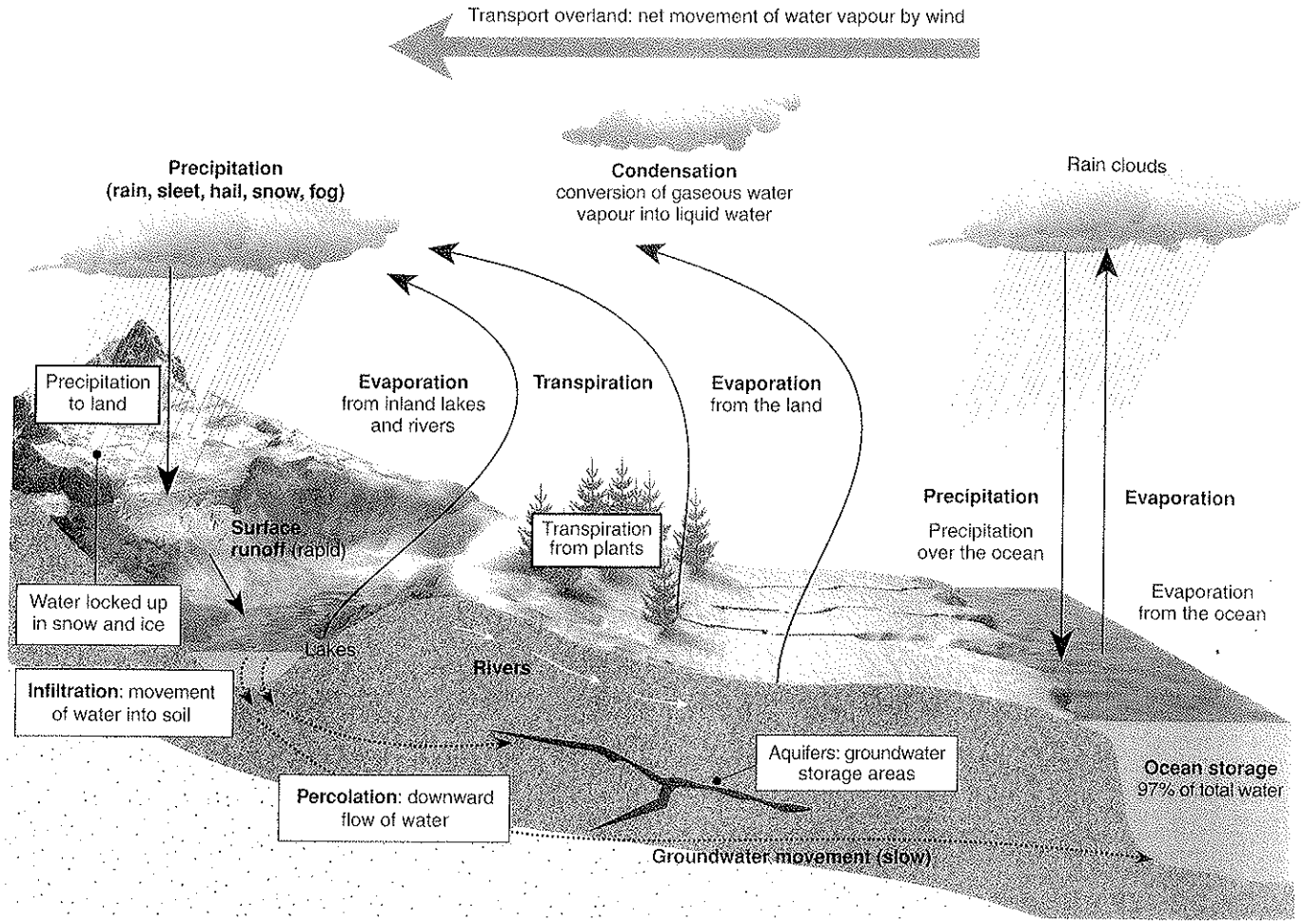
The Water Cycle

The hydrologic cycle (water cycle), collects, purifies, and distributes the Earth's fixed supply of water. The main processes in this water recycling are described below. Besides replenishing inland water supplies, rainwater causes erosion and is a major medium for transporting dissolved nutrients within and among ecosystems. On a global scale, evaporation (conversion of water to gaseous water vapour) exceeds precipitation (rain, snow etc.) over the oceans. This results in a net movement of water vapour (carried by winds) over the land. On land, precipitation exceeds evaporation. Some of this precipitation becomes locked up in snow and ice, for varying lengths of time. Most forms surface and groundwater systems that flow back to the sea, completing the major part of the cycle. Living organisms, particularly plants, participate to varying degrees in the water cycle. Over the sea, most of the water vapour is due to evaporation alone. However on land, about 90% of the vapour results from plant transpiration. Animals (particularly humans) intervene in the cycle by utilising the resource for their own needs.



1. Identify two ways in which water returns to the oceans from the land:

   (a) _____ (b) _____

2. Briefly describe three ways in which humans may intervene in the water cycle, and the effects of these interventions:

   (a) _____

   _____

   (b) _____

   _____

   (c) _____

   _____

3. Identify the main reservoir for water on Earth: _____

4. Identify the main reservoirs for fresh water: _____

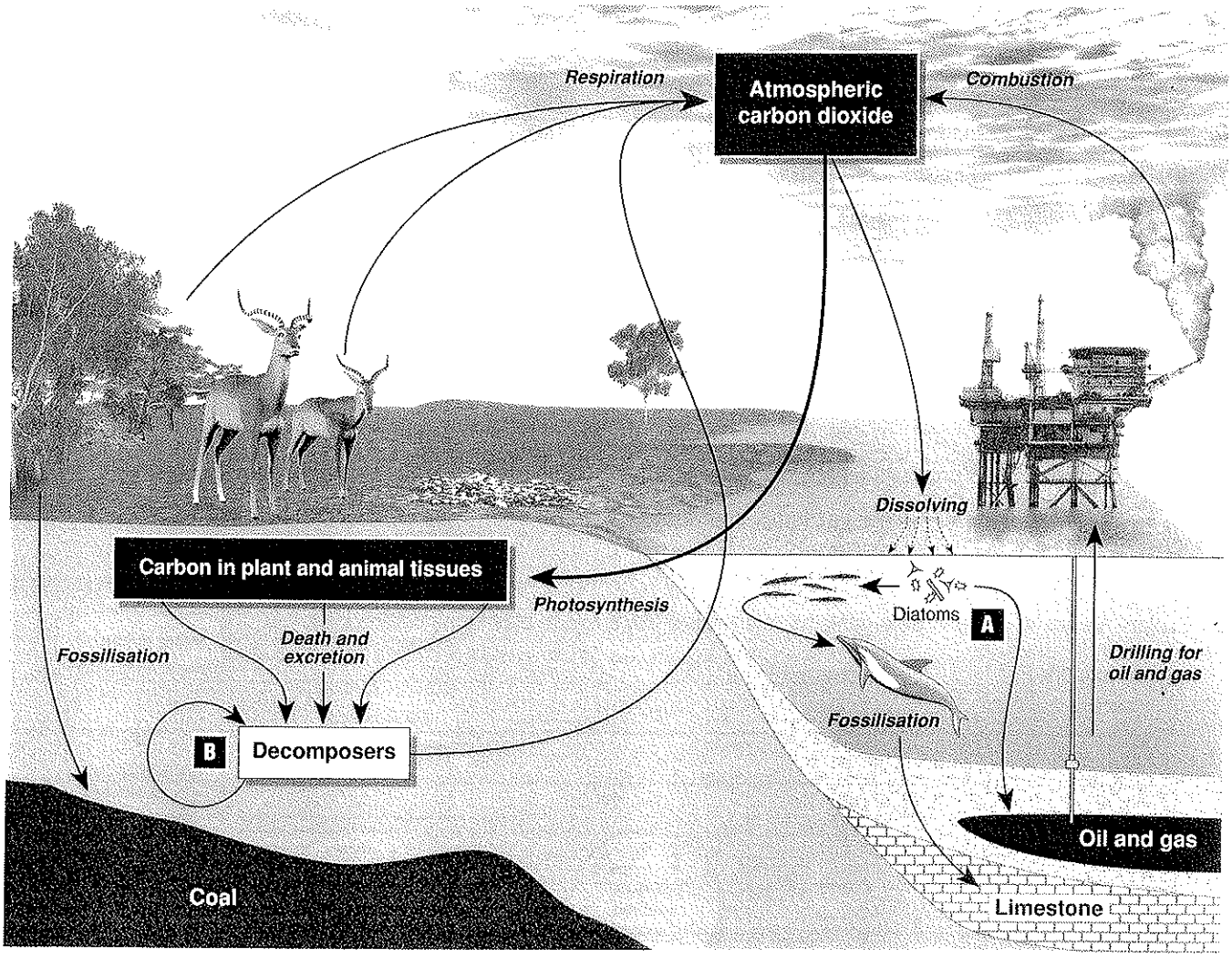
5. Describe the important role of plants in the cycling of water through ecosystems: _____

   _____

Related activities: Atmosphere and Climate, Global Water Resources, Water Use

The Carbon Cycle

Carbon is an essential element in living systems, providing the chemical framework to form the molecules that make up living organisms (e.g. proteins, carbohydrates, fats, and nucleic acids). Carbon also makes up approximately 0.03% of the atmosphere as the gas carbon dioxide (CO_2), and it is present in the ocean as carbonate and bicarbonate, and in rocks such as limestone. Carbon cycles between the living (biotic) and non-living (abiotic) environment: it is fixed in the process of photosynthesis and returned to the atmosphere in respiration. Carbon may remain locked up in biotic or abiotic systems for long periods of time as, for example, in the wood of trees or in fossil fuels such as coal or oil. Human activity has disturbed the balance of the carbon cycle (the global carbon budget) through activities such as combustion (e.g. the burning of wood and **fossil fuels**) and deforestation.



1. In the diagram above, add arrows and labels to show the following activities:

   (a) Dissolving of limestone by acid rain
   (b) Release of carbon from the marine food chain
   (c) Mining and burning of coal
   (d) Burning of plant material.

2. Describe the **biological origin** of the following geological deposits:

   (a) Coal: _____

   (b) Oil: _____

   (c) Limestone: _____

3. Describe the two processes that release carbon into the atmosphere: _____

   _____

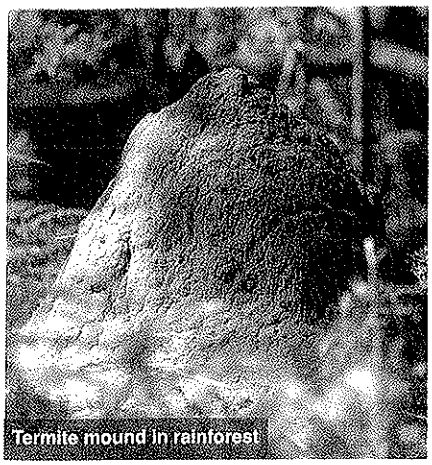
   _____

4. Name the four geological reservoirs (sinks), in the diagram above, that can act as a source of carbon:

   (a) _____ (c) _____

   (b) _____ (d) _____

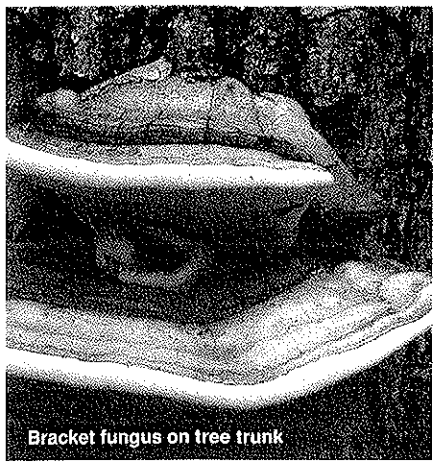
Related activities: Energy Resources, Global Warming


Termite mound in rainforest

Termites: These insects play an important role in nutrient recycling. With the aid of symbiotic protozoans and bacteria in their guts, they can digest the tough cellulose of woody tissues in trees. Termites fulfill a vital function in breaking down the endless rain of debris in tropical rainforests.


Dung beetle on cow pat

Dung beetles: Beetles play a major role in the decomposition of animal dung. Some beetles merely eat the dung, but true dung beetles, such as the scarabs and *Geotrupes*, bury the dung and lay their eggs in it to provide food for the beetle grubs during their development.


Bracket fungus on tree trunk

Fungi: Together with decomposing bacteria, fungi perform an important role in breaking down dead plant matter in the leaf litter of forests. Some mycorrhizal fungi have been found to link up to the root systems of trees where an exchange of nutrients occurs (a mutualistic relationship).

5. Explain what would happen to the carbon cycle if there were no decomposers present in an ecosystem:

6. Study the diagram on the previous page and identify the processes represented at the points labelled [**A**] and [**B**]:

   (a) Process carried out by the diatoms at label **A**:

   (b) Process carried out by the decomposers at label **B**:

7. Explain how each of the three organisms listed below has a role to play in the carbon cycle:

   (a) Dung beetles:

   (b) Termites:

   (c) Fungi:

8. In natural circumstances, accumulated reserves of carbon such as peat, coal and oil represent a **sink** or natural diversion from the cycle. Eventually the carbon in these sinks returns to the cycle through the action of geological processes which return deposits to the surface for oxidation.

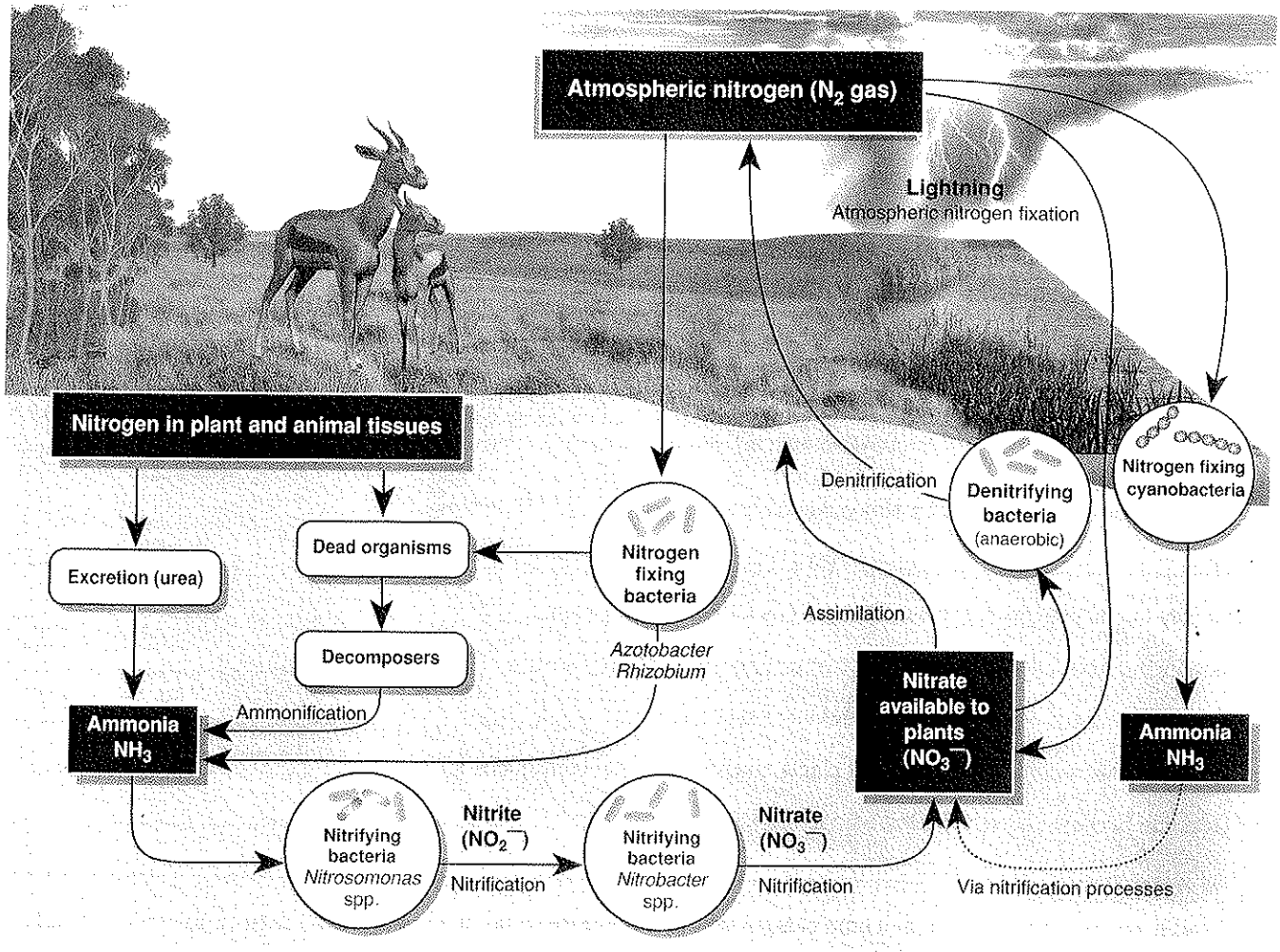
   (a) Describe what effect human activity is having on the amount of carbon stored in sinks:

   (b) Explain two global effects arising from this activity:

   (c) Suggest what could be done to prevent or alleviate these effects:

The Nitrogen Cycle

Nitrogen is a crucial element for all living things, forming an essential part of the structure of proteins and nucleic acids. The Earth's atmosphere is about 80% nitrogen gas (N_2), but molecular nitrogen is so stable that it is only rarely available directly to organisms and is often in short supply in biological systems. Bacteria play an important role in transferring nitrogen between the biotic and abiotic environments. Some bacteria are able to fix atmospheric nitrogen, while others convert ammonia to nitrate and thus make it available for incorporation into plant and animal tissues. Nitrogen-fixing bacteria are found living freely in the soil *(Azotobacter)* and living symbiotically with some plants in root nodules *(Rhizobium)*. Lightning discharges also cause the oxidation of nitrogen gas to nitrate which ends up in the soil. Denitrifying bacteria reverse this activity and return fixed nitrogen to the atmosphere. Humans intervene in the nitrogen cycle by producing, and applying to the land, large amounts of nitrogen fertiliser. Some applied fertiliser is from organic sources (e.g. green crops and manures) but much is inorganic, produced from atmospheric nitrogen using an energy-expensive industrial process. Overuse of nitrogen fertilisers may lead to pollution of water supplies, particularly where land clearance increases the amount of leaching and runoff into ground and surface waters.



1. Describe five instances in the nitrogen cycle where **bacterial** action is important. Include the name of each of the processes and the changes to the form of nitrogen involved:

(a) _____

_____

(b) _____

_____

(c) _____

_____

(d) _____

_____

(e) _____

_____

Related activities: Soil Degradation, Water Pollution
Web links: Nitrogen Cycle Animation

Human Intervention in the Nitrogen Cycle

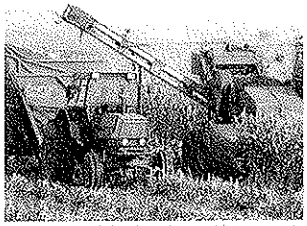
Until about sixty years ago, microbial nitrogen fixation was the only mechanism by which nitrogen could be made available to plants. However, during WW II, Fritz Haber developed the **Haber process** whereby nitrogen and hydrogen gas are combined to form gaseous ammonia. The ammonia is converted into ammonium salts and sold as inorganic fertiliser. Its application has revolutionised agriculture by increasing crop yields.

As well as adding nitrogen fertilisers to the land, humans use anaerobic bacteria to break down livestock wastes and release NH_3 into the soil. They also intervene in the nitrogen cycle by discharging **effluent** into waterways. Nitrogen is removed from the land through burning, which releases nitrogen oxides into the atmosphere. It is also lost by mining, harvesting crops, and irrigation, which leaches nitrate ions from the soil.

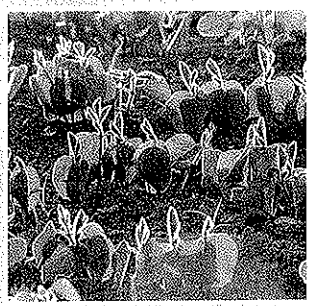
Crop Rotation

Crop rotation is an agricultural practice in which different crops are cultivated in succession on the same area of land over a period of time. Its purpose is to maintain soil fertility and reduce the adverse effects of pests. Legumes, such as peas and beans, are important in the rotation as they restore nitrogen to the soil. Some crops, like potatoes, suppress weeds and improve soil structure. Other crops that may be included in a typical rotation are wheat, barley, and squash. Different crops have different soil requirements and benefits, so changing crops from year to year minimises deficiencies and allows the soil to replenish.

A typical rotation is of three to five years with plants in different rotations being chosen from different families for their specific contributions to pest management and aspects of soil quality (such as nitrogen content and structure).



Humans may intervene in the nitrogen cycle by applying manure (left), which restores soil nitrogen, and by harvesting crop biomass, which removes material that would potentially rot and replenish soil nitrogen.



Legumes, such as soy beans (above, left) are used in crop rotations to restore soil nitrogen. Alternating between fibrous-rooted and deep-rooted crops (e.g. potatoes) improves soil structure.

2. Identify three processes that **fix** atmospheric nitrogen:

   (a) _____ (b) _____ (c) _____

3. Identify the process that releases nitrogen gas into the atmosphere: _____

4. Identify the main geological reservoir that provides a source of nitrogen: _____

5. Identify the form in which nitrogen is available to most plants: _____

6. Identify a vital organic compound that plants need nitrogen containing ions for: _____

7. Describe how animals acquire the nitrogen they need: _____

   _____

8. Explain why farmers may plough a crop of legumes into the ground rather than harvest it: _____

   _____

9. Describe five ways in which humans may intervene in the nitrogen cycle and the effects of these interventions:

   (a) _____

   _____

   (b) _____

   _____

   (c) _____

   _____

   (d) _____

   _____

   (e) _____

   _____