Section 5.1 – Food chains and food webs

The ultimate source of energy in an ecosystem comes from sunlight
This energy is converted to an organic form using photosynthesis which is then passed between organisms

Producers – photosynthetic organisms that obtain their energy through the photosynthesis of sunlight

Consumers – Organisms that feed off of other organisms. They do not produce their own food by photosynthesis. Consumers can be primary, secondary, etc depending on which stage of the food chain they are at. For example a secondary consumer consumes primary consumers, but is consumed by tertiary consumers.

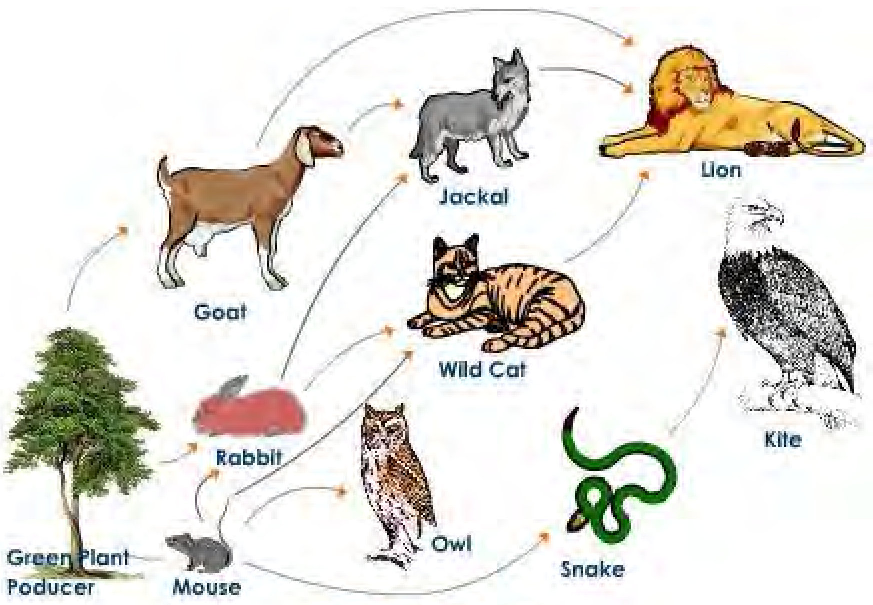
Decomposers – When producers/consumers die, the energy that they contain can be accessed by decomposers that will break down the larger more complex molecules that they are made of into smaller simple components again. The simple components are recycled as they are taken up again by plants. Consumers include, fungi and bacteria and to a lesser extent animals such as detritivores.

<u>Food chains</u>

Describes the feeding relationships between organisms
Each stage of the chain is referred to as being a "trophic level"

<u>Food webs</u>

In reality most animals do not rely upon a single food source.
Within a single habitat there may be many food chains linked together to form a food web.



Food Web in a Forest

Section 5.2 – Energy transfer between trophic levels

Energy losses in food chains

Only 1 - 3% of the energy available to plants is converted into organic matter
This is because:

- Over 90% of the suns energy is reflected back into space by the atmosphere
- Not all wavelengths of light can be absorbed by plants in photosynthesis
- Light may not actually fall of the chlorophyll molecule
- Limiting factors may slow down photosynthesis

The rate at which energy is stored is called “net production”

Net production = gross production – respiratory losses

Only approximately 10% of the energy stored in plants is passed on to primary consumers.
Secondary and tertiary consumers however are more efficient, transferring approximately 20% of the energy available to them.
The low amount of energy absorbed at each stage is due to:

- Some of the organism not being eaten
- Some parts can be eaten but not digested
- Some of the energy is lost in excretion
- Some of the energy is lost via respiration that is used to maintain a high body temperature. This is especially the case in mammals

Because the energy transfer in food chains is inefficient:
Most food chains have only 4/5 trophic levels since there is not enough energy to support a large breeding population at trophic levels higher than these
The total biomass is less at higher trophic levels
The total amount of energy stored is less at each stage of the food chain

Calculating the efficiency of energy transfers

The energy available is usually measured as $kjm^{-2}year^{-1}$

The formula used to calculate the energy transfer is:

$$\textbf{Energy transfer} = \frac{\textbf{Energy available after the transfer}}{\textbf{Energy available before the transfer}} \times 100$$

Section 5.3 – Ecological pyramids

Food chains/webs are useful in showing the direction of flow of energy in a habitat; however they do not provide any quantitative information.

Pyramids of number

Usually the higher up in trophic levels you go the fewer organisms there are. For example, **grass → rabbit → foxes**

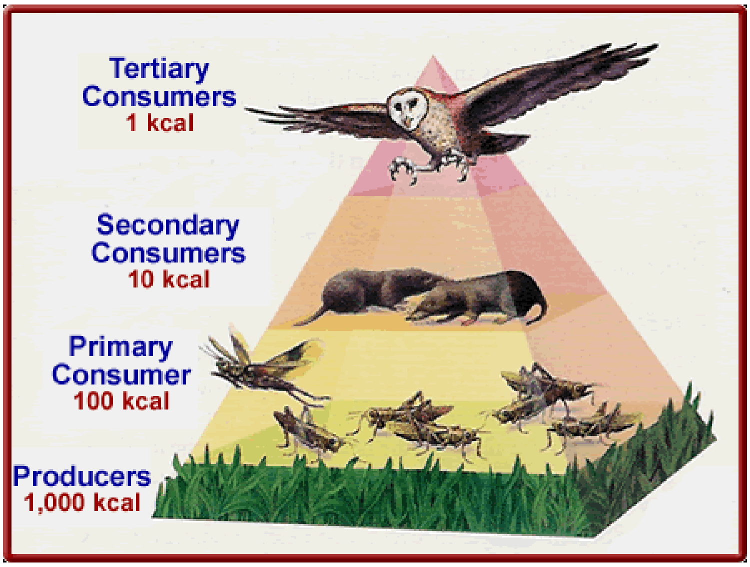
There are however significant drawbacks to this method. These include:
No account is taken for size. For example 1 tree will count the same as one piece of grass. However it is quite obvious that a tree can sustain more life that a blade of grass can.
The number of individuals can be so great it can be almost impossible to count them for example all of the grass in a field.

Pyramids of biomass

This method is more reliable than the last as it does take size into account.
Biomass is the total mass of plants/animals of species in a given place.
Biomass can be unreliable however as there are various different amount of water than can be stored in an organism.
Dry mass is therefore measured instead. However, to do this, organisms must be killed ☹
Biomass is measured in gm^{-2}
Both pyramids of biomass and numbers can be unreliable as they do not account for seasonal differences in the amount of organisms present.

Pyramids of energy

The most accurate representation of energy flow in a food chain
Collecting data can be difficult/complex
Data is usually collected in a given area for a given period of time (e.g. a year)
This is more accurate than using biomass since different organisms may have the same mass but one may have more fat for example than the other and so will have more energy
The energy flow in this type of pyramid is usually measured in $kjm^{-2}year^{-1}$



Section 5.4 – Agricultural ecosystems

What is an agricultural ecosystem?

Largely made up of animals/plants used to made food for humans
Agriculture tries to ensure that as much of the energy available from the sun is transferred to humans as possible
Increases the productivity of the human food chain

What is productivity?

The rate at which something is produced
The rate at which plants for example assimilated energy from the sun into chemical energy is called the **gross productivity** and is measured in $Kjm^{-2}year^{-1}$
Some of the chemical energy that is assimilated by plants is used for respiration, the remainder is called the net productivity.
Net productivity is expressed as:

Net productivity = gross productivity – respiratory losses

Net productivity is affected by two main things:

1.) The efficiency of the crop carrying out photosynthesis. This can be improved if the limiting factors are reduced.
2.) The area of the ground covered by the leaves of the crop

Comparisons of natural and agricultural ecosystems

Energy input

To maintain an agricultural ecosystem it is important to prevent the climax community from forming by excluding the other species in that community
It takes an extra input to do this seeing as it requires removing pests, diseases, feeding animals and removing weeds.
The energy to do this comes from two sources:

1.) **Food –** farmers use energy to do work on the farm. The energy for this comes from the food that they eat.
2.) **Fossil fuels –** Farms have become mechanised and so many different machines are used to plough the crops, transport materials and distribute pesticides. The energy that powers these machines comes from fossil fuels.

Productivity

Productivity in natural ecosystems is relatively low
Energy input in agricultural ecosystems removes limiting factors to improve productivity
Other species are removed to reduce competition for light and other nutrients
Fertiliser is added to the soil to reduce the limiting factor of nitrate concentration on growth.

Section 5.5 – Chemical and biological control of agricultural pests

What are pests and pesticides?

A pest is an organism that competes with humans for food/space
Pesticides are poisonous chemicals that kill pests
Herbicides kill plants, insecticides kill insects, fungicides kill fungi, etc
An effective pesticide should:

- **Be specific** – only kills the organism it is directed at. Should not kill humans, natural predators of the pest, earthworms, and to pollinators such as bees
- **Biodegrade –** once applied should break down into harmless molecules.
- **Be cost effective** – pesticides can only be used for a limited amount of time until the pest develops resistance
- **Not accumulate** – does not build up in parts of an organism or food chain

Biological control

Uses other organisms and does not eradicate the pest but simply controls it.
If the pest was reduced to such an extent the predator would starve and therefore die
The surviving pest would be able to then multiply rapidly
Disadvantages of biological control include:

- Acts more slowly, interval of time between introducing the biological control and actually seeing its effect
- The control organism its self may become a pest

Advantages include:

- Pests do not become resistant
- Very specific, and cost effective seeing as the organism can reproduce itself

Integrated pest – control systems

This uses all forms of pest control with the aim is to determine an accepted level of the pest rather than trying to eradicate it which is costly and counterproductive.

- Choosing animal/plant varieties that are as pest resilient as possible
- Managing the environment and ensuring there are nearby habitats for predators
- Regulating the crops so early action can be taken
- Removing the pest mechanically (by hand)
- Using biological agents if necessary
- Using pesticides as a last resort

How controlling pests effectively increases productivity

Pests compete with the crop for things such as light, and nutrients and so is a limiting factor. In addition to this, some pests may compete with humans by eating the crop. There is a conflict of interest since farmers have to provide cheap food to earn a living whilst

Section 5.6 – Intensive rearing of domestic livestock

Intensive rearing and energy conversion

As you move down a food chain, energy is gradually lost to respiratory losses
This is because in mammals, the rate of respiration high since the organism needs to maintain a high body temperature as well as move around to avoid predators and catch prey. This leaves little energy to be converted into biomass. To ensure that farming of animals is efficient, respiratory losses must be decreased. This can be done as follows:

- Movement is restricted so little energy is lost in muscle contraction
- The environment can be kept warm so less energy is required to maintain a high body temperature
- Nutrition is carefully controlled to ensure organisms receive the optimum amount and type of food so that there is maximum growth and little wastage
- Predators are excluded and so there is no loss to other organisms

Other means may also include:

- selectively breeding animals that are more efficient in converting the food they eat into biomass
- Using hormones to increase growth rate