Year 11
Biology
Ecosystem Dynamics

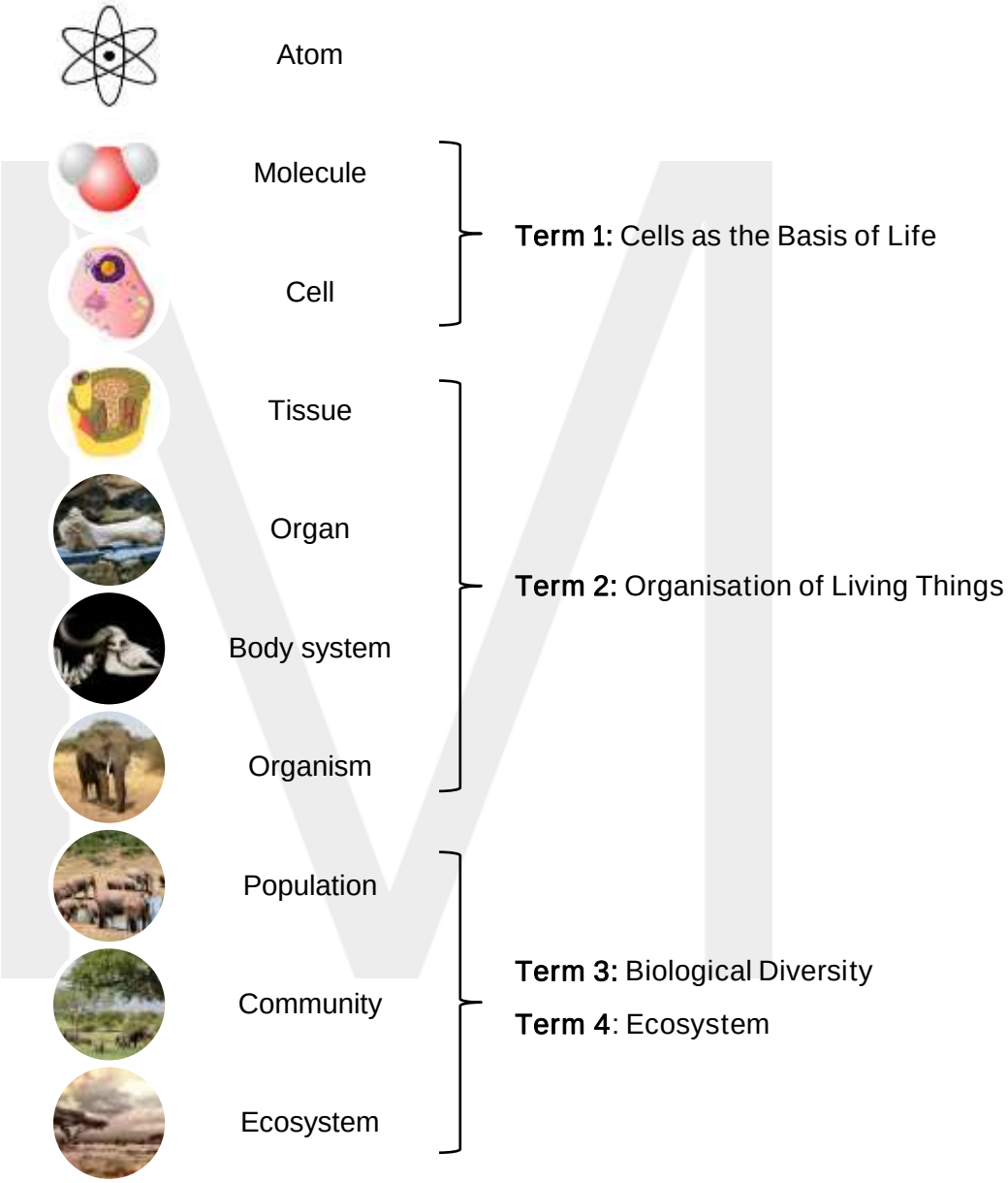
Lesson 1
Abiotic factors
Sample Resources

MATRIX
EDUCATION

1. Introduction to biology and ecology

☐ Welcome to Year 11 biology!

- Biology is the study of life and living organisms on many levels. These levels of organisation are shown below.

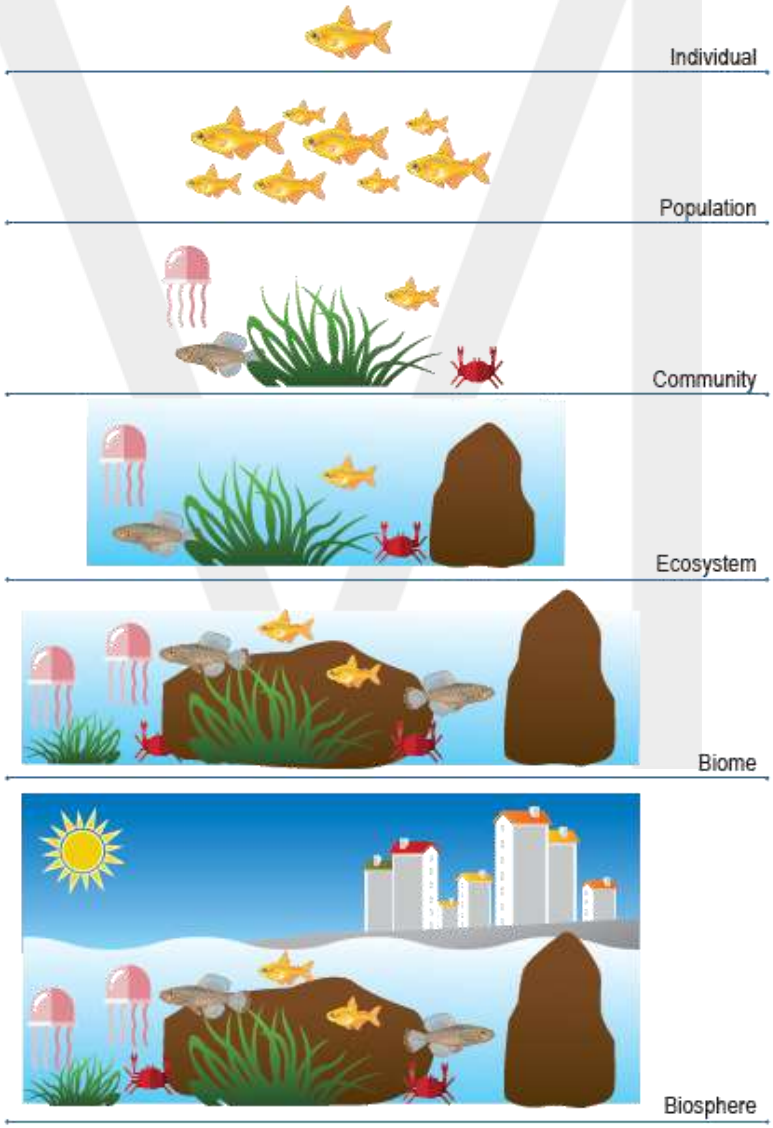


- Whether you have decided to try out Biology for a few terms or whether you are determined to stick with Biology for the HSC exams, we hope that you will find this course interesting and relevant to your future studies!

☐ What is 'ecology'?

- **Ecology** is the branch of biology that deals with the interactions of one **organism** with one another, as well as their **environment**.
  - This term we will be studying ecology, examining the different **levels** of interactions in ecology.
  - Watch this **video** (Length 6:22) as an introduction to what we will be covering this term.

- Recall the different levels of ecology:



- An **ecosystem** consists of all the **living** and **non-living components of an environment**.

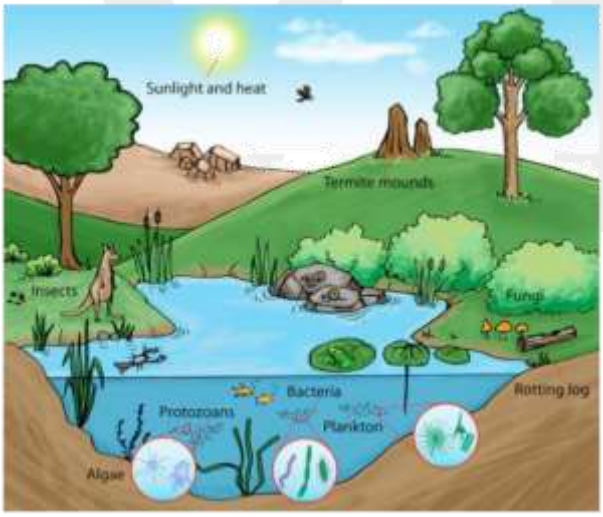
2. Ecological niches

☐ Introduction to abiotic and biotic factors

- Recall that **biotic** factors refer to **living** features of an environment, whereas the **abiotic** factors refer to **non-living** features of an environment.
  - Can you list some examples of **biotic** factors?[1]

  - Can you list some examples of **abiotic** factors?[2]

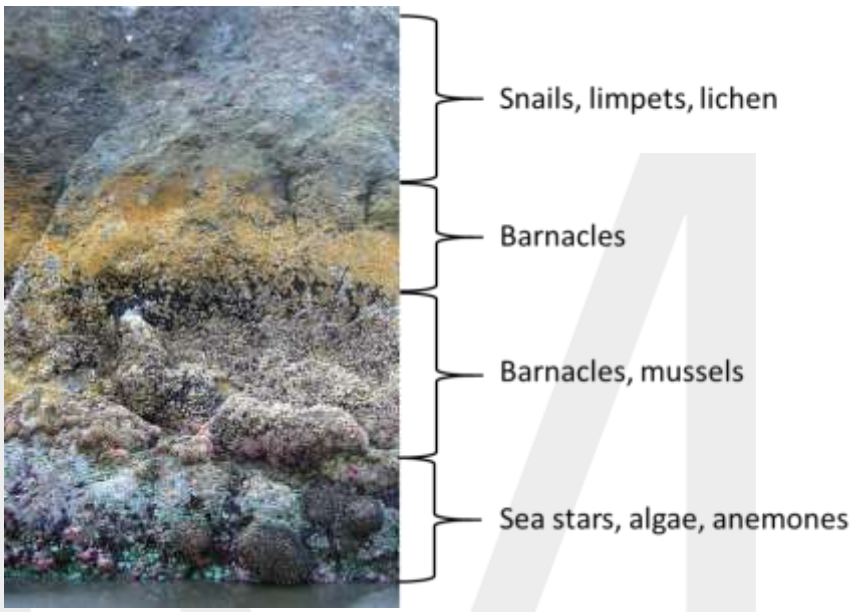
- There is a **close relationship** between abiotic and biotic factors.
  - Many organisms depend on a specific set of abiotic features in order to survive and grow. For instance, trees in a tropical rainforest ecosystem require a relatively stable and warm temperature, and a high humidity.
  - Identify some abiotic and biotic features in the ecosystem below.[3]



By Tsilia yotova (Own work) [CC BY-SA 4.0 (http://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons

☐ Interaction of biotic and abiotic factors

- The **rocky shore** provides a visible example of the **interaction** between biotic and abiotic factors and how they control the distribution of species.
- Organisms are distributed in horizontal bands, due to the different biotic and abiotic pressures in each band.



Intertidal zonation on the West coast of the USA [Public Domain]

- Species differ in their **tolerance** to these pressures. For example:
  - **Moisture** is an important **abiotic** factor. The limpet and the snail *Littorina* survive high up on the dry part of the shore by sealing the entrance to their shells to prevent water loss.
  - **Predation** from sea stars is a **biotic** factor that determines the lower distribution of mussels.
  - Sea stars are **limited** in how high up the shore they can hunt due to risk of drying out from lack of **moisture** (desiccation). Mussels higher up usually grow large as a result.
  - What other abiotic and biotic selection pressures might affect distribution?[4]

☐ Ecological niche

- The tides and other **biotic** and **abiotic** influences on the intertidal zone have created countless **ecological niches**, a term for the **physical space** in which an organism lives and how an organism **functions** in a community.

- An ecological niche is the **role** a species has in its environment including all of its **interactions** with **biotic** and **abiotic** factors, such as:
  - How it meets its needs for food and shelter
  - Competition, predation, parasitism, and mutualism.
  - Soil type and climate

- For example, we can describe the ecological niche of a **dung beetle**:

  - **Where** does the dung beetle live?[5]

  - What does it **eat**?[6]

  - What is its **role** in the ecosystem?[7]

  - Does it have any **predators**?[8]

  - What **abiotic limitations** does it have?[9]

☐ The competitive exclusion principle

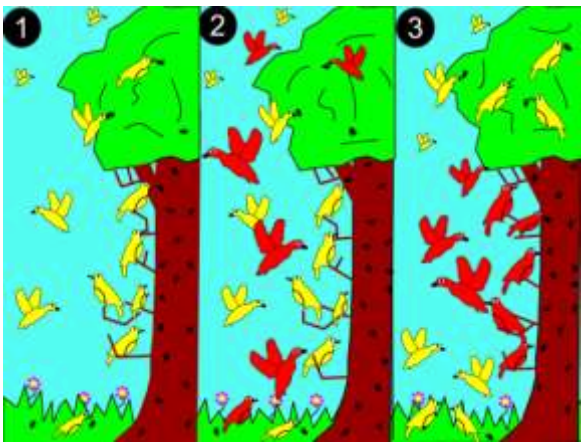
- Different species may compete for the same **niche**. For example, in a forest there may be a **niche** for an organism that can fly and eat nectar from blossoms e.g. bees, butterflies, hummingbirds.



- The Competitive Exclusion Principle (also called Gause's Principle) states that two species **can't coexist** if they are competing for the same resource. As a result, one species will **outcompete** the other species, and eventually the second species is **eliminated**.

- While some species **appear** to be sharing a niche, what is often happening is actually **resource partitioning** where the species adapt to slightly different niches so that they can coexist.

- For example:
  1. A smaller (yellow) species of bird forages for insects along a whole tree.
  2. A larger, invasive (red) species of bird is introduced and competes with the yellow bird for food.
  3. The invasive red species dominates the yellow species in competition for the middle part of the tree. The yellow species adapts to a new niche at the top and bottom and now both birds can coexist.

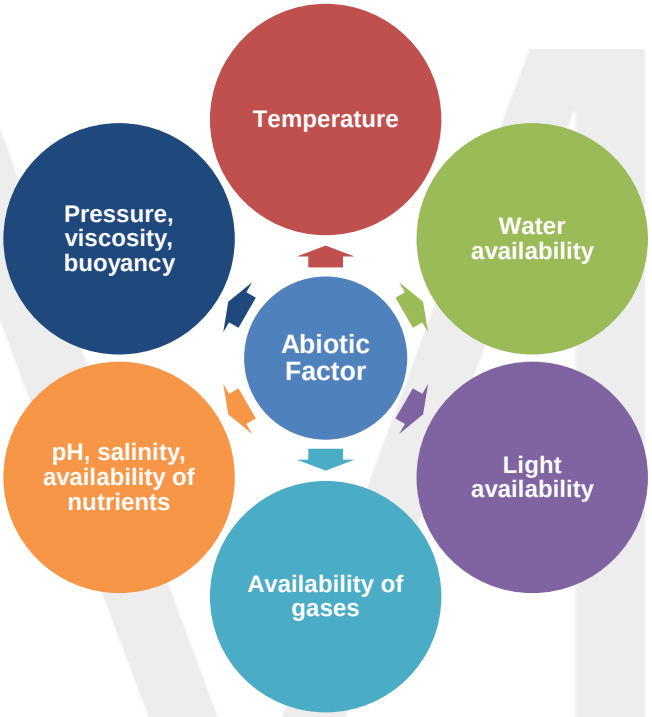


By Dhanscom17 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=40475417

3. Abiotic factors

☐ Introduction

- Studying **abiotic** features is an essential part of ecology.
  - Ecologists consider how abiotic features **impact** on one or more **organisms**.
  - Abiotic features impact the **distribution**, **abundance**, morphology, physiology and ultimately the survival of any organism living in an ecosystem.

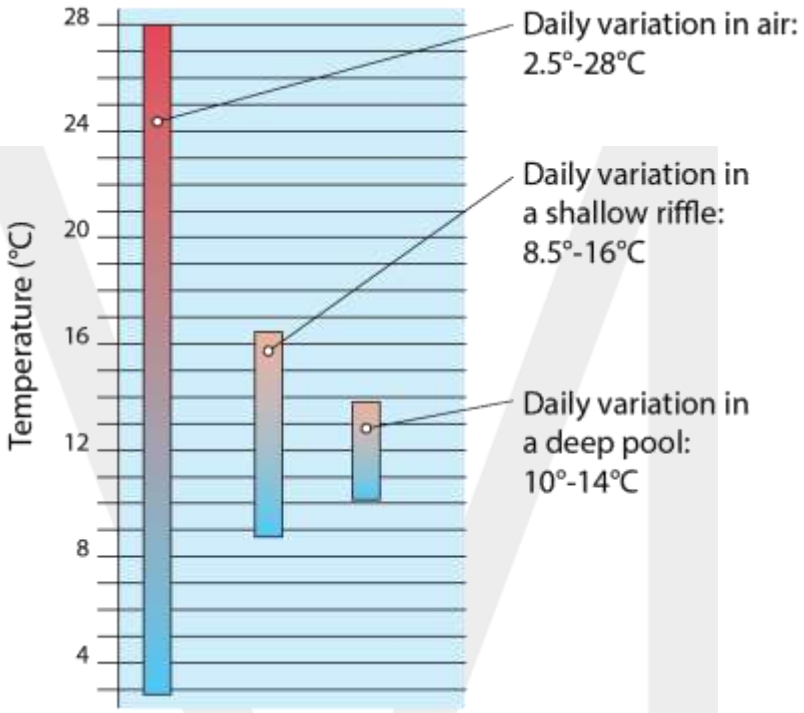


- Abiotic factors vary greatly between different environments and ecosystems, and sometimes can vary greatly even within a single ecosystem.
  - They also impact the organisms in very profound ways, such as their morphology or physiology. We learned about these **adaptations** in Term 3.

- There are countless abiotic features in any ecosystem – we will only focus on a few important examples.

☐ Temperature

- We are all familiar with the concept of **temperature**. Temperature fluctuates throughout the day, week and across seasons.
- Unlike terrestrial environments, **aquatic ecosystems do not experience great variations in temperature** – even over long periods.



- Using the graph above, **compare** the temperature variations that occur in **terrestrial** and **aquatic** environments.[10]

- Temperature affects all aspects of an organism's life, such as **behaviour** and **internal metabolic processes**.
  - The **distribution** of an organism will be determined by the range of temperatures that it can tolerate.
  - Some plants such as banksias actually require the high temperatures of a **fire** in order to germinate and disperse their seeds.
  - Despite extremes in temperature range, many desert organisms have flourished in their environment due to their **adaptations**.

☐ Availability of water

- **Water** is one of the most important resources for all organisms.
  - In humans, water **carries nutrients and dissolved gases** in the blood to all parts of the body. It also dilutes and flushes wastes from the body.
  - Plants also require water. On hot days, the stem and leaves of a plant will wilt because there is not enough water.
  - In fact, water is essential for **photosynthesis**. This is the process in which **plants produce sugars and oxygen from water and carbon dioxide in the presence of sunlight**.

- **Water availability** is determined by a number of factors.
  - **Precipitation** refers to the amount of rainfall (as well as snow and hail) over a period of time. Rainfall is a direct source of water for terrestrial and aquatic environments.
  - **Humidity** refers to the moisture in the air. The more humid it is, the more moist the surrounding air. Humidity can be measured using a **hygrometer** (wet-dry thermometer).

- By contrast, **aquatic environments are abundant in water**. There is no need for aquatic organisms to worry about water availability because they are swallowing and swimming in it!

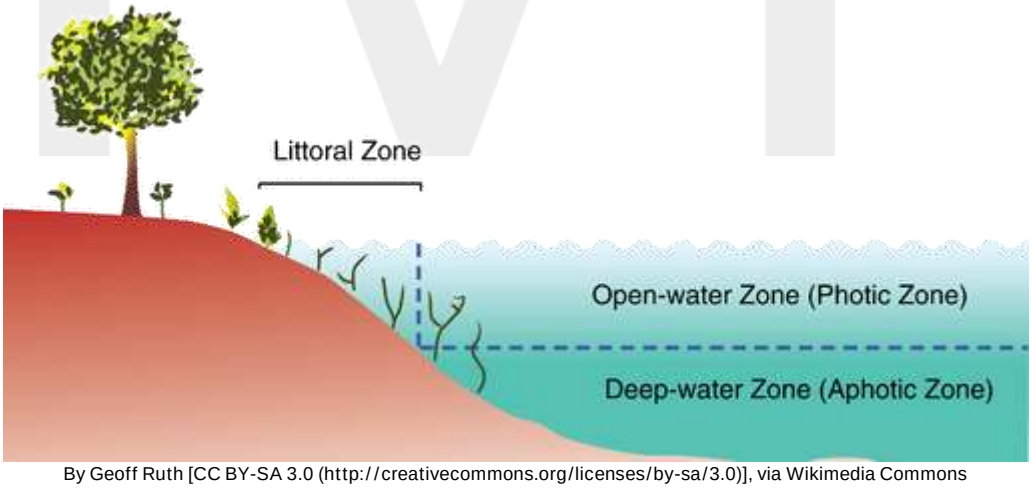
☐ Availability of light

- **Light** is the primary source of **energy** in most ecosystems.
  - Why is light so essential in an ecosystem? What would happen to plants if the sun disappeared?[11]

- **Light intensity** refers to the **amount** of light that falls on a surface in a given time.

- **Light is readily available** in most **terrestrial** environments.
  - However, it can be limited in areas with a dense canopy cover (such as in a forest) but for most terrestrial organisms, neither light intensity nor light quality are limiting factors for their survival.
  - Caves are another terrestrial environment where light is often limited.

- **Light availability varies greatly** in **aquatic** environments.
  - The surface of the water (around 0 – 200m) is known as the **photic zone**. In this zone, sufficient light is usually available for all photosynthetic organisms.



By Geoff Ruth [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

☐ Nutrients

- Like gases, **nutrients** are essential for different organisms. This is why eating is so important – if we did not take in nutrients from the environment we would not be able to grow!
  - The nutrients that plants and animals require in large amounts are called **macronutrients**. Some examples include carbon, hydrogen, nitrogen, and phosphorous.
  - Some other nutrients that are required in smaller amounts are called **micronutrients**, and include aluminium, fluorine, iodine and zinc.

- Nutrients and ions are **continuously cycled** through an ecosystem. The **recycling of matter** is essential in ecosystems. Why does it *matter*?
  - Recall from Junior Science that matter **cannot be created or destroyed**.
  - When organisms die, their bodies must **decompose** in order to **return the nutrients back to the ecosystem**.

- This illustrates the important role **decomposers** play in ecosystems.
  - Decomposers are organisms that obtain their energy by **breaking down** the dead bodies and wastes of other organisms.
  - Can you think of some examples of decomposers?[12]

By Bob Peterson from North Palm Beach, Florida, Planet Earth! (Fungi on Cabbage Palm Uploaded by Jacopo Werther) [CC BY-SA 2.0 (http://creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons
GrahamColm at English Wikipedia [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons

  - Decomposers play a vital role **breaking down** organic molecules into **simple compounds**, which are returned to the soil. This allows plants to take up and **reuse** these **nutrients**.

☐ Nitrogen cycle

- The role of decomposers can be examined when we take a look at the different cycles of matter.

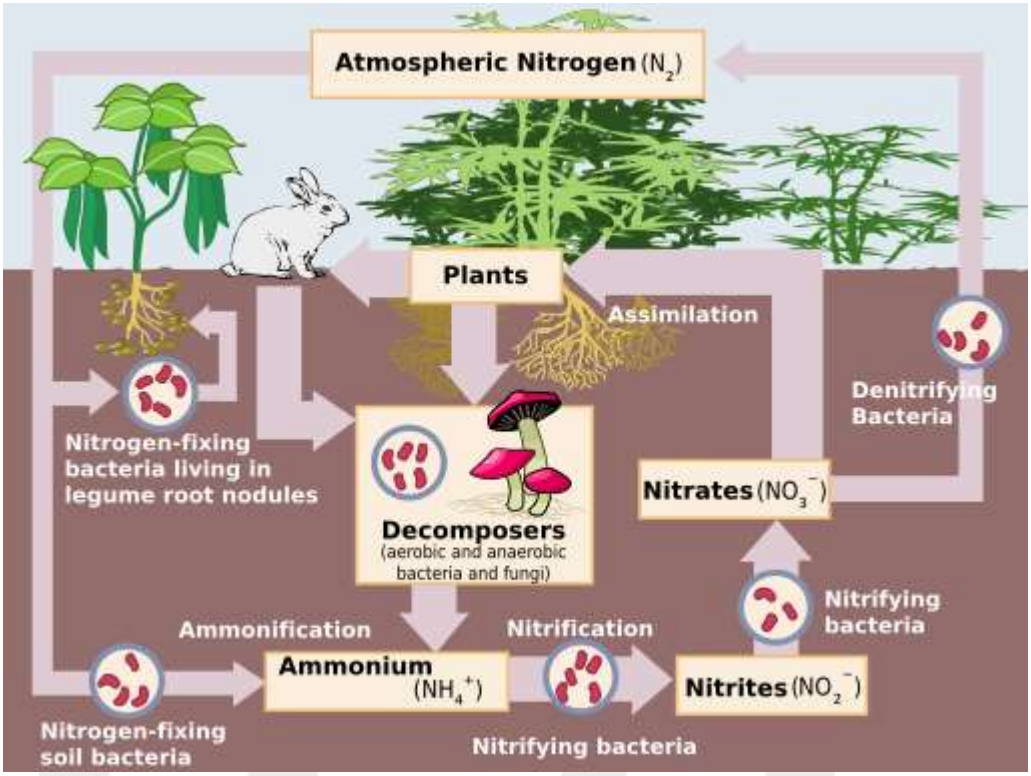
- **Nitrogen** makes up roughly **78%** of our **atmosphere** in its diatomic form, **N_2**.
  - What do we use nitrogen for? Where is it found in living organisms? Hint: look at the diagrams below![13]

"Venice Muscle Beach" by Lin Mei. Available under CC BY 2.0 (https://creativecommons.org/licenses/by/2.0/)
By Sandstein (Own work) [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons

  - How do we obtain nitrogen from the environment?[14]

  - However, plants cannot readily obtain nitrogen this way and they do not possess any mechanisms to utilise atmospheric nitrogen.
  - Luckily, there are **nitrogen-fixing bacteria** present in the soil that can "fix" atmospheric nitrogen into other **soluble nitrogen compounds**.
  - Once nitrogen is in the soil, other bacteria can convert it into other useful compounds to be **taken up by plants**. This enables plants to use nitrogen to make proteins and nucleic acids.

- Check out the nitrogen cycle below! See if you can identify the different types of bacteria that play a part in this cycle.

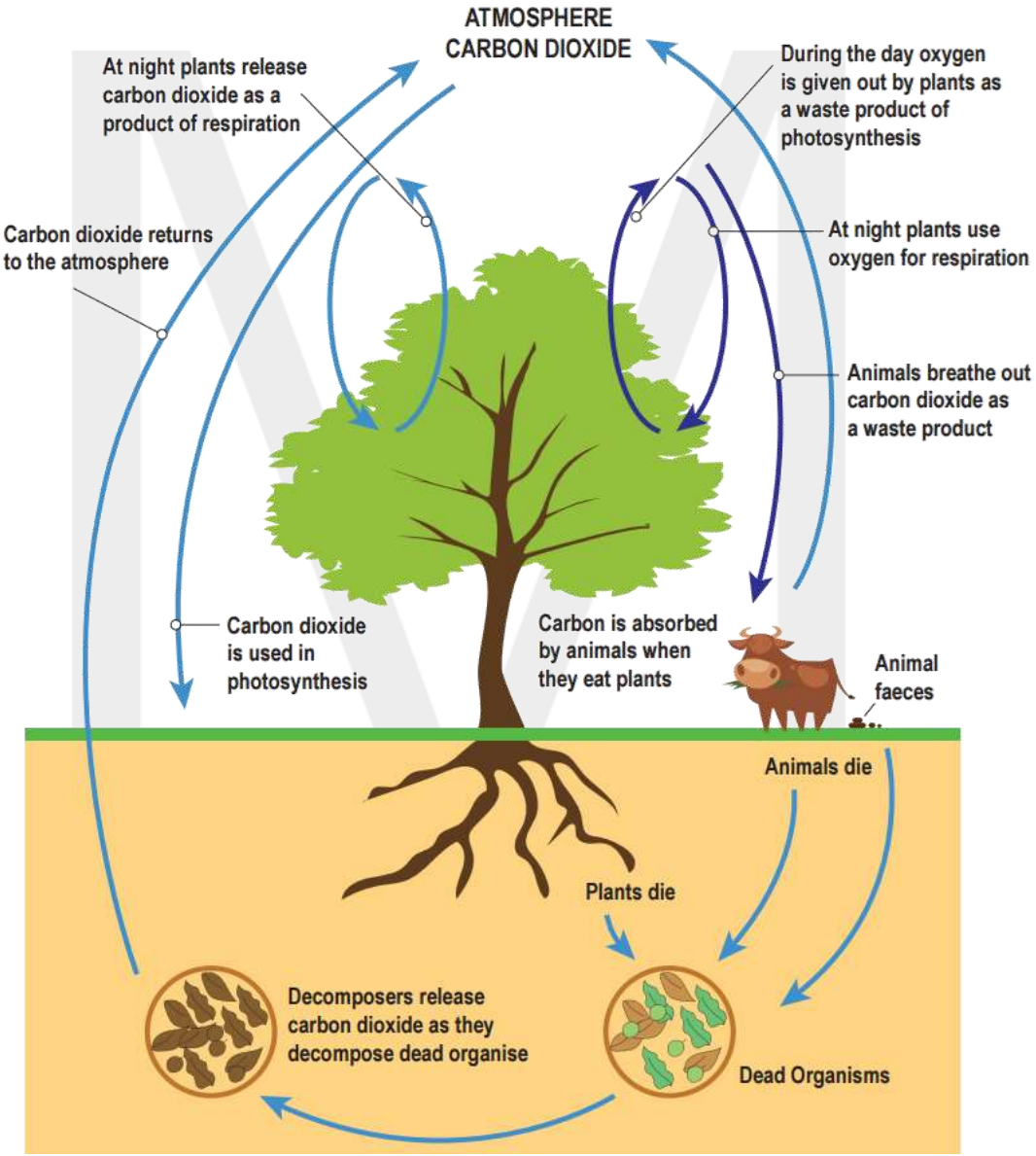


By Cicle_del_nitrogen_de.svg: *Cicle_del_nitrogen_ca.svg: Johann Dréo (User:Nojhan), traduction de Joanjoc d'après Image:Cycle azote fr.svg. derivative work: Burkhard (talk) Nitrogen_Cycle.jpg: Environmental Protection Agency derivative work: Raeky (Cicle_del_nitrogen_de.svg Nitrogen_Cycle.jpg) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

- Notice that there are also **nitrifying bacteria** and **denitrifying bacteria** that play a role in the nitrogen cycle.
- **Decomposers** such as bacteria and fungi are responsible for breaking down wastes and bodies of organisms and returning nutrients to the soil.

☐ Carbon-oxygen cycle

- Another important cycle is the **carbon-oxygen cycle**.
  - It involves the transfer of carbon and oxygen between living and non-living components of an ecosystem.
  - Here is a simple diagram illustrating the relationship between carbon dioxide and oxygen.



- Two important processes that drive this cycle are **photosynthesis** and **respiration**.
  - Describe what happens in **photosynthesis**.[15]

  - Respiration is the process where **oxygen** and **glucose** is converted into **water** and **carbon dioxide** in order to produce **energy**.
  - Which organisms carry out respiration?[16]

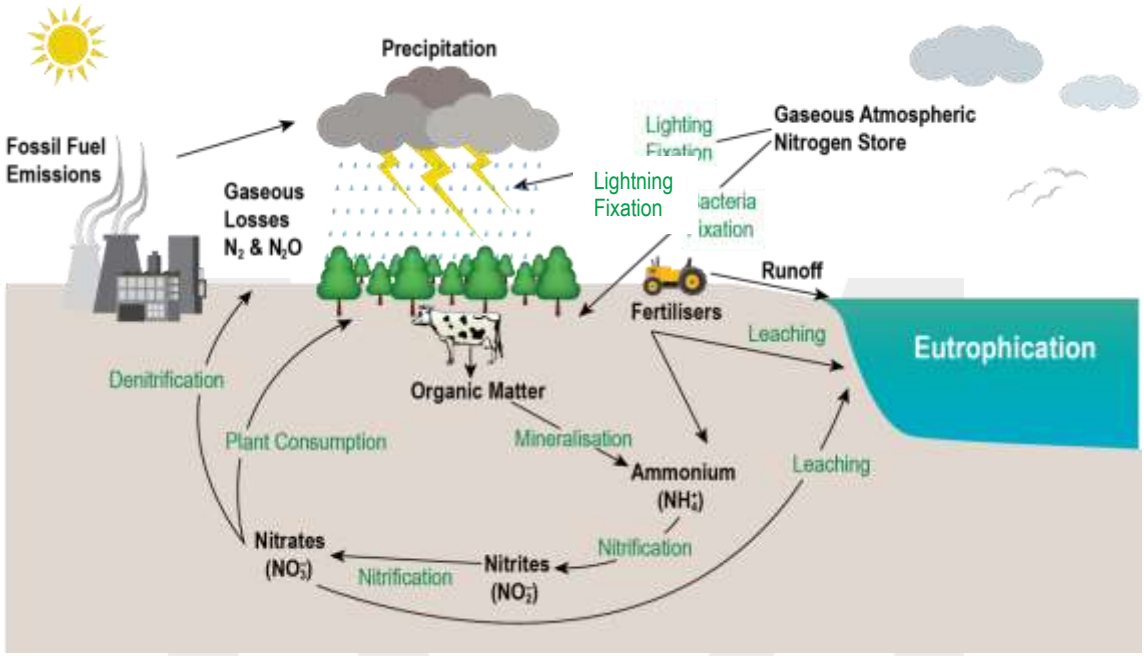
- The carbon-oxygen cycle is not as simple as the previous diagram!
  - The atmosphere only contains a small amount of carbon in the form of **carbon dioxide**. A majority of the carbon in the environment exists **in living organisms** as well as in **rocks and coal**. The **ocean** is also a huge reservoir for dissolved carbon dioxide.
  - **Decomposers** are also responsible for breaking down the wastes and bodies of living organisms.
  - **Human impacts** also contribute to the carbon-oxygen cycle. For instance, the **burning of fossil fuels** releases carbon dioxide into the atmosphere. **Deforestation** has also reduced the amount of plants capable of performing photosynthesis.

- If time permits, check out this **interactive** to learn about the global carbon cycle.

4. Review questions

Concept Check 4.1

Use the following diagram of the nitrogen cycle to answer the following questions.



(a) Describe the role of the following organisms in the nitrogen cycle.

(i) Animals.[17] 1

(ii) Denitrifying bacteria.[18] 1

(iii) Nitrifying bacteria.[19] 1

(b) How would the absence of nitrogen-fixing bacteria affect life on Earth?[20] 2