecosystems
Maintaining rainforests, ensuring habitats here are not destroyed.	Production of greenhouse gases leading to global warming.
Raising awareness among the public about how to protect ecosystems - e.g through large scale community projects.	Introducing non-indigenous species into the environment, which prey on native species.
Reducing water pollution and monitoring the changes over time.	Producing sulfur dioxide in factories which leads to acid rain – affects habitats.
Preserving areas of scientific interest by stopping humans from going there.	Chemicals used in farming leak into the environment - if they leak into a lake, this can cause eutrophication - excessive growth of plant life which can deplete the body of water of oxygen (making it less able to sustain other species such as fish)
Replanting hedgerows and woodlands to provide habitats which were previously destroyed.	Clearing land in order to build on, reducing the number of habitats.
	Overfishing which reduces biodiversity and can lead to endangerment of some species

9.10 - Maintaining Biodiversity

To reduce our negative impact on ecosystems, programs have been put in place to maintain biodiversity.

1. Breeding programs: to stop endangered species from becoming extinct.
2. Protection of rare habitats: to stop the species here from becoming extinct, if damaged they may even be regenerated to encourage populations to live here
3. Reintroduction of hedgerows and field margins around land where only one type of crop is grown: maintains biodiversity as the hedgerows provide a habitat for lots of organisms (because a field of one crop would not be able to support many organisms) and field margins provide areas where wild flowers and grasses can grow.
4. Reduction of deforestation and carbon dioxide production: reduces the rate of global warming, slowing down the rate that habitats are destroyed
5. Recycling rather than dumping waste in landfill: reduce the amount of land taken up for landfills, and slows the rate we are using up natural resources.

9.11B - Factors affecting Levels of Food Security

Food security: having sufficient food to feed the population

Factors which affect food security include:

1. Increasing birth rate and human population, meaning more food is required.
2. Changing diets in developed countries (e.g an increase in meat and fish consumption) means food resources which are already in low amounts become even more scarce as the demand for them increases.
3. New pests and pathogens can destroy crops.
4. Climate change affects food production (such as no rain resulting in crops failing).
5. Conflicts in some countries can affect the availability of water and food.

To feed everyone on Earth, sustainable methods are needed.

9.12, 9.13, 9.14 - Cycling of Materials, The Carbon Cycle, The Water Cycle

Lots of different materials are cycled through ecosystems. The carbon and water cycles are vital for life on Earth.

The Carbon Cycle

- CO_2 is REMOVED from the air in photosynthesis by green plants and algae – they use the carbon to make carbohydrates, proteins and fats. They are eaten and the carbon moves up the food chain.
- CO_2 is RETURNED to the air when plants, algae and animals respire. Decomposers (a group of microorganisms that break down dead organisms and waste) respire while they return mineral ions to the soil.
- CO_2 is RETURNED to the air when wood and fossil fuels are burnt (called combustion) as they contain carbon from photosynthesis.

Decomposition and Composting

Compost

- When biological material decays it produces this.
- It is used by gardeners and farmers as a natural fertiliser.
- To do this they have to provide optimum conditions for decay.
  - If more oxygen is available they respire aerobically, producing heat.
  - The increased temperature increases the rate of decay so the compost is made quicker.

Methane gas

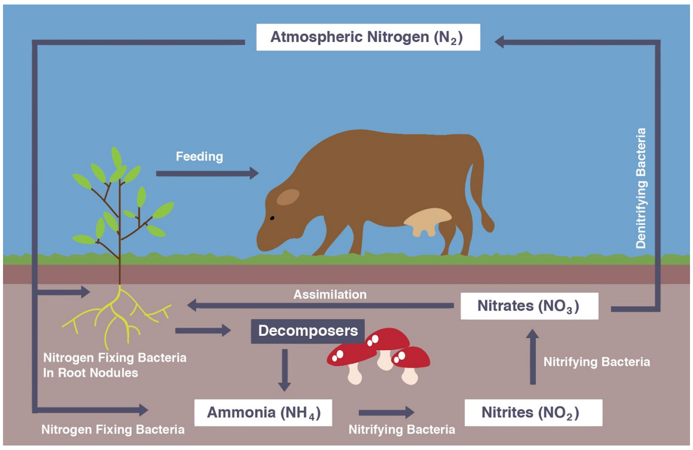
- Microorganisms decompose waste anaerobically to produce methane gas.
- This can be burnt as a fuel.
- Biogas generators are used to produce methane.
  - Require a constant temperature (30 degrees) so the microorganisms keep respiring.
  - It cannot be stored as a liquid so needs to be used immediately.

The Water Cycle

- The sun's energy causes water to evaporate from the sea and lakes, forming water vapour.
- Water vapour is also formed as a result of transpiration in plants.
- Water vapour rises and then condenses to form clouds.
- Water is returned to the land by precipitation (rain, snow or hail), and this runs into lakes to provide water for plants and animals.
- This then runs into seas and the cycle begins again.
- In areas of drought, we can harness the water cycle to produce potable (drinkable) water. For example, desalination is the process by which we remove salt and other

minerals/impurities from seawater to make it drinkable. It is performed by a process called reverse osmosis and generally occurs on a large scale.

9.15 - Nitrates



- Nitrogen gas in the atmosphere is too unreactive so cannot be used directly by plants.
- Nitrogen-fixing bacteria present in the root nodules of legume plants convert nitrogen gas into nitrates that can be used for growth.
- Lightning can convert nitrogen gas into nitrates
- The Haber process converts the hydrogen gas into ammonia.
- Plants absorb nitrates through the roots by active transport.

Nitrogen is often included in fertilisers in the form of ammonium nitrate. This provides an artificial way to ensure that plants get nitrates required for growth, without relying on external processes such as nitrogen-fixing bacteria or lightning.

9.16B - *HIGHER ONLY* Indicator Species and Assessing Pollution

Sometimes it is too expensive to assess how polluted an area is in great detail - in these cases we can use an indicator species to assess the pollution levels. For example:

Polluted water is often identified by the presence of bloodworms or sludgeworms (often called 'sewage worms' for this reason).

Clean water often harbours freshwater shrimps and stonefly. The presence of these species is indicative of clean, unpolluted water.

Air quality can be indicated by a number of species of lichen. In areas where the air is heavily polluted with sulfur dioxide, lichen is less likely to be found. Clean air often provides an ideal environment for lichens, with a rich variety of species being found in clean air. The rose blackspot fungus is more likely to be found in less polluted areas, as sulfur dioxide protects plants from certain fungi.

9.17B and 9.18B - Factors affecting Rate of Decomposition of Food and Compost

A number of factors affect the rate of decomposition.

1. Temperature: Chemical reactions generally work faster in warmer conditions, but if it is too hot the enzymes can denature and stop decomposition.
2. Water: Microorganisms grow faster in conditions with water as it is needed for respiration. Water also makes food easier to digest.
3. Availability of oxygen: Most decomposers respire aerobically.

Particularly in compost:

- If more oxygen is available they respire aerobically, producing heat.
- Increased temperature increases the rate of decay so the compost is made quicker.

9.19B - Rate Changes in the Decay Of Biological Material

You can investigate the effects of temperature on decay by measuring the pH change of fresh milk in the presence of the enzyme lipase.

- Make a solution of milk and phenolphthalein indicator.
- Add sodium carbonate which will cause the solution to become alkaline and therefore appear pink.
- Place the tube in a water bath at a specific temperature.
- Add the lipase enzyme and begin stopwatch.
- Time how long it takes for the pink colour to disappear (i.e. when the pH has decreased).
- Repeat this at different temperatures to see at which temperature the pink colour disappears the quickest, indicating the quickest decomposition.