NITROGEN AND SULFUR IN SOIL ECONOMY

"THE PULSE AND BODY OF THE SOIL"

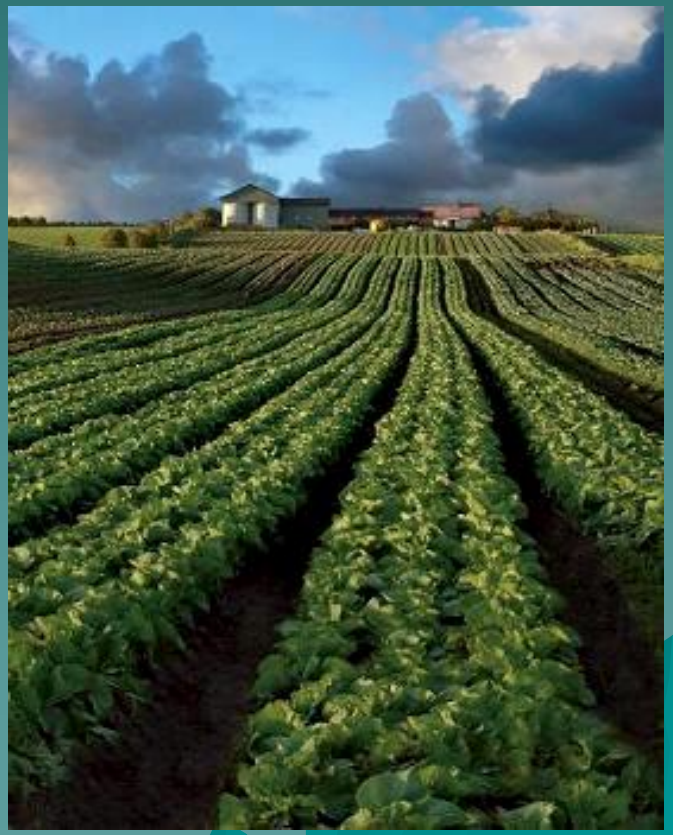
IMPORTANCE OF NITROGEN AND ITS ROLE IN PLANT GROWTH

SHARED CHARACTERISTICS OF NITROGEN AND SULFUR

- Found primarily in organic forms
- Move in soil and into plants as anions
- Responsible for serious global environmental problems
  - N deficiencies (i.e. **chlorosis**)
  - N excesses (i.e. **nitrates**)

CHARACTERISTICS OF N

- N is essential component of **proteins**
- Proteins are nutritionally important
- Supplying N is a major expense in agricultural production

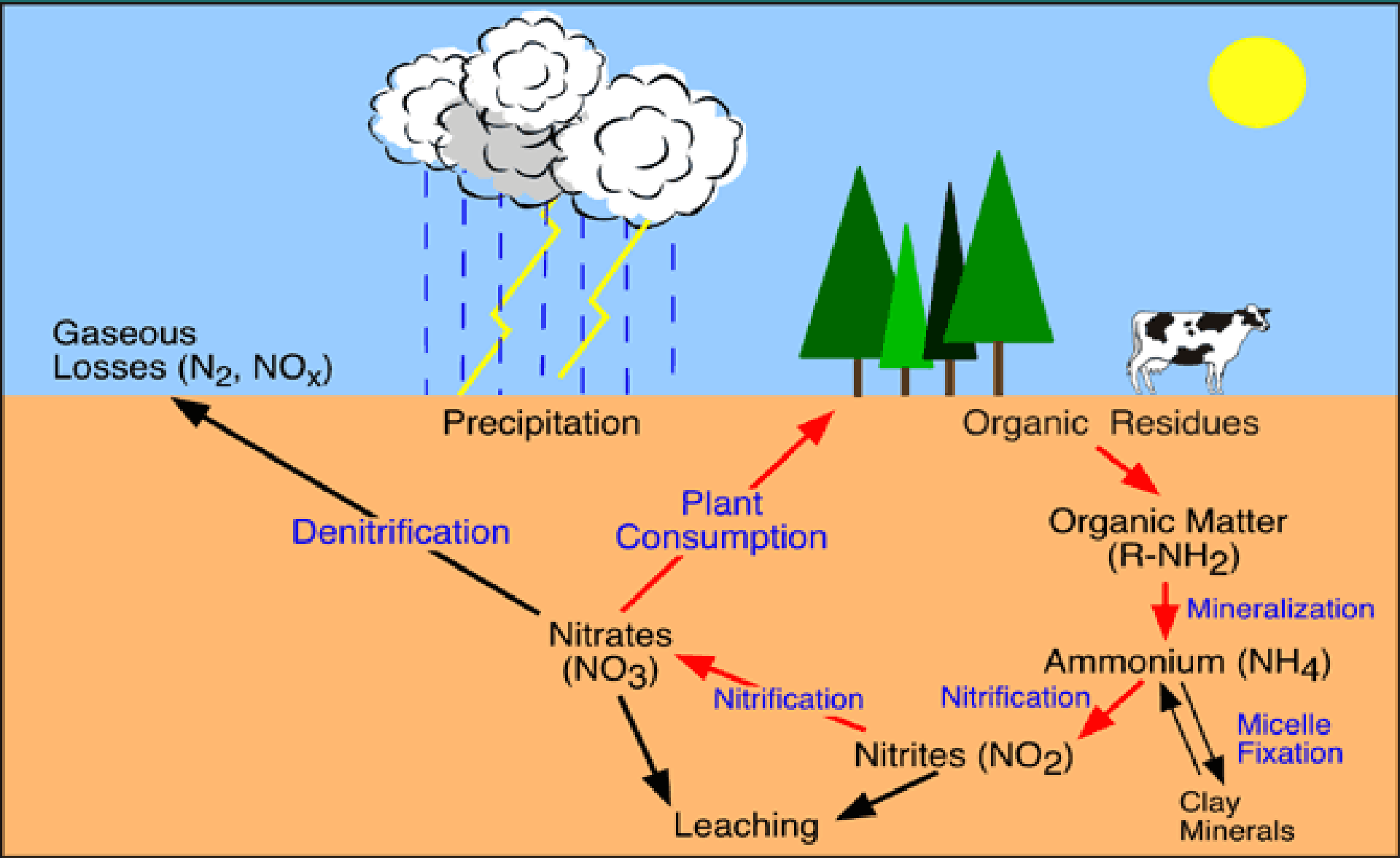


CHARACTERISTICS OF N

- Manufacturing N requires large amounts of fossil fuels

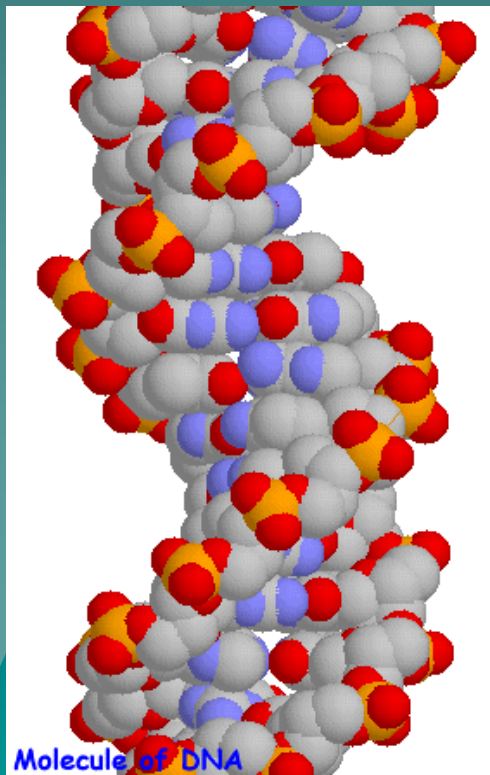
- Soil generate **nitrous oxide** destroys **ozone**

NITROGEN CYCLE

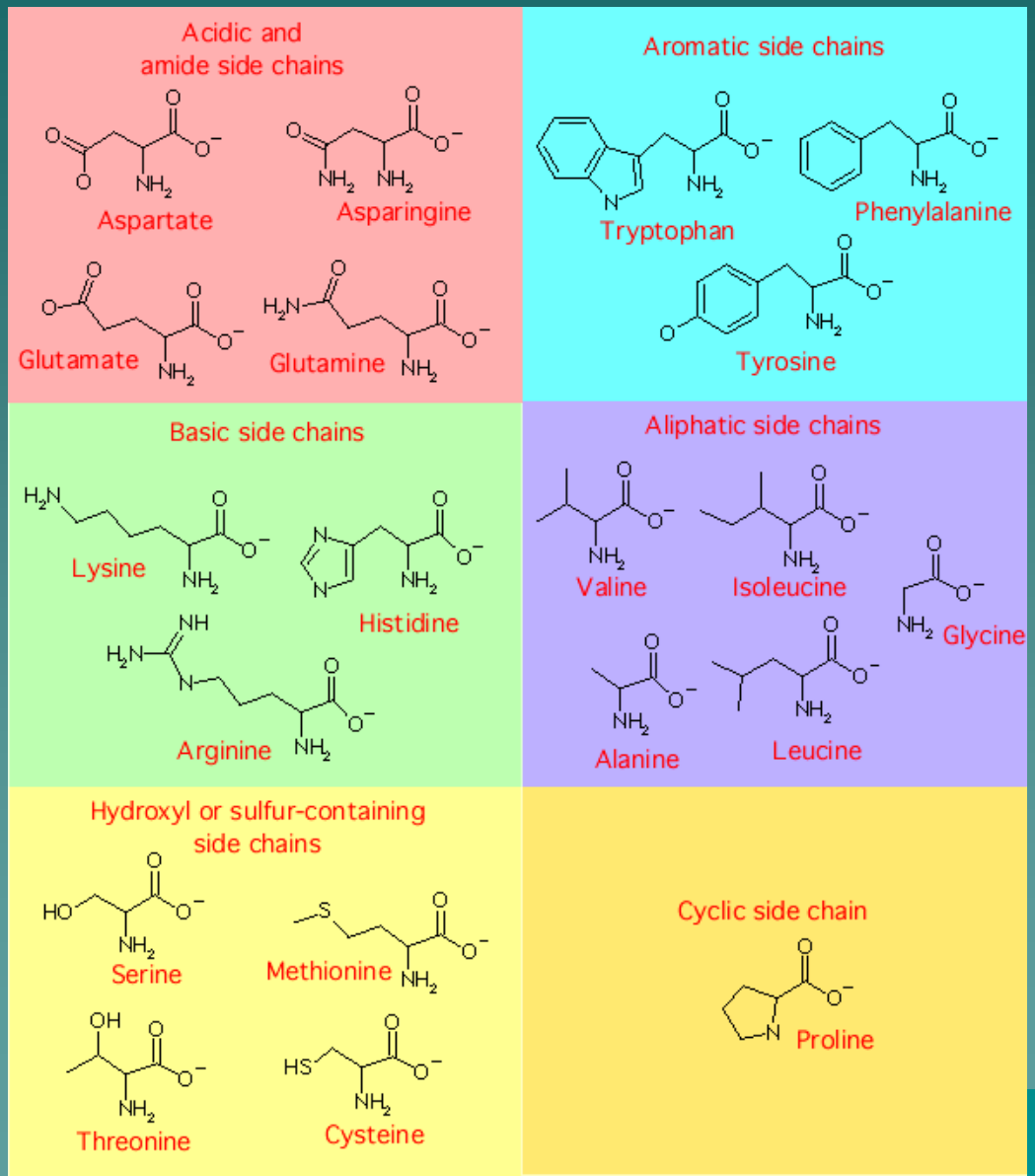


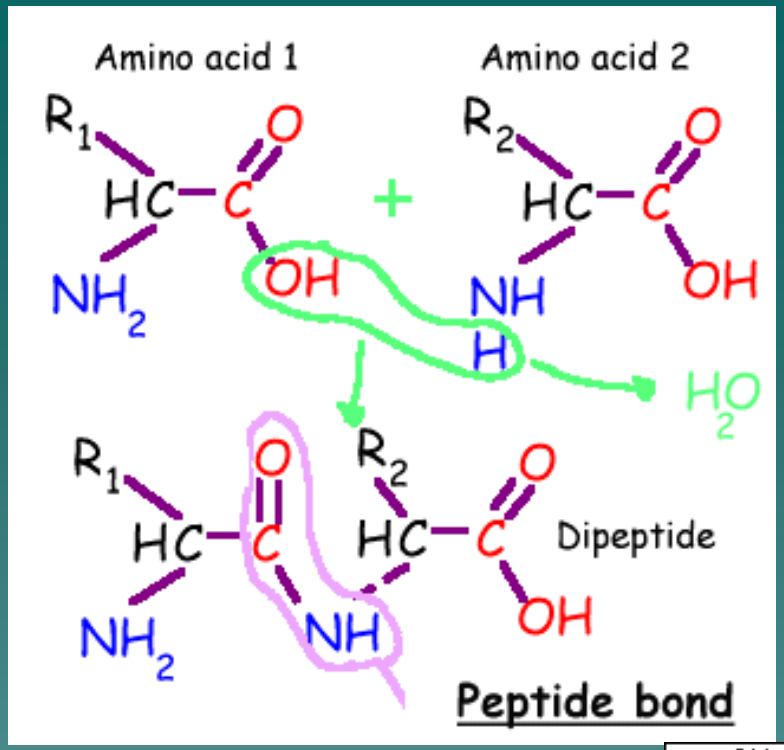
NITROGEN AND PLANT GROWTH AND DEVELOPMENT

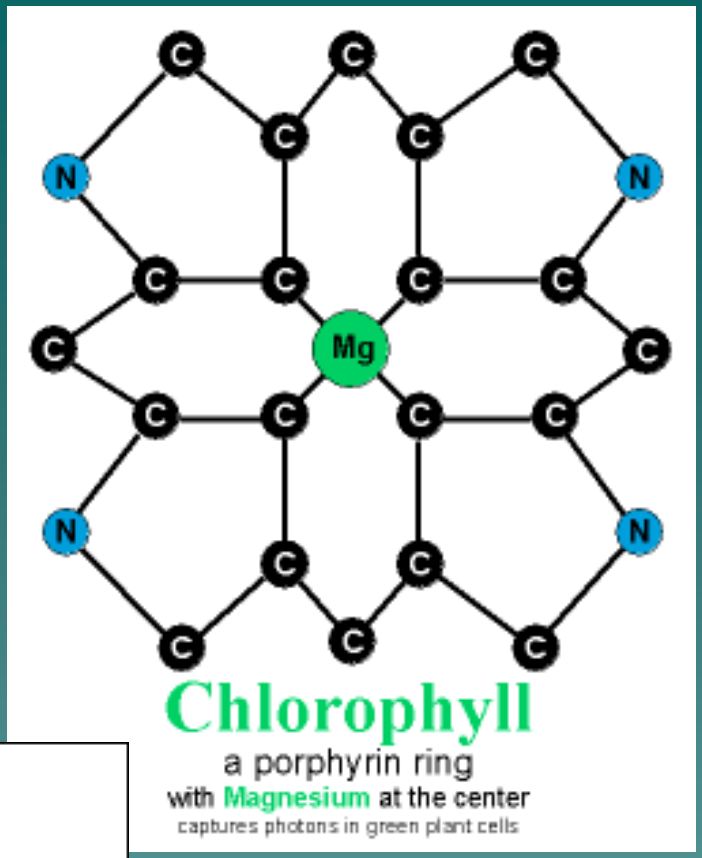
- Integral component of:
  - **Amino acids** for building **proteins** and **enzymes**
  - **Nucleic acids** (DNA, RNA)
  - **Chlorophyll** (photosynthesis)

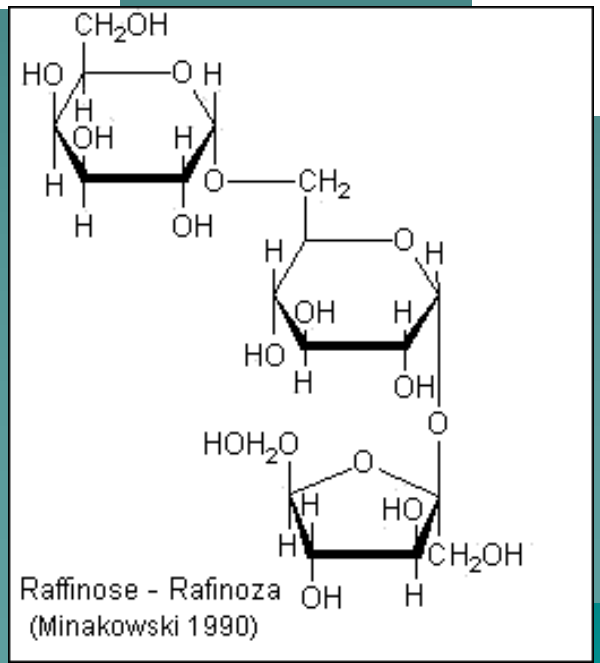


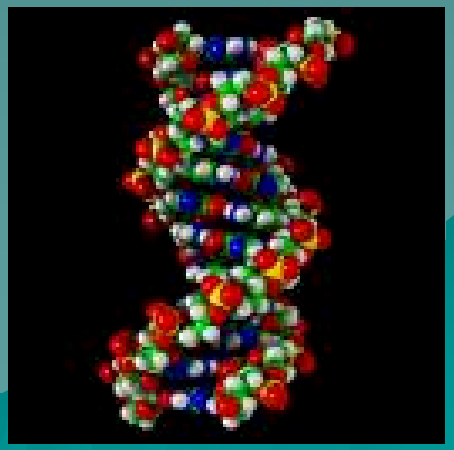
COMMON AMINO ACIDS




Amino acid 1
Amino acid 2
Dipeptide
Peptide bond


Chlorophyll
a porphyrin ring
with Magnesium at the center
captures photons in green plant cells


Raffinose - Rafinoza
(Minakowski 1990)



NITROGEN AND PLANT GROWTH AND DEVELOPMENT

- Integral component essential plant compounds
  - Use of **carbohydrates**
  - Stimulates root growth
  - Assists with uptake of nutrients

NITROGEN AND PLANT GROWTH AND DEVELOPMENT

- N deficient plants are **chlorotic**
- Stunted appearance
- Develop thin, spindly stems

NITROGEN AND PLANT GROWTH AND DEVELOPMENT

- Mobile (easily **translocated**) within the plant

- **Older tissues show chlorosis before younger tissues**

NITROGEN AND PLANT GROWTH AND DEVELOPMENT

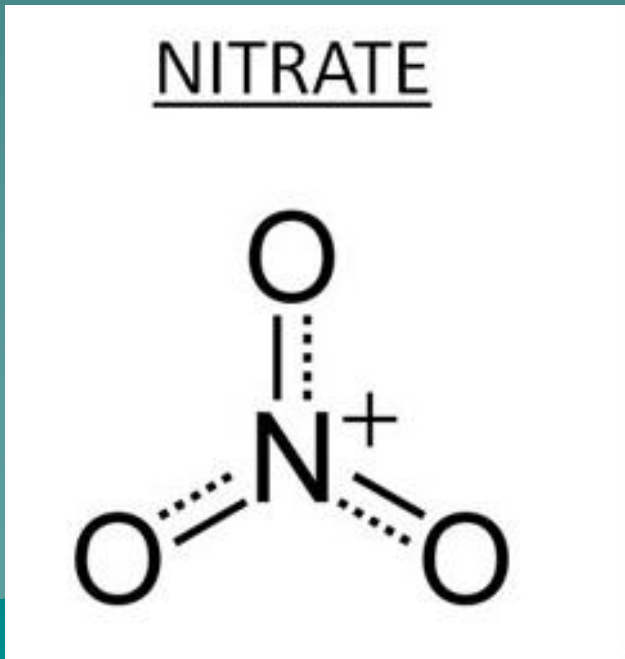
- Excessive N results in excessive vegetative growth
- Plant stems are enlarged, but weak
- Plants are prone to **lodging**
- May delay plant maturity

NITROGEN AND PLANT GROWTH AND DEVELOPMENT

- Increases susceptibility to diseases and insects
- Degrades crop quality
- Flowering reduced
- High **nitrates** in food crops

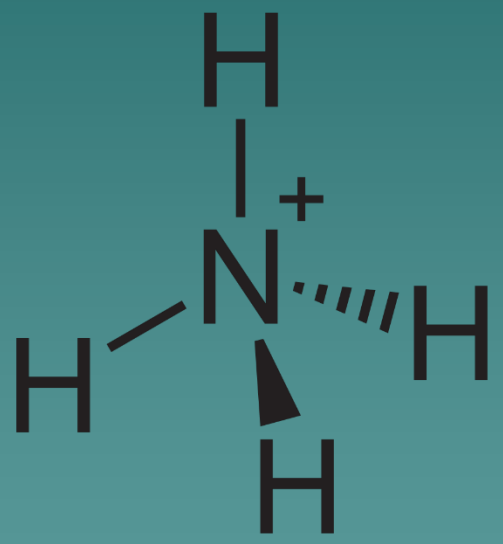
NITROGEN AND PLANT GROWTH AND DEVELOPMENT

- Plant roots take up N from soil solution as **nitrate (NO_3^-)**
  - Moves easily to root in soil water
  - Exchanges at root surface
  - Increases soil pH near roots



NITROGEN AND PLANT GROWTH AND DEVELOPMENT

- Plant roots take up N from soil solution as **ammonium (NH_4^+)**
  - Exchange at root surface
  - Lowers soil pH near roots



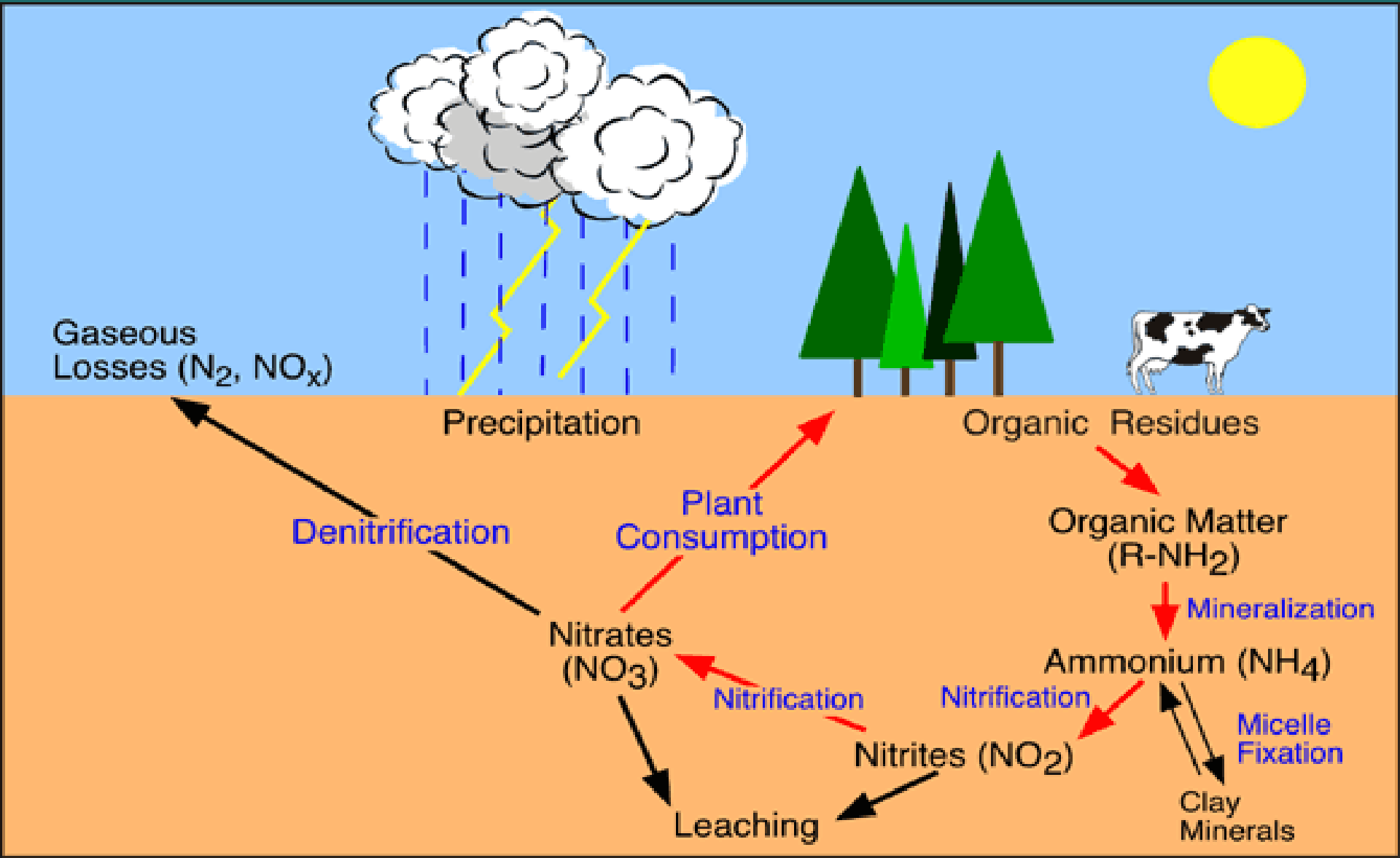
- **A mixture of nitrate and ammonium is best for plants**

NITROGEN FIXATION

- ***Process by which gaseous elemental nitrogen (N) is chemically combined with hydrogen (H) to form ammonia (NH_4^+)***

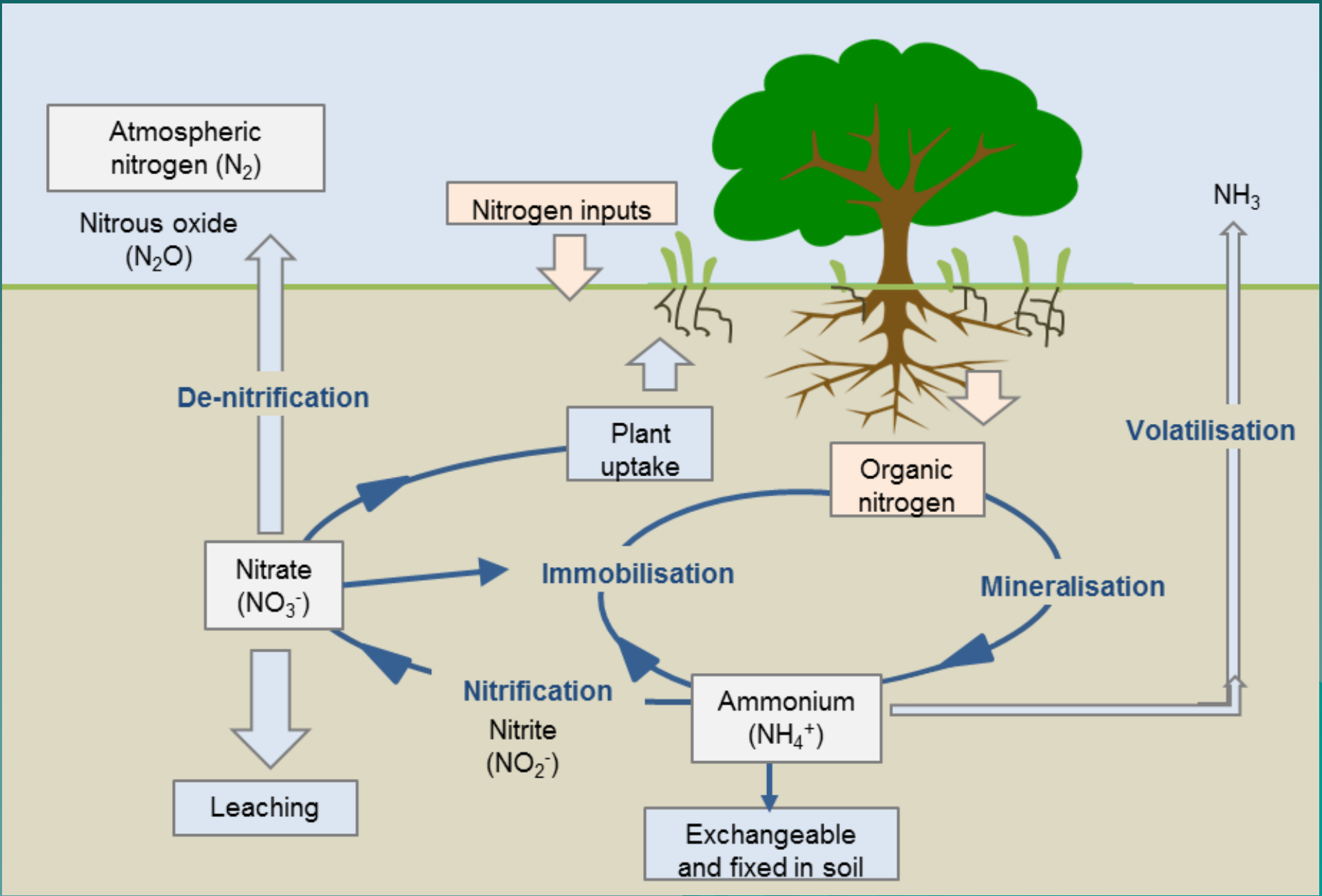
- Occurs at ordinary temperatures and is carried out by certain bacteria, algae, and actinomycetes

NITROGEN CYCLE



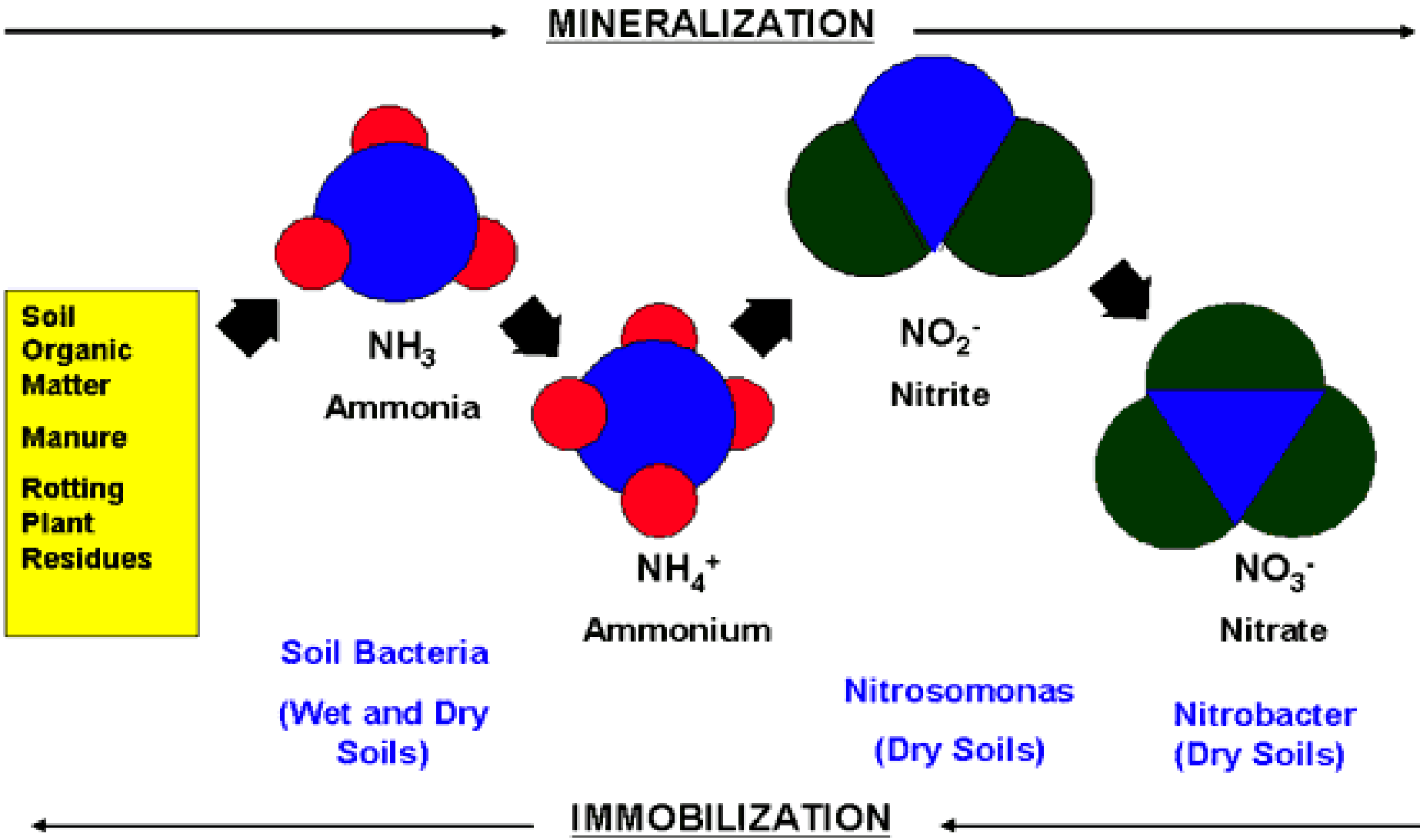
IMMOBILIZATION AND MINERALIZATION

- 95-99% of soil nitrogen is in organic compounds, protected from loss, but unavailable to plants
- Present in **proteins** or **humus**


Atmospheric nitrogen (N_2)
Nitrous oxide (N_2O)
Nitrogen inputs
NH_3
De-nitrification
Plant uptake
Organic nitrogen
Volatilisation
Nitrate (NO_3^-)
Immobilisation
Mineralisation
Nitrification
Nitrite (NO_2^-)
Ammonium (NH_4^+)
Leaching
Exchangeable and fixed in soil

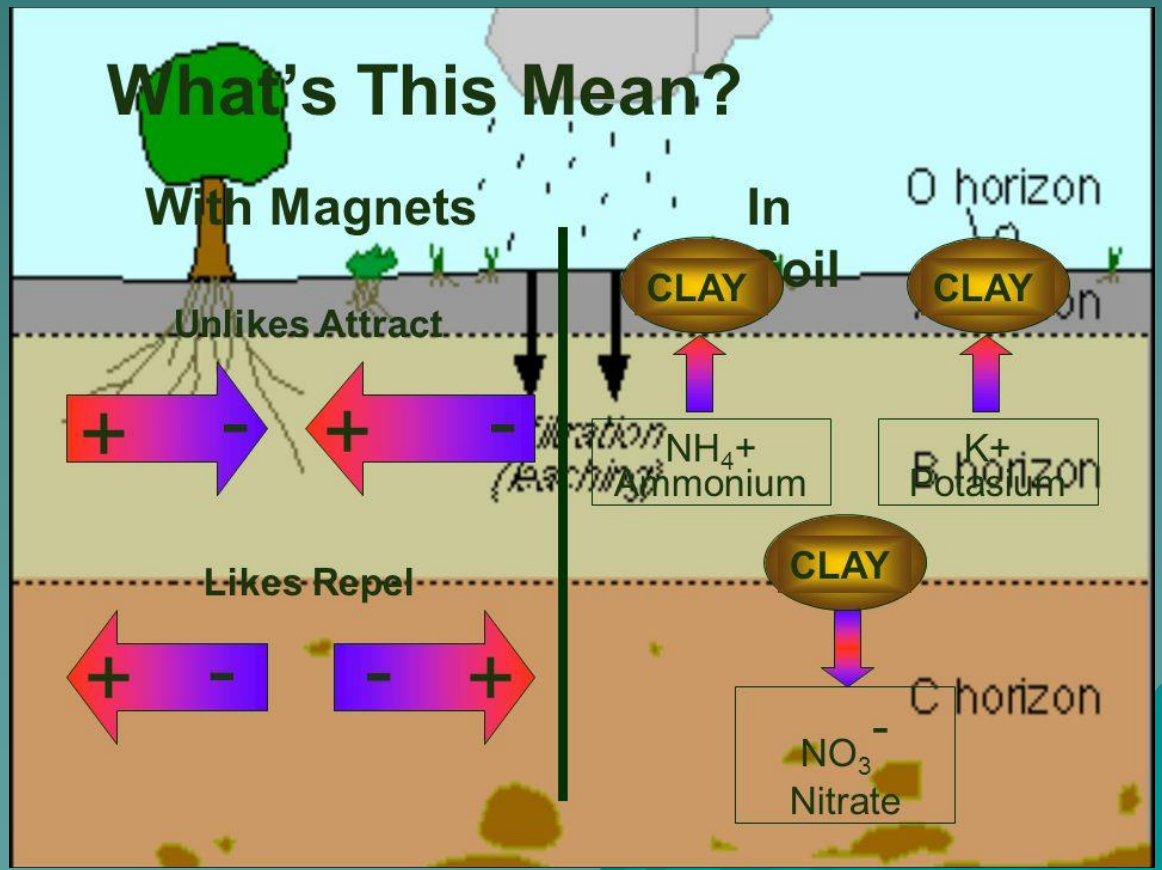
Mineralization and Immobilization

Created by J. Strock
University of Minnesota



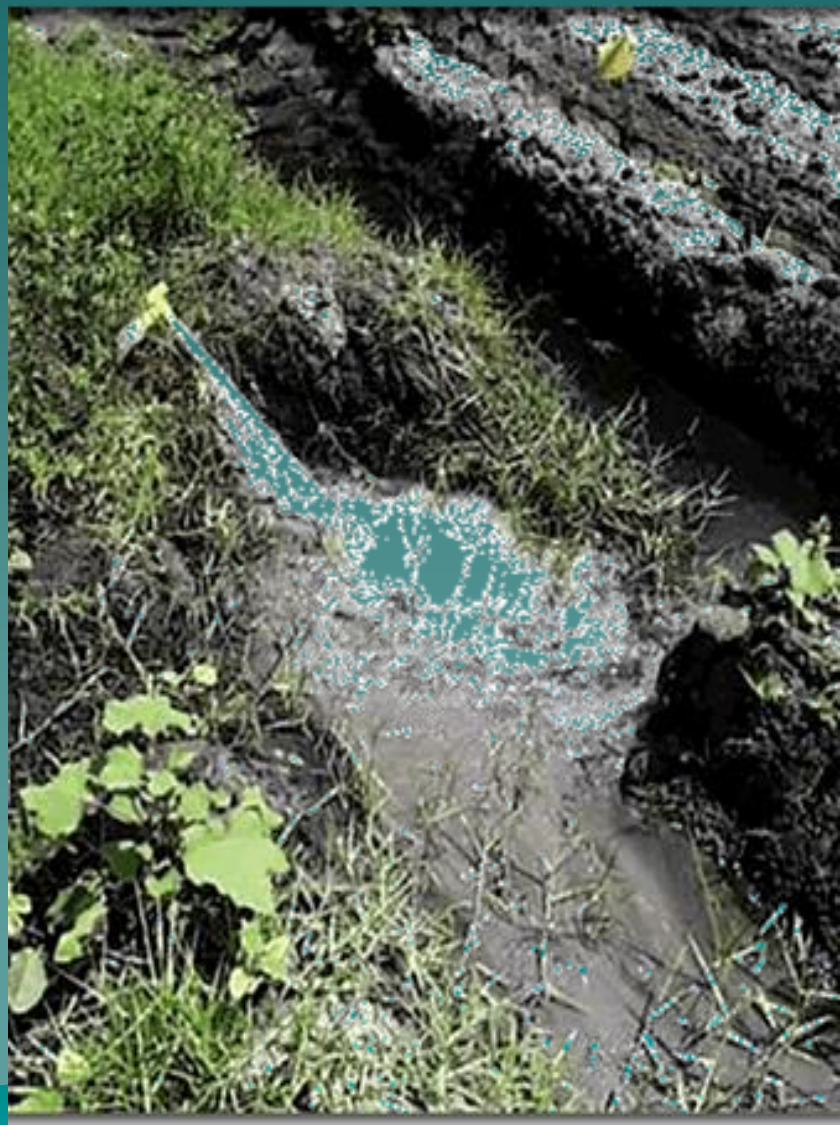
AMMONIUM AND CLAY COLLOIDS

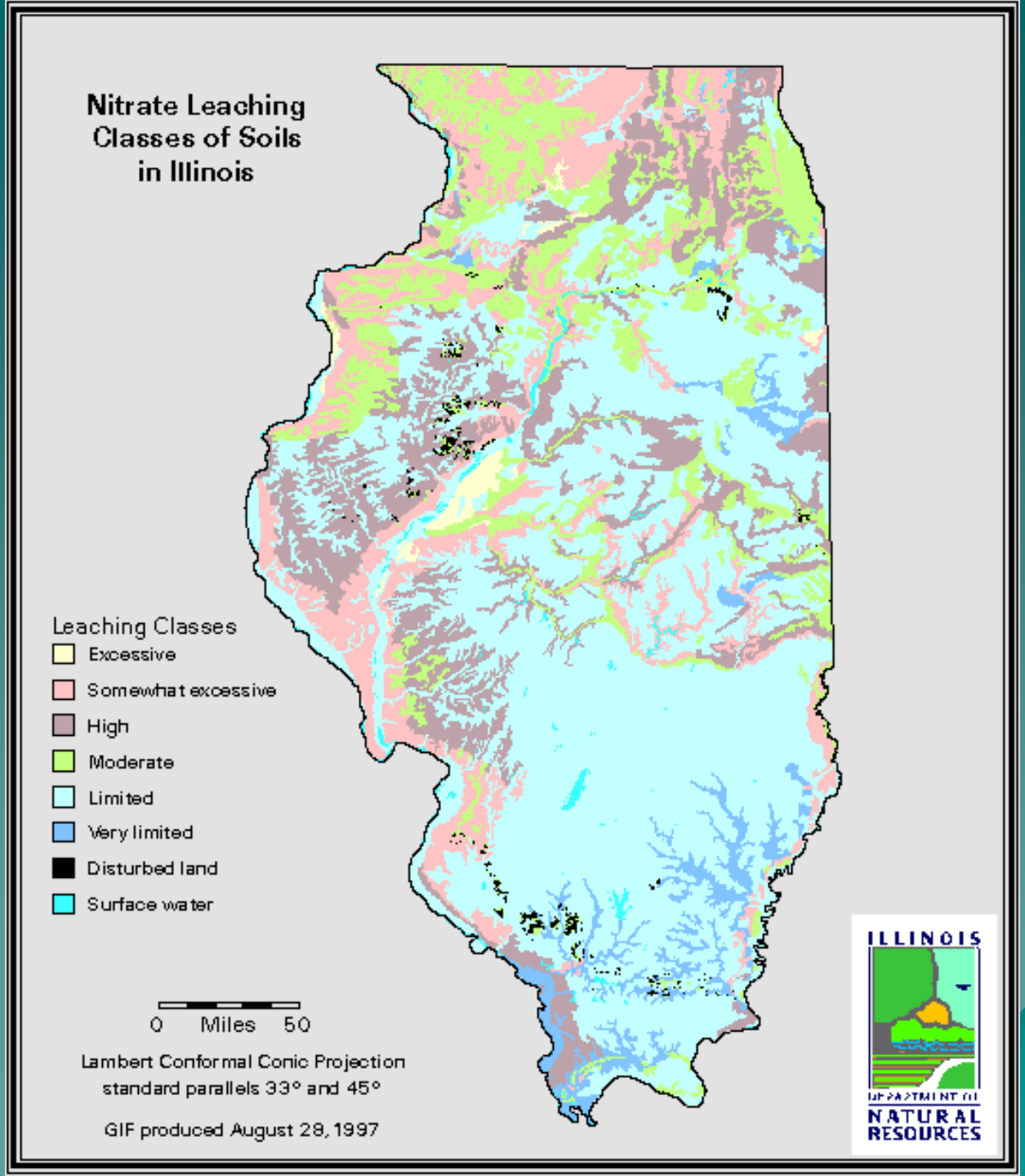
- **NH_4^+ can be held by certain clays**
  - Non-exchangeable form
  - Released slowly to plants and microbes



NITRATE LEACHING PROBLEM

- Negatively charged nitrate ions are repelled by negatively charged clay colloids
- Nitrates move freely with drainage water



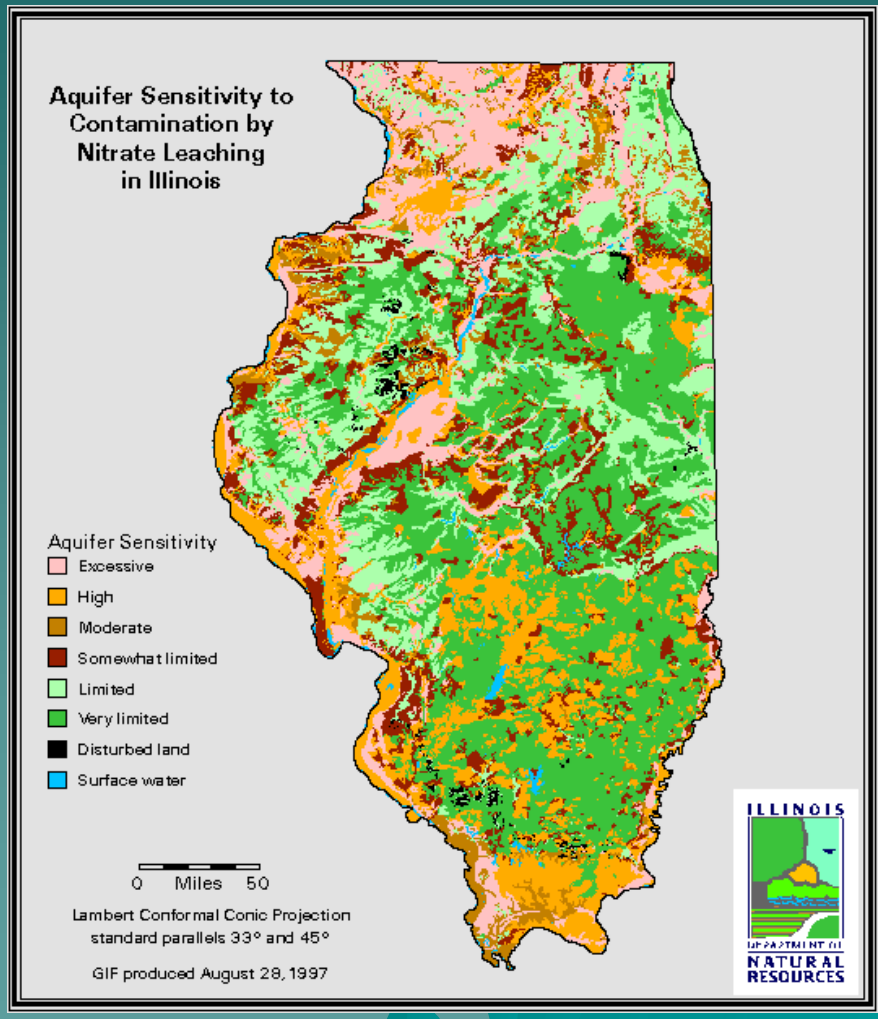

Nitrate Leaching Classes of Soils in Illinois
Leaching Classes
Excessive
Somewhat excessive
High
Moderate
Limited
Very limited
Disturbed land
Surface water
0 Miles 50
Lambert Conformal Conic Projection
standard parallels 33° and 45°
GIF produced August 28, 1997
ILLINOIS
DEPARTMENT OF
NATURAL
RESOURCES

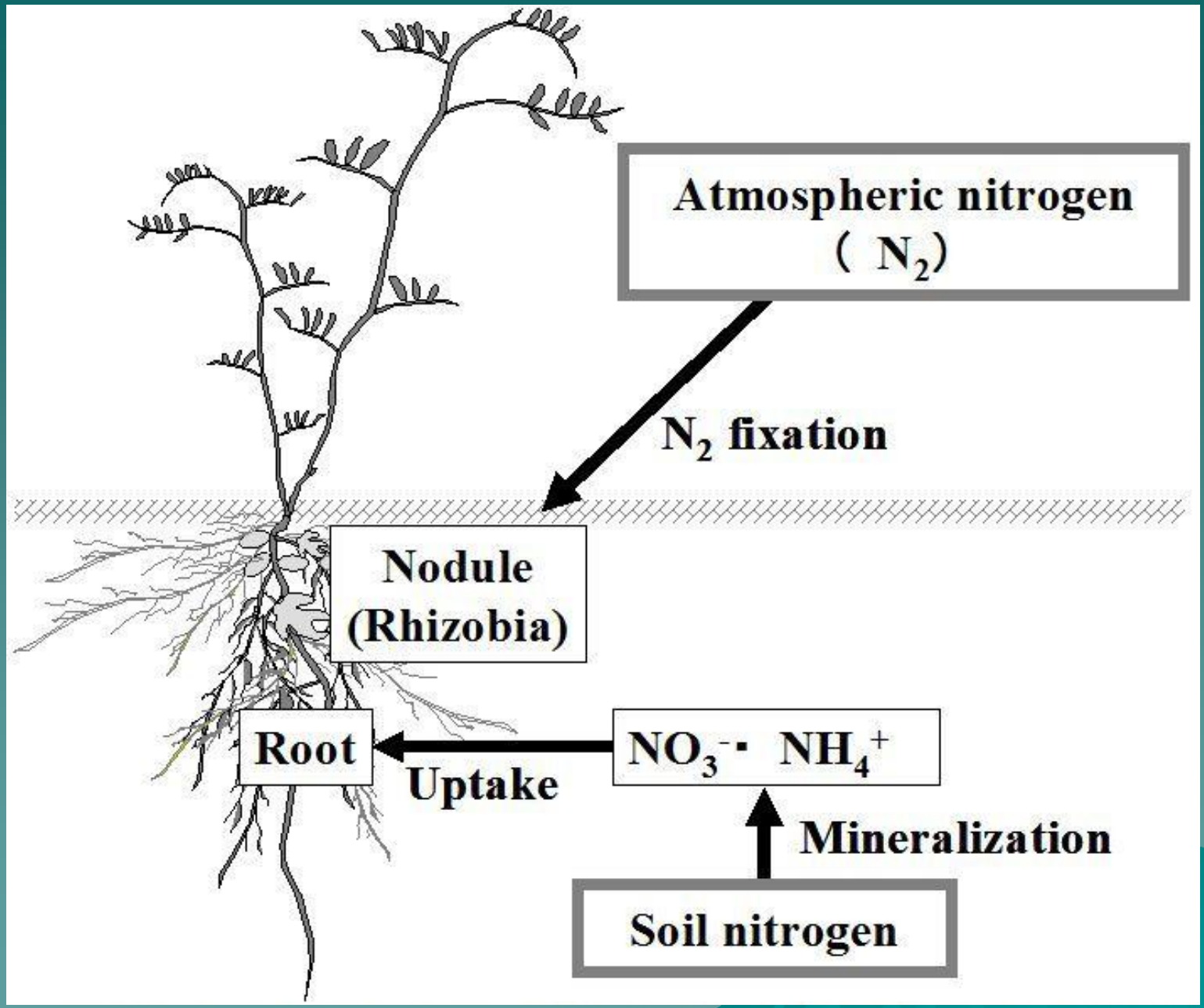
NITRATE LEACHING PROBLEM

- Contributes to **impoverished ecosystem**
- Loss of N
- Facilitates loss of Ca and other cations
- Economic loss equal to value of N lost
- Contaminates drinking water
- Causes **eutrophication**

NITRATE LEACHING PROBLEM

- Amount of water leaching through soil
- Nitrate content of water
- Highest in **highly fertilized sandy soils** with high rainfall
- **Over fertilization**




Atmospheric nitrogen
(N_2)
N_2 fixation
Nodule
(Rhizobia)
Root
Uptake
NO_3^-· NH_4^+
Mineralization
Soil nitrogen

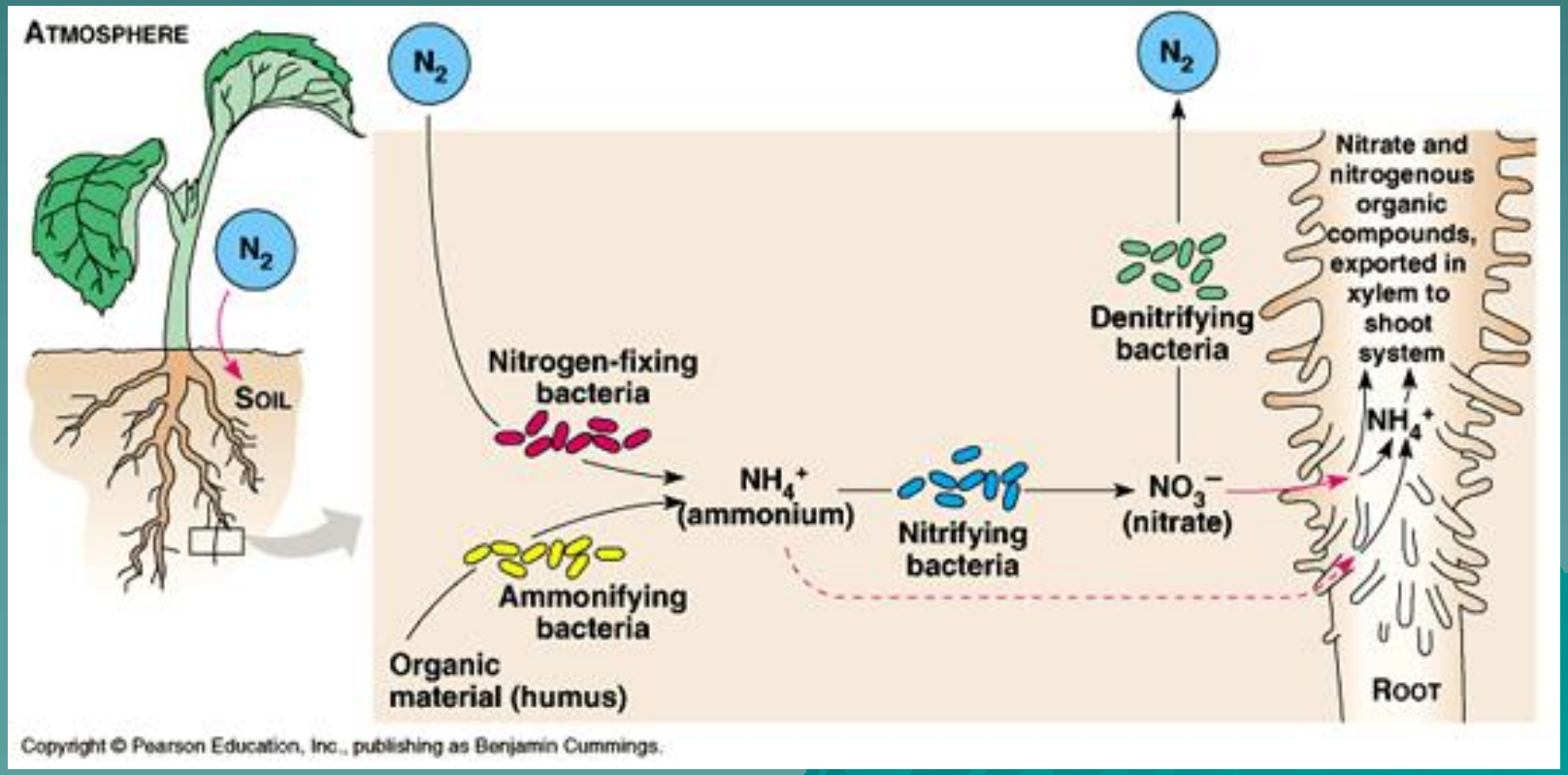
BIOLOGICAL NITROGEN FIXATION

- **Most important biochemical reaction on earth after photosynthesis**
- Atmospheric **di-nitrogen gas (N_2)** converted to N-containing organic compounds via **nitrogen cycle**
- Carried out by **bacteria, actinomycetes, and blue-green algae**

Biological Nitrogen Fixation

$$N_2 + 8\,H^+ + 8\,e^- \xrightarrow{\text{nitrogenase}} 2\,NH_3 + H_2$$

$$16\ \text{Mg-ATP} \longrightarrow 16\ \text{Mg-ADP} + 16\ P_i$$

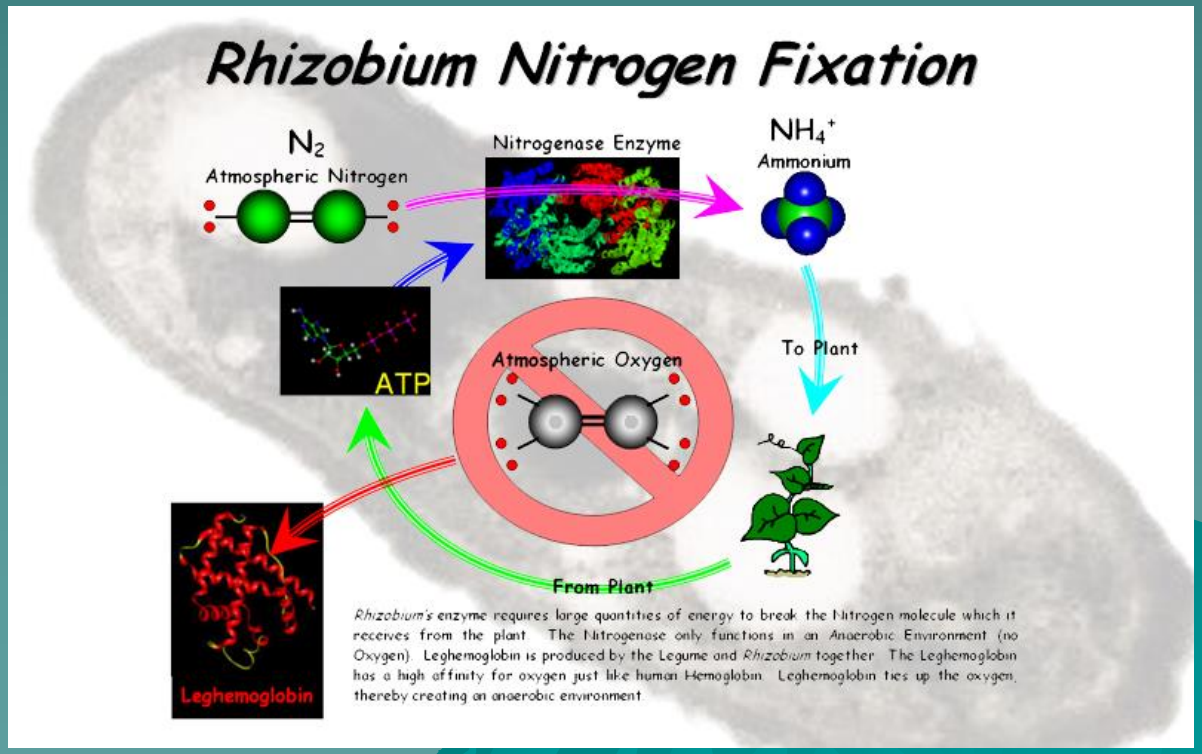


TYPES OF BIOLOGICAL NITROGEN FIXATION

- Legumes with nodules and bacteria
- Non-legumes with nodules and actinomycetes
- Non-legumes without nodules and with cyno-bacteria (blue-green algae)
- Non-symbiotic or free-living legumes

N FIXATION SYSTEMS

- **Symbiotic relationship** between legumes and bacteria (*Rhizobium/Bradyrhizobium*)
- **Provide the major source of fixed N in agriculture**



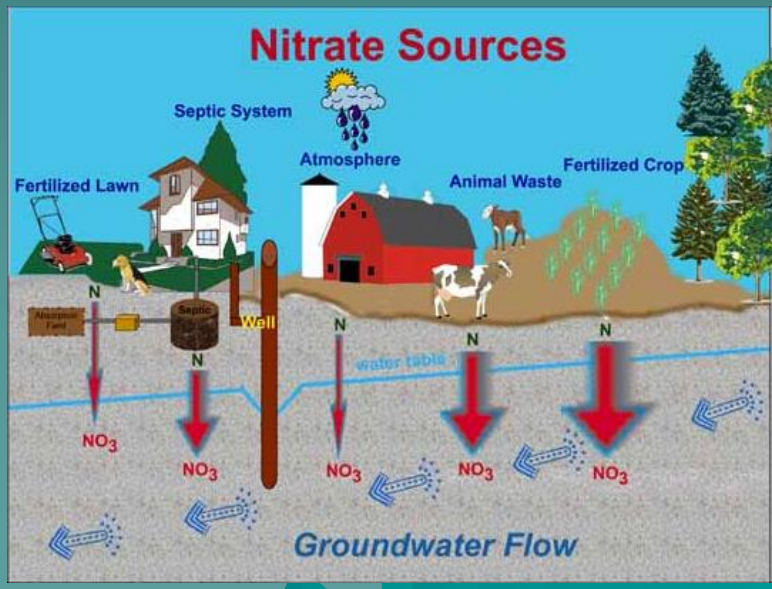
SYMBIOTIC N FIXATION WITH LEGUMES

- Bacteria "infect" plant and form **root nodules** which is site of N fixation
- Plant supplies bacteria with carbohydrates
- Bacteria supply plant with fixed N compounds

REACTION OF N FERTILIZERS

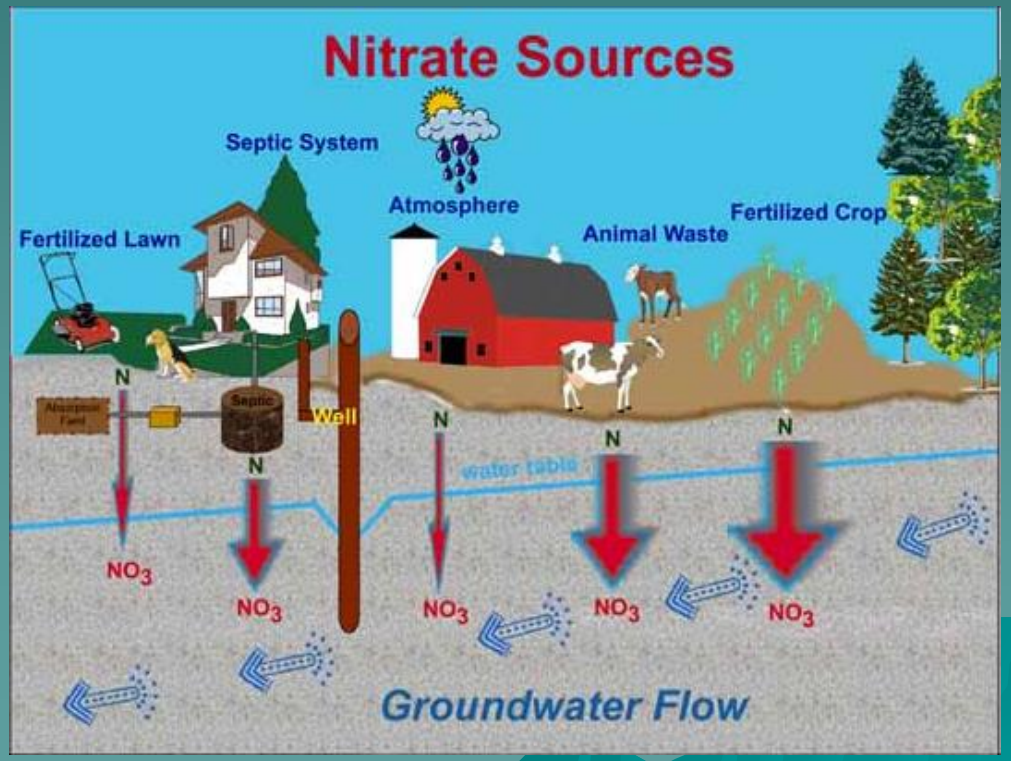
- May increase soil acidity

- Excess N can be lost via:
  - Leaching
  - Surface runoff
  - De-nitrificaiton
  - Ammonia volatilization



PRACTICAL MANAGEMENT OF SOIL N IN AGRICULTURE

- **Challenge is to harmonize N losses and N gains for optimum plant growth**



END OF PRESENTATION