




Pre-AICE Biology S. IV.1-3
Ch. 25 IGCSE Biology; Ch 3 Miller Biology
SC.912.E.7.1 through 7.8, SC.912.L.17.4, SC.912.L.17.5, SC.912.L.17.6, SC.912.P.10.1

Energy and Ecosystems

Vocabulary

- **food chain** as a chart showing the flow of energy (food) from one organism to the next beginning with a producer
(e.g. mahogany tree → caterpillar → song bird → hawk)
- **food web** as a network of interconnected food chains showing the energy flow through part of an ecosystem
- **producer** as an organism that makes its own organic nutrients, usually using energy from sunlight, through photosynthesis
- **consumer** as an organism that gets its energy by feeding on other organisms

- **herbivore** (*primary consumer*) as an animal that gets its energy by eating plants
- **carnivore** (*secondary consumer*) as an animal that gets its energy by eating other animals
- **decomposer** as an organism that gets its energy from dead or waste organic matter
- **ecosystem** as a unit containing all of the organisms and their environment, interacting together, in a given area
e.g. decomposing log or a lake
- **trophic level** as the position of an organism in a food chain, food web or pyramid of biomass, numbers or energy



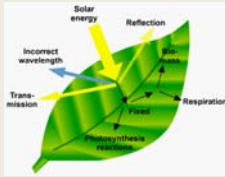
Organisms in their Environment
15 min.

Energy Flow

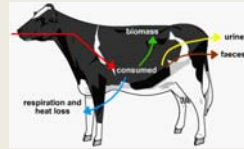
- Energy flows through ecosystems
- All energy enters ecosystem as **sunlight** and converted to *chemical energy* in organic molecules during photosynthesis (producers)
- Energy transferred along food chains as one organism feeds upon another
- Energy lost as **heat** (respiration) between exchanges, resulting in decrease in biomass and energy in successive trophic levels

Energy Flow

- Plants convert less than 3% of sunlight to chemical energy
 - Transmission through the leaf
 - Reflection
 - Incorrect wavelength
- Energy fixed via photosynthesis



- Overall efficiency of transfer of energy from producer to primary consumer is rarely greater than 10%

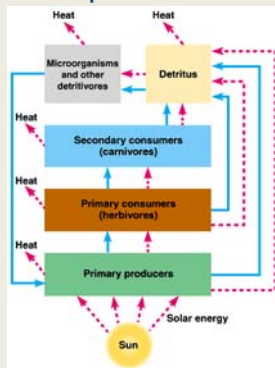


(S-Cool, 2000)

Fungi decomposing a log



Trophic Levels



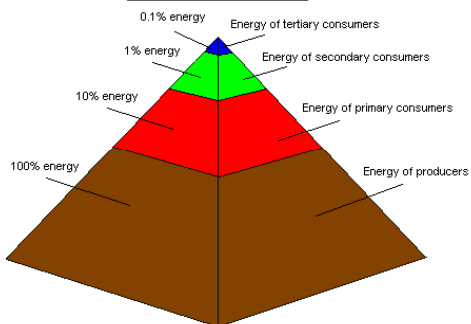
On average, about 90% of the energy is lost at each level in a food chain. This means that in long food chains, very little of the energy entering the chain through the producer is available to the top carnivore. So there tend to be small numbers of top carnivores. The food chain below shows how energy reduces through the chain. It is based on maize obtaining 100 units of energy.

maize → locust → lizard → snake
 100 units 10 units 1 unit 0.1 unit

In shorter food chains, less energy is lost.

(Mackean, 2009)

Ecological Pyramid



Food Chains

A food chain usually starts with a photosynthetic plant, which gains its energy from the Sun. The arrows used to link each organism to the next represent the direction of energy flow. They always point towards the 'eater', and away from the plant. The feeding level is known as the **trophic level**.

- Plants are producers (they make – or produce – food for other organisms).
- Animals that eat plants are primary consumers (a consumer is an 'eater'). They are also called herbivores.
- Animals that eat other animals are secondary, or possibly tertiary, consumers depending on their position in the chain. They are also called carnivores.

(Mackean, 2009)

Phytoplankton

- Plants of the watery world (salt and fresh)
- Microscopic, single celled algae are the basis of the food pyramid in the water



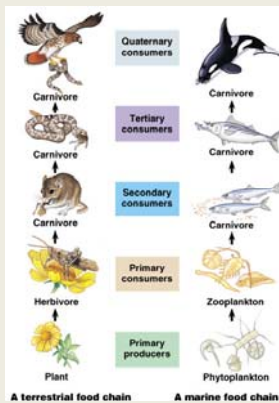
Zooplankton

- Small animals, called crustacea, that feed on the phytoplankton



Food Chains

Examples of terrestrial and marine food chains

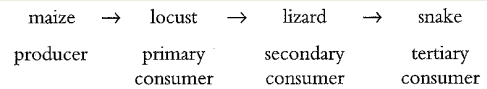


a food chain shows links between a series of organisms feeding on one another

IGCSE

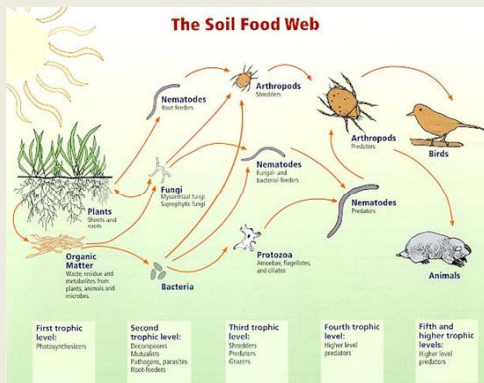
Examiner's tips

- Make sure you can write a food chain involving three consumers, with the arrows in the correct direction.
- Always start with the producer on the left of the diagram.
- Practice labelling each trophic level in your food chain under the organisms (producer, primary consumer, etc.).
- Don't waste time drawing the plants and animals: this will not get you any extra marks.

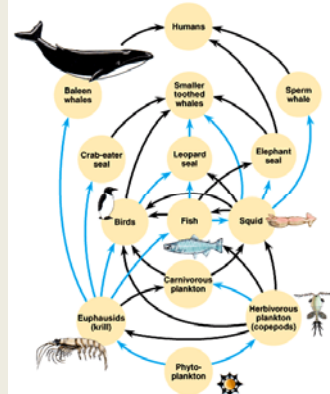


(Mackean, 2009)

The Soil Food Web



Food Web



a food web shows a group of interlinked food chains

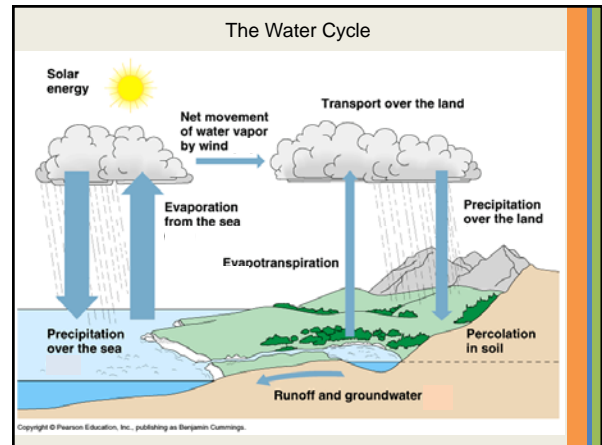
Productivity

- Rate at which plants convert light energy into chemical potential energy
- Measured in kilojoules of energy transferred per square meter per year
 - ($\text{kJ m}^{-2} \text{ year}^{-1}$)
- Gross primary productivity
 - Total quantity of energy converted by plants
- Net primary productivity
 - Energy which remains as chemical energy after plants have supplied their own needs in respiration



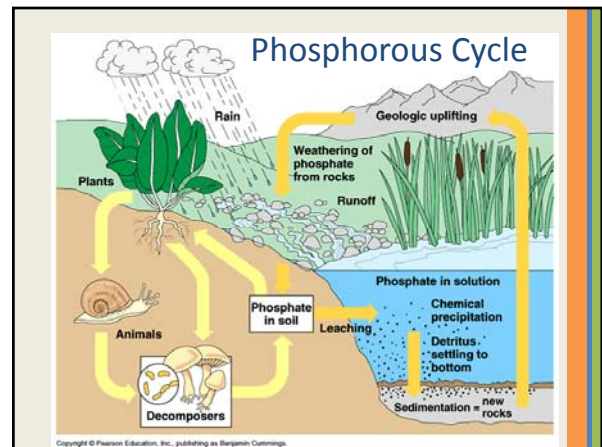
Water Cycle

- Tiny proportion of the water which is recycled passes through living organisms
 - Animals lose water by evaporation, defecation, urination, and exhalation. Gain water from their food and drink.
 - Plants take up water from the soil and lose it by transpiration
- Wind blowing over water/oceans and sun shine evaporate water
 - vapor enters the atmosphere and forms clouds, released as precipitation



Phosphorous Cycle

- Essential material in bone formation, teeth, DNA and RNA
 - Plants obtain phosphorous from soil and water
 - Animals obtain phosphorous from eating plants or other animals
- Leaches from rocks into soil

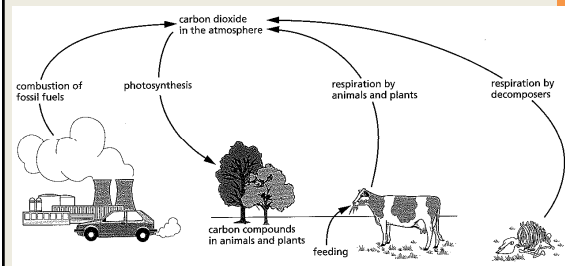


Carbon Cycle Key Points

- Carbon moves into and out of the atmosphere mainly in the form of carbon dioxide.
- Plants take carbon dioxide out of the air by photosynthesis.
- Plants convert carbon dioxide into organic materials (carbohydrates, fats and proteins).
- Herbivores obtain carbon compounds by eating plants. Carnivores gain carbon compounds by eating other animals.
- Animals and plants release carbon dioxide back into the air through respiration.
- When organisms die they usually rot (decompose). Decomposers break down the organic molecules through the process of respiration, to release energy. This also releases carbon dioxide into the air.
- If a dead organism does not decompose, the carbon compounds are trapped in its body. Over a long period this can form fossil fuels such as coal, oil or gas.
- Combustion of fossil fuels releases carbon dioxide back into the air.

(Mackean, 2009)

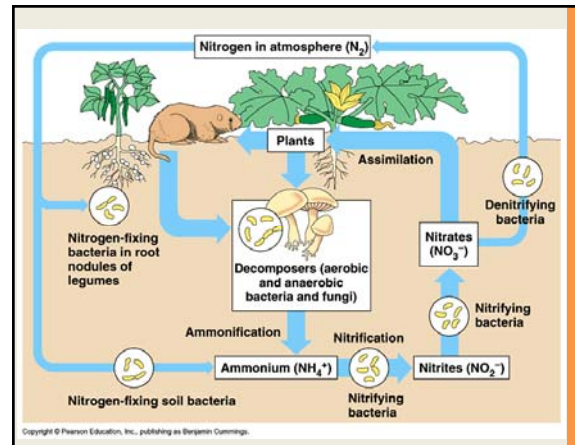
The Carbon Cycle



(Mackean, 2009)

Nitrogen Fixation

- Naturally or synthetically
 - Living organisms
 - Atmosphere
 - Haber process
- Essential element for all living things
 - Proteins and nucleic acids
- Air: 78% N₂ gas
 - Unusable in this form
 - Must be converted to ammonia (NH₃) or nitrate (NO₃⁻) ... known as **nitrogen fixation**



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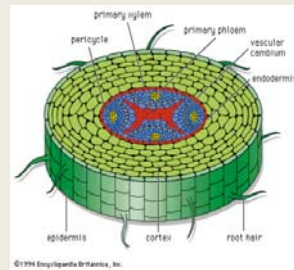


Nitrogen fixation

- Only **prokaryotes** are capable of fixing nitrogen
- Bacteria called *Rhizobium*
 - Soil (limited)
 - Root nodules (most productive)
 - Mutualism

Plants

- Nitrates transported out of nodules on root into xylem and distributed to all parts of the plant
- Most of the nitrogen ends up as part of protein molecules in the plant
 - Seeds
 - Storage tissues
- Deficiency causes pale color



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- Interesting links:
- http://www.nitrogenfree.com/problem/nitrogen_cycle.php
 - http://www.progressivegardens.com/growers_guide/plantnutr.html

Fixation in the Atmosphere

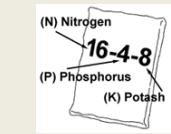


- Lightning passes through atmosphere
- Produces huge quantities of energy
- Causes nitrogen to react with oxygen forming nitrogen oxides, which dissolve in rain

Fixation by Haber Process

- Nitrogen gas and hydrogen gases are reacted together (1:3) using porous iron as a catalyst to make ammonia
 - High pressure (2175 to 3626 psi)
 - High temperature (1022° F or 550° C)
 - Exothermic rxn
- Haber Process utilized in the manufacture of approx. 100 million tons of fertilizer every year

Agricultural Supplements to Soil Nitrogen



- Various forms of commercial fertilizer are added to agricultural fields to supplement the nitrogen lost through plant harvest.

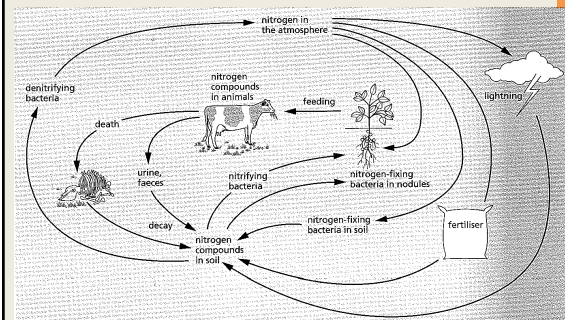
Return of the Nitrates

... to the soil

- When plants and animals die, decomposers break down proteins into amino acids.
 - Nitrogen released as Ammonia
 - Converted to nitrate and nitrite ions by **nitrifying bacteria**
 - Occurs only in well aerated soils

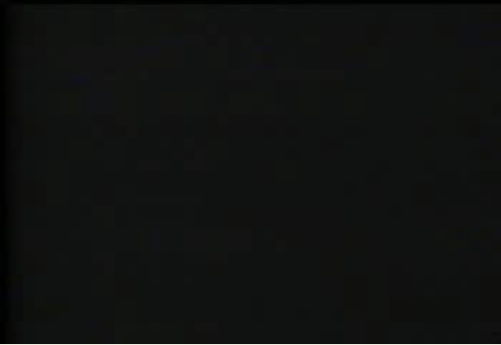
Denitrification

- Denitrifying Bacteria provides itself with energy by reversing nitrogen fixation and converting nitrate to nitrogen gas
 - Sewage treatment plants
 - Compost
- Brings nitrogen cycle full circle



(Mackean, 2009)

Importance of the Nitrogen Cycle



14 minutes

Resources

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