7.4 Nitrogen cycle

The role of decomposers, and recycling nitrogen within an ecosystem

Decomposing organic material

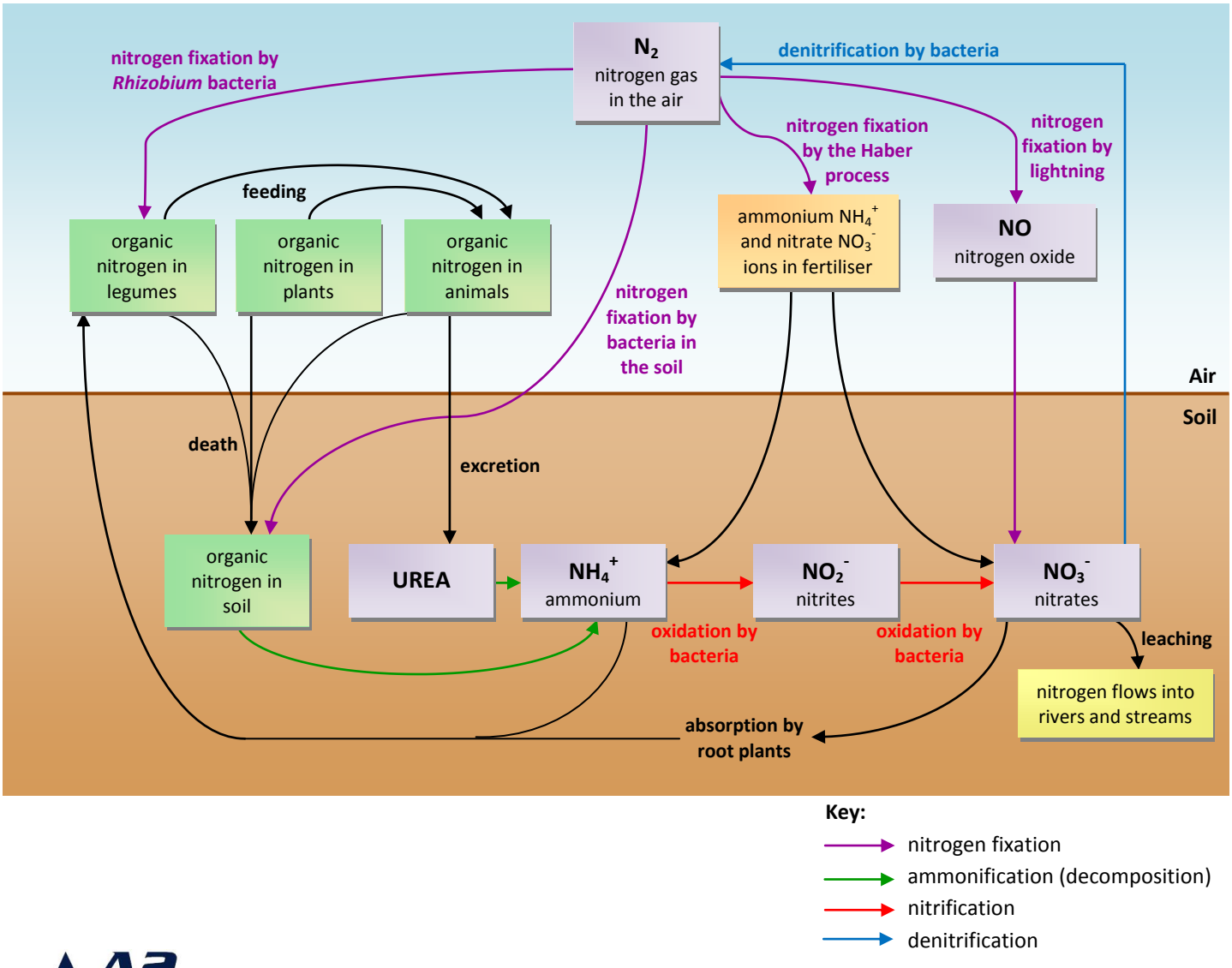
Materials and energy are lost when an organism dies or excretes, and this dead and waste organic material can be broken down by **decomposers**, including fungi and bacteria (and a small amount of animals). These microorganisms involved in decomposition feed in a way which is different from animals, which is described as **saprotrophically**, and the organisms themselves are described as *saprophytic*.

These organisms secrete enzymes onto dead and waste matter, which digest the material into small molecules which can be absorbed into the decomposers' bodies. Once absorbed, as with other organisms, the molecules are either used for respiration (and other life processes) or stored.

If bacteria and fungi did not break down dead organisms, energy and valuable nutrients would remain trapped within them. By digesting such materials, microbes get a big enough supply of energy to sustain life and grow, and the trapped nutrients are not wasted, but **recycled**. Microbes have a particularly important role to play in the *global carbon cycle*, and also the *global nitrogen cycle*.

The nitrogen cycle

Living things need nitrogen to make proteins and nucleic acids. Nitrogen is cycled between the *biotic* and *abiotic* components of an ecosystem in a cycle known as the **nitrogen cycle**. The four major processes which occur as part of the cycle are nitrogen fixation, ammonification, nitrification and denitrification.



Nitrogen fixation

Nitrogen, whilst making up almost 80% of the atmosphere, is very unreactive and plants are unable to use it directly, instead, they must have a supply of materials where nitrogen is *fixed*, such as in **ammonium** ions (NH_4^+) or **nitrate** ions (NO_3^-). Nitrogen fixation occurs when *lightning* strikes, or through *the Haber process*, but these only account for 10% of total **nitrogen fixation** – the majority comes from nitrogen-fixing bacteria.

Most of the **nitrogen-fixing bacteria** exist freely in the soil, fixing nitrogen using it to make amino acids (this nitrogen comes from the air in the soil). Nitrogen-fixing bacteria, such as ***Rhizobium***, also live inside the root nodules of many **legumes** (bean plants). They have a symbiotic relationship: the bacteria supply the plants with nitrogen-fixed molecules in return for organic compounds such as glucose from the plant.

Ammonification

Unlike with nitrogen fixation, the process of **ammonification** produces nitrogenous compounds (mainly ammonium) from *dead* matter. Dead materials and waste materials are decomposed by the types of microbes discussed on the previous page, and they convert the *organic nitrogen* (the initial form of nitrogen found in dead/waste matter) back into ammonium. This process may also be called *mineralisation*.

Nitrification

When **chemoautotrophic** bacteria in the soil absorb ammonium, **nitrification** happens. Ammonium is released by bacteria involved in putrefaction of proteins found in waste or dead organic matter. Rather than getting their energy from sunlight (like *photoautotrophic* bacteria), these bacteria gain energy by oxidising ammonium to produce **nitrites** (NO_2^-), or by oxidising nitrites to produce **nitrates** (NO_3^-).

These reactions only happen in well-**aerated** soils, as they require plenty of oxygen. Nitrates can be absorbed by plants straight from the soil to help produce nucleotide bases and amino acids.

Denitrification

Annoying, **denitrification** is not the opposite of nitrification. This process uses different bacteria, which convert nitrates back into nitrogen gas. This occurs when the bacteria are under *anaerobic* conditions, because they can break down nitrates to release nitrogen gas and oxygen gas. The oxygen is used to fuel aerobic respiration, and the nitrogen gas is released back into the atmosphere. Plants cannot take up this nitrogen gas, as it is not fixated – so this step simply returns nitrogen back into the air, which can then be fixated again under aerobic conditions by nitrogen-fixing bacteria.

Nitrogen fixation nitrogen → nitrates/ammonium	*Nitrogen-fixing bacteria fix atmospheric nitrogen to other molecules (mainly to make amino acids), many live in root nodules of legumes supplying them with nitrogenous compounds*
Ammonification nitrogen → ammonium	*Breakdown of dead or waste matter by bacteria in order to produce ammonium using the organic nitrogen of the waste tissue*
Nitrification ammonium → nitrites nitrites → nitrates	*Under aerobic conditions, chemoautotrophic bacteria oxidise ammonium to produce nitrites, and others oxidise those nitrites to produce nitrates which can be absorbed by the plants directly from the soil*
Denitrification nitrates → nitrogen	*Conversion of nitrates back into nitrogen gas which is released back into the atmosphere as part of the cycle – the bacteria use the oxygen to respire aerobically*