WJEC (Wales) Biology GCSE

Topic 1.6: Ecosystems, Nutrient Cycles and Human Impact on the Environment

Notes

('Higher Tier only' in **bold**)

Food chains and food webs

Sunlight is the source of all energy in biological systems. It is absorbed by photosynthetic organisms (producers) and converted to chemical energy (biomass) during photosynthesis. This biomass is transferred between organisms during feeding (and is used for growth, repair, etc.) before eventually returning to the soil when decomposers break down dead material and waste.

Trophic levels

A food chain describes the feeding relationships between organisms and the resultant stages of energy and biomass transfer. Each stage is known as a trophic level. A simple food chain is shown below (the arrows represent the direction of energy transfer):

producer → primary consumer → secondary consumer → tertiary consumer

Producers are always the first trophic level because:

- They provide all energy for the food chain via photosynthesis
- The rest of the food chain involves the transfer of this energy

Primary consumers are normally herbivores whilst secondary and tertiary consumers are carnivores. Decomposers can obtain energy from dead organisms at any point in a food chain.

Food webs show how different food chains are interlinked and how members of an ecosystem are interdependent.

Energy loss

Energy transfer is inefficient. At each stage of a food chain energy is lost for a variety of reasons:

- 90% of the sun's energy is reflected
- Respiration to generate heat energy, energy for movement etc. in animals
- Some parts of organisms are indigestible
- Egestion, excretion

There are rarely more than four or five trophic levels in a food chain; above this, there is insufficient energy to support another breeding population.

To calculate the efficiency of energy transfer:

$$\textbf{efficiency} = \frac{\textbf{biomass available after transfer}}{\textbf{biomass available before transfer}} \times \textbf{100}$$

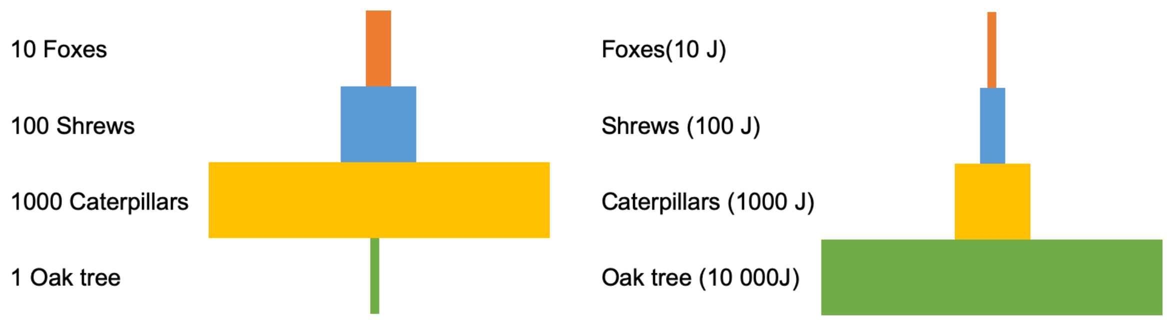
The less efficient the energy transfers, the fewer the trophic levels and the fewer the number of organisms at each trophic level.

Pyramids of numbers and biomass

Feeding relationships can be illustrated as pyramids.

A pyramid of numbers represents the number of organisms per unit area at each trophic level.
A pyramid of biomass shows the dry mass of living material per unit area at each trophic level.

Pyramids of biomass generally take a 'true pyramid' form (as energy is lost at each trophic level). In comparison, pyramids of numbers are often not pyramid shaped as they don't take size and mass of organisms into account.



(a) Pyramid of numbers **(b) Pyramid of biomass**

Microorganisms

Decomposition is the breakdown of dead materials into simpler organic matter.

Decomposers (e.g. bacteria, fungi) are important in the recycling of organic matter, that is returning vital nutrients to the soil. They release enzymes which catalyse the breakdown of dead material into smaller molecules such as nitrates, phosphates etc. This ensures a balance in ecosystems: the processes that remove materials from the soil are balanced by the processes that return them.

Nutrient cycles

Nutrient cycles are the processes by which materials cycle through the living and non-living components of an ecosystem. There is a fixed amount of nutrients on Earth which must be constantly recycled.

The carbon cycle

1. Photosynthesising plants remove CO_2 from the atmosphere.
2. Eating passes carbon compounds along a food chain.
3. Respiration in plants and animals returns CO_2 to the atmosphere.
4. Organisms die and decompose. Decomposers (bacteria and fungi) break down dead. material and release CO_2 via respiration.
5. Combustion of materials (e.g. wood, fossil fuels) releases CO_2.

The nitrogen cycle

1. **Organisms die and decompose. Decomposers break down proteins and urea into ammonia.**
2. **Bacteria in the soil convert ammonia into nitrates which are taken up by plants and used to build proteins.**
3. **Nitrogen-fixing bacteria (in the soil and root nodules of legumes) also convert nitrogen gas into nitrates which are taken up by plants.**
4. **Feeding passes nitrogen through the food chain.**
5. **Denitrifying bacteria convert nitrates in the soil back to nitrogen gas. This occurs in anaerobic conditions e.g. waterlogged soils.**

Human impact on the environment

The needs of the human population sometimes conflict with the conservation of the environment e.g. a rising human population means we need more food, however, farmland disrupts natural habitats and reduces biodiversity.

It is important to balance the need for resources with the need to preserve the biodiversity of ecosystems. This is essential to protect ecosystems and endangered species, whilst still maintaining quality of life for humans.

Intensive farming

Intensive farming is an agricultural system characterised by the use of machinery, chemicals (fertilisers, pesticides etc.) and battery methods to maximise space and produce high crop yields. It has both advantages and disadvantages:

Advantages	Disadvantages
• Maximum crop yields - cheaper to produce and greater profits • Maximises space for crops and machinery • Enables more food to be grown to meet the demands of the growing population	• Reduces biodiversity • Excess fertiliser can wash into water sources causing eutrophication and death of many species • Chemicals may enter the human food chain or cause damage to other wildlife • Hedgerows (food source and shelter to many species) removed • Battery farming (limiting the movement of animals to reduce energy losses)

	may be seen as unethical • Use of antibiotics to minimise risk of disease leads to antibiotic resistance • High input cost

Eutrophication

Excess fertiliser or untreated sewage may wash into water sources causing eutrophication:

1. Fertiliser or sewage enters rivers and lakes.
2. Nutrient build-up in water.
3. Algal bloom blocks sunlight.
4. Aquatic plants cannot photosynthesise ∴ less oxygen produced.
5. They die and decompose.
6. Decomposers further deplete oxygen levels.
7. Animals can no longer respire aerobically so die.

Pollutants in food chains

Some chemicals that do not break down rapidly (e.g. heavy metals) can enter food chains and accumulate in organisms. At higher trophic levels they become very concentrated and may become toxic to larger animals such as whales.

Detecting pollution

Electronic meters

Water pollution can be detected by the use of electronic meters which measure changes in pH or oxygen levels.

Indicator species

An indicator species is a species whose presence or absence in an environment provides indication of environmental conditions e.g. pollution levels.

Lichens are a type of indicator species that can be used to measure air pollution. Different types of lichen grow in different levels of air pollution e.g. bushy lichens grow in cleaner air than crusty lichens. The abundance and distribution of lichens indicate levels of pollution.

However, indicator species are less accurate than non-living indicators and do not provide a definitive figure for pollution levels.