

JURONG WEST SECONDARY SCHOOL
SECONDARY FOUR – BIOLOGY (6093)

Chapter 10: ORGANISMS AND THEIR ENVIRONMENT

Learning Outcomes:

Candidates should be able to:

- a) briefly describe the non-cyclical nature of energy flow
- b) describe the roles of producers, consumers and decomposers in food chains and food webs
- c) explain how energy losses occur along food chains, and discuss the efficiency of energy transfer between trophic levels
- d) interpret pyramids of numbers and biomass
- e) describe how carbon is cycled within an ecosystem and outline the role of forests and oceans as carbon sinks
- f) describe how human activities, such as deforestation and use of fossil fuels, cause an increase in atmospheric carbon dioxide concentration, leading to global warming
- g) discuss how human actions can reduce the effects of global warming

ENGAGE - Activity 1.1 – The living organisms around us

Watch the following video "Dead stuff _The secret ingredient in our food chain."
As you watch the video, think of the following:

What is another word for 'dead stuff'?

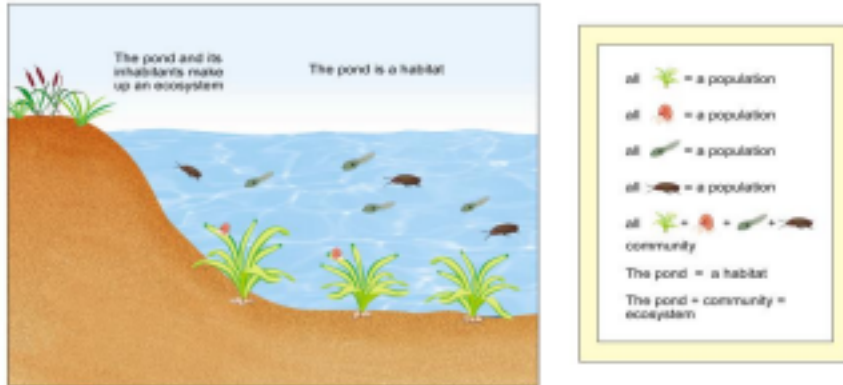
21.1 What is Ecology?

- The study of the **interactions** of **organisms** with **one another**, as well as with their **environment**.

Prepared by: Ms Pui Li Xian & Ms Domina Ng

Commented [PLX1]: https://www.youtube.com/watch?v=KI7u_pcfAQE

Commented [PLX2]: detritus (FYI)



Common terminologies in Ecology

Definition Term

The place where an organism lives. E.g. pond, freshwater stream, forests **Habitat**

A group of organisms of the **same species** living in a particular habitat **Population**

All the populations or organisms living and interacting with one another in a particular habitat (E.g. Mangroves, Mudskippers, Fiddler crabs,

Community

Soldier crabs living in a mangrove swamp)

A community together with its **abiotic** environment **Ecosystem**

The study of interactions of organisms with one another, as well as with their environment **Ecology**



The Abiotic Environment (FYI)

- It consists of **physical factors** such as
 - Light intensity
 - Temperature
 - Amount of water available
 - Oxygen content
 - Salinity of soil and/or water
 - pH of soil and/or water

b) explain the terms **producer**, **consumer** and **trophic level** in the context of food chains and food webs

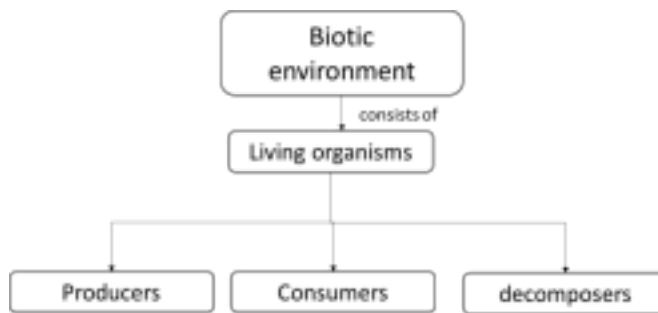
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Commented [PLX4]: <https://www.thinkinglink.com/scene/1293967096413159427?buttonSource=viewLimits>

Commented [PLX5]: https://youtu.be/E1op_7-yTN4

- c) explain how energy losses occur along food chains, and discuss the efficiency of energy transfer between trophic levels

The Biotic Environment



1. Producers

- Contain **chlorophyll** which **traps** and **convert light energy** into **chemical energy**. Chemical energy is stored in glucose.
- Synthesise glucose from carbon dioxide and water, and they produce oxygen as a by-product during photosynthesis.
- Producers affect the lives of other organisms because they provide them with energy and oxygen.
- All food chains start with **producers**. (**first trophic level**)
- E.g. green plants and green algae

2. Consumers

- **Consumers are not able to make their own food.**
- **They obtain energy and nutrients by feeding on other organisms.**
- Three types:
 1. **Primary consumers** (herbivores): Animals that feed on plants.
 2. **Secondary consumers** (carnivores): Animals that feed on primary consumers.
 3. **Tertiary consumers** (carnivores): Animals that feed on secondary consumers.

3. Decomposers

- Obtain energy by breaking down dead organisms, faeces and excretory products
- The decomposition process releases inorganic nutrients, such as **carbon** and nitrogen, for nutrient cycling.
- E.g. fungi, bacteria and earthworms.
- **Note that decomposers are not included in food chains/webs.**

Think! Do decomposers release ALL of the energy stored in the bodies of dead **organisms**?

Commented [PLX6]: There are some components that cannot be broken down e.g. bones

Food chain

Food chain: A series of organisms through which energy is transferred in the form of

food **Trophic level:** Each feeding level of organism in a food chain



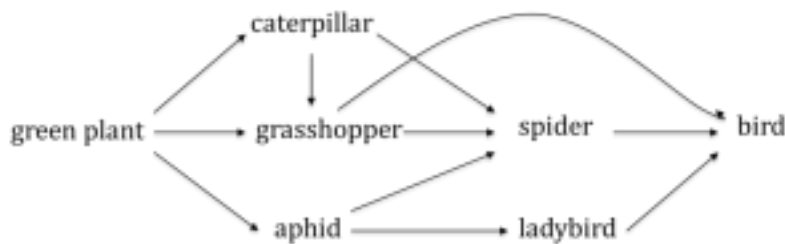
1st Trophic level 2nd Trophic level 3rd Trophic level 4th Trophic level

Think! Generally, food chains do not have more than **four trophic** levels. Why?

The reason why food chains do not have more than four trophic levels is because energy is lost at each trophic level. Only about 10% of the energy from one trophic level is transferred to the next level.

Food webs

Food webs: Interlinked food chains



1st Trophic level 2nd Trophic level 3rd Trophic level 4th Trophic level

Think!

a) Do organisms higher in food web eat everything that is lower in the food web? _____ b) What is the **main source of energy** in the food web? _____

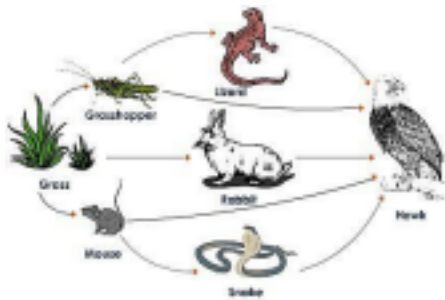
Commented [PLX7]: The reason why food chains do not have more than four trophic levels because energy is lost at each trophic level. Only about 10% of the energy from one trophic level is transferred to the next level.

Commented [PLX8]: Organisms higher in a food chain eat some, but not necessarily all of the organisms below them in a food web

Commented [PLX9]: Sunlight

- The biotic environment consists of **all the living things** that an organism **interacts** with in its **habitat**.
- The life of each organism depends on, and is influenced by, other organisms around it.
- A change in **one population** affects the **other populations** in the **community**.

Look at the following food web. The organisms are interdependent on one another. What do you think will happen if the population of hawk starts to decrease due to pollution?



Simulation

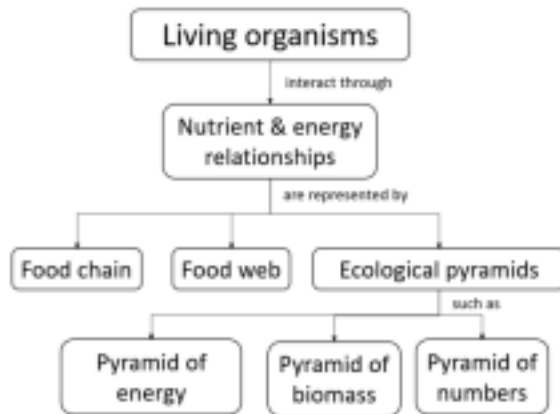
Here you will see how different populations affect each other in an ecosystem.

- The addition or removal of one species affects many other species with which it might compete for, or provide food.
- In this simulation, you will get a chance to "build your own" ecosystem, and explore the effects of these interrelationships.

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https://pbskids.org/plumlanding/games/ecosystem/feed_the_dingo.html

- a) briefly describe the **non-cyclical nature** of energy flow
 d) describe and interpret **pyramids of numbers and biomass**



Energy & Nutrient Flow overview

- Ecosystems use both **energy** and **inorganic nutrients**.

ENERGY (non-cyclic)

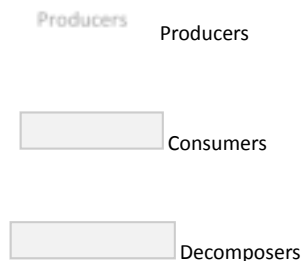
- Energy enters an ecosystem in the form of **light and heat energy** from the **sun**.
- Light energy is converted to **chemical energy** that is passed from organism to organism in the form of glucose.
- Energy is **lost as heat** energy to the environment. The energy that is lost as heat **cannot be recycled**. Hence, energy has to be constantly supplied to the ecosystem.

INORGANIC NUTRIENTS

- Unlike energy, inorganic nutrients such as **carbon** and **nitrogen**, can be supplied from within the ecosystem itself.
- They are obtained from the abiotic environment and they flow through the ecosystem in a **cycle**.
- Nutrients are **continually recycled**.

OVERALL

Energy and nutrients are transferred from one organism to another in the following direction via feeding:



Non-cyclic energy flow in an ecosystem



- The **Sun** provides the **main energy source**, light energy in an ecosystem.
- Light energy is converted into **chemical energy** by producers via **photosynthesis**.
- Energy from producers is passed from one trophic level to another via **feeding**.
- **The flow of energy in an ecosystem is non-cyclic.**
- Energy is lost as **heat energy** to the environment, through **respiration**. Since this heat energy does not return to the same system or to the organisms that produced it, it cannot be recycled in the ecosystem.
- Egested and excreted materials as well as dead organisms contain trapped **chemical energy** (in the form of carbohydrates, proteins and fats). This energy is released through the activity of decomposers.
- See next section: **pyramid of energy**

Ecological pyramids

Ecological pyramids can be used to compare the trophic levels of a food chain.

Watch a video on
ecological pyramids

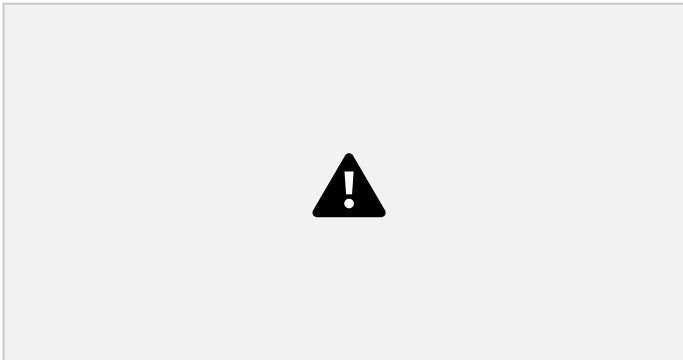


Explore the

pyramid of energy

1. Pyramids of energy

- Represents the total energy in each trophic level of a food chain over a certain period of time



- **Energy is lost to the environment as food is transferred from one trophic level to another.** Energy is lost to the environment:
 - as **heat energy** during **respiration**,
 - in **uneaten body parts (trapped as chemical energy)**,
 - through **undigested matter** egested by consumers (**trapped as chemical energy**), and
 - through **waste products** excreted by consumers (**trapped as chemical energy**)
 - About **90% of energy is lost** when it is transferred from one trophic level to another.

****The pyramid of energy** is always broad at the base and narrow at the top because energy is lost as we go down the food chain.

Commented [PLX11]: <http://www.youtube.com/watch?v=Njp1krliUEg>

Commented [PLX12]: <https://www.ck12.org/biology/energy-flow/lesson/Energy-Pyramids-MS-LS/>

2. Pyramids of biomass

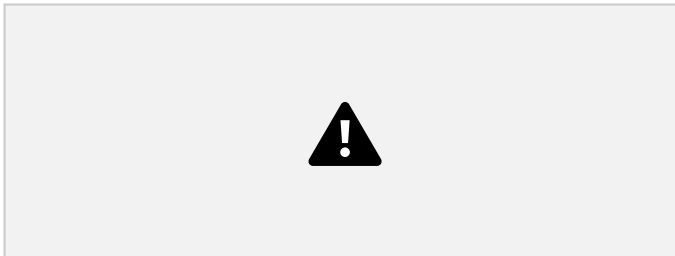
- Allows the comparison of the **mass (dry mass*)** of organisms present in each trophic level at a particular time
- Constructed based on the dry mass of organisms in each at a particular time



*The dry mass of an organism refers to the mass of the organism when it has been completely dried (i.e. all the water molecules have been removed from the organism).

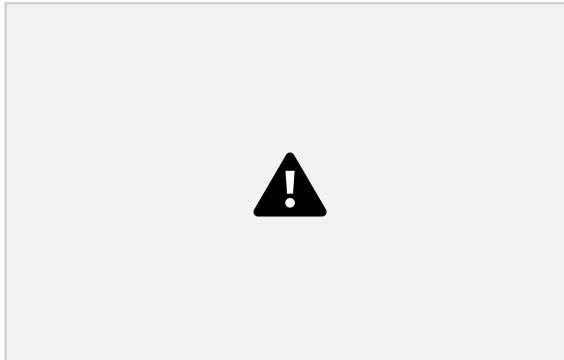
3. Pyramid of numbers

- Allows the comparison of the **number** of organisms present in each trophic level at a particular time
- Constructed based on the number of organisms at each trophic level



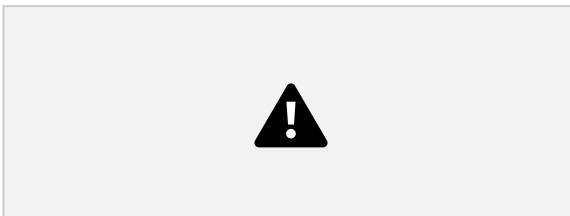
Some exceptions

- Most ecological pyramids are pyramid-shaped, but there are exceptions.
- A **pyramid of numbers** can be inverted if:
 1. organisms in one trophic level are **parasitic** on organisms of another trophic level, and
 2. **many small organisms feed on a large organism.**
- A pyramid of biomass can be oddly shaped if:
 1. *organisms in one trophic level have a **high reproductive rate.***



- The pyramid of numbers is inverted. As there is only one tree. There are many aphids that are parasitic on the tree and many protozoa are parasitic on the aphids.
- The pyramid of biomass remains broad at the bottom and narrow at the top. This is because one tree has a comparatively large biomass to support the other populations.

The diagram shows a pyramid of numbers in an ecosystem on land.
Which organisms are **smallest** in body size?



Commented [PLX13]: A. because A is in large quantity. For B to support such a large number, A is the parasite.

1 Fig. 1.1 shows a number of organisms living together.



Fig. 1.1

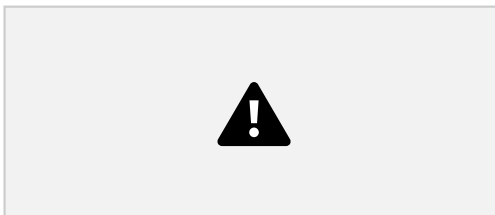
- (a) In the space below, draw and label a food chain linking the organisms shown. Indicate on your drawing where energy enters the chain.

Tree → caterpillar → bird

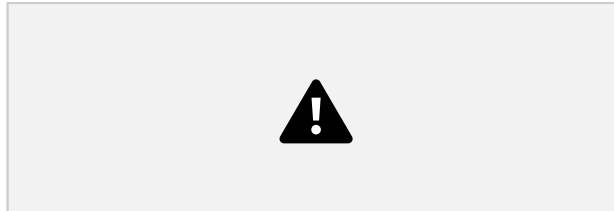
- (b) In the space below, draw and label a pyramid of biomass for the organisms in this habitat.



- (c) Draw and label a pyramid of numbers for the same habitat.



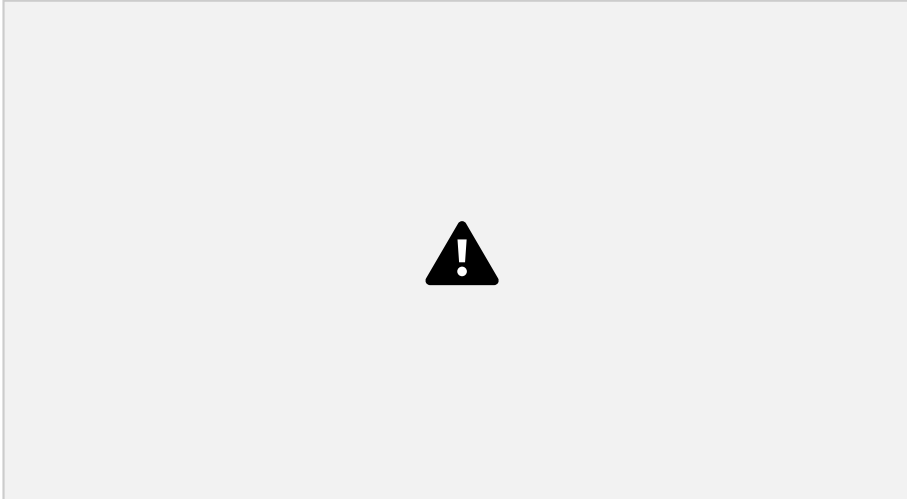
- (d) The birds in this habitat then become severely infected by parasites e.g. fleas. Draw a labelled pyramid of numbers below to include these parasites.



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4E Science Biology Chapter 10 Notes

Let's consider the **number** and **biomass** of organisms in the grassland ecosystem shown in this picture.

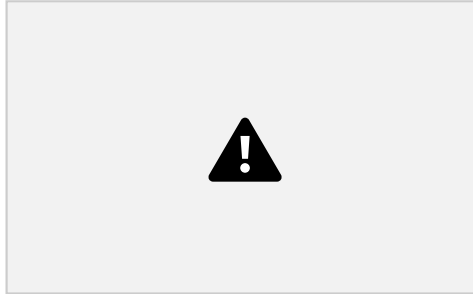


Fill in the blanks in the table below using the information provided in the picture.

You may need to use a calculator to help you calculate biomass. Assume that the area of grassland shown is 14000 m².

organism	Number	Mass per individual (g)	Total mass of all individuals (g)	Biomass (g/m ²)
Grass	25,000,000	0.1	25,000,000 x 0.1 = 2,500,000	2,500,000 / 14,000 = 180
Zebra	4	235,000	940,000	67
Lion	1	180,000	180,000	13

e) describe how **carbon is cycled** within an ecosystem and outline the role of forests and oceans as carbon sinks



Nutrient Cycling

- In a balanced ecosystem, nutrients are not lost but **continually recycled**.
- The cycling of these nutrients is brought about by physical, chemical and biological processes, involving both the abiotic and biotic environments. **Carbon** is one of the many nutrients that are cycled in the environment.

Carbon Cycle

- **Carbon** is constantly **removed** from and **released** into the atmosphere in the form of **carbon dioxide**.
- Hence, the concentration of carbon dioxide in the environment is **fairly constant**.
- **Photosynthesis**: **Carbon dioxide** from the atmosphere is **taken up by producers**. **Carbon** is fixed into cells (as organic molecules such as **glucose**).
- **Feeding**: animals feed on plants/prey on other organisms. Carbon from plants/prey incorporated into organism (link back to topic on Nutrients & Nutrition in Humans – which nutrients contain carbon?)
- The **carbon atoms** are then released as carbon dioxide through **respiration**.
- **Combustion**: carbon dioxide released when **fossil fuels** are burnt.
- **Decomposition**: undigested food and wastes passed out by animals/dead organisms. Bacteria/fungi **decompose** these materials, releasing **carbon dioxide** when they respire.

Scan to watch the carbon cycle!



Carbon dioxide **is removed**
from the environment via



Photosynthesis

Feeding

Fossilisation

When animals feed on green plants, the **carbon**
compounds become part of their bodies.

Carbon compounds may be preserved as fossil
fuels (e.g. coal, natural gas and oil).

Processes that **release** carbon dioxide
into environment

Respiration

Carbon compounds such as
glucose are broken down
into **carbon dioxide**.

Combustion

The combustion of **fossil**
fuels such as coal and natural
gas **release carbon dioxide**

Decomposition

When organisms die, the dead
matter is broken down into simple
substances like **carbon dioxide** by
decomposers when they

respire.(e.g. bacteria, fungi etc.)

16

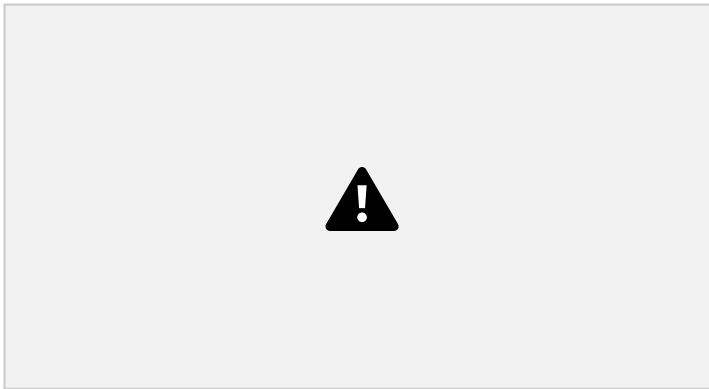
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The importance of the carbon cycle:

- It ensures a **continuous supply** of **carbon dioxide** for **photosynthesis**. Photosynthesis converts energy from the Sun into chemical energy in food.
- It enables **energy to flow** through the ecosystem. Carbon compounds carry the trapped solar energy from one organism to another in the food chain.

The diagram shows how energy from food is used by a gazelle.



What percentage of energy from the gazelle is available to consumers and decomposers?

Commented [PLX15]: C

14 (growth and repair) + 46 (urine and faeces) = 60

Percentage available to consumers and decomposers = $60/100 \times 100\%$ = 60%

Carbon Sink

A carbon sink is an area that stores **carbon compounds** for an indefinite period. It stores more carbon than it releases.

Forests as carbon sinks

- Forests are also important carbon sinks.
- Atmospheric carbon dioxide is absorbed by the plants and used in **photosynthesis**.
- A large amount of carbon compounds is stored in **trees (as cellulose, starch and other carbohydrates)**.
- Remains of dead trees may form **coal** – a fossil fuel.

Oceans as carbon sinks

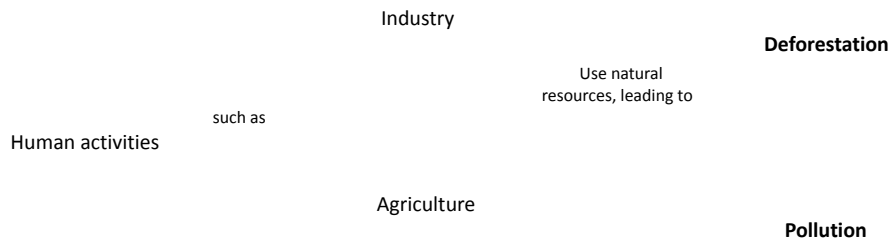
- Oceans are the **largest** carbon sinks on Earth.
- The role of oceans as carbon sinks is driven by two processes, **SOLUBILITY** and **PHOTOSYNTHESIS**.
- The carbon dioxide that dissolves in the ocean's water is absorbed and used by **phytoplankton** and **algae** in photosynthesis.
- A portion of the carbon compounds found in oceans is **buried in the seabed** and is stored as fossil fuels such as **natural gas** and **oil**.



How humans disrupted a cycle essential to all life

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HOW DO WE AFFECT THE ECOSYSTEM?



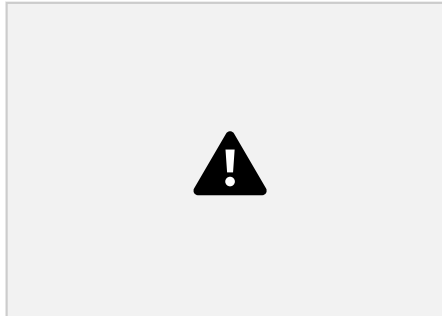
Natural resources

We use natural resources every day:

- The air we breathe
- Natural gas: fuel for vehicles etc.
- Coal
- Water

Natural resources are essential to the survival of humans and all other living organisms • Their use must be **controlled and regulated**

- Depletion of natural resources upsets the balance of nature and causes lasting environmental damage which are largely irreversible.



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(f) describe how human activities, such as deforestation and use of fossil fuels, cause an increase in atmospheric carbon dioxide concentration, leading to global warming

How do we affect the Ecosystem?

1. Deforestation

2. Pollution

1. Deforestation

- The **clearing of forests** is known as [deforestation](#).
- Clearing of land serves purposes such as:
 - **Urban development**
 - Growing of **crops**
 - Growing of grassland for **farming livestock**
 - Use as **firewood** as a source of fuel
 - Wood used as a **construction material**, and also turned into pulp to make paper
- Sadly, forests are being cleared faster than they can be replaced.
- Impact:
 - Soil erosion
 - Lack of leaf canopy to protect soil from impact of falling rain.
 - Decomposing roots that are unable to hold onto soil.
 - the soil is exposed to direct rainfall, and the water is not absorbed and retained.
 - The topsoil would be easily washed away during heavy rain.
 - Flooding
 - Eroded soil deposits in nearby river/stream
 - This blocks the flow of water →
water level rise → overflow →
flood

Watch
deforestation

- Reduction in Biodiversity and Extinction
 - **Loss of habitat** for many species of animals
 - The remaining amount of forested land may not be enough to support a breeding population of these animals.
 - Animals may become **endangered** or **extinct** → leading to **loss of biodiversity**.
- Desertification
 - Occurs on a large scale, over a long period of time
 - Without the leafy canopy, sunlight falls directly onto the ground and causes water to **evaporate** from the ground.
 - This creates a **desert-like condition** that is not suitable for plants to grow.
- **Global Warming**
 - Occurs on a large scale, over a long period of time
 - Reduced plant life results in less **carbon dioxide** being removed from the atmosphere via **photosynthesis**.
 - When trees in the forest are cut, they release into the atmosphere all the carbon dioxide they have been storing.
 - Further emissions of carbon dioxide are created by the trees are left to rot on the forest floor or when they are burnt.
 - Carbon dioxide is a **greenhouse** gas. It traps heat within the Earth's atmosphere and results in **warmer climates**.

g) discuss how human actions can reduce the effects of global warming

GLOBAL WARMING

- Human activities that cause an increase in carbon dioxide concentration in the atmosphere can lead to global warming. These include:

- 1) **Deforestation** (see above)
- 2) **Combustion of fossil fuels like coal and gas**

- Carbon dioxide is a **greenhouse** gas:

- It forms a layer over the Earth's surface and **traps heat** within the Earth's atmosphere.
 - This creates a **greenhouse effect** that causes **global warming**
 - An **enhanced greenhouse effect** may **result in climate change**, which can in turn cause **ice sheets** in Greenland and Antarctica **to melt** → **sea levels rise** and cause **flooding** in many countries
- High concentration of carbon dioxide **dissolves in sea water**, causing sea water to become more **acidic**.
 - The acidic sea water dissolves calcium compounds in the shells of shellfish → Weakening their shells and making them more vulnerable to predators.

Global Warming vs Climate Change

Global Warming Climate Change

Rise in global temperature Changes in weather patterns over a long period of time

Mainly **caused by** increasing concentrations of

greenhouse gases such as CO₂

Leads to rising sea levels, melting ice sheets,
shifts in flowering/ plant blooming times and

unpredictable weather changes (e.g. intense
hurricanes/ winter storms)

Essentially, global warming leads to climate change!



WHAT CAN WE DO TO REDUCE THE EFFECTS OF ENHANCED GLOBAL WARMING?

1) Reduce use of:

- **Fossil fuels** (use solar/wind energy instead)
- **Consumption of energy** (use more efficient devices e.g. LED light bulbs)
- **Daily consumption of electricity, water, paper and plastic**

2) Replace petrol powered vehicles with hybrid or electric vehicles

3) Forest management:

- **Conservation of forest** – prevents disruptions to natural cycles such as carbon cycle, thus decreasing global warming
- **Indiscriminate felling of trees should be prevented**
- **Reforestation** – plant new seedlings to replace trees that have been removed or destroyed
- **Control forest fires** – prevent man-made fires set by people to provide land for agriculture
- **Education programmes** should be conducted to make people aware of importance of forests and methods which forests can be conserved

THE SINGAPORE GREEN PLAN 2030

A nationwide movement to advance Singapore's national agenda on **sustainable development**.

The Green Plan charts ambitious and concrete targets over the next 10 years, strengthening Singapore's commitments under the UN's 2030 Sustainable Development Agenda and Paris Agreement, and positioning us to achieve our long-term net zero emissions aspiration by 2050.

This plan aims to ensure that Singapore will remain a **green and liveable home for current and future generations**. Some key initiatives include:

- **Reduce carbon emissions** and **keep our environment clean**
- **Save resources and energy**
- **Use cleaner energy** and **lower our carbon footprint**

Find out more about the SG Green Plan here!

<https://www.greenplan.gov.sg/>

The End

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