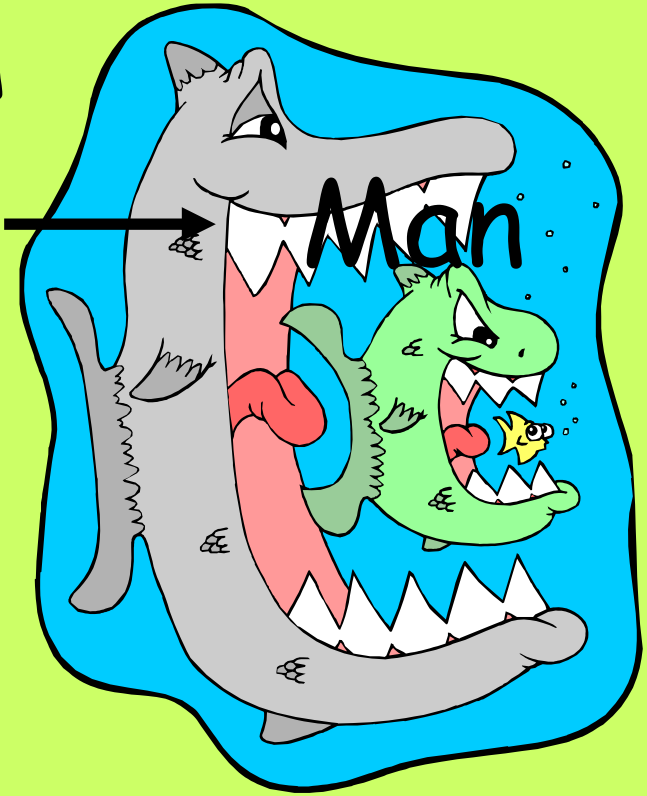
Energy Flow in Ecosystems

- All energy ultimately flows from the sun.
- It passes from organism to organism in a system known as food chains.
- There are two main types of food chain.

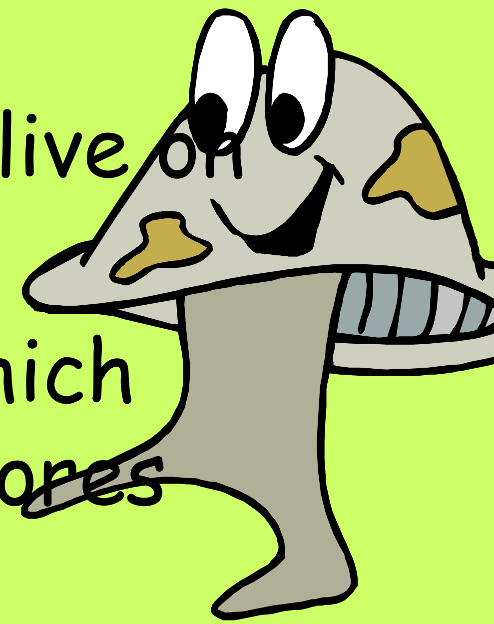
Grazing Food Chains

- These are the more common, familiar food chain
- Eg Grass ⟶ Cow ⟶ Man

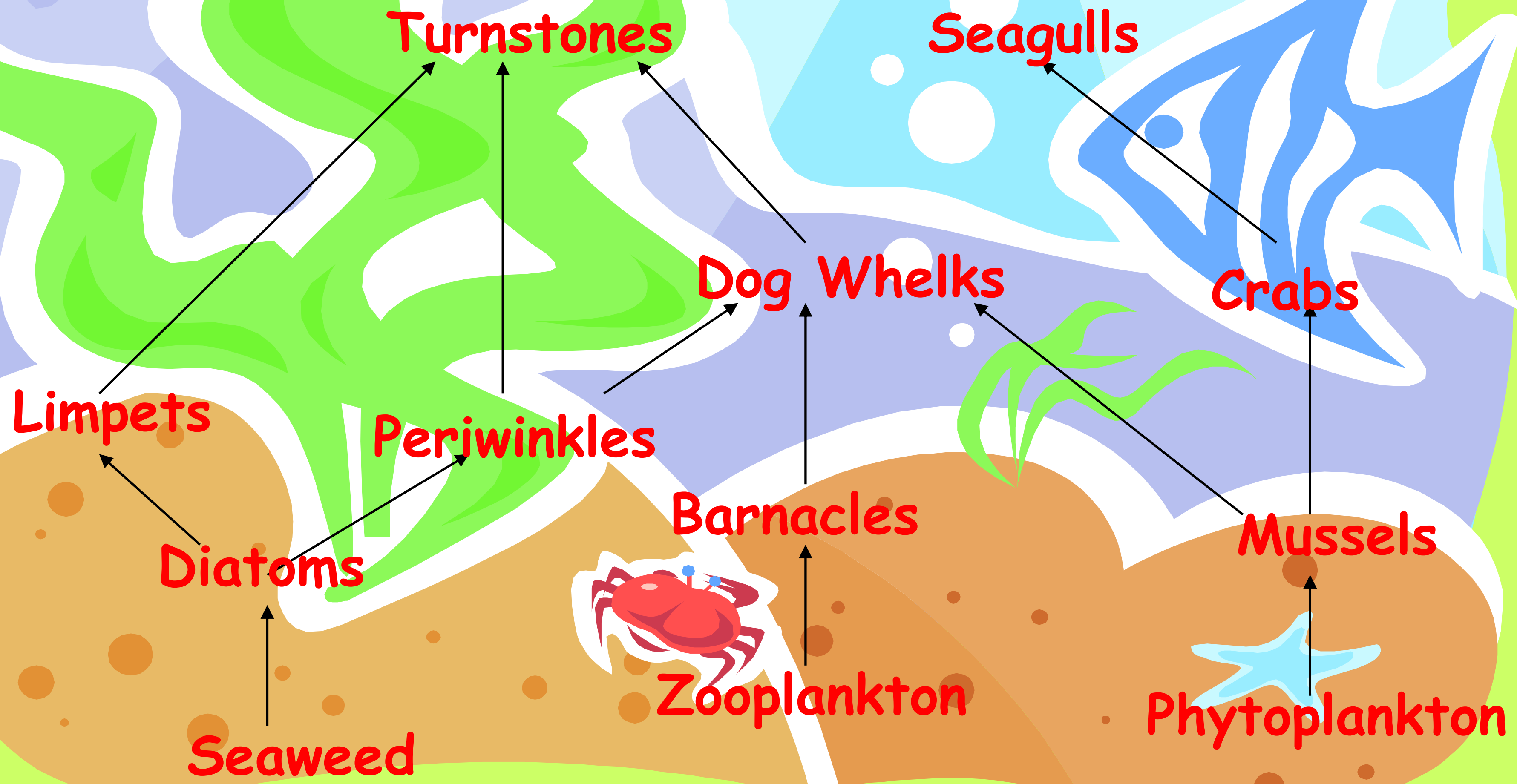


Detritus Food Chains

- Detritus is dead and waste material not eaten by consumers.
- **Detritivores** are animals which eat detritus eg millipedes, woodlice, earthworms.
- These food chains do not start with producers.
- **Saprophytes** are microbes which live on detritus.
- **Decomposers** are all organisms which consume detritus ie both detritivores and saprophytes



- Food Webs
- Feeding relationships in ecosystems are complex and interconnecting.
- Many animals are omnivores feeding on more than one trophic level



Energy Transfer

- All organisms depend on primary production – the production of organic molecules by producers.
- The sugars made in photosynthesis accumulate as the GROSS PRIMARY PRODUCTION (GPP).
- A lot of this is used up in respiration. What is left is known as the NET PRIMARY PRODUCTION (NPP).

NPP = GPP – RESPIRATION

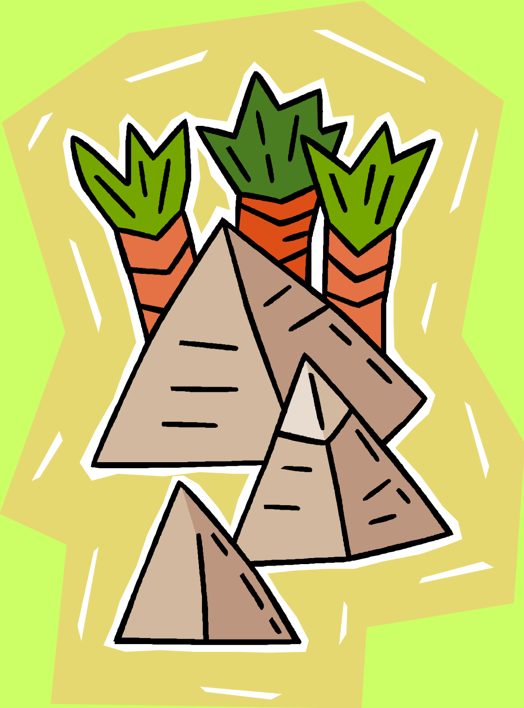
- NPP represents the potential energy available to primary consumers

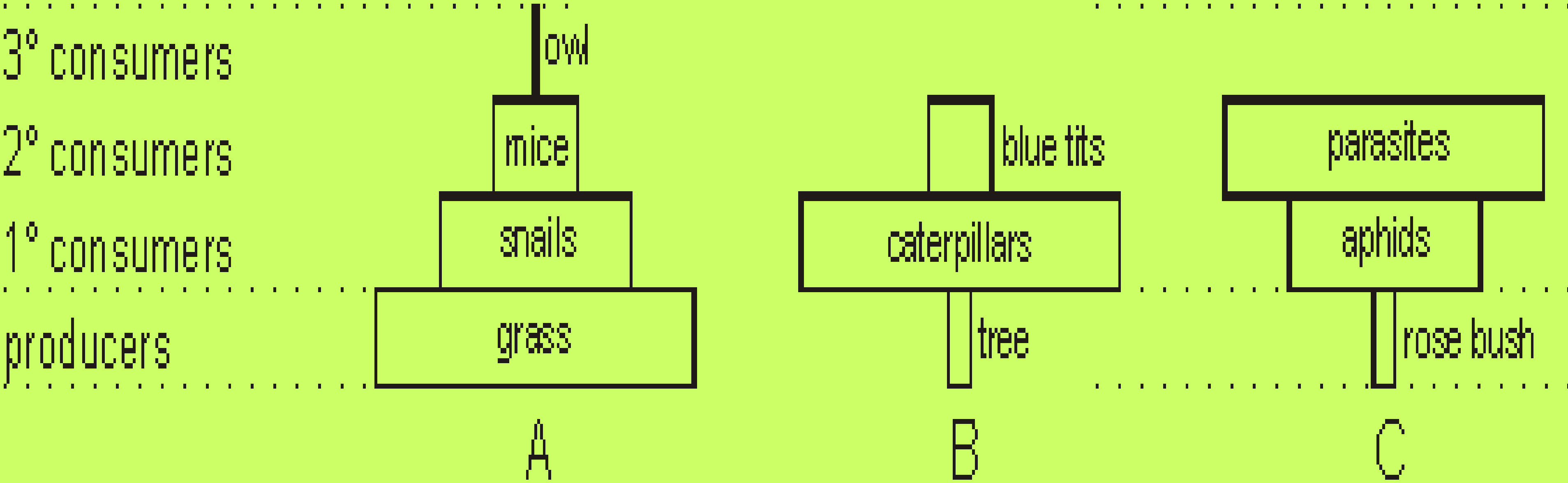
Trophic Levels

- As energy flows through food chains it flows from producer to consumer etc. A more accurate term is a TROPHIC LEVEL. (trophic-to feed)
- Producers TROPHIC LEVEL 1
- Primary consumers TROPHIC LEVEL 2
- Secondary consumers TROPHIC LEVEL 3
- Tertiary consumers TROPHIC LEVEL 4
- Detritivores and decomposers can operate at a number of trophic levels.

Pyramids

- Food webs describe feeding relationships but don't give any idea of numbers (not quantitative).
- Can use a **pyramid of numbers**
- **Drawbacks**
- Don't give any indication of the relative mass of the organism

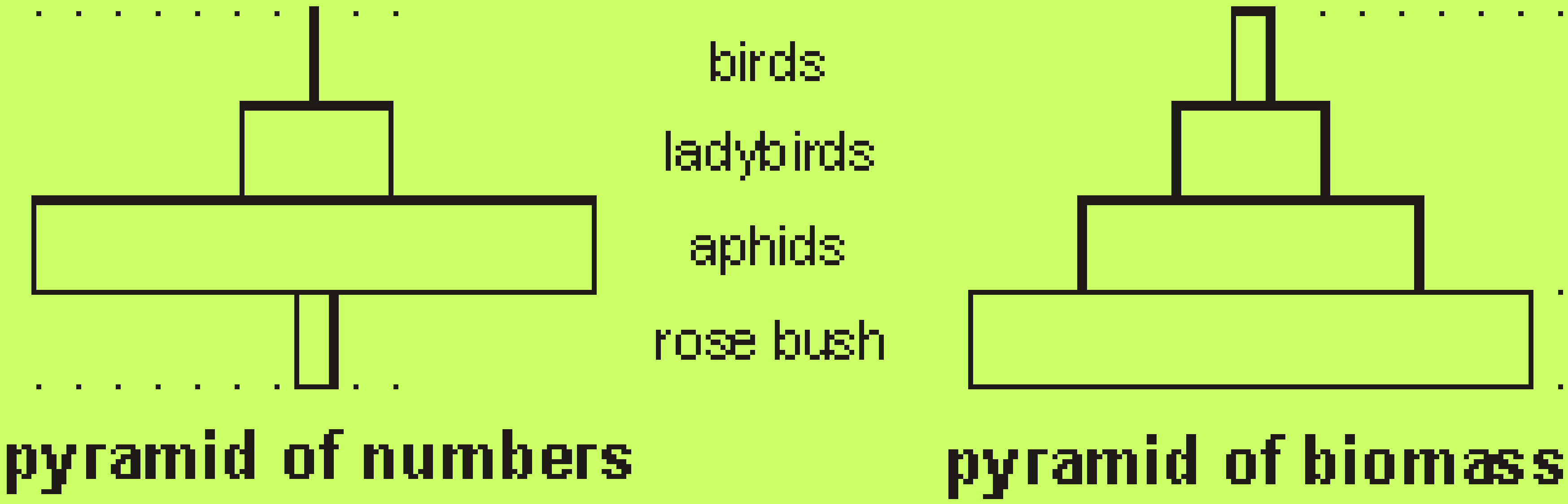




B and C are **inverted** pyramids typical of chains containing **single large producers** or **parasites**.

Pyramids of Biomass

- Uses biomass instead of numbers



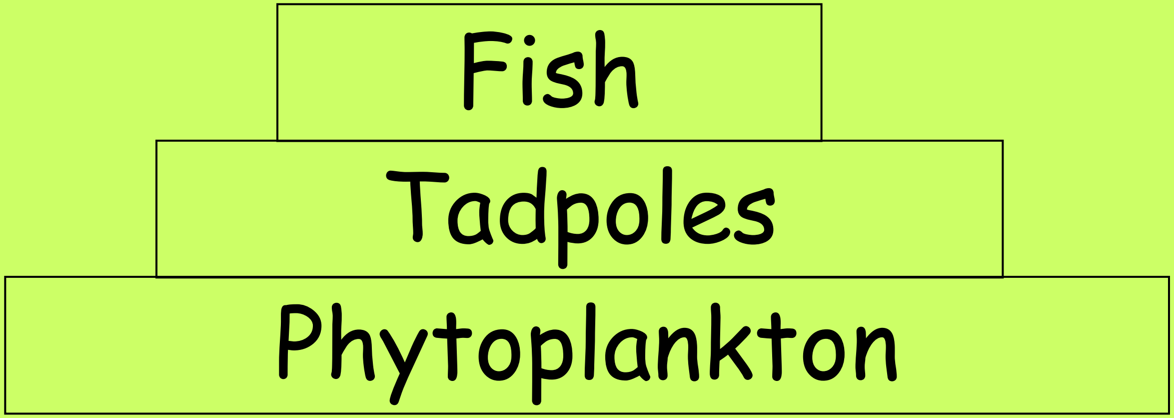
Drawbacks with using biomass

- Biomass when recorded is just a "snapshot" in time. Gives no indication of the rate at which organisms grow.
- Eg phytoplankton- tiny producers which grow very quickly (have a high productivity)
- But they are constantly harvested by primary consumers therefore at one particular time they would be small in numbers but over a period their biomass would be huge.

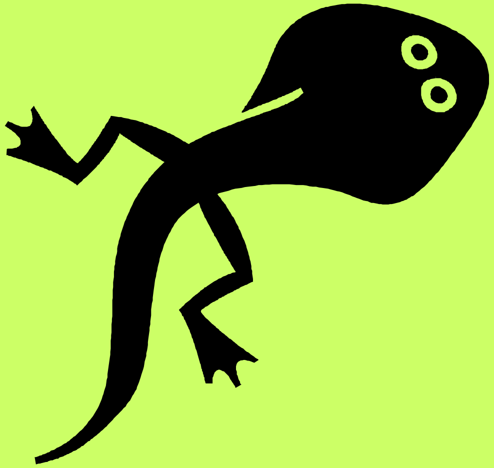
Zooplankton
Phytoplankton

Pyramids of Energy

- Shows the amount of energy transferred from 1 trophic level to the next per unit area per unit time.
- Most accurate



- Since only some of the energy is passed on, these pyramids are never inverted.
- **Drawbacks**
- The information is very hard to obtain as it requires destruction of the organism.



Energy loss in food chains

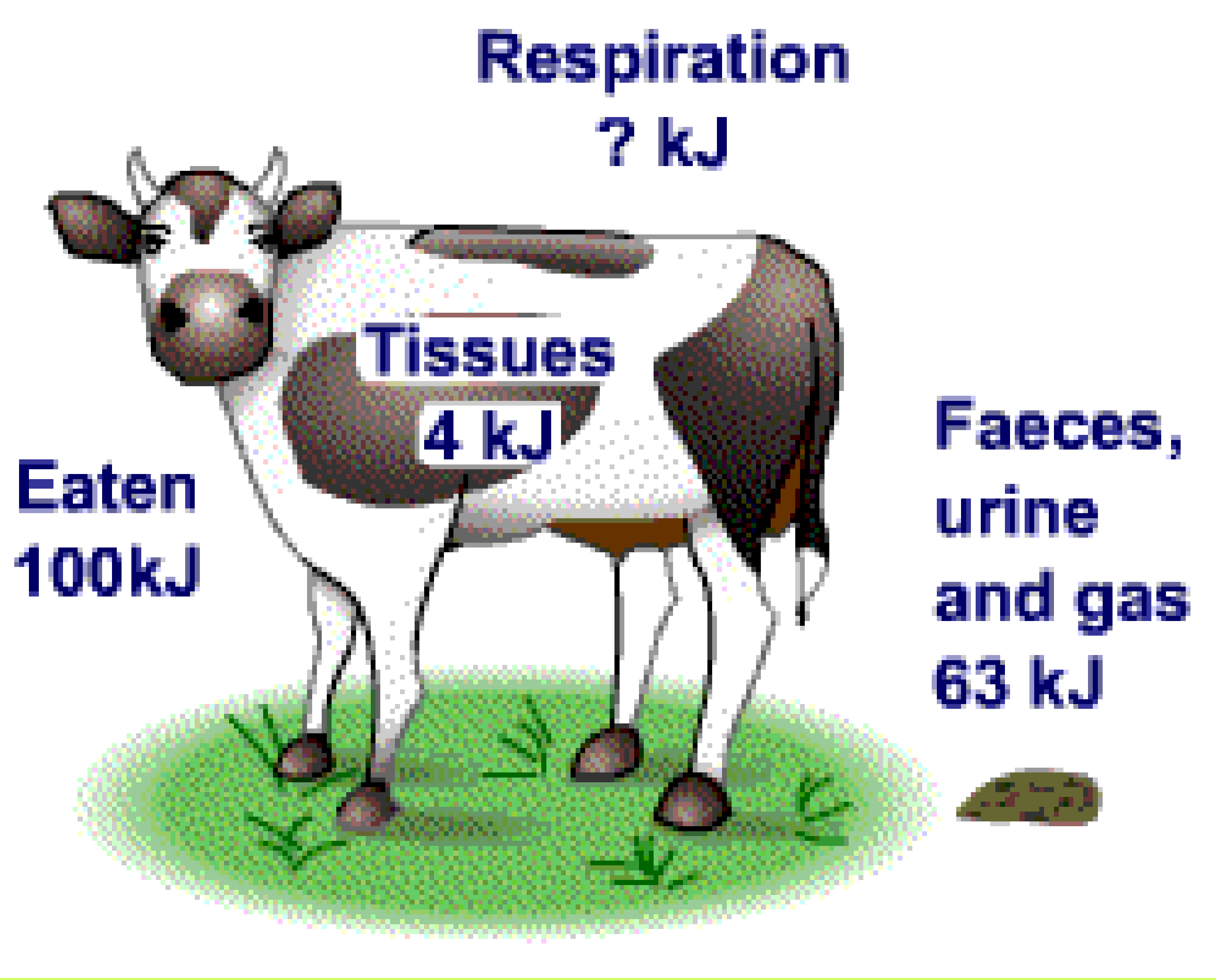
- Only approximately 2% of the sunlight energy available to a plant is used in photosynthesis.
- This is because it:
  - does not strike a chloroplast and passes through the leaf
  - is reflected off the cuticle into the atmosphere
  - used to heat up water in the leaf

There is a reduction in energy at progressive trophic levels due to:

- Loses to the decomposer food chain
- Loses through egestion and excretion
- The difficulty of digesting plant material (eg cellulose) and the relatively high loses via egestion in primary consumers (herbivores)
- Losses through respiration (with energy dissipated as heat)
- The relatively high loses via respiration in endotherms (mammals and birds)

Energy Efficiency

- This bullock has eaten 100 kJ of stored energy in the form of grass, and excreted 63 kJ in the form of faeces, urine and gas.
- The energy stored in its body tissues is 4 kJ.
- So how much has been used up in respiration?


Respiration
? kJ
Tissues
4 kJ
Eaten
100kJ
Faeces,
urine
and gas
63 kJ

- Energy cannot just disappear - it must all be accounted for.
- So the total amount of energy used up by the bullock must equal the total taken in as food.
- Using this fact we can easily work out how much energy the bullock has used up in respiration.

total energy input =	100 kJ
∴ total energy used =	63kJ + 4kJ + respiration
energy used in respiration =	100 - 63 + 4
energy used in respiration =	**33kJ**

- **We can also work out the energy efficiency at each trophic level by dividing the *useful energy output* by the *total energy input*.**
- **Multiplying this fraction by 100 gives you the percentage efficiency.**
- **"Useful" means "available to the next trophic level";**
- **so the calculation for the bullock goes like this:**

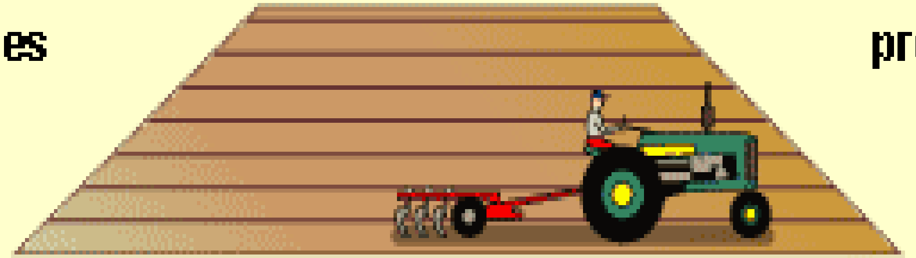
$\frac{4}{100}$

useful energy output =	4kJ
total energy input =	100kJ
energy efficiency =	**0.04**
x 100 to get % =	**4%**

Agriculture & Energy

1 hectare of land

produces



produces

0.3 tonnes of beef

or 1,200 steaks

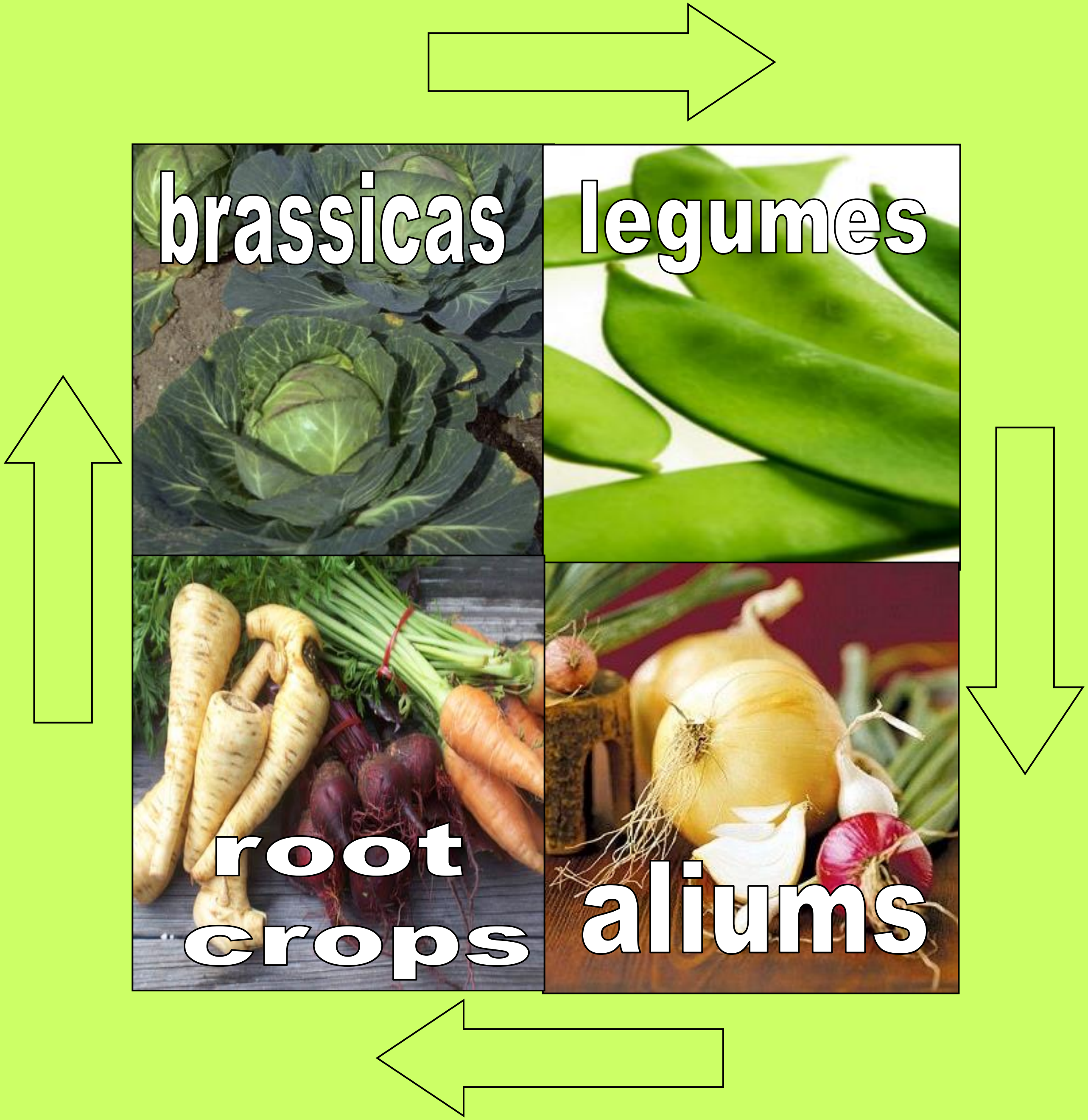
OR

7.5 tonnes of wheat grain

or 11,500 loaves of bread

appreciate traditional farming methods

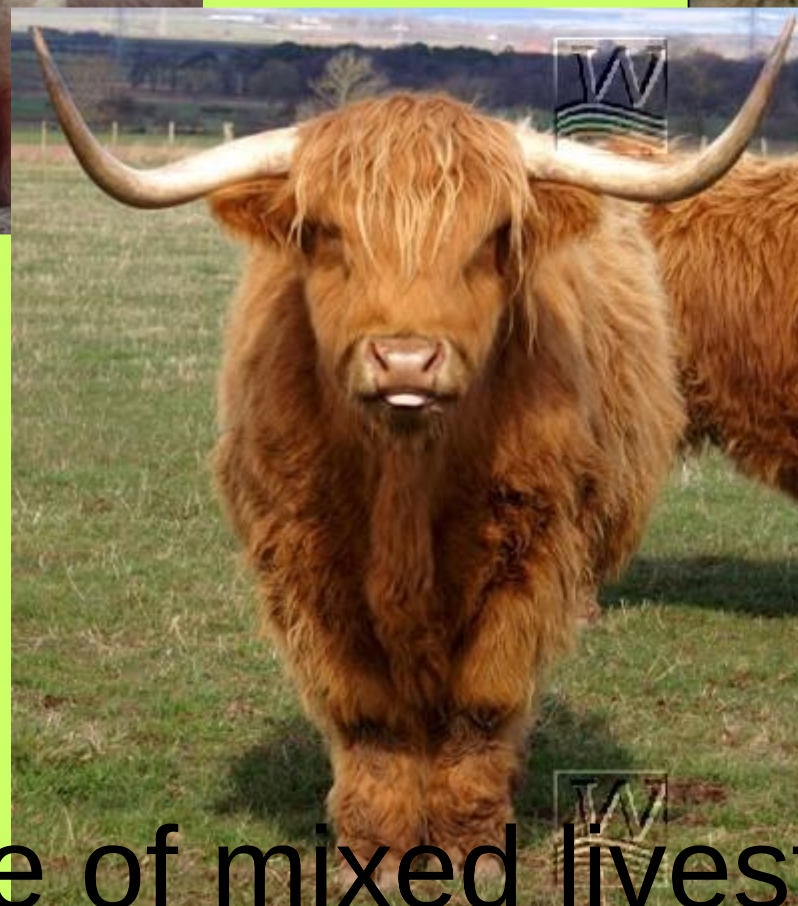
Use of a wide variety of crops



Use of crop rotation

- Reduced risk of development of mineral deficient soils

- Reduced risk of problems with pests



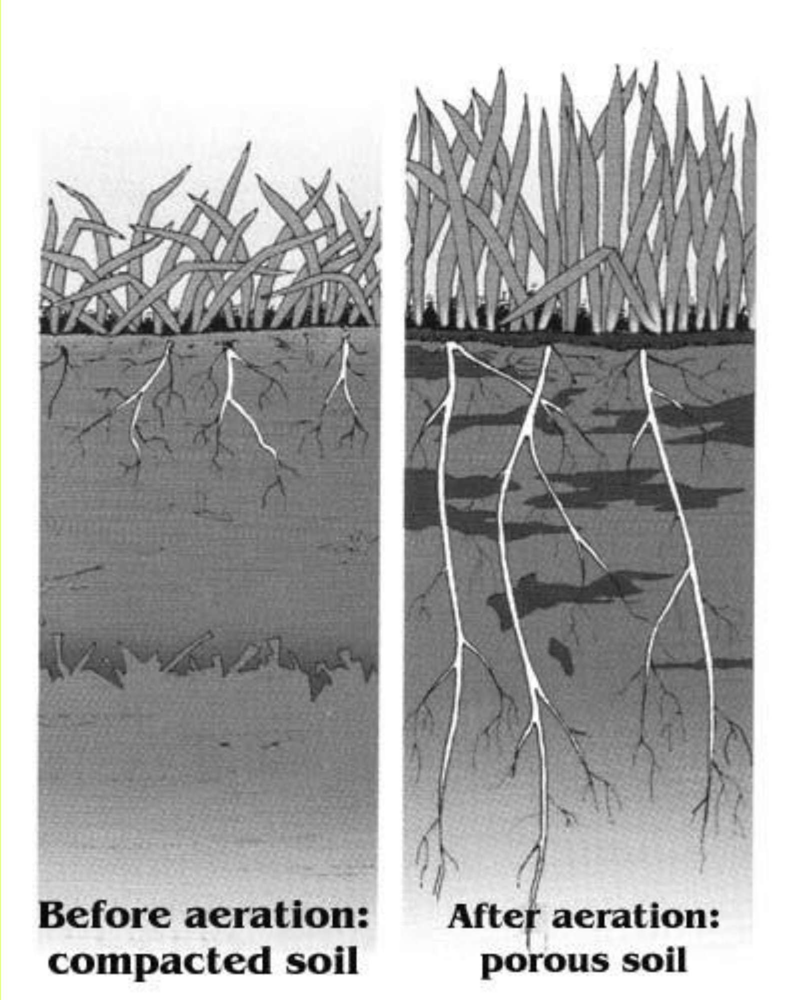
Use of mixed livestock

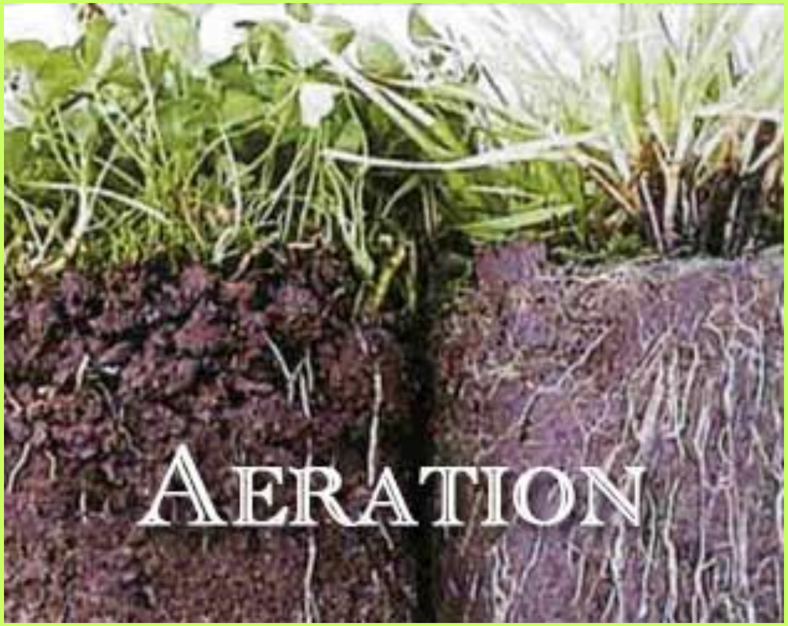
Use of organic fertiliser

Farmyard manure, horse, cattle, chicken

Advantages of organic fertiliser

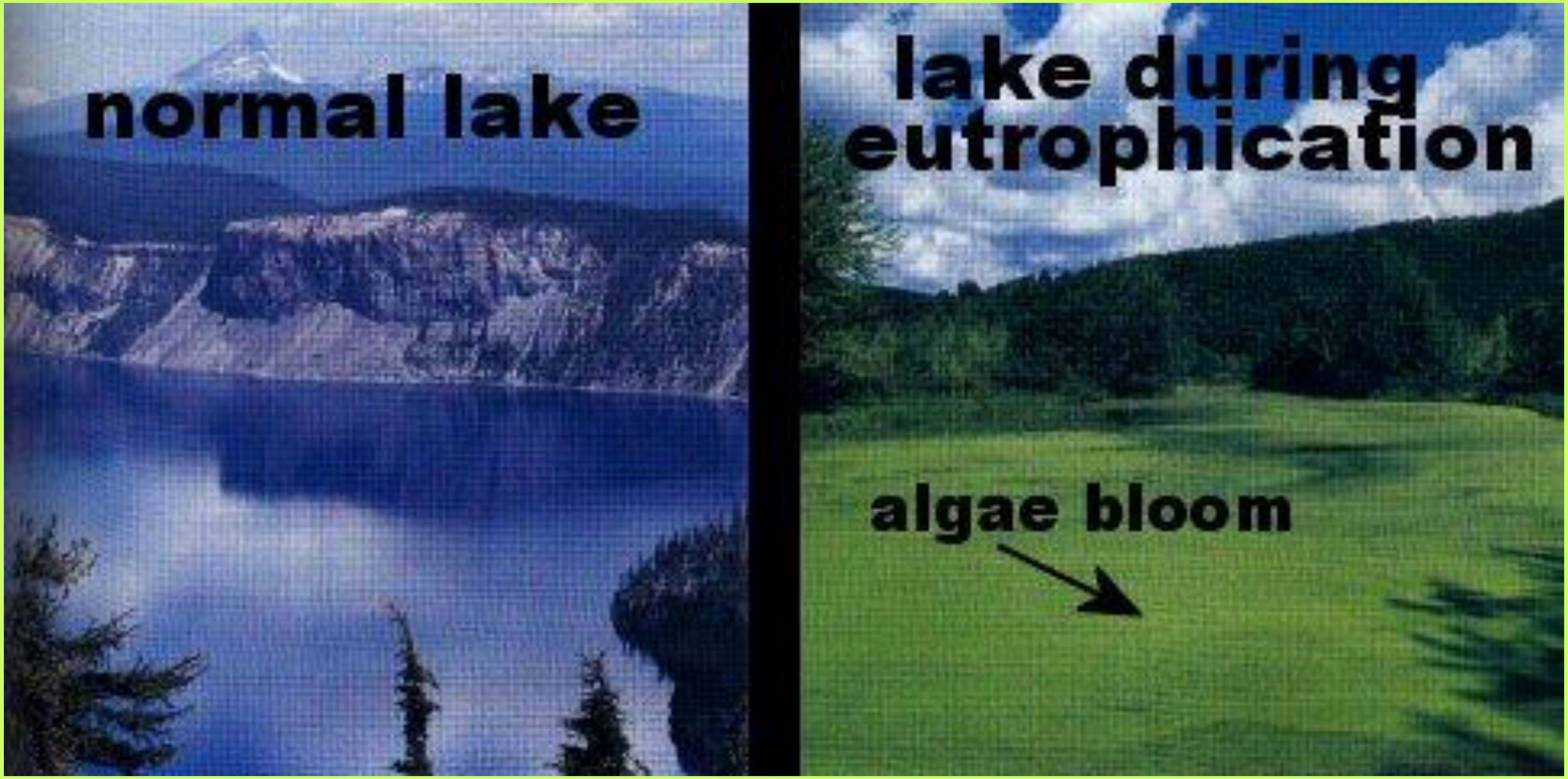
- Improved soil crumb structure and therefore improved soil aeration and drainage





Advantages of organic fertiliser

- Reduced risk of eutrophication of water bodies



problems of agricultural pollution in Northern Ireland

eutrophication

- Eutrophication is the mineral enrichment of water bodies such as Lough Neagh and Lough Erne
- Minerals include nitrates and phosphates
- The major source of nitrate input into Lough Neagh and the rivers of the Lough Erne catchment is lowland agriculture
- Phosphates come from artificial fertilisers (NPK) and from household waste (used in washing powders etc as a brightener), although these can be removed in sewage works.

- Algae use the excess minerals to grow rapidly producing algal blooms
- This reduces the transparency of the water so that plants below are unable to obtain sufficient sunlight for photosynthesis and die
- Algae have a short life span resulting in large amounts of decomposing plant material which releases unpleasant odours

- Decomposers such as bacteria use oxygen from the water as they break down the dead algae
- This increases the BOD (biological oxygen demand) of the water
- As there is less oxygen available for organisms such as invertebrates, this impacts on their predators and consequently there is a decrease in biodiversity in the lake
- This has resulted in the loss of fisheries and
- health risks from contamination of drinking water by toxic algae, which are costly to remove

Ballyroney Basin Biodiversity Profile

Drumlins,Lake, wildfowl

organic pollution by slurry and silage effluent

- Slurry is a solution of faeces and urine usually collected from animals kept in sheds. It is stored in silos and added to crops as a fertiliser

- Silage is grass that has been preserved to feed ruminants. Unlike hay it is moist and is partly fermented by bacteria, acidic conditions maintain the nutrients in the grass. It is stored in silos but the liquid formed, called silage effluent, may leak into rivers and streams.

- What effect do you think slurry and silage effluent will have on BOD values in water bodies?

- How will this effect flora, fauna and biodiversity in water bodies?

Issues with slurry application include:

- Need for optimal soil/weather conditions to minimise the risk of pollution
  - Slurry needs to be broken down in the soil by decomposers to release minerals directly to the roots.
  - Soil temperature and pH will affect the rate of decay and slurry can be washed away through the soil.
  - Therefore should not be applied
    - When soil is waterlogged. This is when water appears on the surface of the land when pressure is added.
    - When land is flooded or likely to flood.
    - When soil has been frozen for 12 hours or longer.
    - When land is snow covered.
    - If heavy rain is forecast within the next 48 hours.
    - Where land is steeply sloping with an average incline of 20% or more and where other factors such as waterways, soil conditions, ground cover and rainfall presents a significant risk of water pollution occurring.

Issues with slurry application include:

- The need for ‘closed periods’ when slurry is not applied
  - It should be applied when growth is optimum
  - No application is allowed from 15 October to 31 January.

- Nitrates and Phosphorus Regulations NI


spreading slurry


eating silage

Monitoring of water bodies

- Indicator species are organisms that, by their presence, abundance, lack of abundance, or chemical composition, demonstrate some distinctive aspect of the character or quality of an environment.

  In water bodies aquatic invertebrates are commonly surveyed as indicators of water quality and the health of aquatic ecosystems.

- Tubifex or ‘sewage worms’ are almost always associated with water quality that has been degraded by inputs of sewage or other oxygen-consuming organic matter such as slurry or silage effluent

- Tubifex worms can tolerate severely oxygen deprived water, in contrast with most of the animals of unpolluted environments, such as mayflies (Ephemeroptera) and stoneflies (Plecoptera), which require well-oxygenated conditions.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strategies to reduce the risk of eutrophication in water bodies due to leaching of artificial fertilisers

- Careful application of levels so that ‘supply does not exceed demand’ in the target crop
- Only apply artificial fertiliser immediately prior to or during periods of vigorous plant growth
- Do not apply artificial fertiliser when heavy rain is forecast
- Do not apply artificial fertiliser adjacent to water bodies

governmental guidelines exist which must be followed in the application of organic and artificial fertilisers

DARD NI Code of Good Agricultural Practice for the Prevention of Pollution of Water

EC Nitrates Directive Action Programme (NI is a total territory designation for this EC Nitrates Directive)

Understand that sustainable farming depends on the effective management of the conflict between increased food production and the need for environmental conservation

- Promote use of polyculture instead of monoculture resulting in:
  - Greater biodiversity
  - Greater difficulty for pest populations to become established
- Increased use of organic fertiliser (farmyard manure);
  - Improves existing soil crumb structure, aeration and drainage
  - Reduces risk of soil erosion
  - Reduces risk of leaching and thereby reduces risk of eutrophication

- Improved maintenance of existing hedgerows / replanting of hedgerows;
  - Decreases the risk of sol erosion
  - Improves biodiversity
- Terracing / ploughing across slopes to reduce soil erosion

Understand the concept of managed timber production as a sustainable resource

- Use of photodegradable plastic around / between crop plants (e.g. maize) to prevent growth of weeds and reduce dependence on herbicides;

- Integrated Pest Management Systems that include use of:
  - Specific, natural predators / parasites of pests
  - Non-persistent pesticides
  - Sterile males of pest species
  - Crop rotation (more difficult for pest species to become established)
  - Selective breeding / genetically modified varieties of crops with improved pest / disease resistance.

LINKS

BBC NEWS | UK | Northern Ireland | New 'timber power plant'

BBC NEWS | Science/Nature | Fight to save 'set aside' schemes

coppicing and woodland management

National Trust | Hatfield Forest | Managing the landscape | Coppicing

Biodiversity | Northern Ireland Forest Service