Water Vapor: A GHG

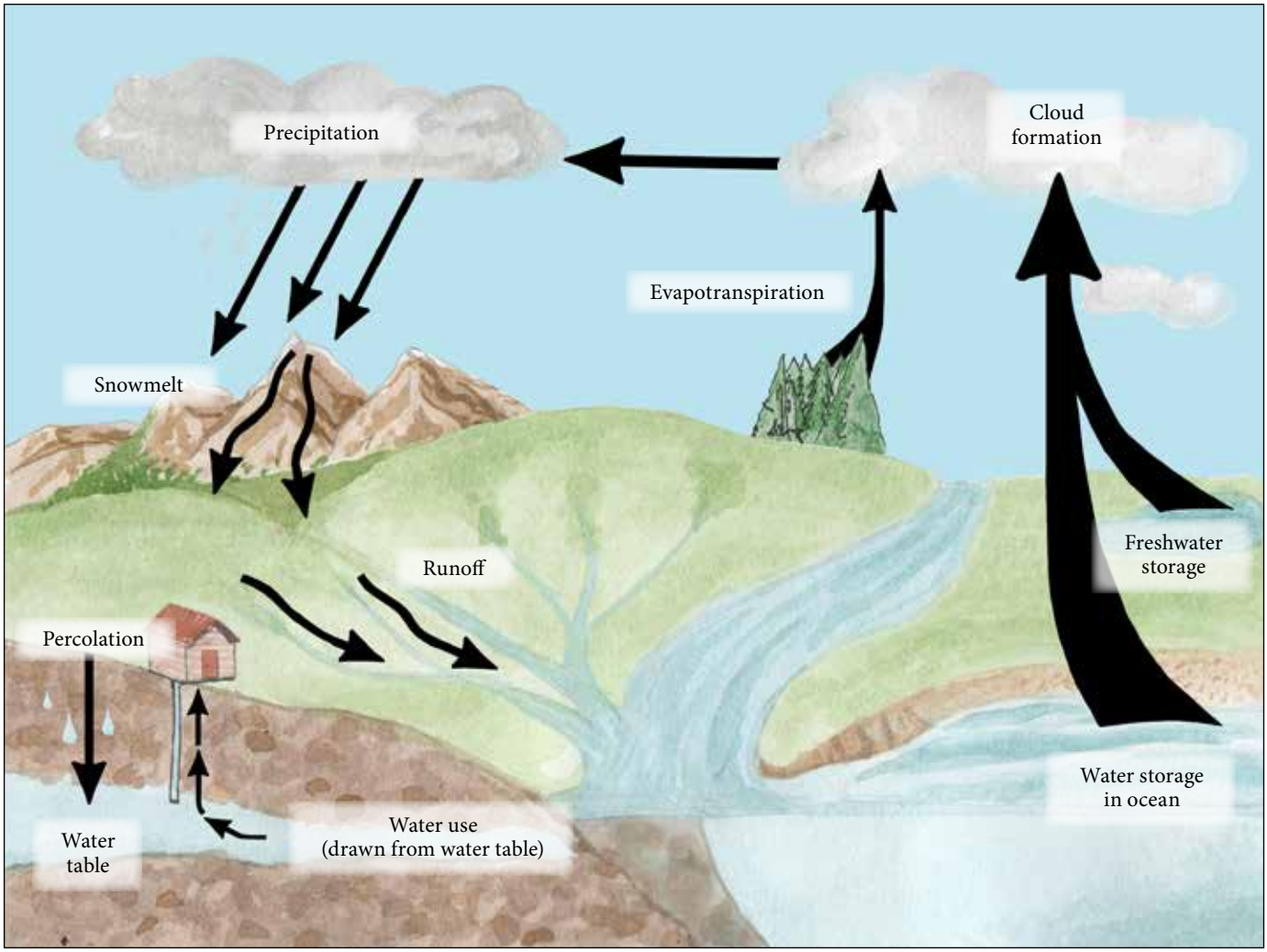
Water vapor in our atmosphere is an important greenhouse gas (GHG). On a cloudy day we can see evidence of the amount of water vapor in our atmosphere. During a heavy rainstorm—and especially during a hurricane—it is easy to see that our atmosphere is a huge reservoir of water vapor.

Water vapor is one of the greenhouse gases that is present around the planet and helps reflect heat back to Earth's surface, keeping it within the atmosphere. Water vapor has a bigger influence on Earth's climate than any of the other greenhouse gases.

Why do scientists think it is so important? Water vapor is the most abundant greenhouse gas on Earth. As a result, it is a very effective absorber of infrared radiation.

The water cycle is the major natural process that influences the amount of water vapor in the atmosphere, although it is evaporation that turns liquid water into a gas. Water evaporation from the ocean produces about 67% of Earth's water vapor, or approximately 505,000 km^3 (121,000 mi^3) of water, about 398,000 km^3 (95,000 mi^3) of it over the oceans. Ongoing evaporation helps cool the ocean (as heat is removed from the ocean's surface water molecules and transformed into gaseous water molecules). Without this natural process, the ocean would heat up and, in turn, cause global air temperatures to rise. Evaporation from lakes and other bodies of water also occurs, but since approximately 74% of Earth's surface (an area of some 361 million square kilometers) is covered by ocean, most water vapor comes from the ocean reservoir.

Ocean waves



Discuss the following with your group:

- Water vapor sources: Where does water vapor in the atmosphere come from?
- Water vapor sinks: What removes water vapor from the atmosphere and stores it for a long time?
- Which human activities could cause more or less water vapor to be in Earth's atmosphere?

Carbon Dioxide: A GHG

Carbon dioxide (CO_2) is a greenhouse gas (GHG) that is found in our atmosphere. Respiration by animals, including humans, and other organisms is the largest source of naturally produced CO_2 on Earth. Carbon exists in all living organisms and is needed for growth and reproduction. All living things act as carbon sinks, storing carbon. Plants take up CO_2 during photosynthesis and convert it into biomass (plant matter). Long-lived plants, such as trees, are natural carbon sinks. Carbon is also released into the atmosphere as wood is burned in natural forest fires or fires caused by deforestation.

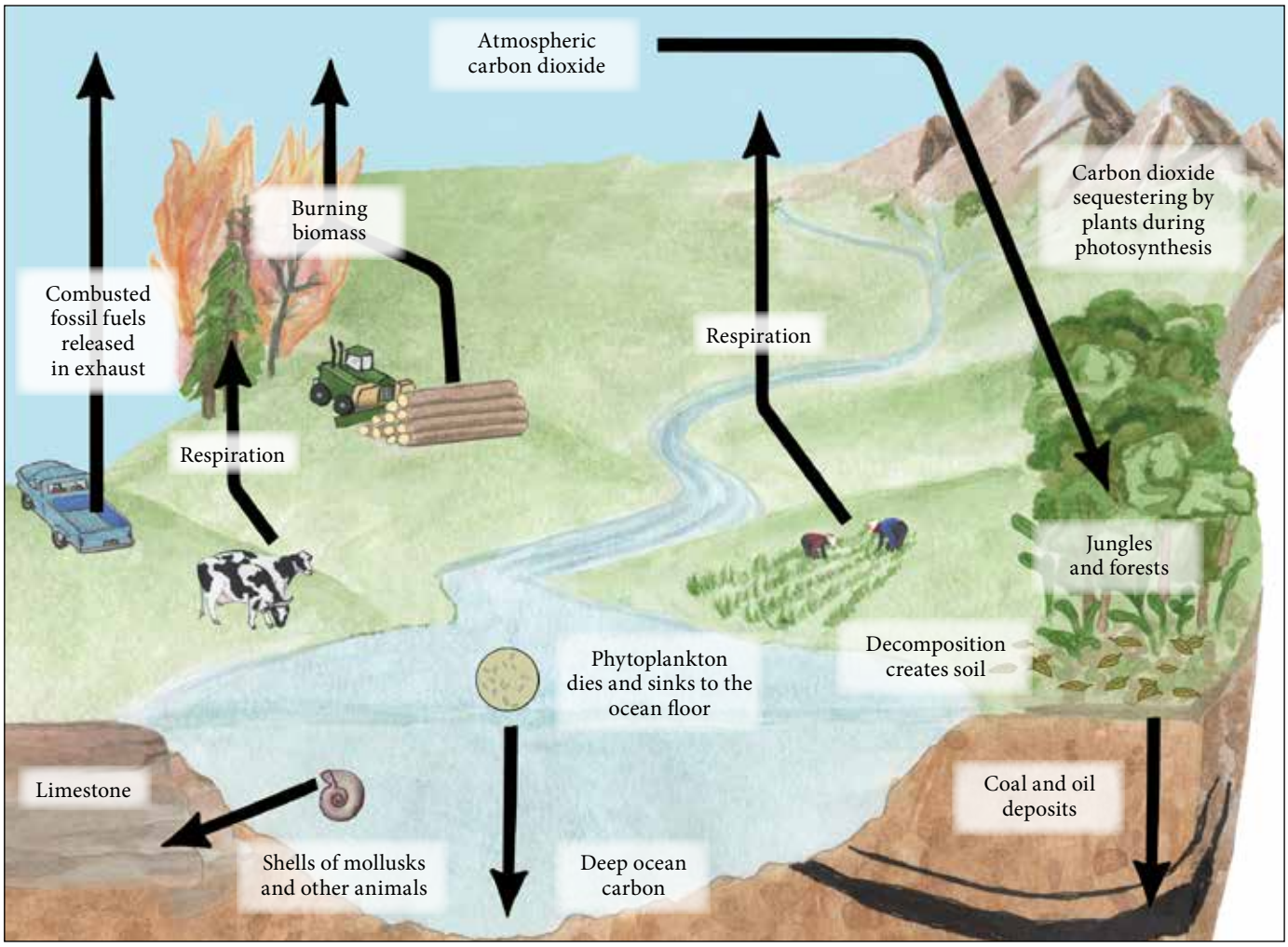
Short-lived plants, such as grasses, annual crops like corn, wheat, tomatoes, and other plants, take up carbon dioxide during growth and release this same CO_2 back to the atmosphere, or to the soil when they die in the fall. People and animals consume plants harvested by farmers, and their bodies convert carbon from the plants into carbohydrate energy needed for growth and reproduction.

Wind and wave action cause atmospheric carbon dioxide to mix into the ocean, where it becomes dissolved CO_2. Some CO_2 is also converted into calcium carbonate, the main ingredient in shells and skeletons. The ocean is home to vast numbers of shelled organisms. Because shells and skeletons are so hard and heavy, when organisms with shells or skeletons die, their bodies settle to the ocean floor or are washed ashore by tides. The shells and skeletons that sink to the deep ocean create a real carbon sink. When shells are compressed under weight, such as the weight of the entire ocean, they become carbonate rock, such as limestone and marble. These rock formations are a big reason why the ocean is a carbon sink. Weathering and temperature changes break apart carbonate rock and release the carbon locked inside.

When terrestrial organisms (plants and animals) die, microorganisms in the soil break down or decompose the dead material. Some of the carbon is released to the atmosphere as carbon dioxide, and some remains in the soil. In this way, soils are a sink for carbon. Soils store more carbon than the atmosphere or living organisms.

Fossil fuel deposits (oil, coal, and natural gas) are ancient plants that did not decompose completely and were compressed underground or under the ocean. These concentrated forms of carbon release energy and CO_2 when burned. In 2006 alone, California released over 400 million tons of CO_2 from human-related activities.

Logs



Discuss the following with your group:

- Carbon dioxide sources: Where does carbon dioxide in the atmosphere come from?
- Carbon dioxide sinks: What removes carbon dioxide from the atmosphere or stores it for a long time?
- Which human activities could cause more or less carbon dioxide to be in Earth's atmosphere?

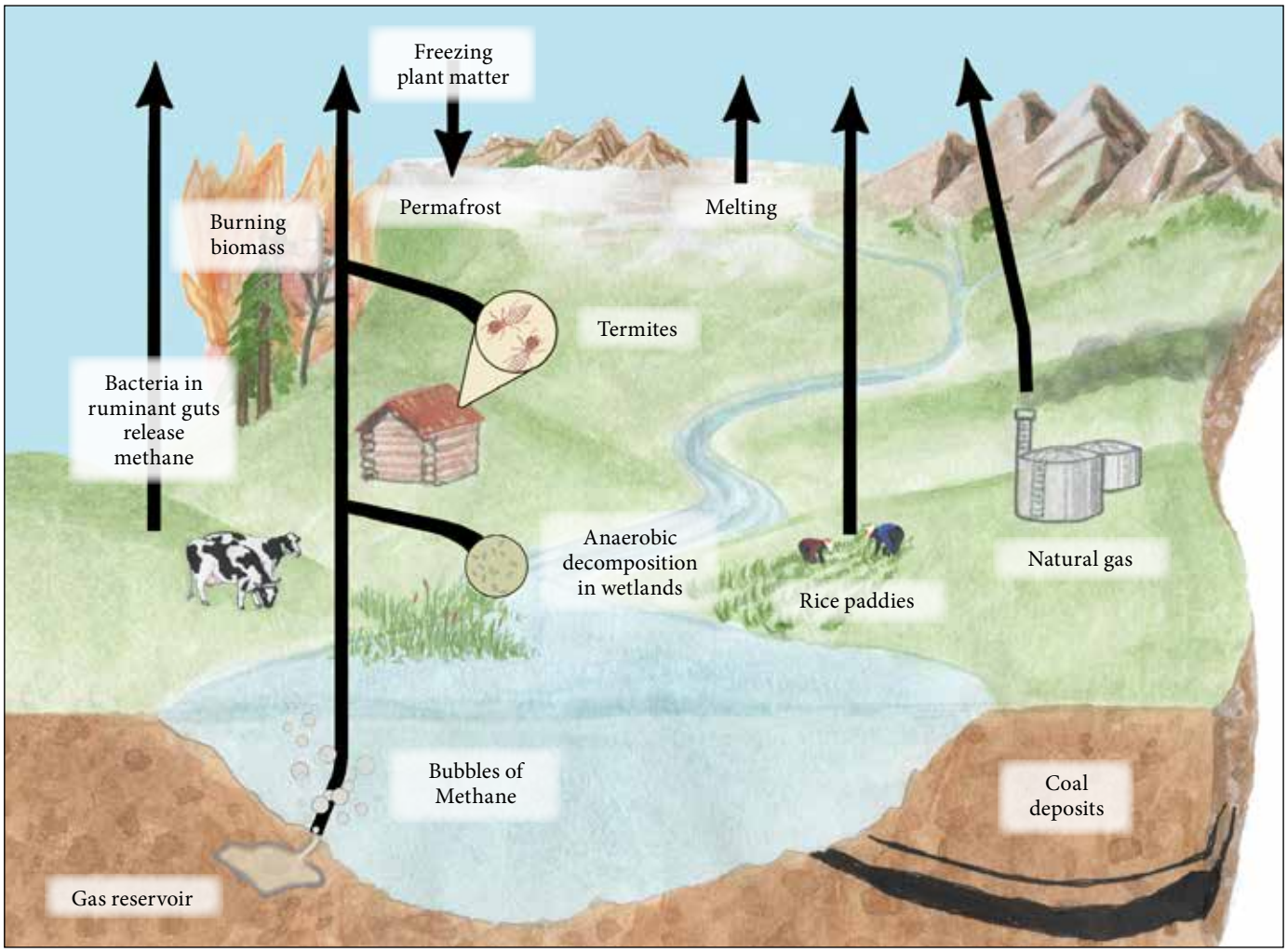
Methane: A GHG

Methane (CH_4) is a greenhouse gas (GHG) in our atmosphere. It is a carbon-based gas, like CO_2. Methane is produced when animal waste or dead organisms decompose and when plant matter is burned. Human activities, such as cattle ranching and decomposition of waste in landfills, also produce large quantities of methane. Methane gas is also a type of fossil fuel used for energy. Millions of years ago, plants that were only partially decomposed were buried underground. Under pressure, the carbon from these once-living organisms turned into methane gas. People burn methane as a source of energy—producing CO_2.

Methane is also produced by the decomposition of plants in wetlands. If you have ever gotten stuck in the muck along the edge of a pond, you have probably smelled the stinky gas that was released when your foot finally slurped out of the muck. Methane is a colorless, odorless gas; methane is the principal component of "natural gas" which has other components with odors. Other moist soils—even frozen ones—form methane, too. Moist soils that are frozen for at least two years in a row are called "permafrost." Permafrost exists at high latitudes and in alpine areas (high in mountains). Specially adapted low-growing plants can live in permafrost. When these plants die, the carbon stored within the plant material becomes trapped within the permafrost as methane. When permafrost melts, it releases methane into the atmosphere.

Plants take up carbon dioxide from the atmosphere and, through photosynthesis, convert it into plant material. Agricultural crops and other plant materials are frequently used as sources of biomass for energy production. As the biomass is burned or decomposed,

Forest fire



some of the carbon it contains is converted into methane, and released into the atmosphere.

Some animals can also release methane gas. Ruminants, such as cattle, goats, sheep, bison (buffalo), giraffes, and deer, have a special process for digesting grass and the other plant material they eat. Bacteria work as part of this digestive process, breaking down plant matter and releasing methane as animals exhale and emit gas. As termites consume wood, their digestive processes create methane in a similar manner. The amount of methane cows and termites produce is significant.

Discuss the following with your group:

- Methane sources: Where does methane in the atmosphere come from?
- Methane sinks: What removes methane from the atmosphere or stores it for a long time?
- Which human activities could cause more or less methane to be in Earth's atmosphere?

Nitrous Oxide: A GHG

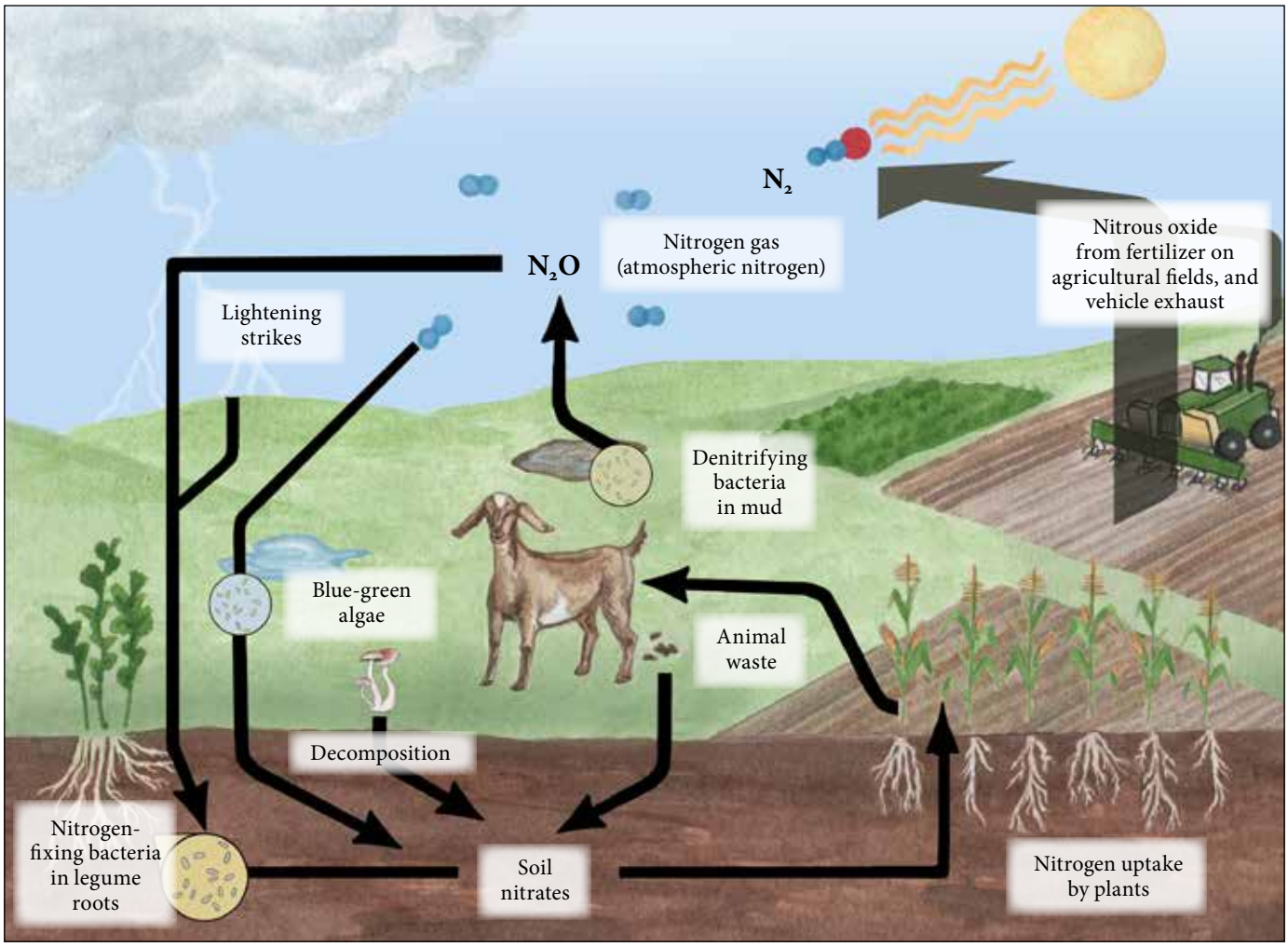
Nitrogen (N_2) is the most common gas in the atmosphere, where it comprises about 78% of the air by volume. Nitrogen, like carbon, is involved in a natural cycle, where, in different chemical forms, it moves between the atmosphere, ocean, fresh water, soil, plants, and animals. It is released into the soil when animal waste or dead plants and animals decompose. Human activities that release large quantities of nitrogen include fertilizing farmland, burning forests, burning wood for energy (heat), and turning soil.

Nitrogen atoms are found in many different molecules, including nitrous oxide (N_2O), in which two atoms of nitrogen combine with one atom of oxygen. Nitrous oxide, which has very different chemical characteristics from pure nitrogen, is one of the atmosphere's important greenhouse gases (GHG). Photolytic reactions (light-driven reactions) in the stratosphere are the major N_2O sink in the atmosphere.

Nitrous oxide is produced and released naturally and from human-related sources. About 66% of the largest human-related sources are associated with soil management for agriculture. The use of nitrogen-based fertilizers to improve the soil on farms is the largest contributor to this problem. Other human-related sources of nitrous oxide include sewage treatment, farm animals' waste products, burning of fossil fuels, and production of chemicals like nitric acid. The principal natural sources of nitrous oxide are decomposition and bacterial action in soil. Rather than just using oxygen for respiration, many species of bacteria can use nitrates, nitrogen-containing molecules in the soil, as the basis for respiration. This process, called "denitrification," releases nitrous oxide into the atmosphere.

Recent research indicates that concerns about nitrous oxide are of greater importance than was once believed. The amount of nitrous oxide gas in the atmosphere increased during the 20th century, and that increase is continuing today. The

Sewage treatment plant



annual increase in atmospheric nitrous oxide has been about 0.25% each year during the last century. Although this seems like a very small number, it is important in comparison to other GHGs because of its potential to increase global temperatures. Scientific research indicates that, over a 100-year period, nitrous oxide has a 300 times greater "global warming potential" than carbon dioxide.

Discuss the following with your group:

- Nitrous oxide sources: Where does nitrous oxide come from?
- Nitrous oxide sinks: What removes nitrous oxide from the atmosphere or stores it for a long time?
- Which human activities could cause more or less nitrous oxide to be in Earth's atmosphere?