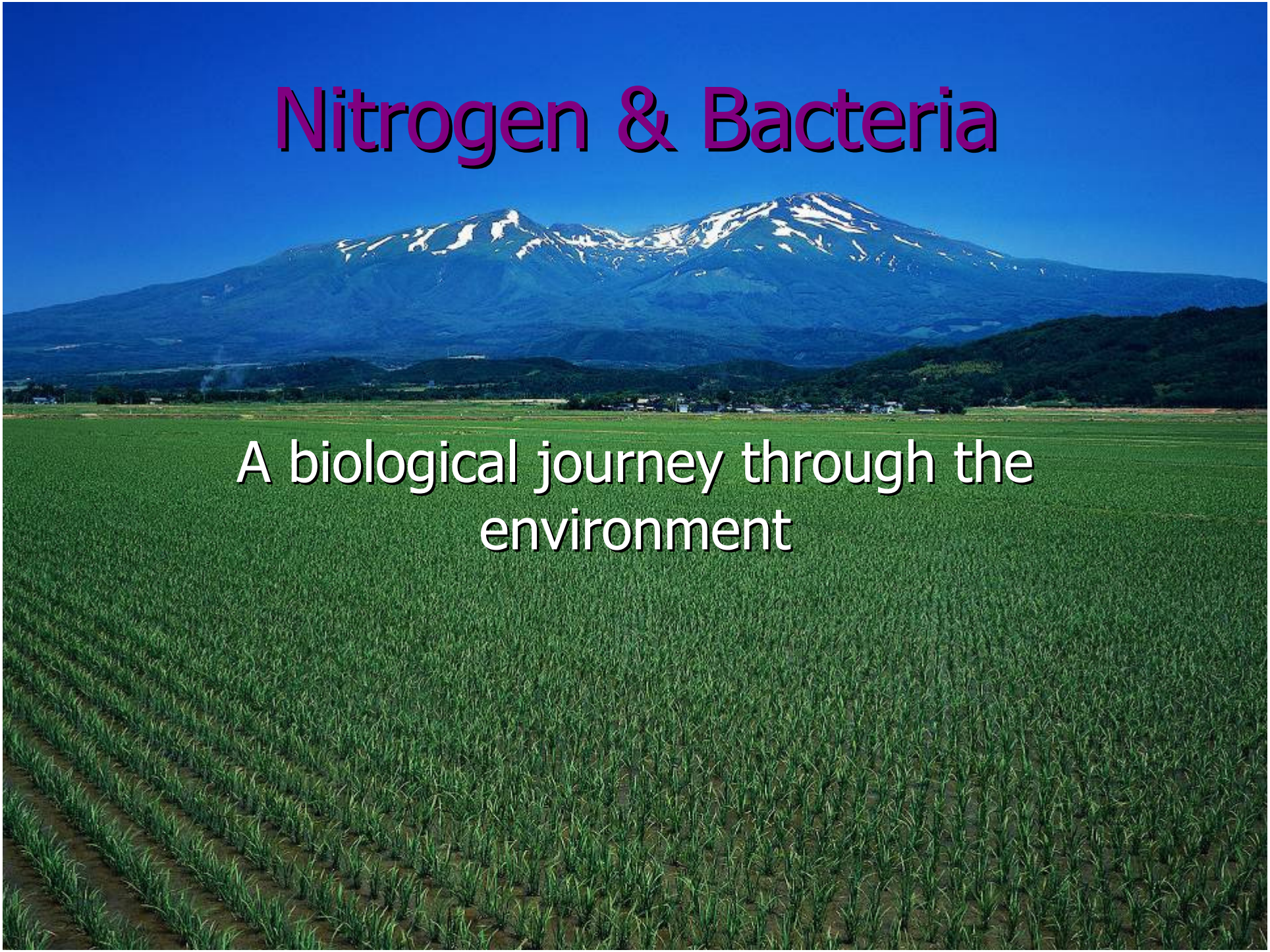
Nitrogen & Bacteria



A biological journey through the environment

Sources of Nitrogen to the Environment

Agricultural

Natural

Transportation

Industrial

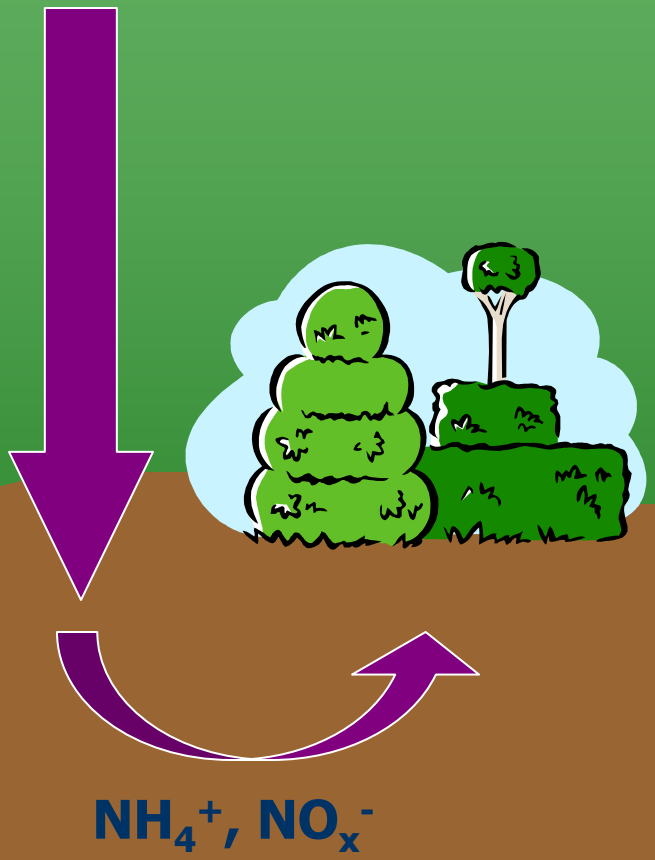
Nitrogen as a pollutant

- Too much Nitrogen can cause ecological and human health problems.

- Eutrophication of ground waters leads to death of fish & other water life. Excessive algae growth consumes all available oxygen.

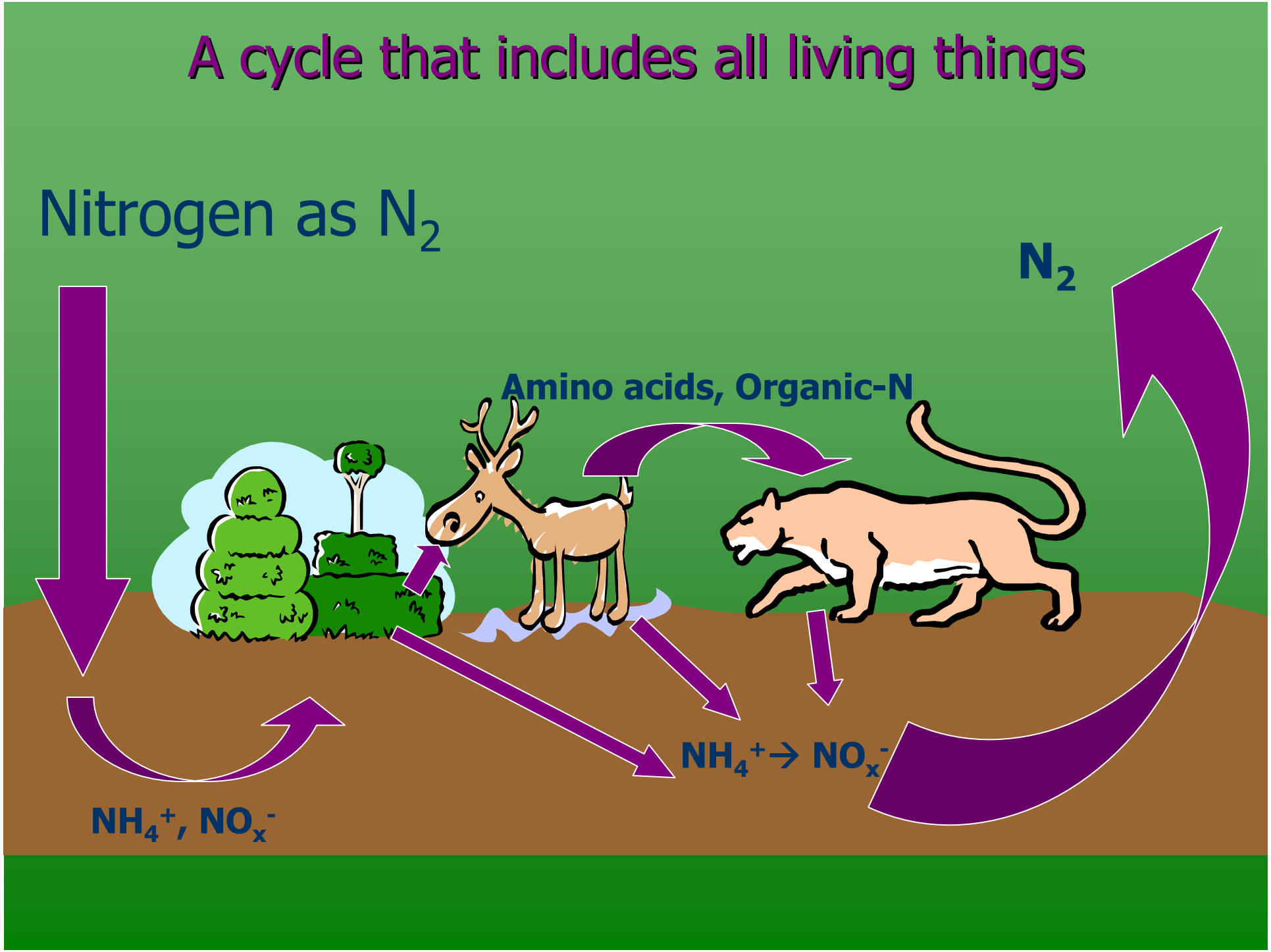
- Nitrite (NO_2) in drinking water poses a health risk to infants. When there is excess nitrite, red blood cells have a reduced oxygen-carrying capacity.

Nitrogen in the Atmosphere



- Nitrogen is not very stable in crystals (rocks), but is very stable in the atmosphere.
- The atmosphere is 78% Nitrogen, 21% Oxygen, and 1% everything else.
- The first step in Nitrogen transformation occurs in the soil.

A cycle that includes all living things

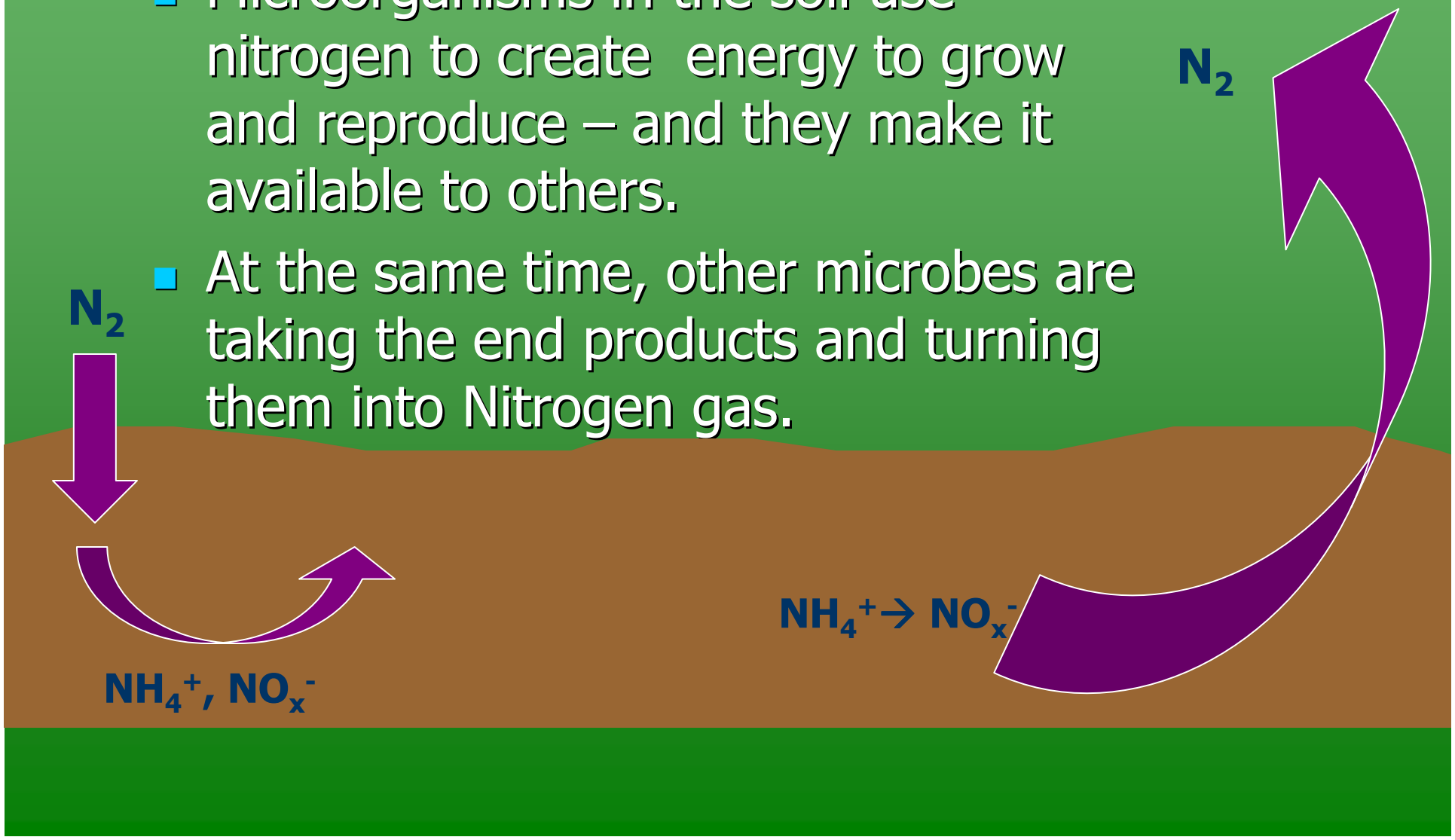


N: An essential element for life on earth

- Nitrogen is critical for the formation of cells and the biological activity in all living things – microbes, plants & animals
- It is part of …
  - Amino acids – the building blocks of life.
  - Proteins – the workhorse of cells, such as
    - Globular proteins, such as enzymes that trigger activity
    - Fibrous proteins, which provide structure
    - Membrane proteins, which

Where does N transformation start?

- Microorganisms in the soil use nitrogen to create energy to grow and reproduce – and they make it available to others.
- At the same time, other microbes are taking the end products and turning them into Nitrogen gas.



Bacteria use Nitrogen as a source of energy and as an essential element for growth

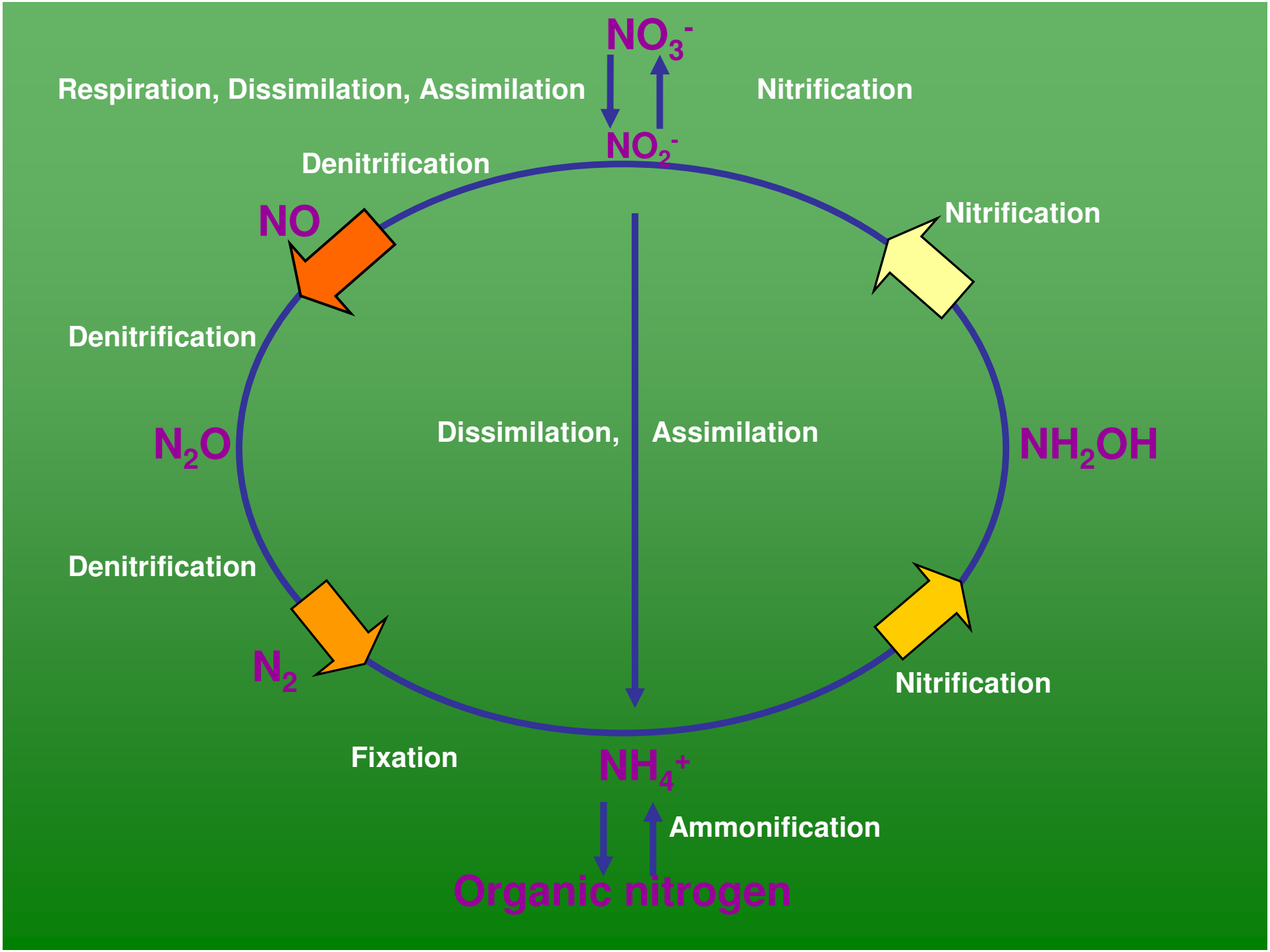
Examples:

Fixation of Nitrogen for cell growth:

N2 + Energy → Ammonium (NH4+) → Amino acids → Proteins

Dissimilation of Nitrogen for energy:

Nitrate (NO_3^-) + Organic matter → Nitrogen gas (N_2) + CO_2 + *Energy*!


NO_3^-
Respiration, Dissimilation, Assimilation
Nitrification
NO_2^-
Denitrification
NO
Nitrification
Denitrification
N_2O
Dissimilation,
Assimilation
NH_2OH
Denitrification
N_2
Nitrification
Fixation
NH_4^+
Ammonification
Organic nitrogen

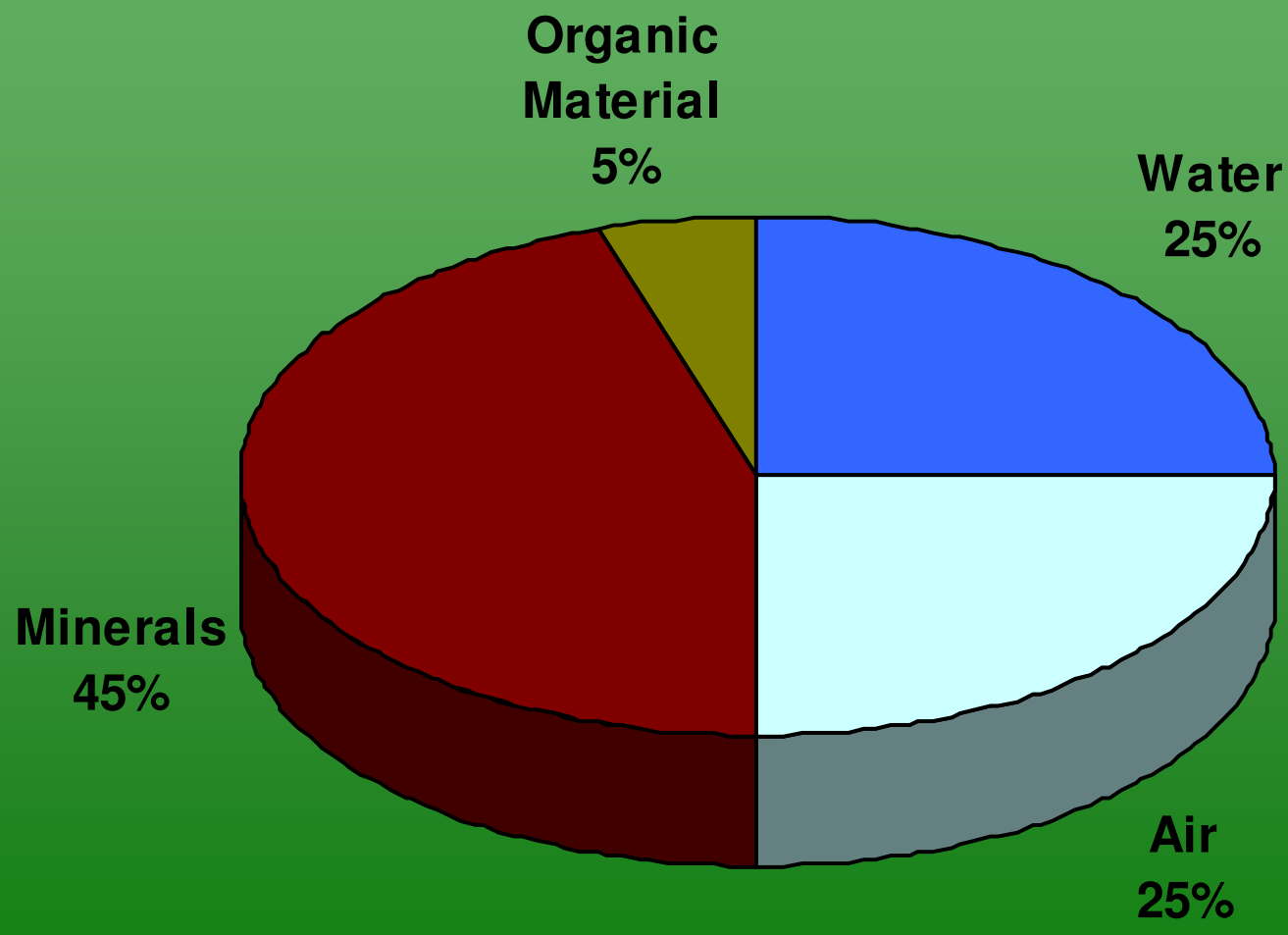
Michael T. Madigan

Figure 19-6b Brock Biology of Microorganisms 11/e

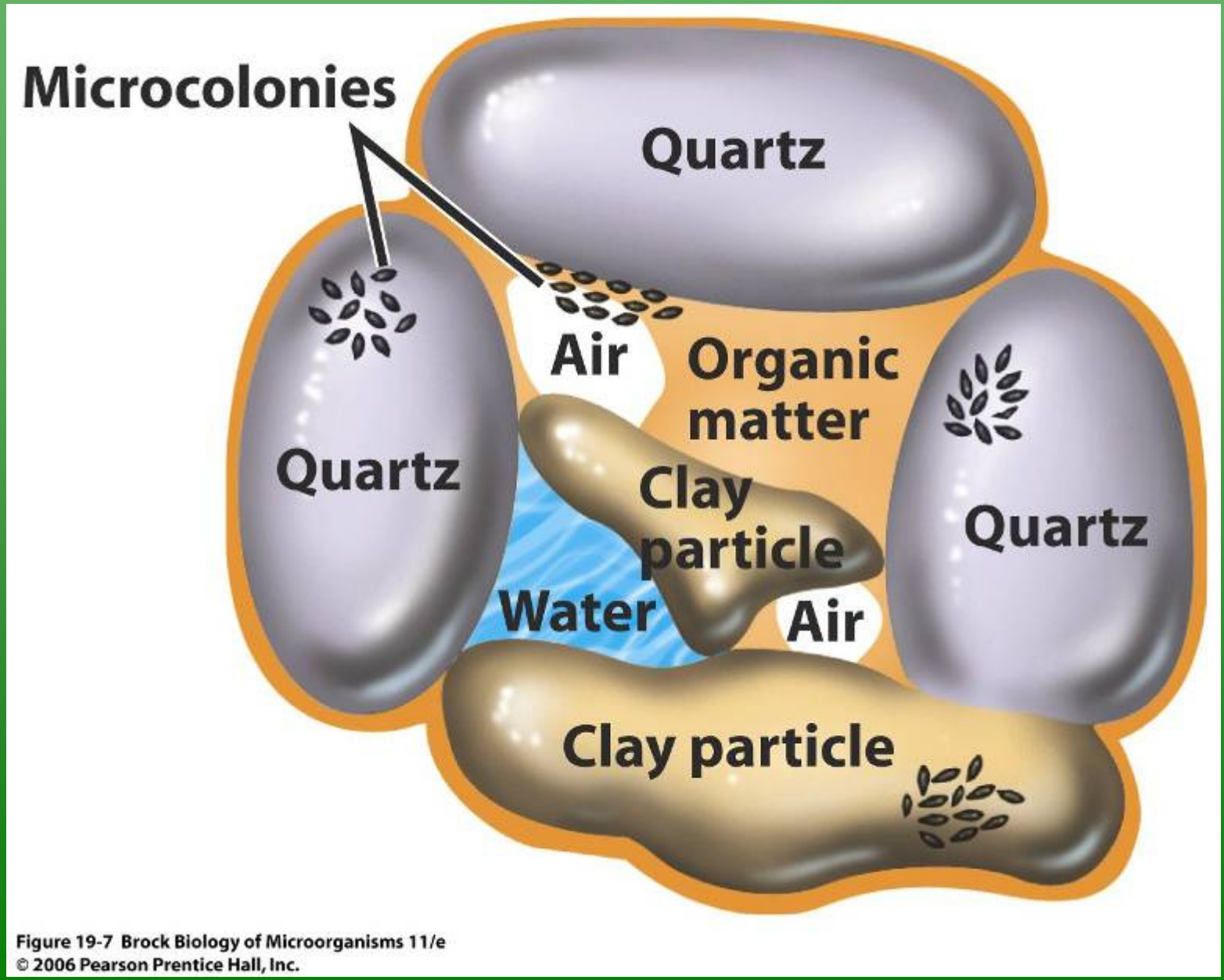
Soil formation

- Soil is formed slowly as rock breaks into tiny pieces near the Earth's surface.
- Organic matter decays and mixes with the broken rock to form soil.
- Microbes, such as bacteria and fungi, help break down the organic matter.

What makes up soil?



Bacteria create microcolonies within the soil



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What are bacteria?

A simple design that comes in lots of shapes and sizes.

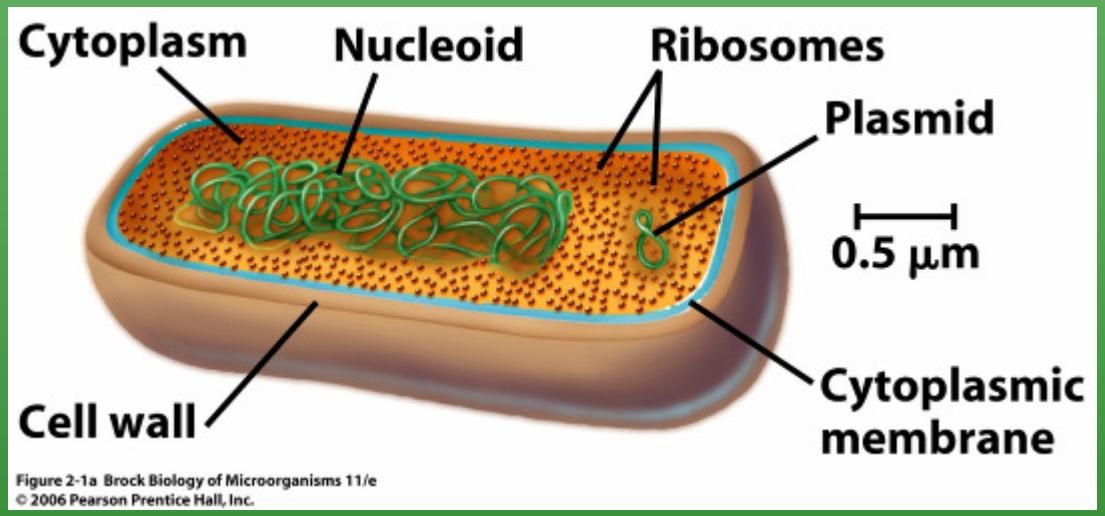

Figure 2-1a Brock Biology of Microorganisms 11/e
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- Single-cell organisms
- Nucleoid instead of nucleus
- Ribosomes – where proteins are made
- Cell wall

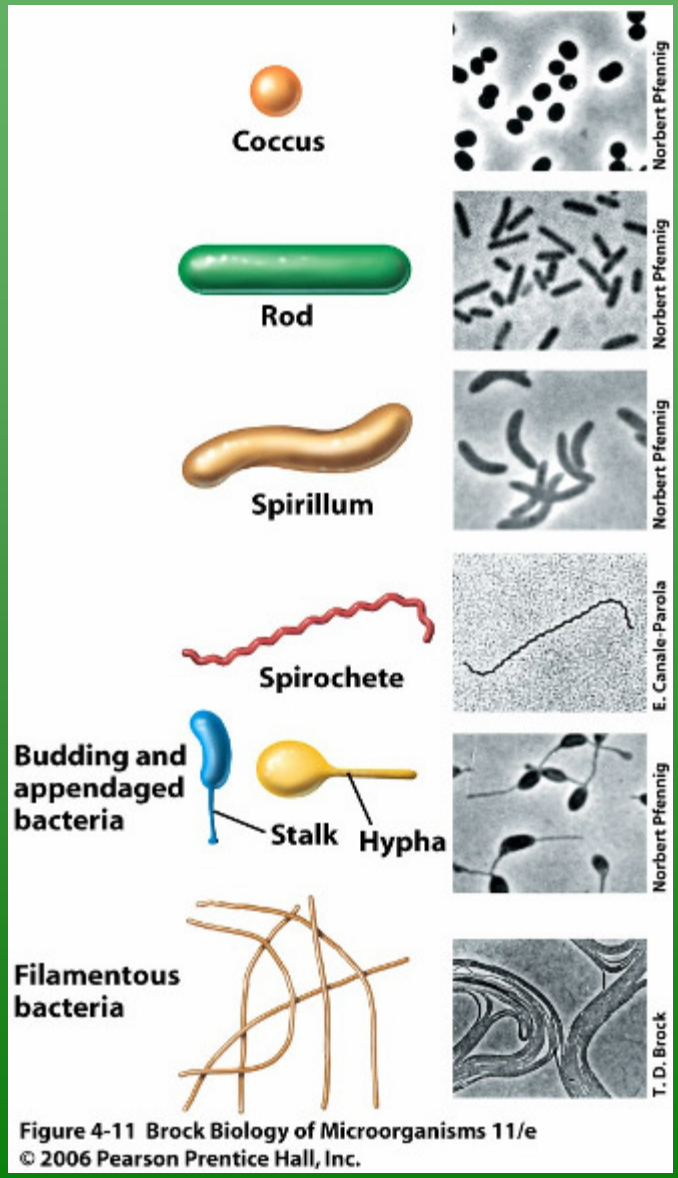

Figure 4-11 Brock Biology of Microorganisms 11/e
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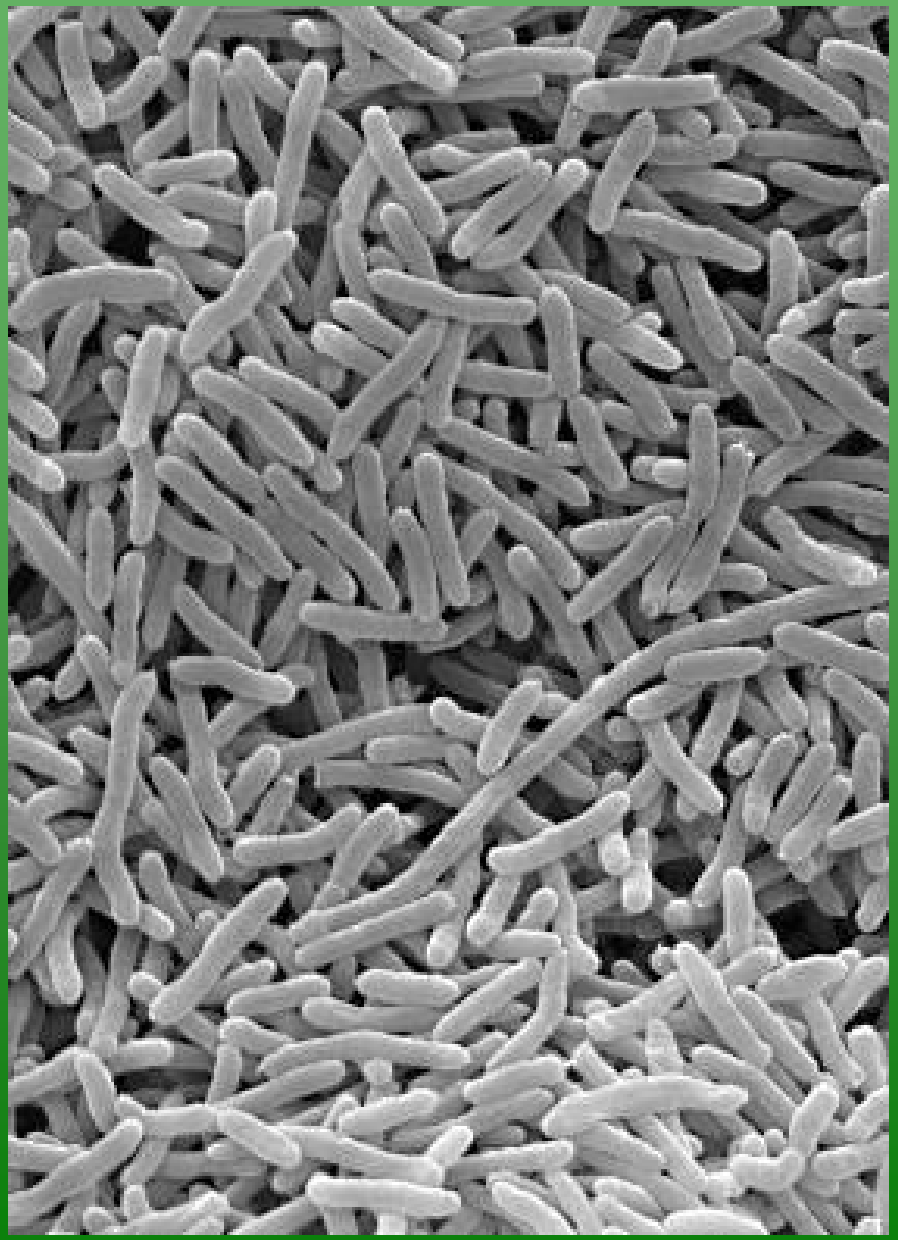
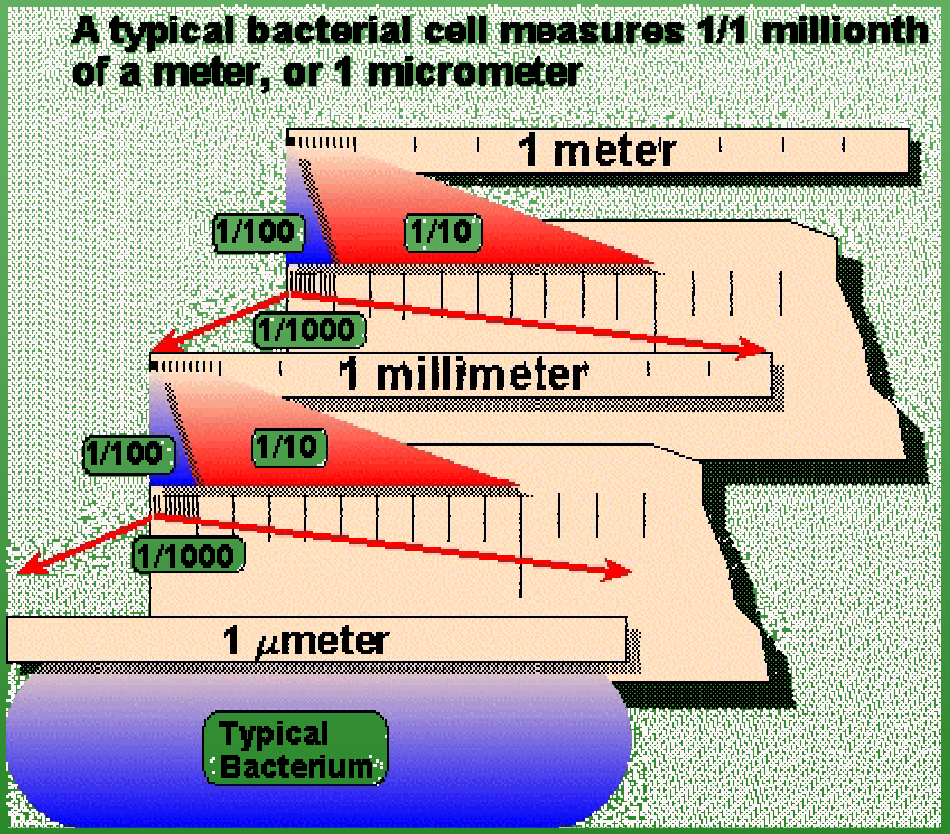
Bacteria are small





Small

What do bacteria need to survive?

- Carbon
  - Organic matter
  - CO_2
- Water
- Vitamins & Minerals
- Energy source

All of this can be found in soil.

- In the ground, soil bacteria have everything they need.
- They can be found almost every environment, because they will eat just about anything.
- Bacteria have unique metabolic capabilities that allow them to utilize inorganic molecules such as nitrogen, iron, sulfur and hydrogen for energy and growth.

The bulk of microbial activity will occur in the upper levels of the soil.

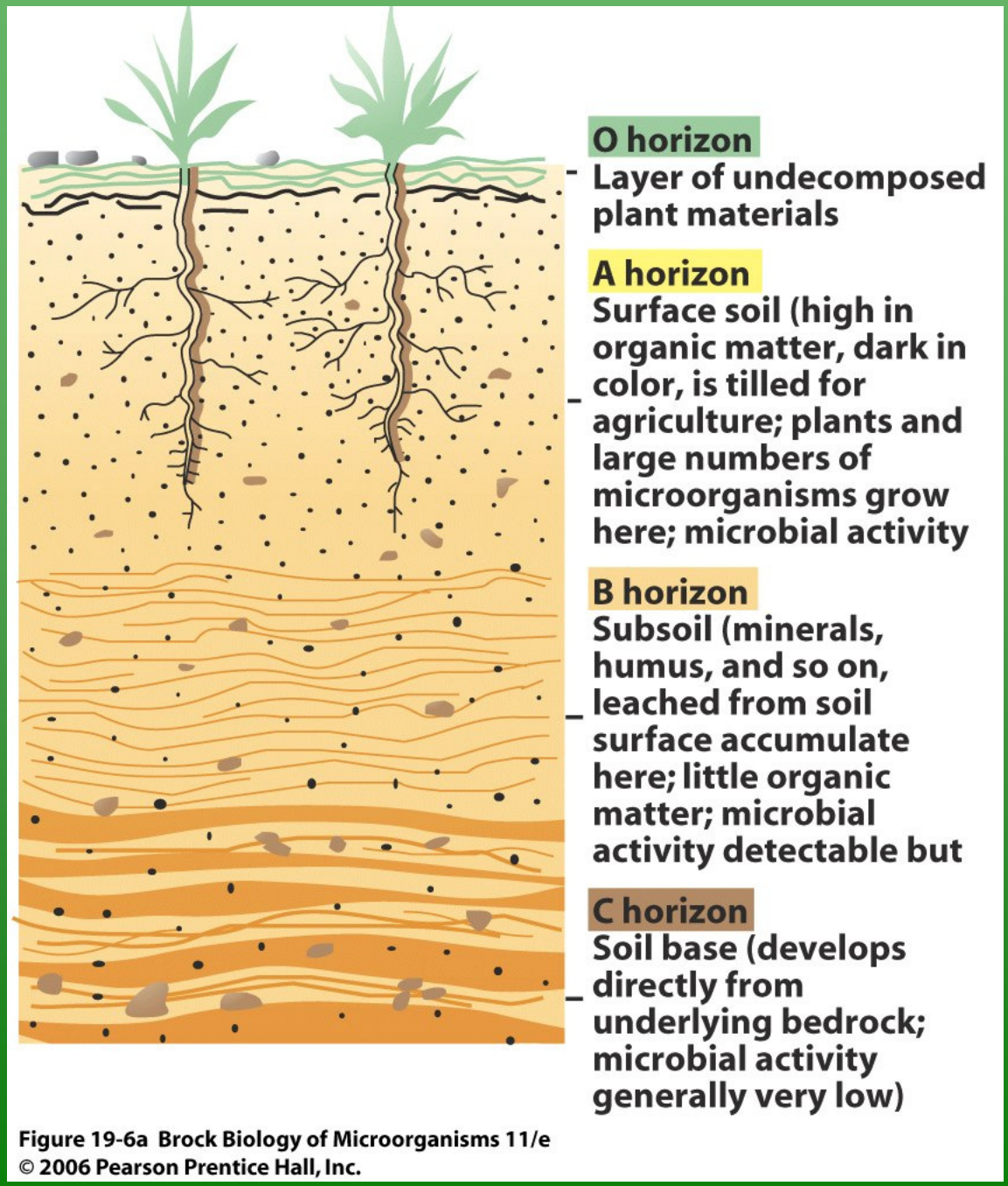


Figure 19-6a Brock Biology of Microorganisms 11/e

What role do bacteria play in soils?

- Cycle elements between ecosystems.
  - Breakdown dead organic matter, which adds nutrients to the soil.
  - Restore oxygen to the atmosphere.
  - Fix nitrogen ($N_2 \rightarrow NH_4^+$) that other organisms can use to make proteins.
  - Return the nitrogen to the atmosphere.
- All life on Earth depends on bacteria.

Some critical roles that bacteria play in the Nitrogen cycle

- Fixation of N_2 to NH_4^+ for plants
  - Nitrogen fixing "plants" are actually bacterial colonies located on the roots.
- Remediation of soils contaminated with too much Nitrate/Nitrite
  - NO_3^- → N_2 gas → back to atmosphere

Some Elemental Cycles dependent on bacterial activity

- Carbon Cycle
  - Organic carbon → CO_2
- Iron Cycle
  - Fe(III) → Fe(II) → Fe(III)…
- Sulfur Cycle
  - SO_4^{-2} → H_2S → S^0 → SO_4^{-2}

Reasons to love bacteria

Food production

Medicine

Energy: Methane & Ethanol

Reasons to love soil bacteria

Bioremediation of polluted soils

Release of nutrients
to food crops

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