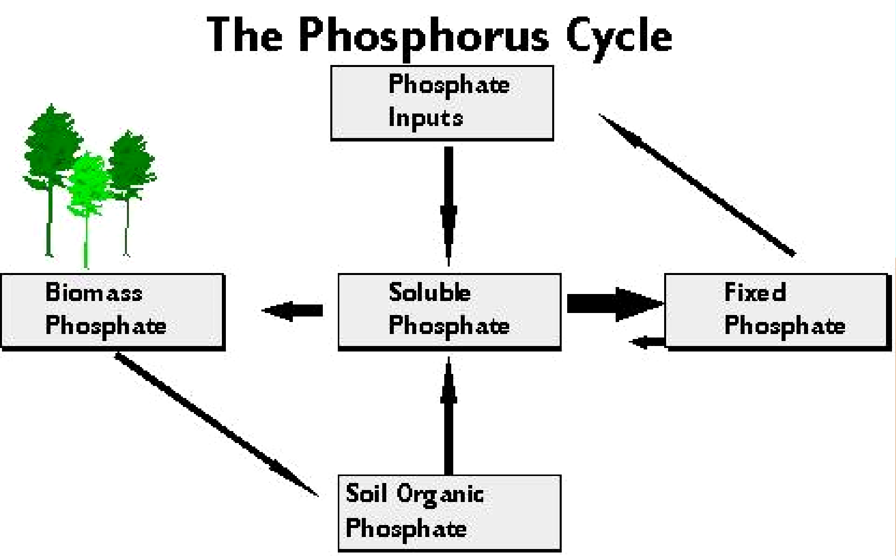
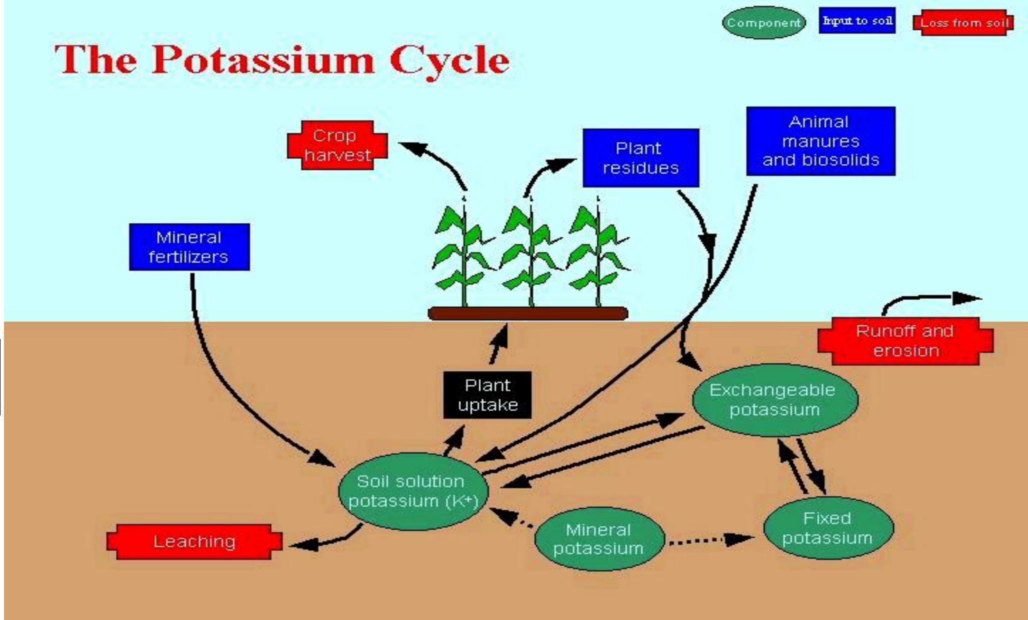
SOIL PHOSPHORUS, POTASSIUM, AND MICRONUTRIENTS





PHOSPHORUS

- Second only to N in importance

- Levels are low in native soils

- P must be continually replenished from soil minerals and OM

- Plant generally absorb P as inorganic phosphates (HPO_4^{-2} or $H_2PO_4^-$)

PHOSPHORUS

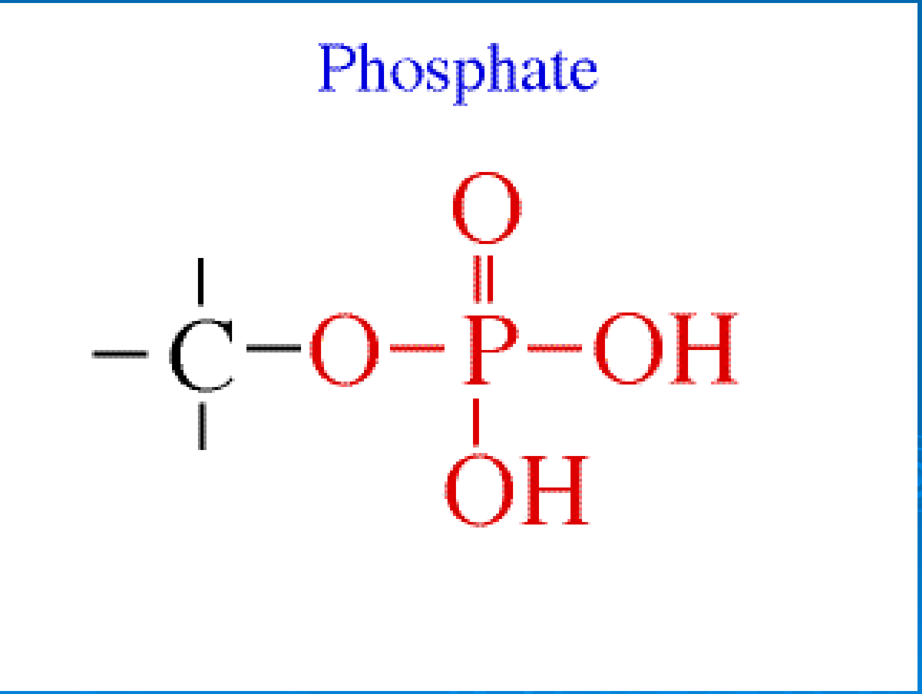
- Must be converted to simple inorganic phosphate for plant uptake

- Crop removal will diminish soil P levels

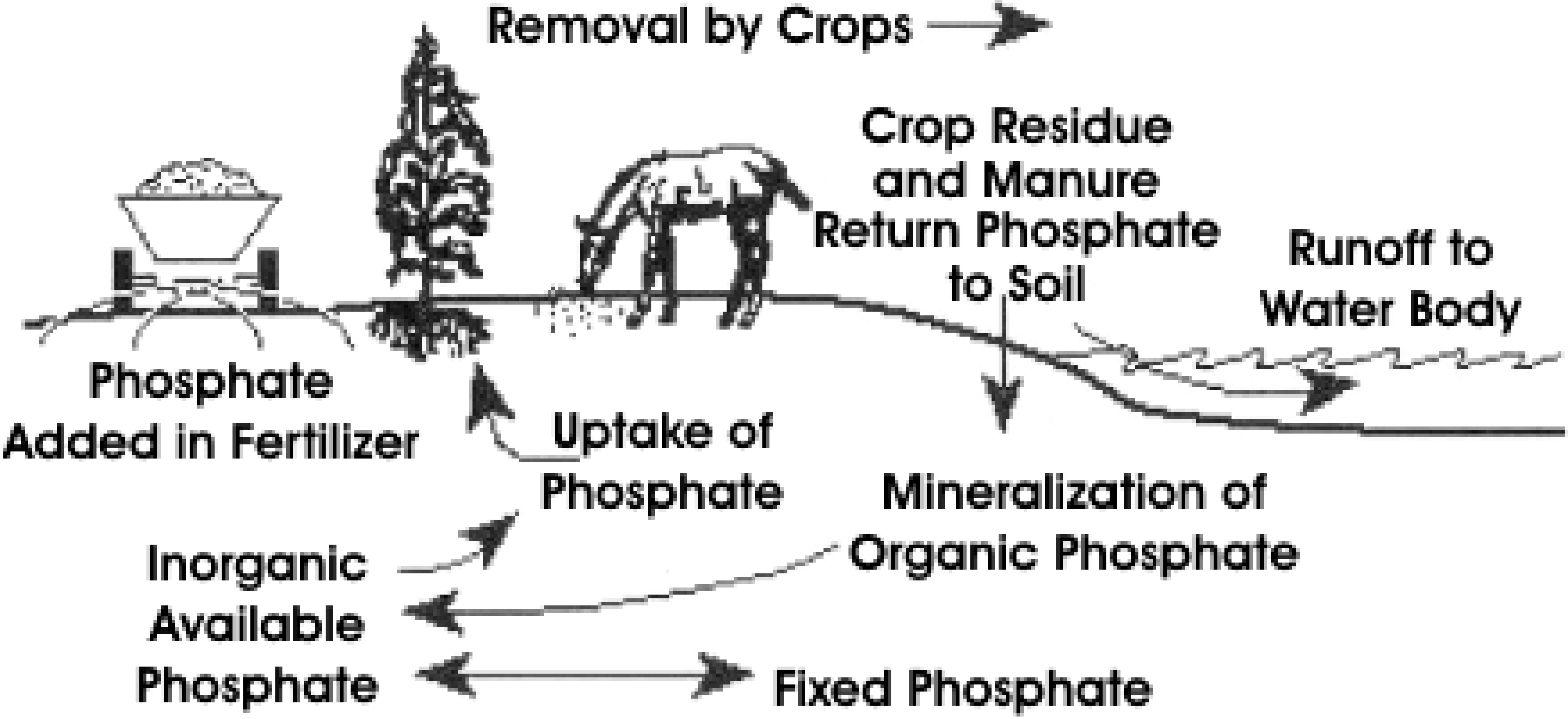
- Excessive applications leads to **eutrophication** (Gr. "***well nourished***")

SOURCES OF PHOSPHORUS

- Commercial fertilizers
- Animal manure
- Biosolids
- Crop residues

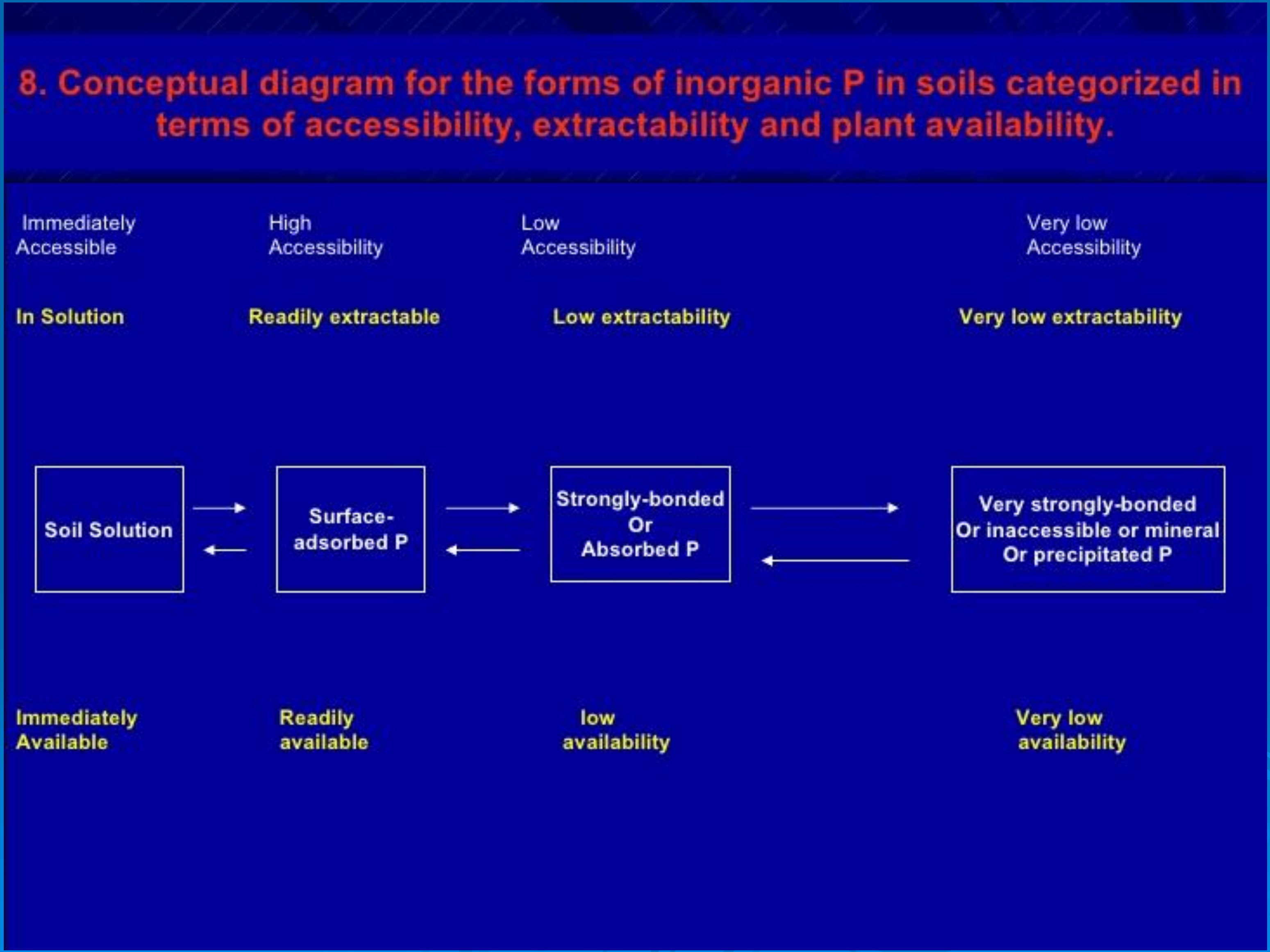


The Phosphorus Cycle



Source: Busman et al., 1997.

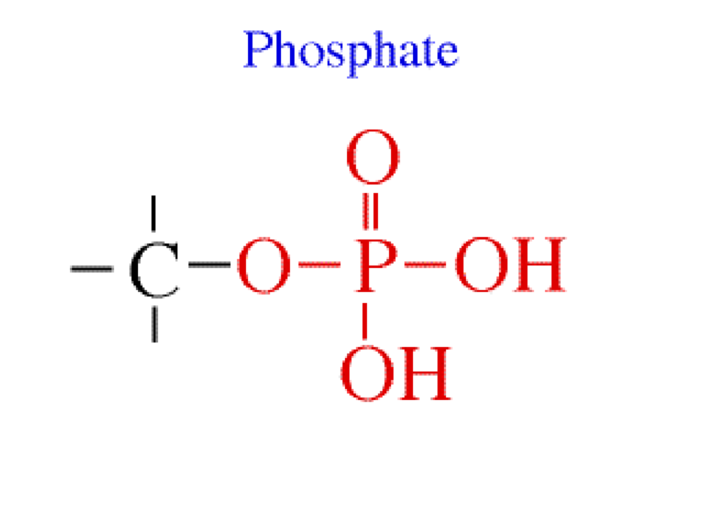
AVAILABILITY OF P IN SOILS



AVAILABLE PHOSPHORUS

- P in soil solution
  - Very low
  - Plants absorb P as phosphate ions

- Uptake by roots and **mycorrhizae**
  - Slow diffusion of P ions to root surface

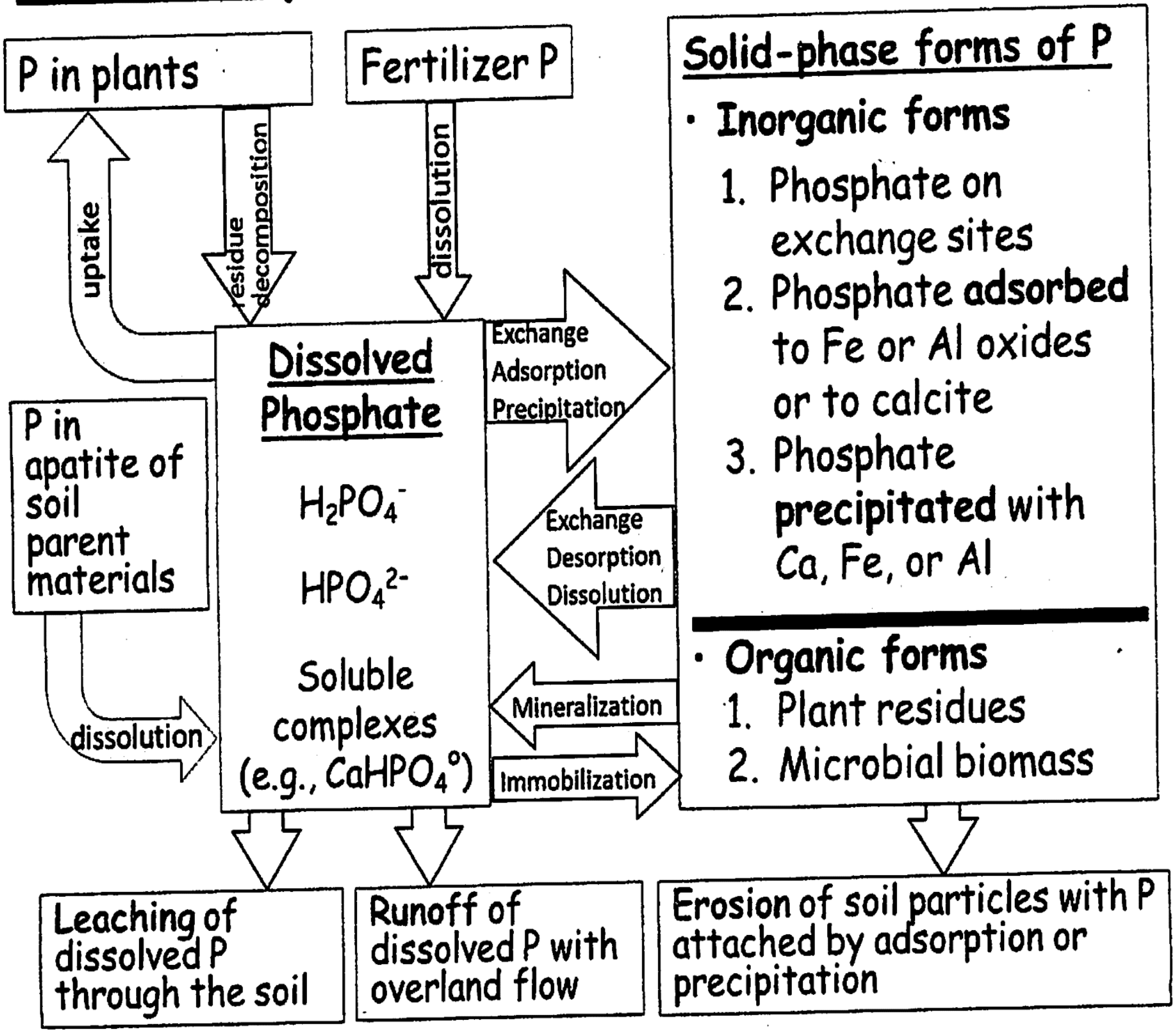


- **Plants take up soluble P as orthophosphate ($H_2PO_4^-$ or HPO_4^{-2})**

AVAILABLE PHOSPHORUS

- **Chemical forms in soils**
  - Organic P's
  - Calcium-bound inorganic P's
  - Al and/or Fe bound inorganic P's
  - Most P's have very low solubility and not readily available for plant uptake

Soil Phosphorus



THE PHOSPHORUS CYCLE

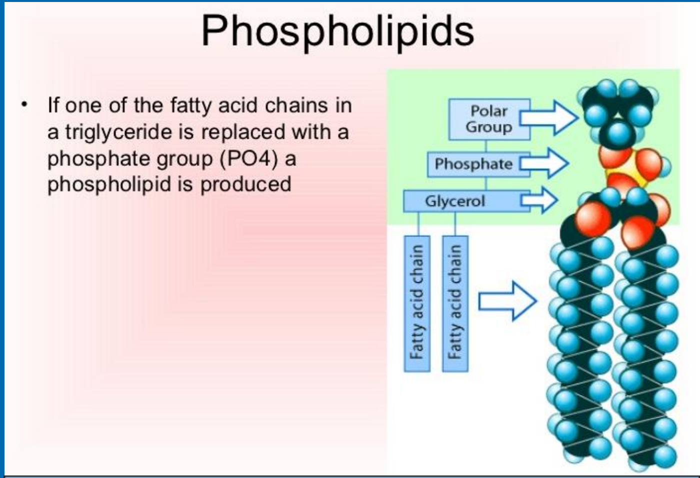
- **Losses**
  - Plant removal
  - Erosion of P-carrying soil particles
  - P dissolved in surface runoff water

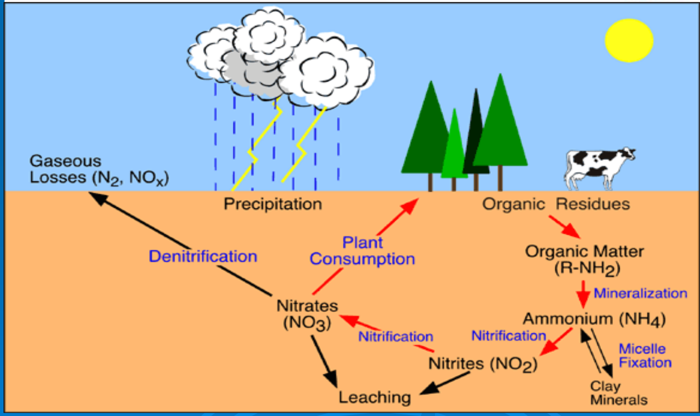
- **Gains**
  - Fertilizers
  - Manure
  - Plant residues

IMPORTANCE OF PHOSPHORUS FOR PLANT GROWTH

- **Phospholipids** (cellular membranes)

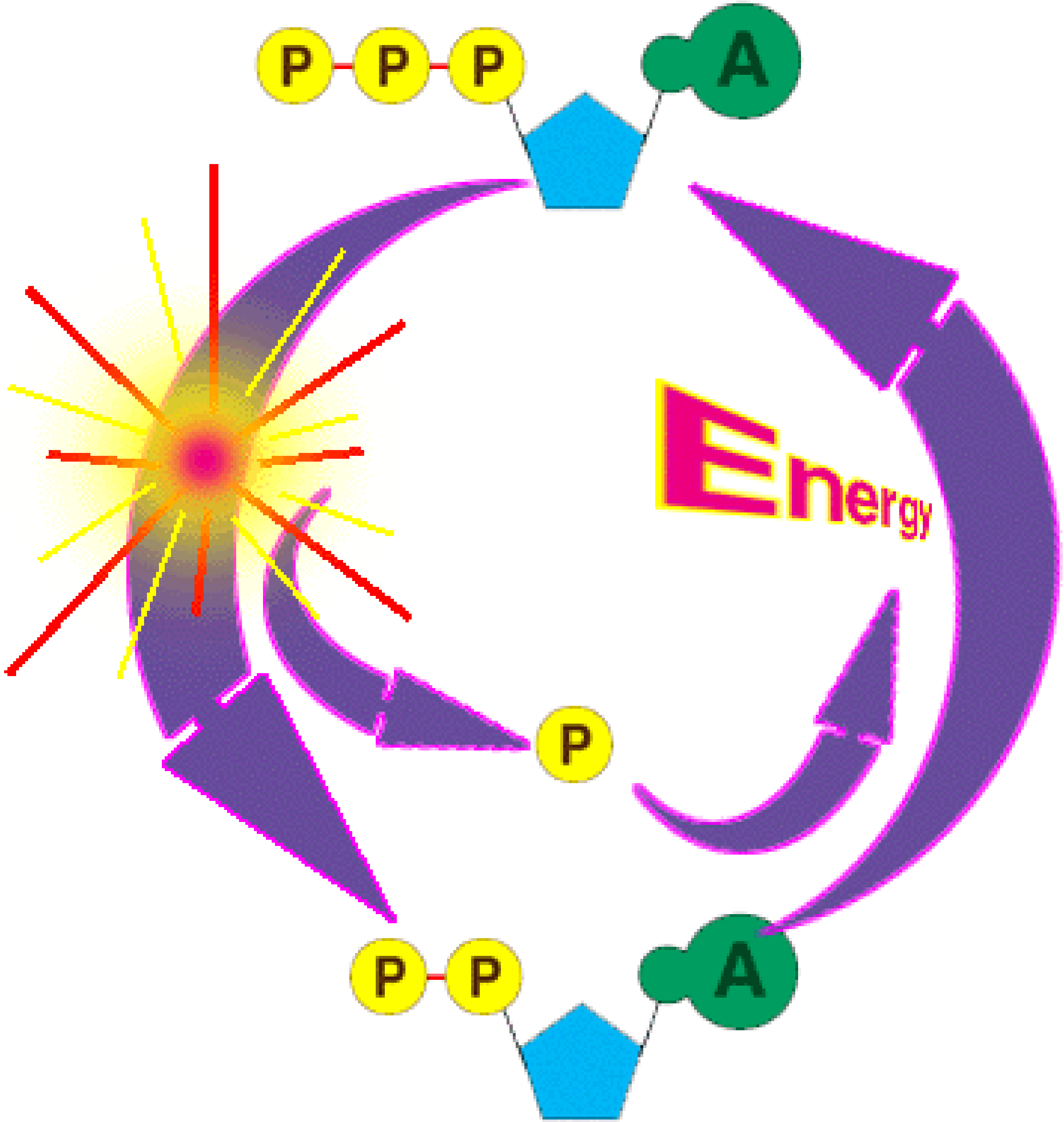
- Enhances **plant physiology:**
  - Photosynthesis
  - N fixation
  - Flowering
  - Fruiting
  - Maturation
  - Root growth

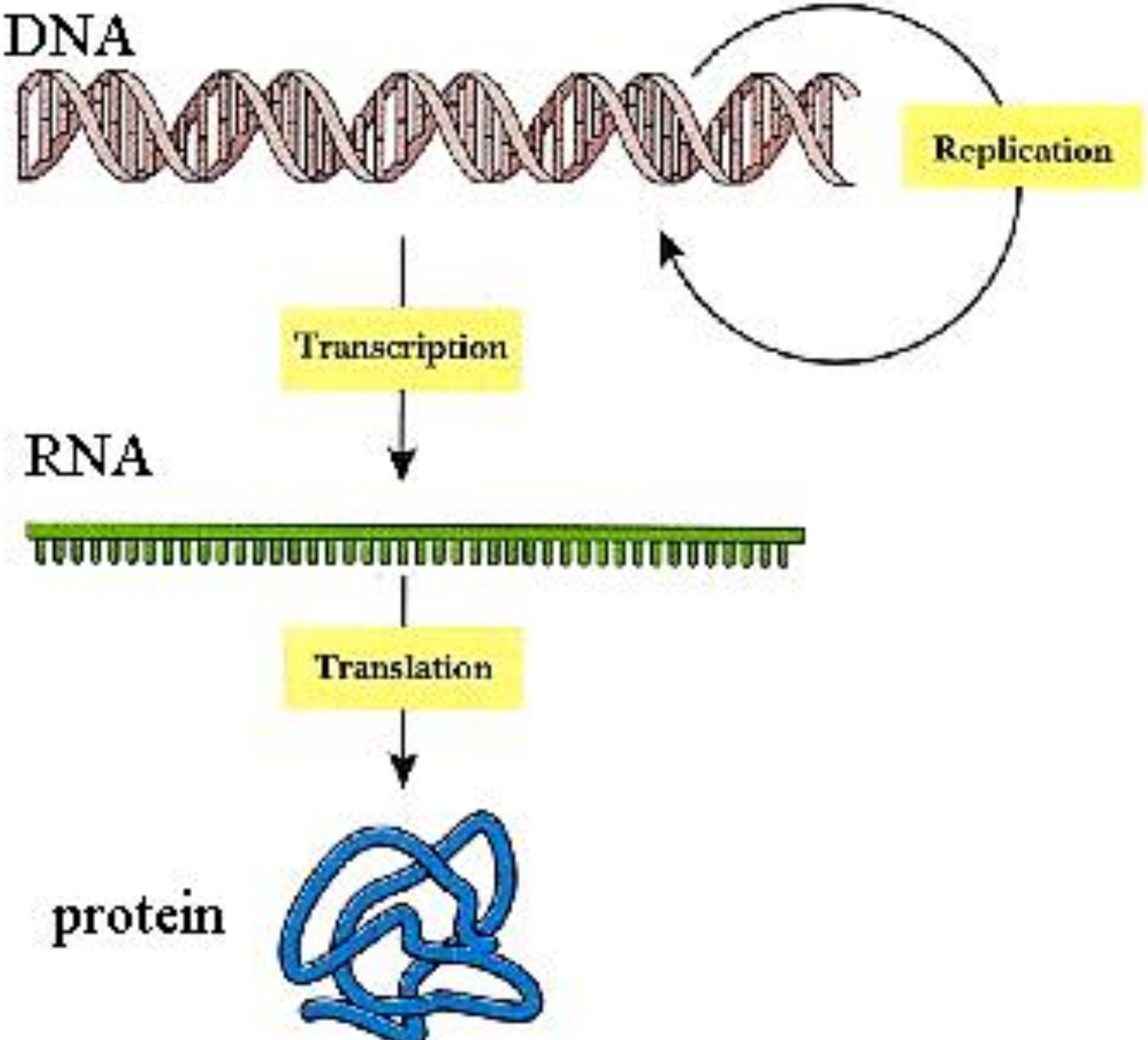




IMPORTANCE OF PHOSPHORUS FOR PLANT GROWTH

- **ATP** (“energy currency”)
- **DNA** (seat of genetic inheritance)
- **RNA** (directs protein synthesis)


P
P
P
A
Energy
P
P
P
A


DNA
Replication
Transcription
RNA
Translation
protein

P Deficiency Symptoms

- Stunting
- Thin and spindly stems
- **Dark, bluish-green or purple foliage**

P Deficiency Symptoms

- Chlorosis
- Leaf senescence
- **Very mobile in plant**
- **Deficiencies appear first in older leaves**

P Deficiency Symptoms

- Needed in large amounts by **meristematic** tissues
- Delayed maturity and sparse flowering
- Poor seed quality

P AND ENVIRONMENTAL QUALITY

- Accelerated eutrophication

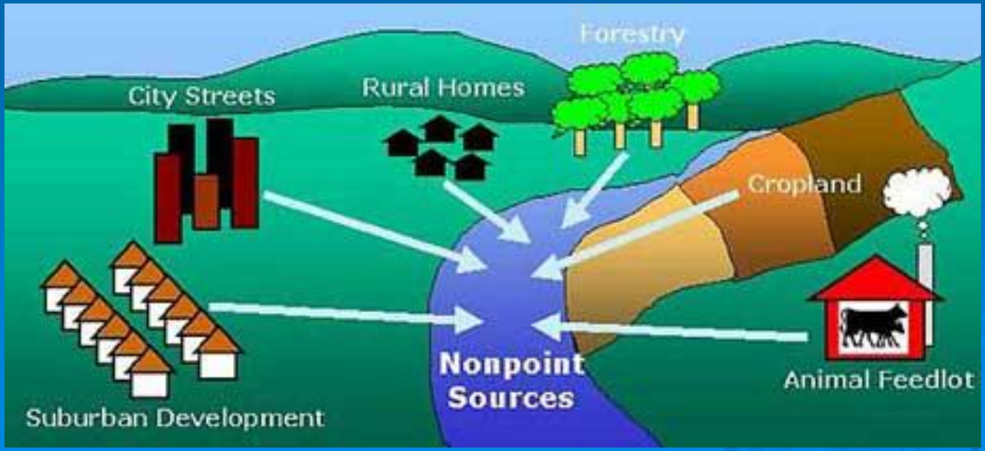
- Soluble sources of P may be be **fixed** (**unavailable**)

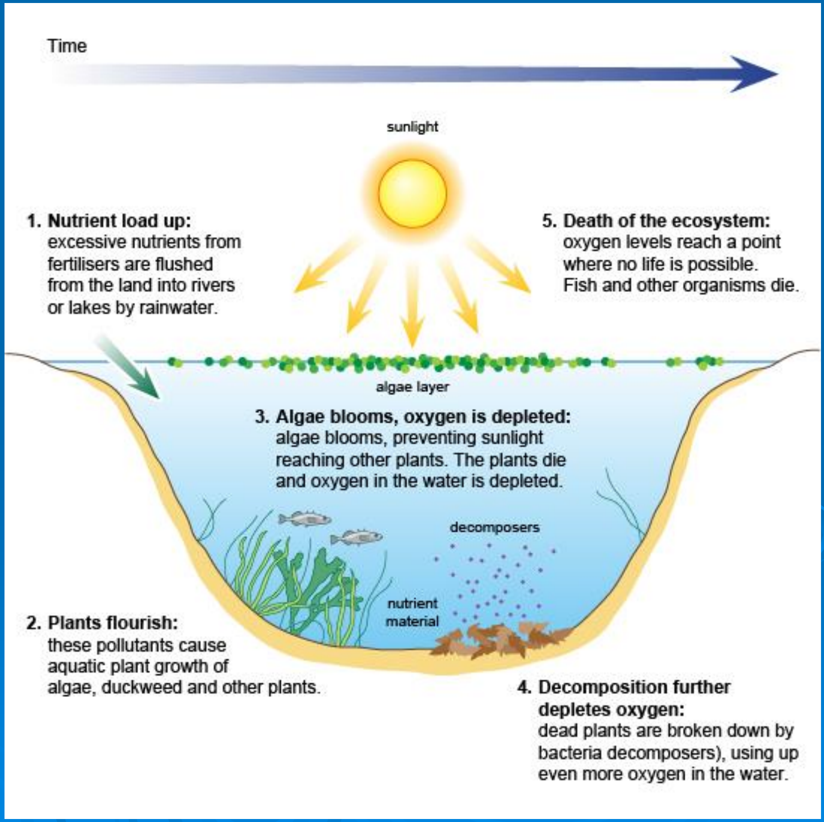
P AND WATER QUALITY

- **Point sources** of pollution

P AND WATER QUALITY

- **Non-point sources** of pollution
  - Fertilizers
  - Manures
  - Municipal wastes



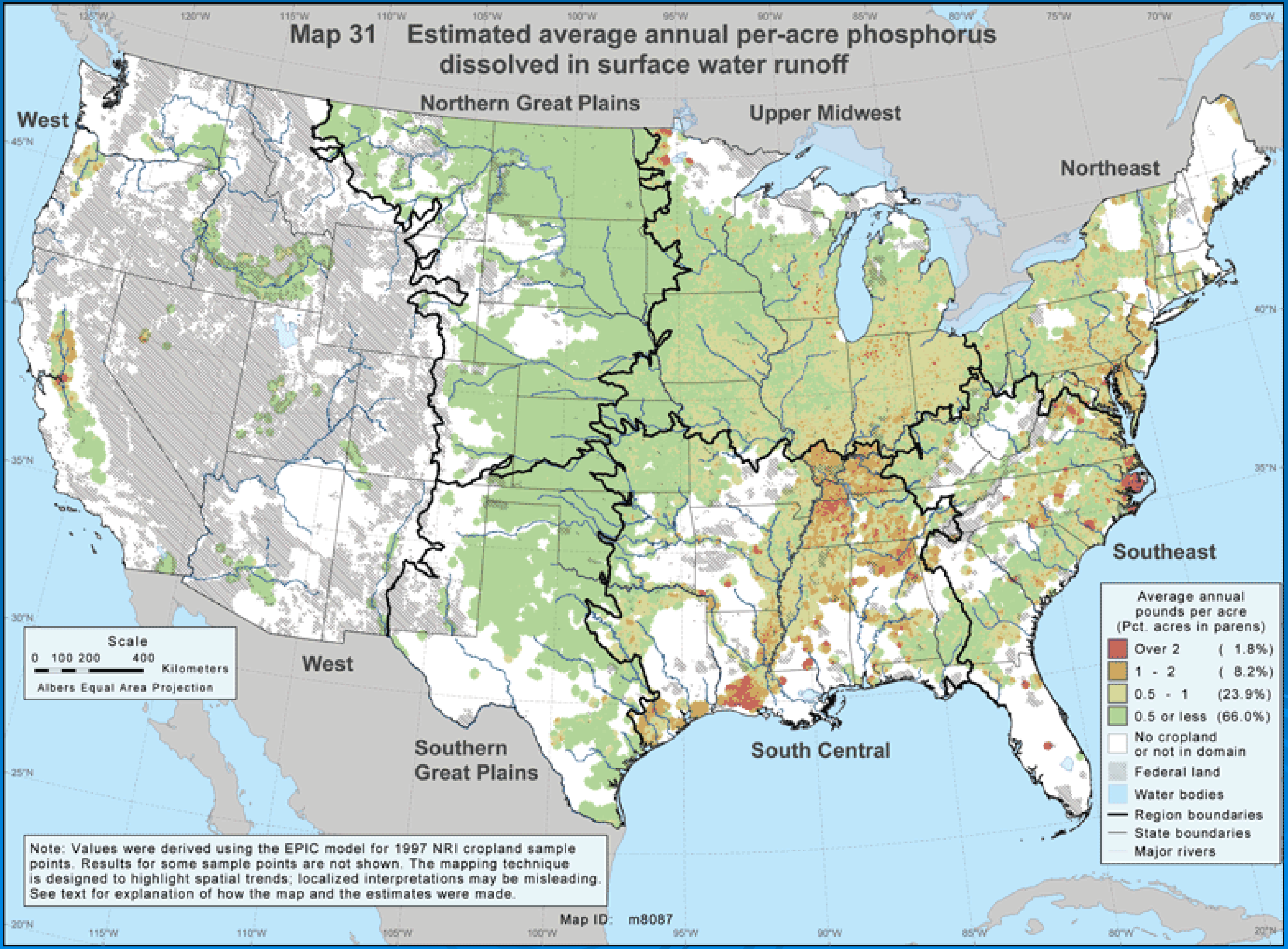


P AND ENVIRONMENTAL ISSUES

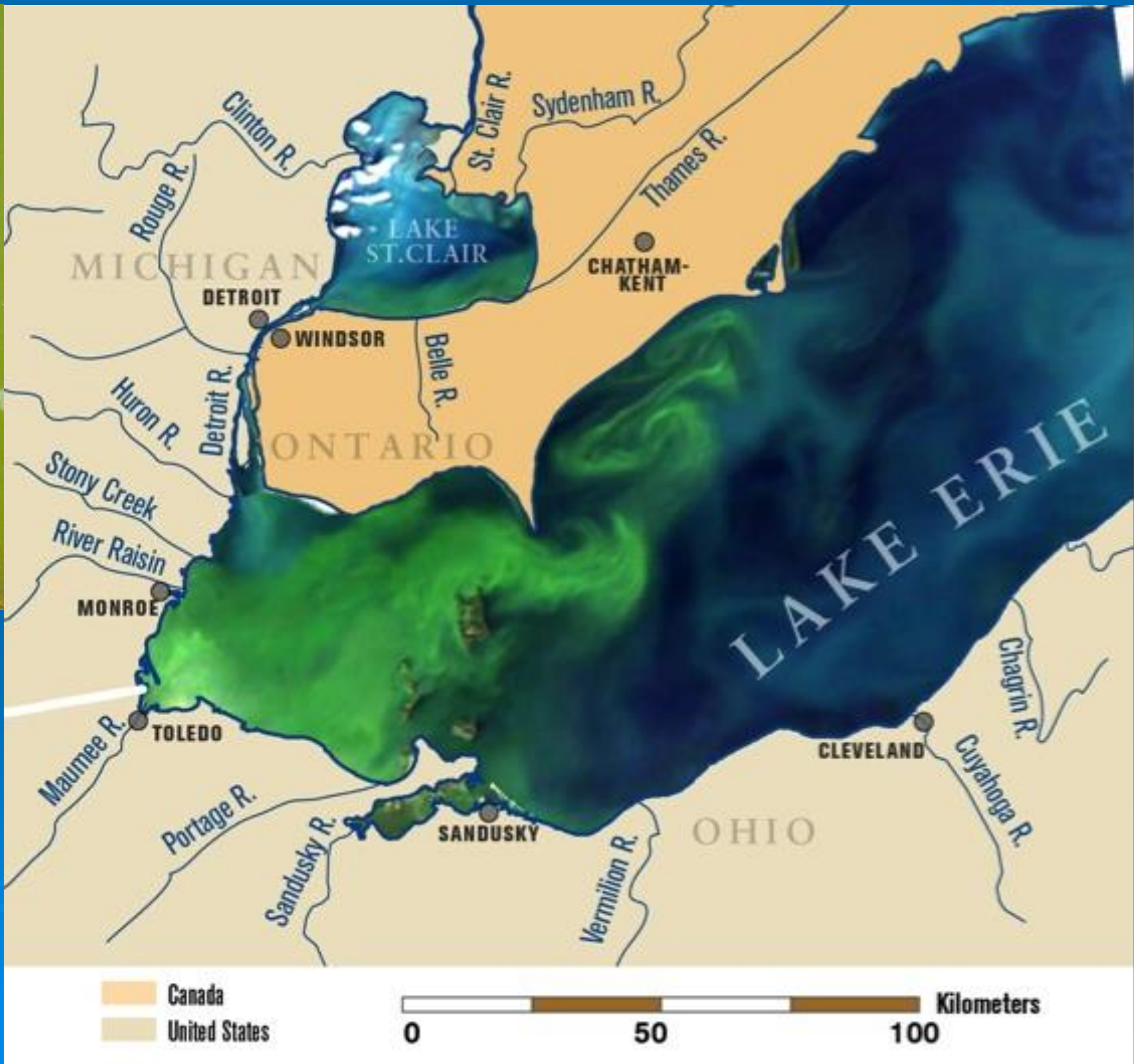
- **Runoff**
  - **Total P** = Particulate P + Dissolved P
  - **Particulate P** (carried in eroded sediment)
  - **Dissolved P** (carried in runoff water)

- Plant harvesting
- Fires
- Animal feedlots

ESTIMATED DISSOLVED P IN SURFACE WATER RUNOFF

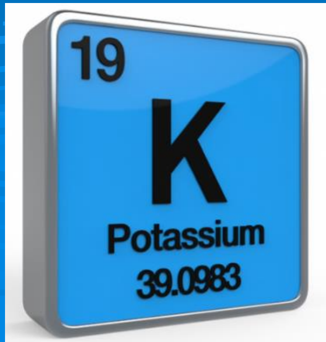


LAKE ERIE ALGAL BLOOMS



POTASSIUM (K)

- Not as direct a role as P in the environment
- Inadequate amounts can limit plant growth
- ***Soils possess large amounts of K***
- ***Plants require K in large amounts***

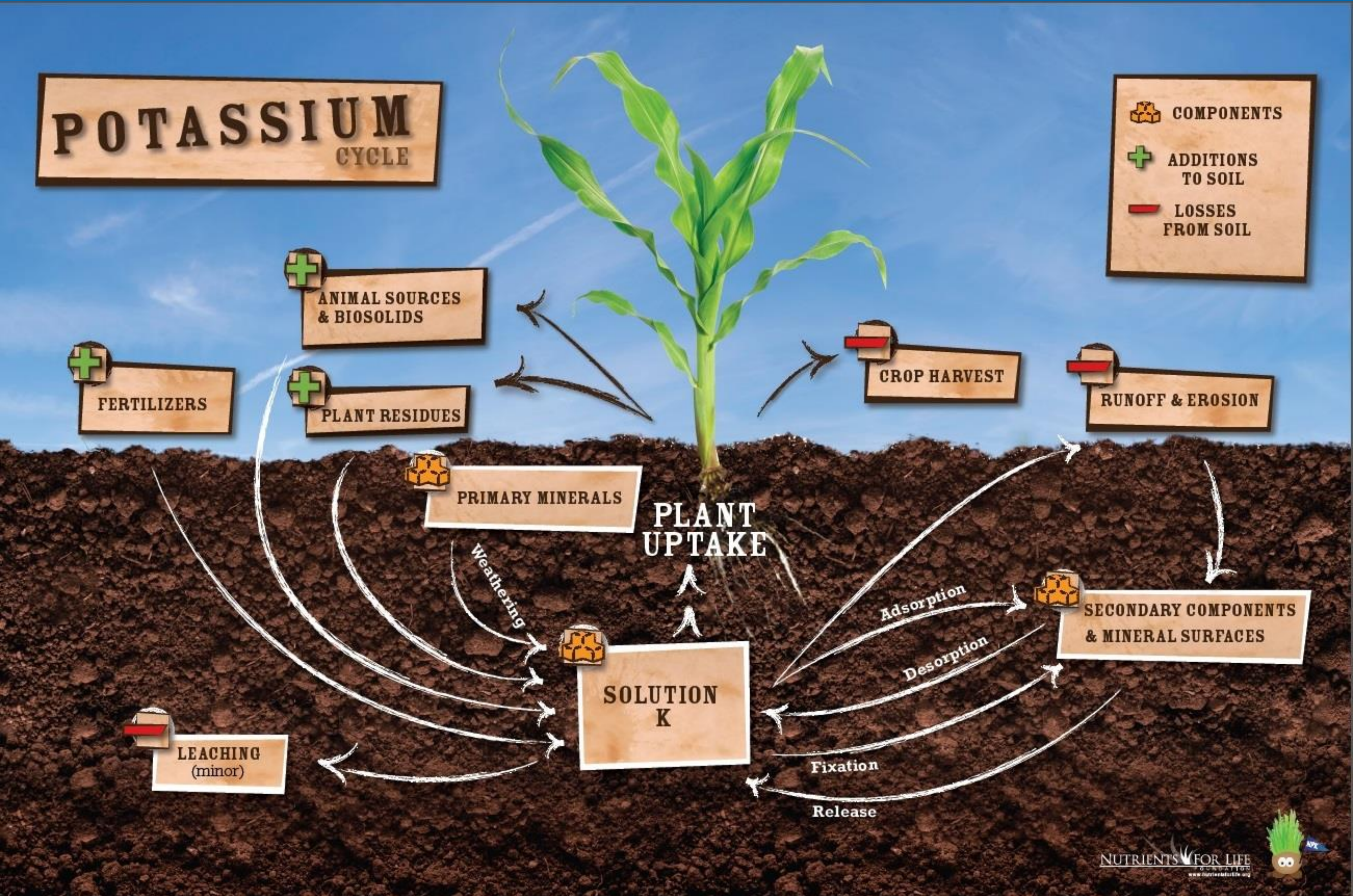


POTASSIUM (K): NATURE AND ECOLOGICAL ROLES

- **Third most likely to limit plant production**
- Present in soil only as K^+
- Does not form any gases to be lost to atmosphere

POTASSIUM: NATURE AND ECOLOGICAL ROLES

- K behavior is influenced by CEC and mineral weathering
- Causes no **off-site** pollution problems
- Not toxic and does not contribute to eutrophication


POTASSIUM
CYCLE
COMPONENTS
ADDITIONS TO SOIL
LOSSES FROM SOIL
ANIMAL SOURCES & BIOSOLIDS
FERTILIZERS
PLANT RESIDUES
CROP HARVEST
RUNOFF & EROSION
PRIMARY MINERALS
PLANT UPTAKE
Weathering
SOLUTION K
Adsorption
Desorption
SECONDARY COMPONENTS & MINERAL SURFACES
Fixation
Release
LEACHING (minor)
NUTRIENTS FOR LIFE

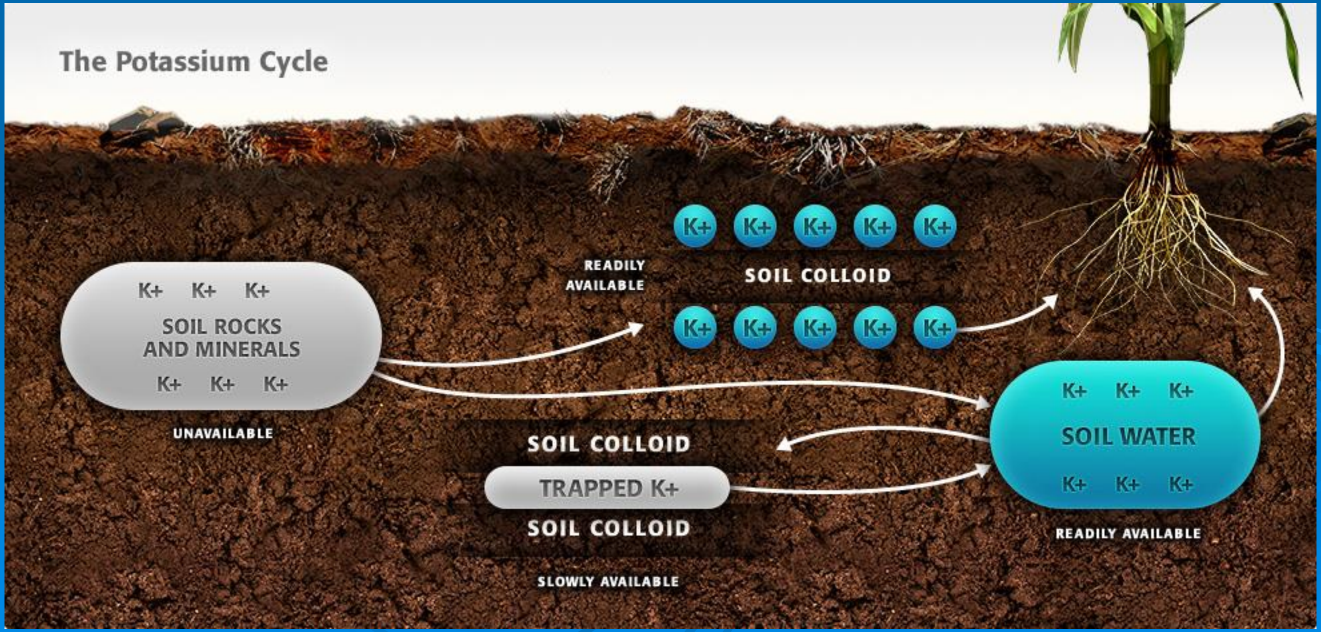
SOURCES OF POTASSIUM

- K re-distributed from other sources
  - Irrigation water
  - Commercial fertilizer
  - Sediment deposition
  - Precipitation
  - Manure and biosolids
- Weathering of K-contain primary minerals
  - Micas and feldspars

SOURCES OF POTASSIUM

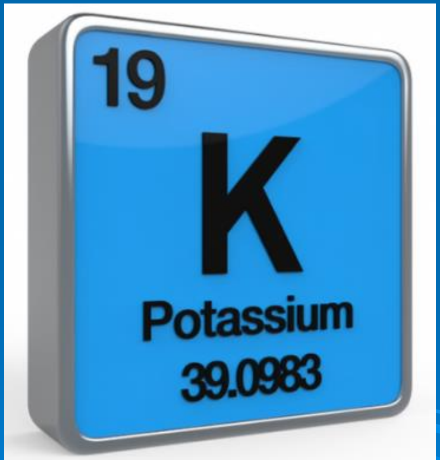
- K released from silicate materials
  - Illite, vermiculite, smectite

- **K de-sorption from surfaces and edges of silicate minerals termed "exchangeable K"**



POTASSIUM IN PLANT NUTRITION

- Acts as a **cellular enzyme activator**
  - Activates over 80 different enzymes
  - Energy metabolism
  - Starch synthesis
  - Nitrate reduction
  - Photosynthesis
  - Sugar degradation

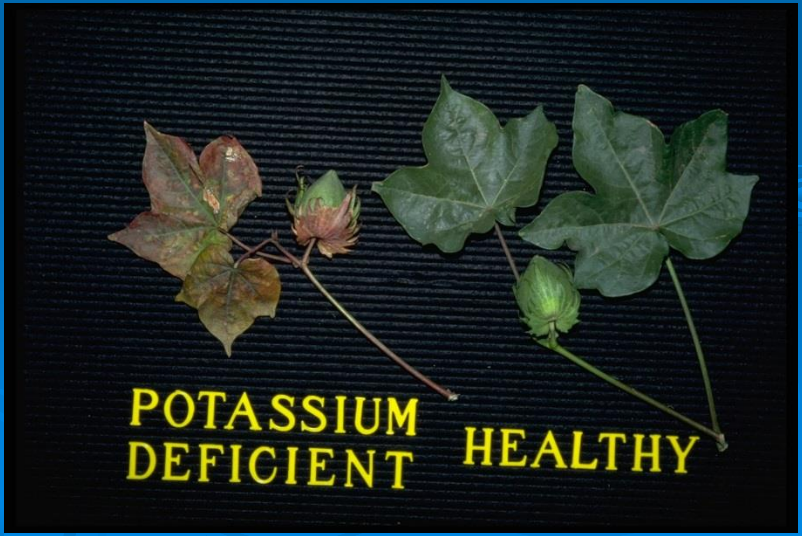


POTASSIUM IN PLANT NUTRITION

- Helps plants adapt to stresses
  - **Drought tolerance** by regulating internal osmotic pressure
  - **Winter hardiness**
  - Increases resistance to **fungal diseases**
  - Increases tolerance to **insect pests**

POTASSIUM DEFICIENCY SYMPTOMS IN PLANTS

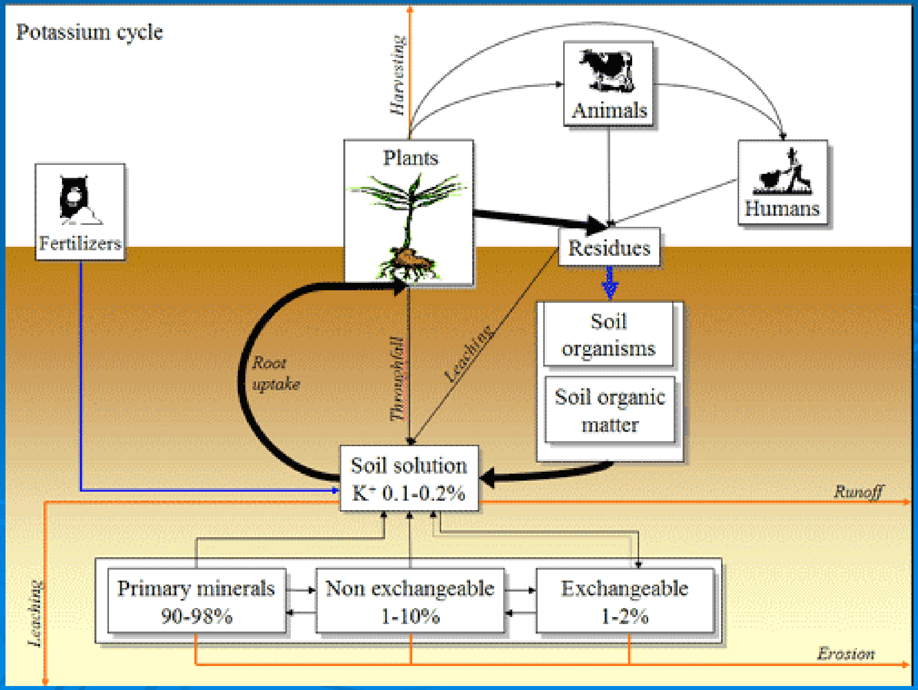
- Easy to recognize
- **Chlorosis** of older leaf tips and edges
- **Necrosis** of leaf tips and edges
- Ragged leaf margins






FORMS AND AVAILABILITY OF POTASSIUM

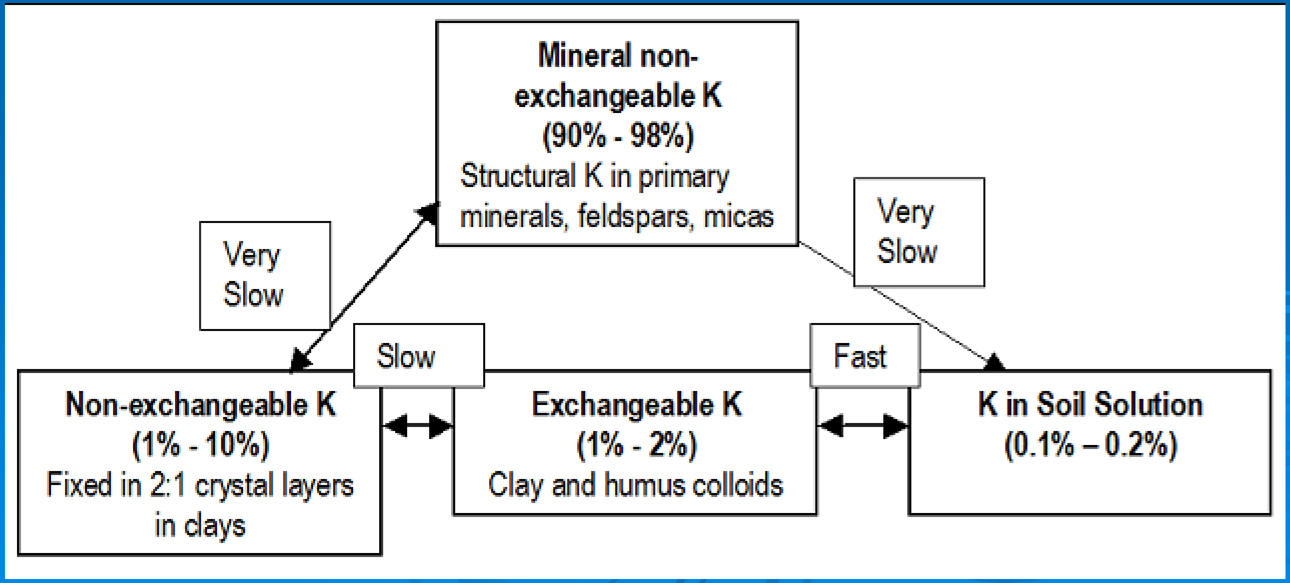
- **Primary mineral structure**
- **Non-exchangeable K** in secondary minerals
- Unavailable (90%-98%)
- Slowly available



FORMS AND AVAILABILITY OF POTASSIUM

- **Exchangeable K on soil colloids**
- Readily available (1%-2%)

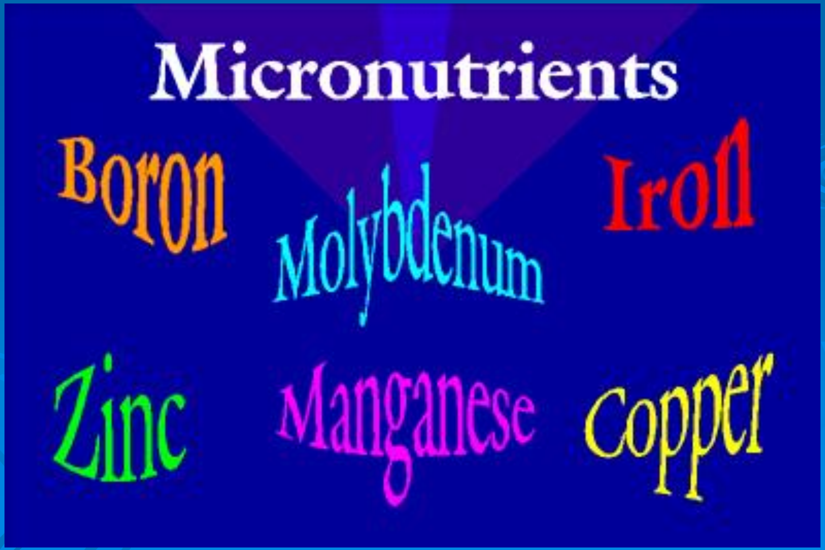
- **K soluble in water**
- Readily available



MICRONUTRIENTS

- **Nine (9)** micronutrients required for plant growth

- Deficiencies can lead to:
  - Stunted growth
  - Low yields
  - Plant death



MICRONUTRIENT ELEMENTS

- Equally important
- Needed in smaller amounts

Fe	Mn	Zn
Cu	Co	Ni
Bo	Mo	Cl

MICRONUTRIENTS

- Small applications or deficiencies can yield:
  - Dramatic results
  - **Phytotoxicity**

TABLE 4.
Suggested rates and sources of secondary and micronutrients for foliar application.[z]

Element	Lbs. element per acre	Suggested source
Calcium (Ca)	1-2	Calcium chloride or calcium nitrate
Magnesium (Mg)	1-2	Magnesium sulfate (Epsom salts)
Manganese (Mn)	1-2	Soluble manganese sulfate or finely ground manganese oxide
Copper (Cu)	0.5-1.0	Basic copper sulfate or copper oxide
Zinc (Zn)	0.3-0.7	Zinc sulfate
Boron (B)	0.1-0.3	Soluble borate
Molybdenum (Mo)	0.06	Sodium molybdate (2 ounces)
Iron (Fe)	1-2	Ferrous sulfate

[z] *Use a minimum of 30 gallons of water per acre.*

INCREASED ATTENTION TO MICRONUTRIENTS

- Greater removal of micronutrients
- Reduced use of impure salts and organic manures

INCREASED ATTENTION TO MICRONUTRIENTS

- Increase knowledge of plant nutrition
- Human nutrition and trace elements
- **Toxicity due to over application**

ORGANIC COMPOUNDS AS CHELATES

- **Chelates** – resulting from the reaction of micronutrients with organic molecules forming organo-metallic complexes
  - Surrounded by C, H, and O

- **Fe chelates are more available to plants**

DEFICIENCY SYMPTOMS AND MICRONUTRIENTS

- Most are relatively **immobile**
- Not readily transferred from older leaves to younger leaves
- **Concentrations are lowest and symptoms more pronounced in younger leaves**

ROLE OF Fe in PLANT NUTRITION

- Plenty of Fe in soils, but not readily available
- Readily absorbed as Fe^{+2} or Fe^{+3}
- Essential in redox reactions, respiration, photosynthesis, and enzyme reactions
- Generally needed at 50-250 ppm dry weight

ROLE OF Fe in PLANT NUTRITION

- Unavailable at pH’s > 7.5
- Soils with low OM create Fe deficiencies
- Deficiencies include stunting, chlorosis, and young tissue impacted first
- Fe is not easily translocated in plant

MANAGEMENT OF Fe in PLANT NUTRITION

- Chelated fertilizers are most effective
  - Fe-EDDHA or Fe-EDTA
  - Can be expensive

- Foliar sprays containing Fe salts or chelates can be effective

MANGANESE (MN) DEFICIENCIES

- Important in soils with high Mg
- Mn is an **essential element**
- **Becomes increasing soluble as pH decreases (pH_{water}=5.6)**
- **Plants may look chlorotic**
- Toxicity occurs in flooded soils

END OF PRESENTATION