ECOLOGY

6.4 Nutrient transfer in ecosystem

Objectives :

- Describe the carbon cycle, limited to photosynthesis, respiration, feeding, decomposition, fossilization and combustion

- Discuss the effects of the combustion of fossil fuels and the cutting down of forests on the carbon dioxide concentrations in the atmosphere

- Describe the water cycle, limited to evaporation, transpiration, condensation and precipitation

- Describe the nitrogen cycle in terms of: – decomposition of plant and animal protein to ammonium ions –

nitrification – nitrogen fixation by lightning and bacteria – absorption of nitrate ions by plants – production of amino acids and proteins – feeding and digestion of proteins – deamination – denitrification

- Explain how Ecosystems have the potential to be sustainable over long periods of time.

- *Practical skill: Setting up sealed mesocosms to try to establish sustainability.*

Resources

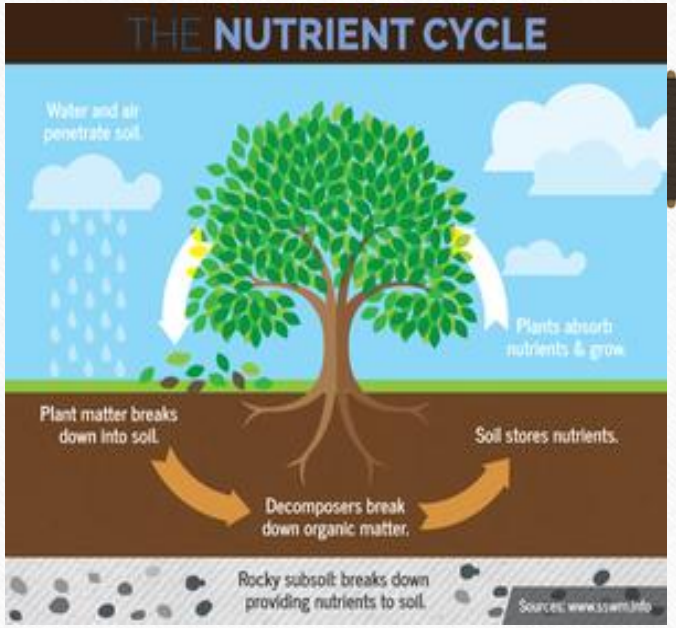
Book pages 136,137,138

Nutrients consisting of elements such as carbon, nitrogen and phosphorus are required by an organism for growth and metabolism.
Since there is a limited supply of inorganic nutrients, they must be recycled among organisms. Saprotrophs recycle nutrients and return them to the environment to be reused.

Autotrophs obtain inorganic nutrients available in the ecosystem such as water and carbon dioxide and convert them to organic nutrients such as glucose.

Organic nutrients are then transferred to heterotrophs through food. Saprotrophic bacteria and fungi decompose dead organic matter and release nutrients back to the soil as inorganic nutrients.

This ensures the recycling of nutrients within an ecosystem.



Carbon cycle :

Carbon is found in nature as coal, CO_2 or as molecules containing Carbon such as Glucose.

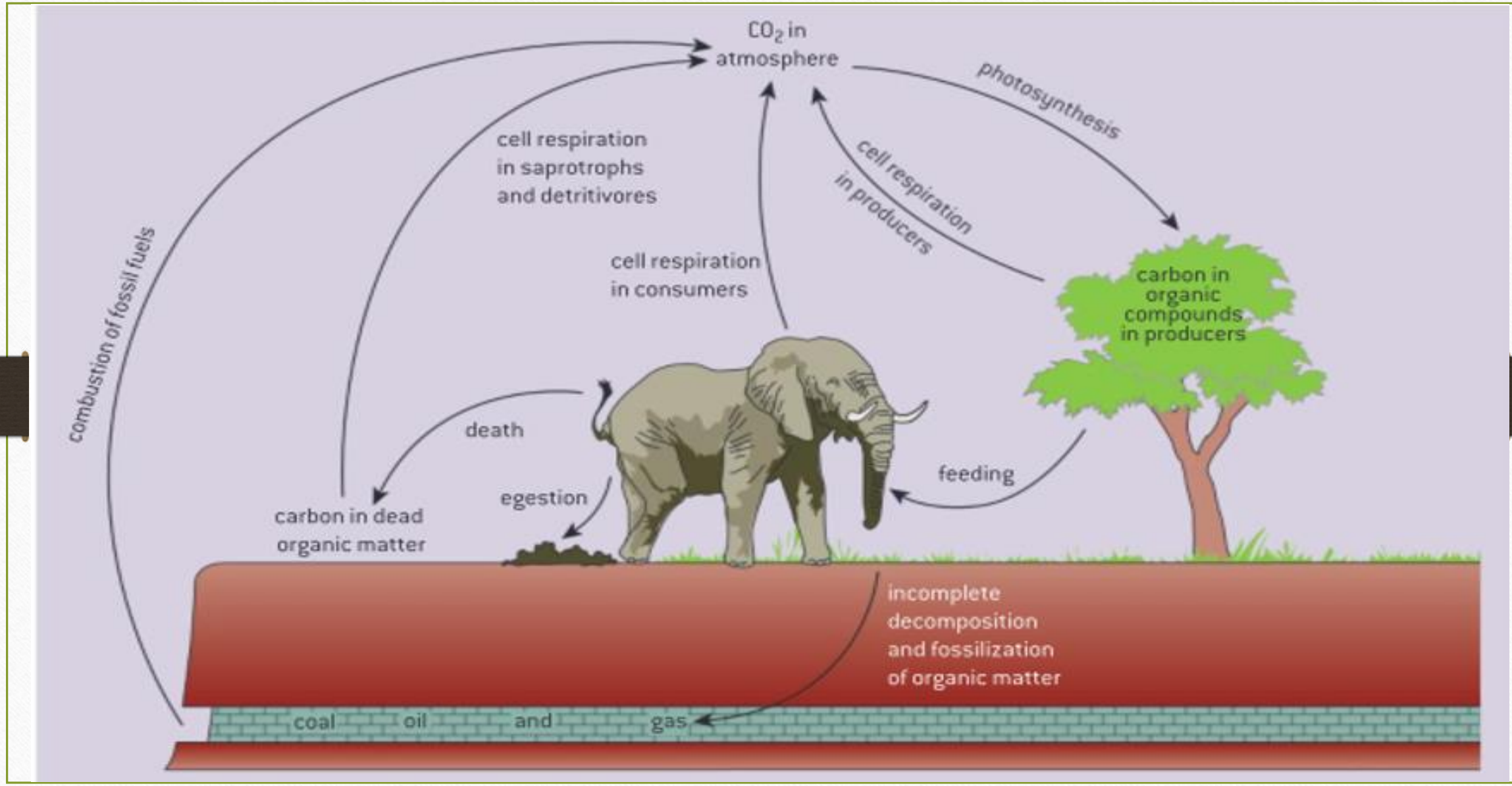
- The Percentage of CO_2 in air is 0.04 %
- When plants carry out photosynthesis, Carbon is taken from air in the form of CO_2 and become part of glucose or starch molecules in the plant.

Plants break down some of the glucose by respiration, the carbon in glucose becomes part of a CO_2 molecule once again and is released back into air.

Some of the carbon in the plant will be eaten by animals, when animals respire they release the carbon as CO_2 back into the air

When animals and plants die, decomposers feed on them, the carbon becomes part of the decomposers' bodies. When they respire they release CO_2 back into the air .

https://www.youtube.com/watch?v=NHqEthRCqQ4


CO_2 in atmosphere
photosynthesis
cell respiration in producers
cell respiration in saprotrophs and detritivores
cell respiration in consumers
combustion of fossil fuels
carbon in organic compounds in producers
death
feeding
egestion
carbon in dead organic matter
incomplete decomposition and fossilization of organic matter
coal
oil
and
gas

Carbon is continually available in ecosystems because of carbon cycling .

Carbon is present in the atmosphere or in water in the form of carbon dioxide. Sources of carbon dioxide include:

• **Cellular respiration**: Carbon dioxide is produced by the cellular respiration of all living organisms. Carbon dioxide diffuses out of organisms into water or the atmosphere.

• **Methane oxidation**: Methane is a gas that is produced as a waste product by methanogenic archaea, which are organisms that live in anaerobic conditions such as wetlands and the digestive tract of some living organisms such as cows and humans. When methane is produced, some of it is oxidized in the atmosphere into carbon dioxide and water.

• **Combustion (burning) of fossil fuels (fossilized organic matter):**

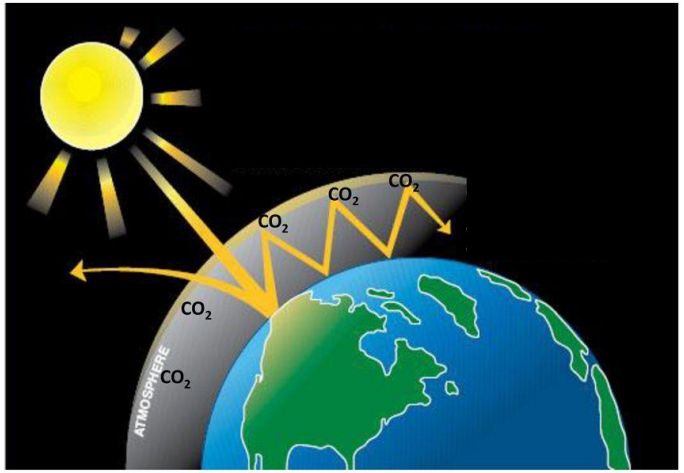
When saprotrophs decompose dead organic matter, decomposition is not fully completed due to various conditions such as anaerobic or acidic conditions. The building up of large amount of partially decomposed dead organic matter forms peat. When peat from past geological eras is exposed to high pressure and heat over millions of years, it is converted into fossil fuels including coal, oil or gas.

The combustion (burning) of such fossil fuels releases carbon dioxide back into the atmosphere.

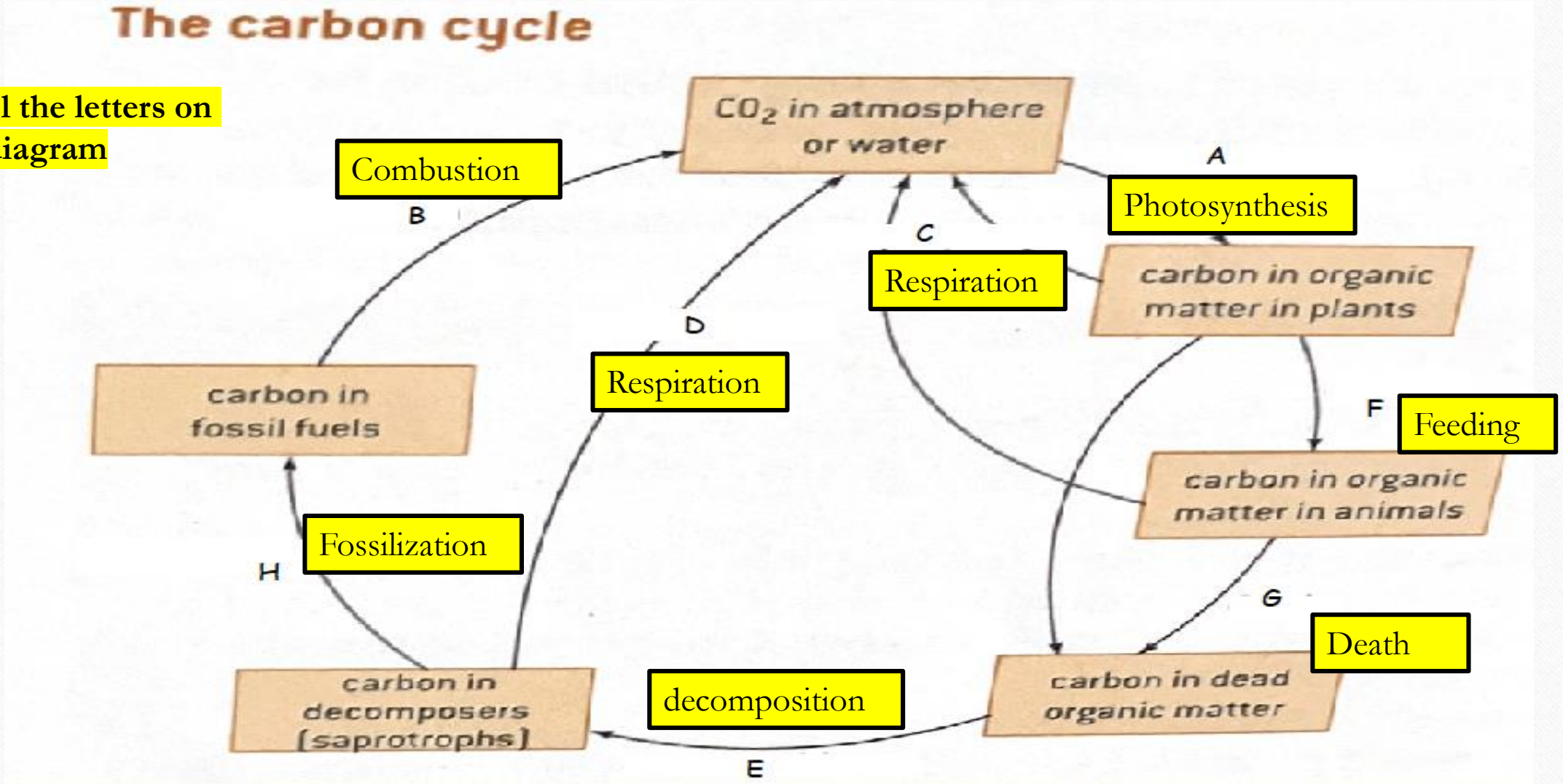
Carbon dioxide in the atmosphere and in water is then transferred to producers by photosynthesis. Carbon is transferred from one living organism to another through feeding.

Carbon dioxide, and the way it is continually recycled by the carbon cycle, plays a major role in the greenhouse effect and climate change.

https://www.youtube.com/watch?v=oJAbATJCugs



Label the letters on the diagram



The effects of the combustion of fossil fuels and the cutting down of forests on the carbon dioxide concentrations in the atmosphere.

When fossil fuels are burned, they release large amounts of carbon dioxide, a greenhouse gas, into the air. Greenhouse gases trap heat in our atmosphere, causing global warming. Already the average global temperature has increased by 1C.

Cutting down trees reduces the amount of photosynthesis and if the trees are burned after cutting , all the carbon locked in trees will be released into the air as CO2 increasing its levels in the atmosphere which may lead to global warming

The increased levels of CO2 and other gases leads to the enhanced greenhouse effect which causes global warming.

Short wave-length infrared radiation passes from the sun freely through the atmosphere reaching the earth, the earth absorbs some of the radiation and becomes warmed and then re-emits it as longer wave infrared radiation.

Carbon dioxide doesn't let all of this infrared radiation pass through to the space, trapping it in the atmosphere making the atmosphere warmer/ greenhouse effect.

As the amounts of CO2 and other greenhouse gases increase in the atmosphere, more infrared radiation is trapped and this heats up the atmosphere and causes a rise in the earth's surface temperature-> **this is called the enhanced greenhouse effect which may lead to global warming**

Global warming: When the increased levels of carbon dioxide and other gases form a blanket around earth preventing heat from escaping back to space increasing the temperature of the atmosphere.

Effects of global warming :

1.**Increasing atmospheric temperature** which causes melting of icebergs from poles and sea levels would rise and Increases floods

2. **Changing climate and weather->** more water evaporates from seas - more rainfall.

3.**Increasing fires in forests**

There might be some beneficial effects too - more CO_2 and a higher temperature -> rate of photosynthesis might increase - higher yields will be gained from some crops

Note: Global warming can also lead to the extinction of some species

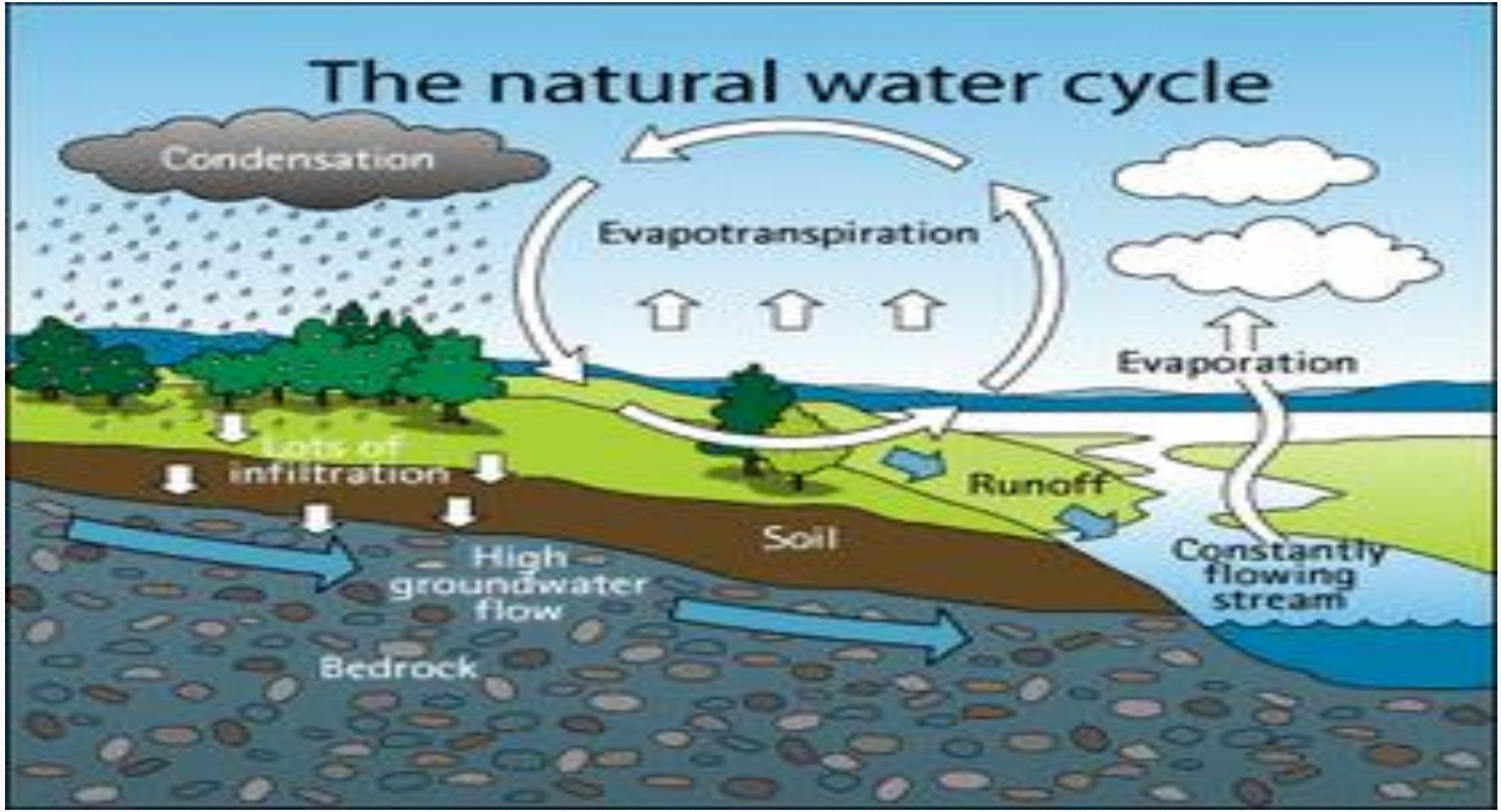
Water cycle : https://www.youtube.com/watch?v=FzYjPpxP-Cw

Some of the water in the lakes and seas evaporates, changing into (water vapour As the water vapour rise high into the atmosphere, it cools and some of it condenses to form droplets of liquid water. These water droplets form clouds by condensation .

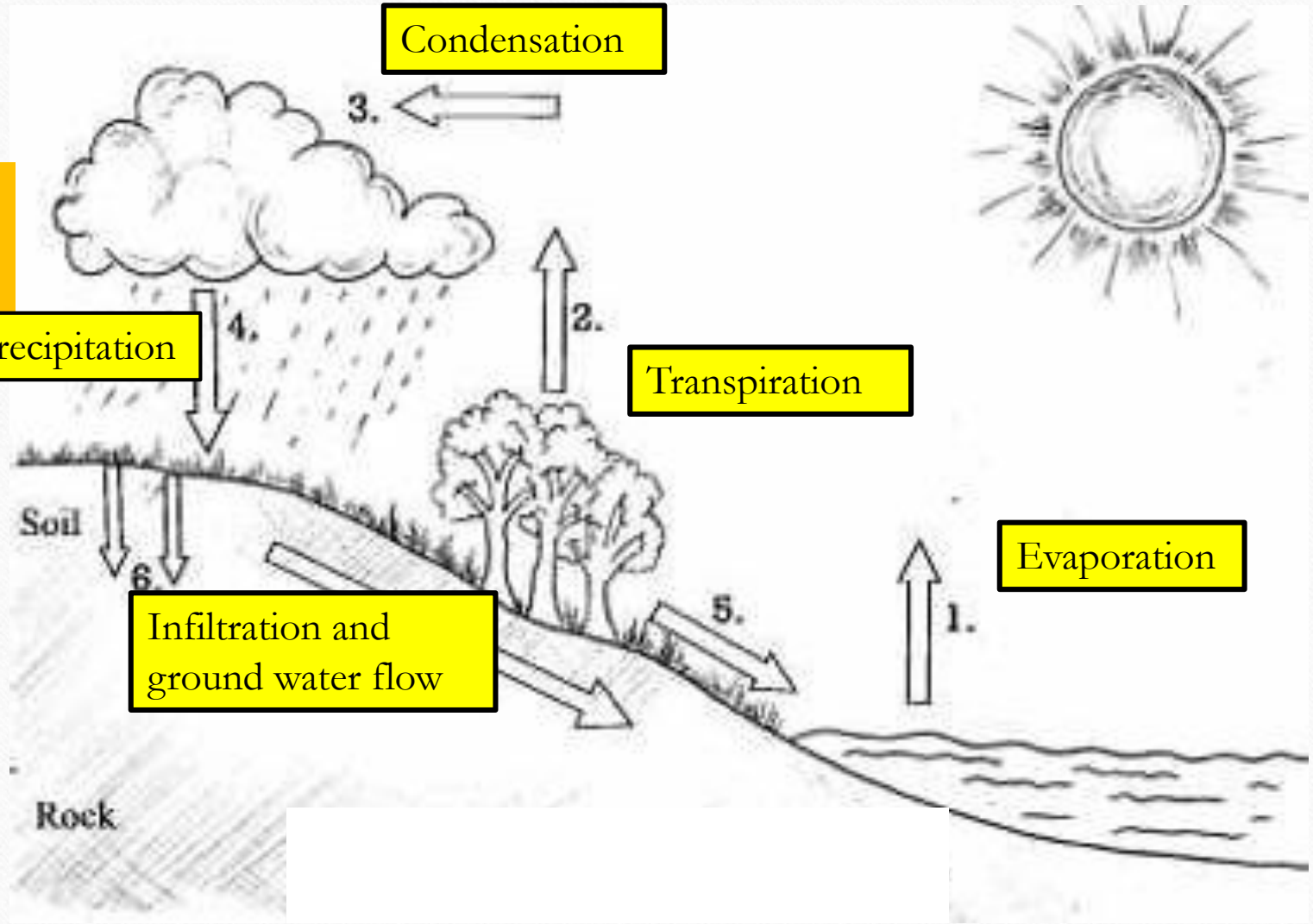
The water droplets in the cloud become very big to the point that they cannot float in the air anymore so they fall to the ground as rain, hail or snow. This is called Precipitation.

Some of this water soaks into the ground and is taken up by plant roots.

Plants use some of this water but most of it is lost by transpiration which returns water vapour back to the atmosphere. Some of the ground water that seeps into the ground is not absorbed by plants and may form streams and rivers that eventually carry water into a sea. Ground water may soak deep into the ground and stay there for many years.


The natural water cycle
Condensation
Evapotranspiration
Evaporation
Lots of infiltration
Runoff
Soil
High groundwater flow
Constantly flowing stream
Bedrock

Label the processes on the water cycle diagram



Nitrogen Cycle: https: https://www.youtube.com/watch?v=CjlaqrtJXWQ

https://contrib.pbslearningmedia.org/WGBH/conv20/lsps07-int-nitrogen/index.html
simulation

https://play.kahoot.it/v2/gameblock?quizId=ac9a2b64-6e6e-4ec0-ab08-0536bff01808

The nitrogen cycle describes the way in which nitrogen passes between living and non-living parts of an ecosystem. **Animals take in nitrogen in the form of proteins** when they eat plant tissue or animal tissue; they break down proteins into amino acids in digestion and convert them into new proteins in their own body tissues. Any amino acids that the body does not need are broken down in the liver by deamination and the nitrogen is returned to the environment.

As plants don't eat, they can't take their nitrogen in as proteins _Nitrogen gas (N2) makes up about 78% of the total air. As we can see the air contains plenty of nitrogen but this form is an unreactive form that cannot be used by plants In order for nitrogen to be used to make proteins, it must first be changed into a more reactive form such as ammonia (NH3) or Nitrates (NO3)
this process is called nitrogen fixation

Nitrogen fixation

It is the process of changing nitrogen into other reactive forms such as Nitrate, ammonia or ammonium ion so as to be used by plants. Nitrogen can be fixed by the following processes:

A. Lightening: it provides enough energy which combines Nitrogen with oxygen forming Nitrogen Oxide e.g. NO2 This nitrogen dioxide is dissolved in rain and is washed into the soil as nitrates.

B. Nitrogen fixing bacteria: These bacteria live in the soil or are found in the roots nodules (small swellings) of legume plants such as peas and beans, these bacteria use nitrogen gas in the air spaces in the soil and change it into ammonia \ but this reaction only happens in the presence of oxygen. The plants can then use the fixed nitrogen to make amino acids, DNA, RNA or chlorophyll.
Note: crop rotation: It involves the planting of different seeds on the same land in different years or seasons

- Farmers can plant legumes in crop rotation to avoid using nitrogen fertilizers.

C. Artificial fertilizers: *there is an industrial chemical process called Haber process where nitrogen and hydrogen gases are reacted together to form, ammonia, N2 +3 H2 ---->2 NH3, the ammonia is used to make ammonium compounds and nitrates which are used as fertilizers* ***.(Haber process is only for reading)***

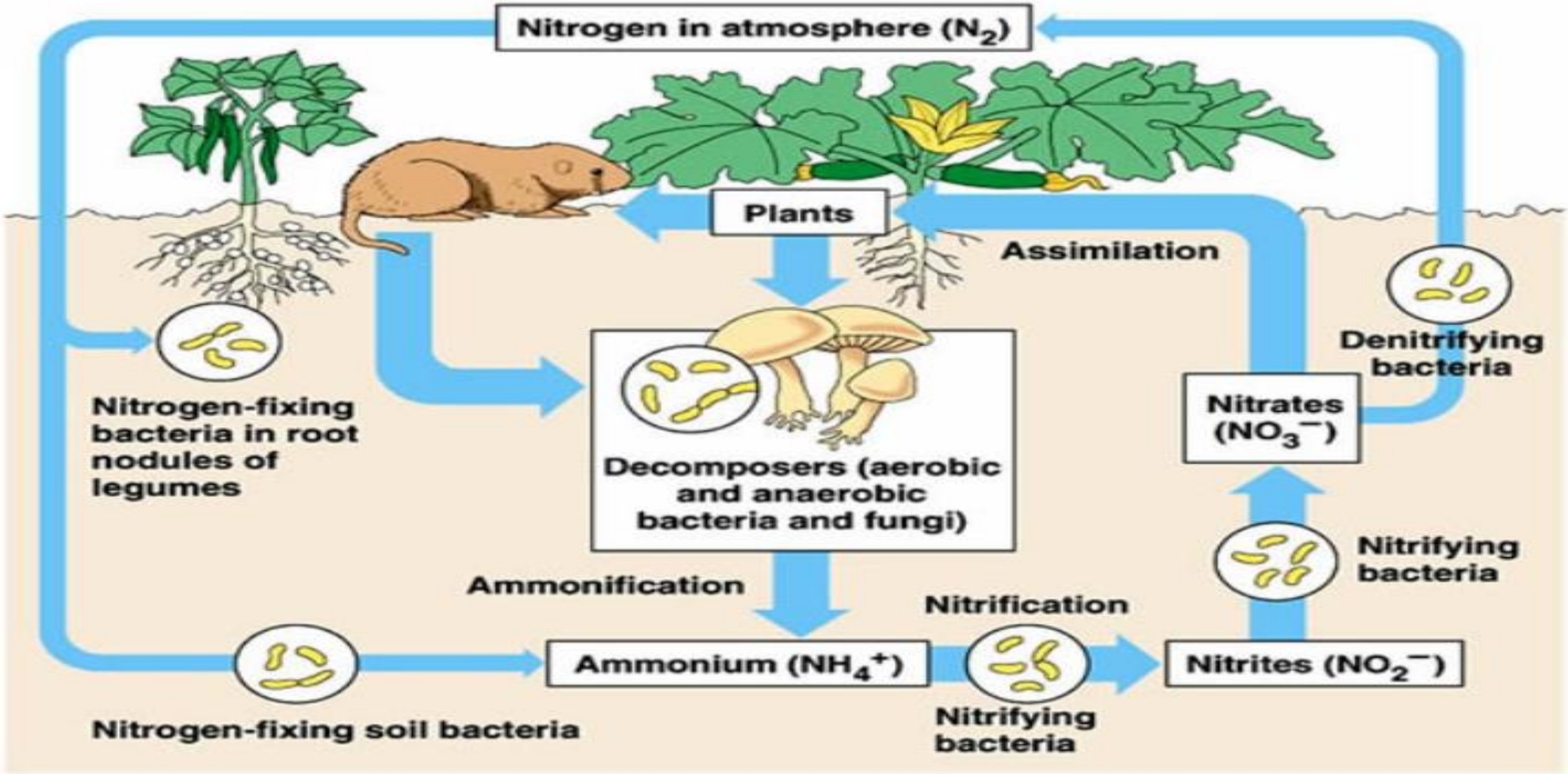
Once the nitrogen has been fixed, it will be absorbed by plant roots and it will be used to make proteins. When animals eat plants they obtain their nitrogen in the form of proteins.

Nitrification: Ammonia into nitrates

When an animal or a plant dies they are eaten by saprotrophs and detritivores (e.g earthwarm) and become excreted as faces (this increases the surface area), decomposers then break down the proteins in these wastes to amino acids. Amino acids are then deaminated into ammonia The ammonia that is released is then converted by another type of bacteria called nitrifying bacteria first into nitrites and then into nitrates that the plants can use again.

A third type of bacteria called Denitrifying bacteria plays a role in the nitrogen cycle these turn ammonia and nitrates back into nitrogen gas which returns back to the atmosphere , completing the nitrogen cycle , this takes place rapidly in very wet soil .

Note: Nitrification process needs oxygen, in the absence of oxygen denitrifying bacteria will start converting nitrate into nitrogen gas. That's why water-logged soils tend to lose nitrate as nitrogen gas. Farmers plough fields to improve oxygenation of the soil and reduce denitrification.



Nitrogen Cycle

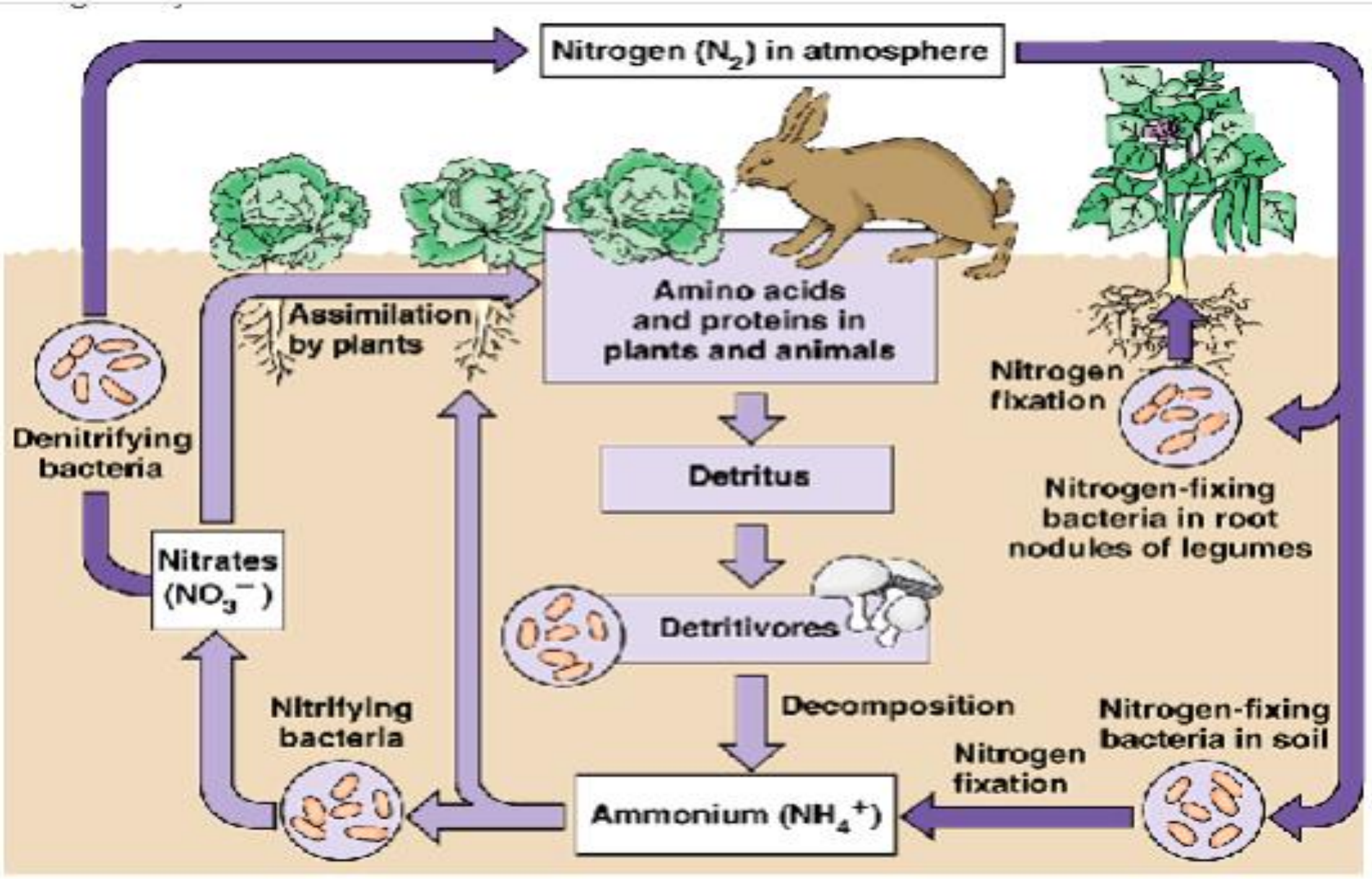

Nitrogen (N_2) in atmosphere
Amino acids and proteins in plants and animals
Assimilation by plants
Denitrifying bacteria
Nitrogen fixation
Nitrogen-fixing bacteria in root nodules of legumes
Detritus
Detritivores
Nitrates (NO_3^-)
Nitrifying bacteria
Decomposition
Nitrogen-fixing bacteria in soil
Nitrogen fixation
Ammonium (NH_4^+)

Fig. 2.2 shows part of the nitrogen cycle.

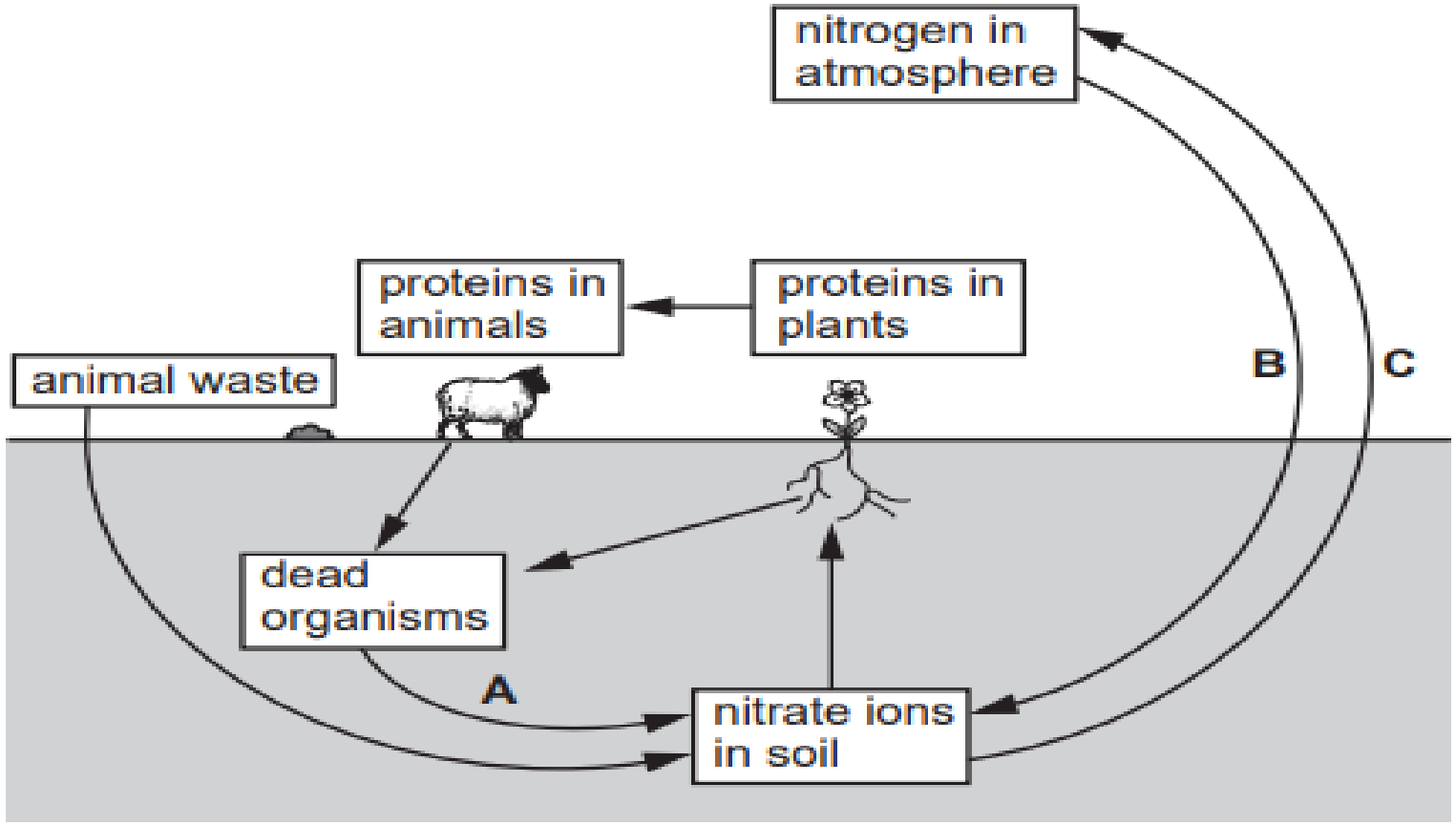


Fig. 2.2

(i) Describe processes **A**, **B** and **C** in Fig. 2.2.

A : Nitrification
B : nitrogen fixation
C : denitrification

(ii) State the name of the process that plants use to absorb nitrate ions.

Active transport

Sustainability of ecosystems https://www.youtube.com/watch?v=H7UxssJ5rXU

Ecosystems tend to stay sustainable for a long period of time by insuring that there is a continuous supply of energy; this energy is provided by sunlight. Recycling of nutrients and waste products by saprotrophs is also needed for an ecosystem's sustainability.

Mesocosm http://pickchur.com/2013/02/53-years-old-sealed-bottle-garden/ story

A mesocosm is a model of a larger ecosystem. The term mesocosm comes from the term "meso" which means "medium" and "cosm" which means "world".

When setting up a mesocosm, you can either have it as a closed or open ecosystem. Closed ecosystems sealed in glass are preferred as they prevent the entry and exit of external matter but at the same time allow light to enter and leave.

Mesocosms allow us to examine factors that may affect natural ecosystems under controlled conditions. Therefore a mesocosm is considered a valuable tool to study biotic and abiotic features in ecological research.

For example, you can set up a mesocosm to examine the effect of increased levels of carbon dioxide on specific types of organisms. Manipulation of environmental factors in a mesocosm enables us to observe the effect of such factors and therefore build an understanding of the correlations between biotic and abiotic factors. However, the limited space in a mesocosm does not allow organisms to behave in the same way that they behave in a natural environment, which may affect results obtained.

You can create a simple mesocosm by using a glass jar to which you add a mixture of biotic and abiotic factors, and ensure it is tightly sealed and placed close to sunlight (figure 9). The biotic and abiotic factors may include:

Biotic factors - these include different living organisms from plants (example, cactus) and animals (example, worms, etc.)

Abiotic factors - these may include non-living organic matter such as dead leaves, humus, soil, pebbles and water.

https://www.youtube.com/watch?v=69hYV9ti_R8

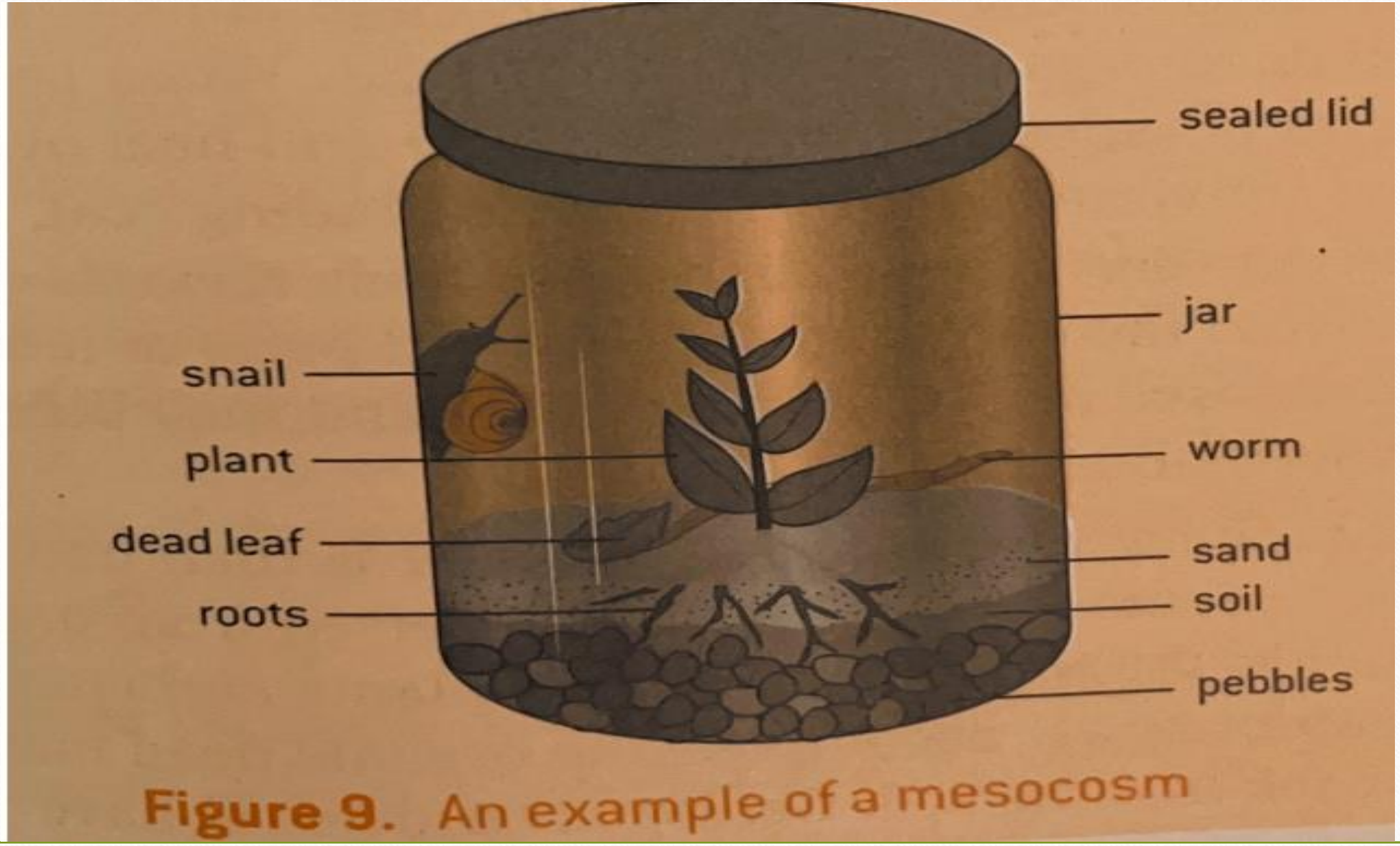


Figure 9. An example of a mesocosm