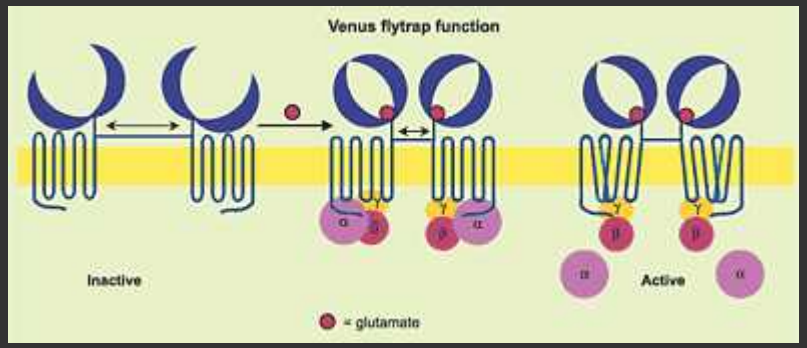
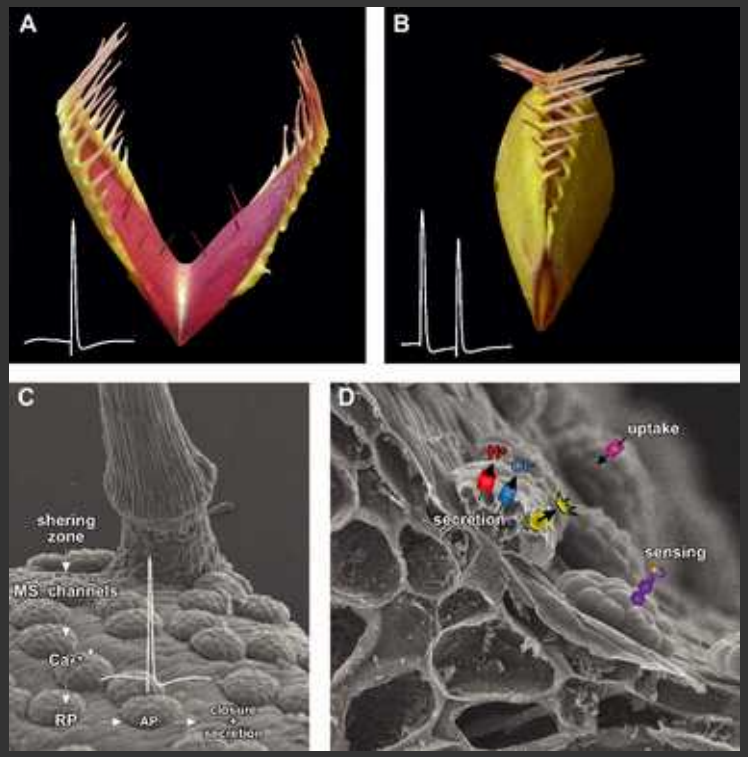
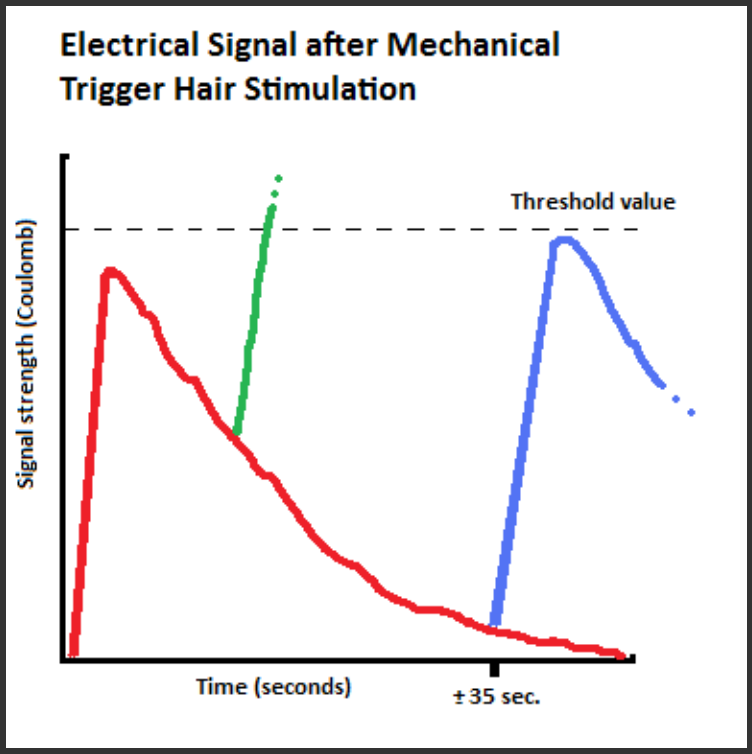
Carnivorous plants

- Why do some plants eat animals?
- Why should we care about plant conservation?
- How did plant carnivory evolve?
- Where do carnivorous plants live….and why not other places?
- What major nutrients do plants need and in what forms?
- What is soil? Can you describe aspects of its complexity?
- What processes are going on at the interface of plant roots and soil?


bTV
BARCROFT TV







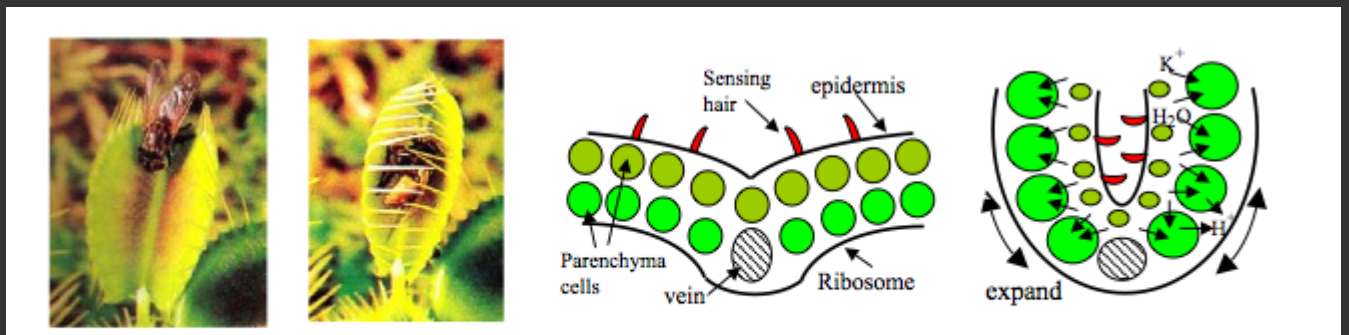


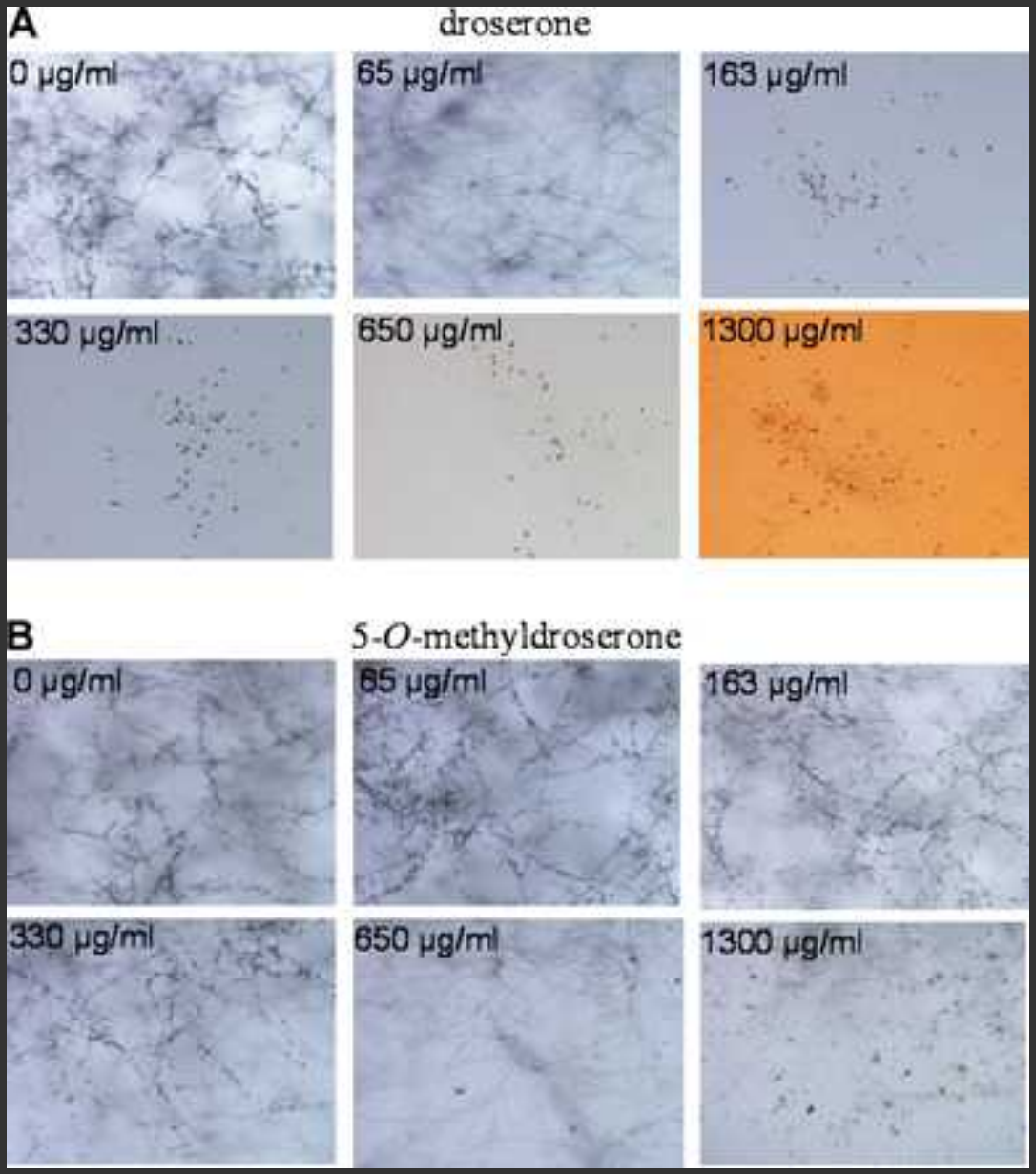
Fig. 5. Venus flytrap in action. When an insect touches the trigger hairs (a, c) the trap closes rapidly (b,d). The closure is caused by the rapid expansion growth of the outer leaf epidermis which must involve ion transport (d).


Smithsonian
CHANNEL

Carniverous plants are rare and some are endangered.

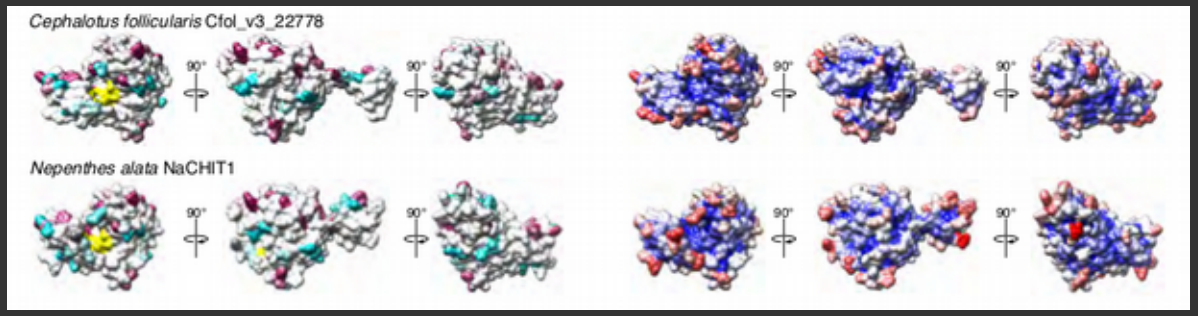
- Who gives a crap!?
- If they are rare they aren't important to the ecosystem.
- Can you make an argument for why we should spend money/time conserving them?

Our latest and best antifungal drug comes from carniverous plant enzymes



Why do some plants eat insects?

Evolution of plant carnivory



Chitinase can fight off fungal infections....and digest insect exoskeletons

What are the costs of carnivory?

Where are carniverous plants found?

What is it like there?

Type of peat	Depth (cm)	Total organic matter	Water soluble compounds	Ether/ alcohol soluble materials	Hemi-cellulose	Cellulose	Lignin and derivates	Nitrogenous compounds
Sphagnum (Main, USA[1])	20–36	95.7	5.2	7.8	24.1	17.1	18.0	0.8
Saw-grass (Florida, USA[1])	80	93.3	2.1	2.3	4.4	2.2	60.1	3.5
Woody sedge (Washington, USA[1])	25–40	93.5	5.9	7.7	7.0	3.2	38.2	3.3
Papyprus (Israel[2])	50–100	77.3	7.9	1.7	6.0	1.7	41.4	17.9
Forest woody (Sumatra, Indonesia[3])	subsurface layer	97.0	1.9	9.4	2.0	10.6	64.0	4.4
Forest woody (Borneo, Indonesia[3])	subsurface layer	98.6	0.9	9.0	2.0	3.6	75.7	3.9
Papyrus vegetation[2]			9.6	4.0	21.5	26.8	18.0	3.6

Carniverous plants succeed only where other plants fail.

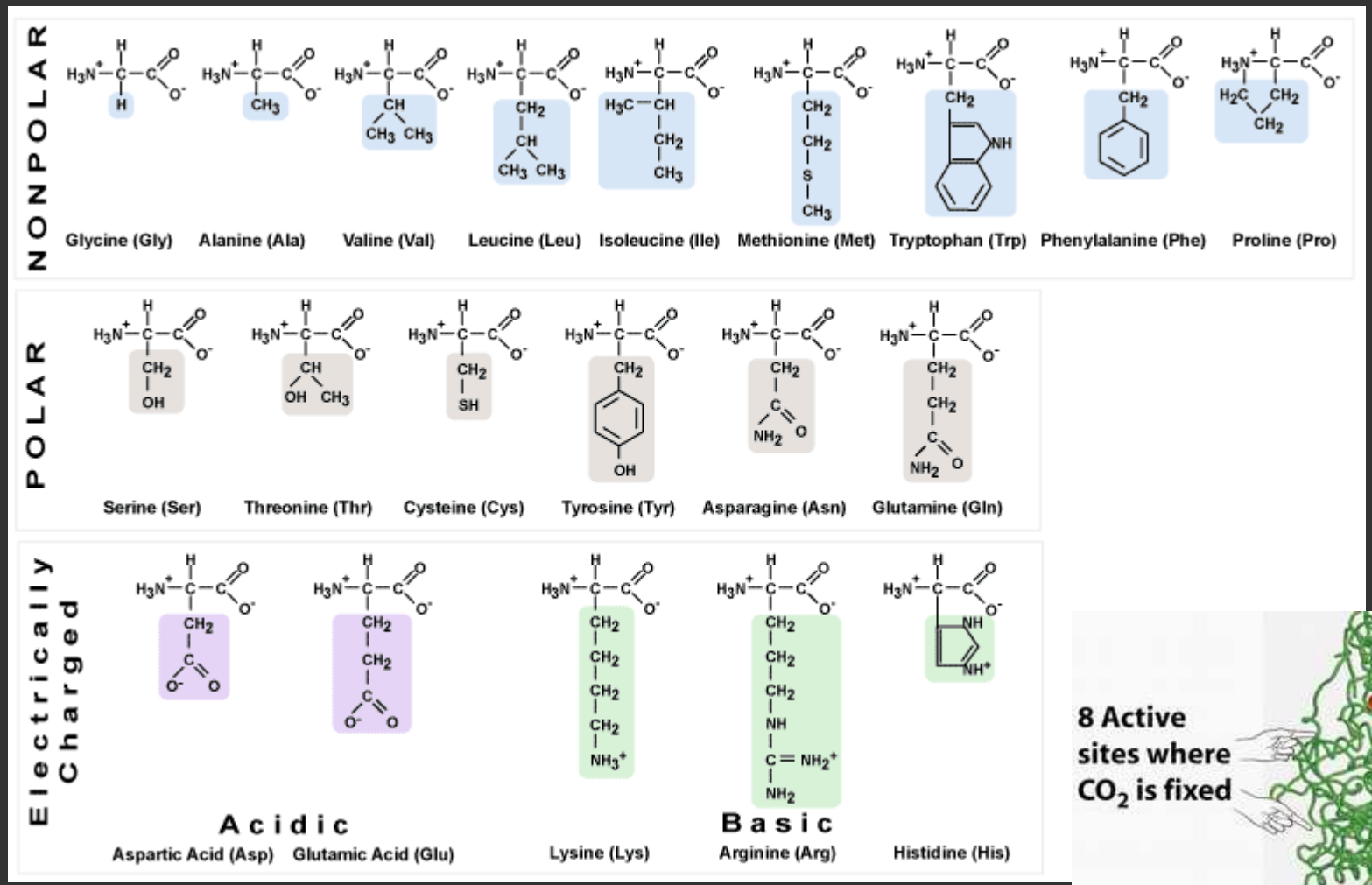
What nutrients do plants need?

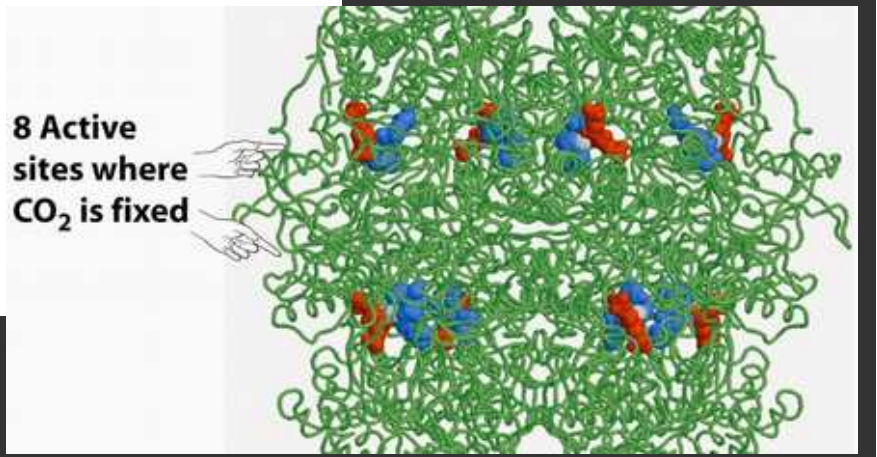
Plant nutrition

Table 37.1 Essential Elements in Plants

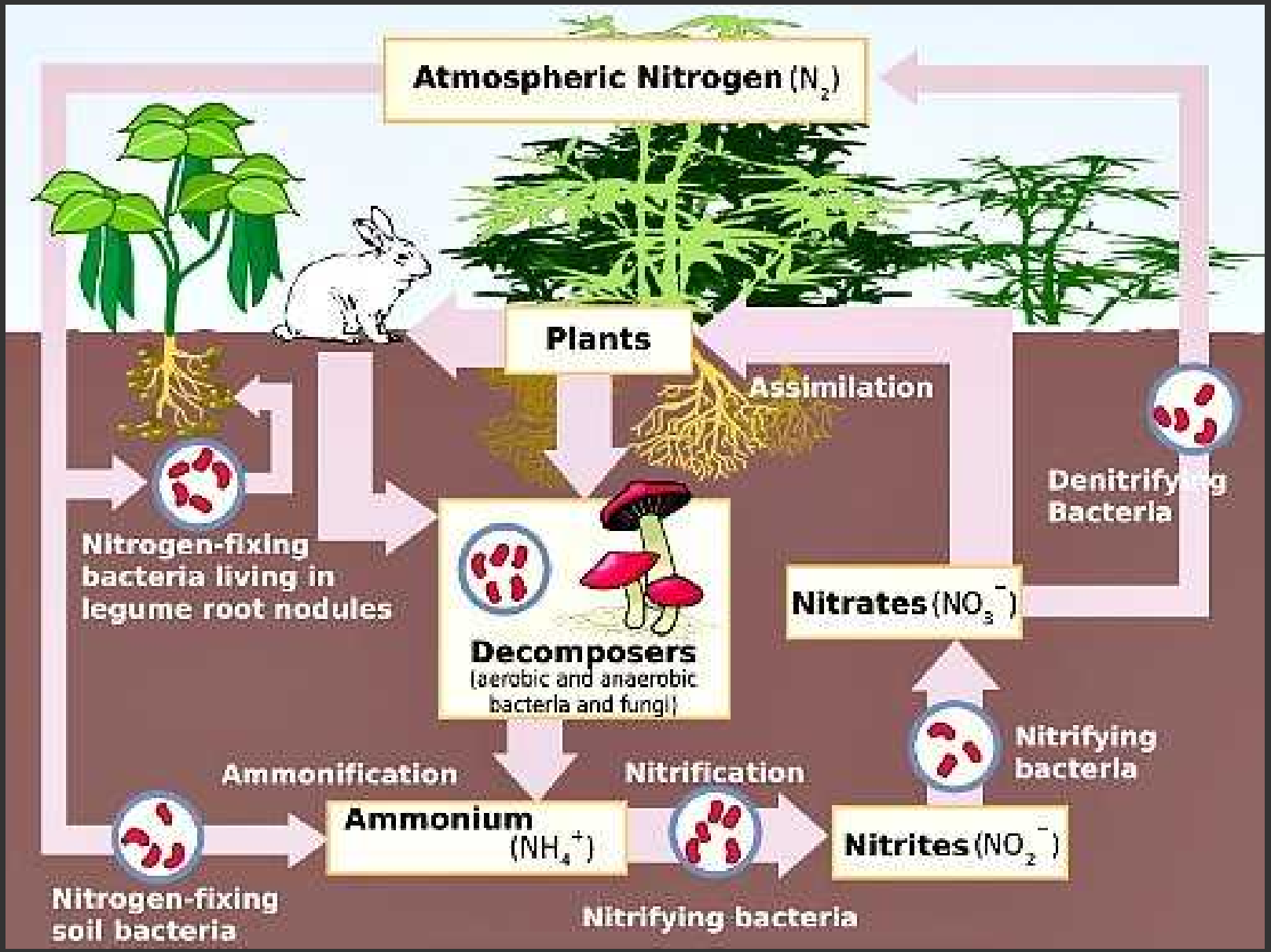
Element	Form Available to Plants	% Mass in Dry Tissue	Major Functions
Macronutrients			
Carbon	CO_2	45%	Major component of plant's organic compounds
Oxygen	CO_2	45%	Major component of plant's organic compounds
Hydrogen	H_2O	6%	Major component of plant's organic compounds
Nitrogen	NO_3^-, NH_4^+	1.5%	Component of nucleic acids, proteins, hormones, chlorophyll, coenzymes
Potassium	K^+	1.0%	Cofactor that functions in protein synthesis; major solute functioning in water balance; operation of stomata
Calcium	Ca^{2+}	0.5%	Important in formation and stability of cell walls and in maintenance of membrane structure and permeability; activates some enzymes; regulates many responses of cells to stimuli
Magnesium	Mg^{2+}	0.2%	Component of chlorophyll; activates many enzymes
Phosphorus	$H_2PO_4^-$, HPO_4^{2-}	0.2%	Component of nucleic acids, phospholipids, ATP, several coenzymes
Sulfur	SO_4^{2-}	0.1%	Component of proteins, coenzymes
Micronutrients			
Chlorine	Cl^-	0.01%	Required for water-splitting step of photosynthesis; functions in water balance
Iron	Fe^{3+}, Fe^{2+}	0.01%	Component of cytochromes; activates some enzymes
Manganese	Mn^{2+}	0.005%	Active in formation of amino acids; activates some enzymes; required for water-splitting step of photosynthesis
Boron	$H_2BO_3^-$	0.002%	Cofactor in chlorophyll synthesis; may be involved in carbohydrate transport and nucleic acid synthesis; role in cell wall function
Zinc	Zn^{2+}	0.002%	Active in formation of chlorophyll; activates some enzymes
Copper	Cu^+, Cu^{2+}	0.001%	Component of many redox and lignin-biosynthetic enzymes
Nickel	Ni^{2+}	0.001%	Cofactor for an enzyme functioning in nitrogen metabolism
Molybdenum	MoO_4^{2-}	0.0001%	Essential for symbiotic relationship with nitrogen-fixing bacteria; cofactor in nitrate reduction

Nitrogen

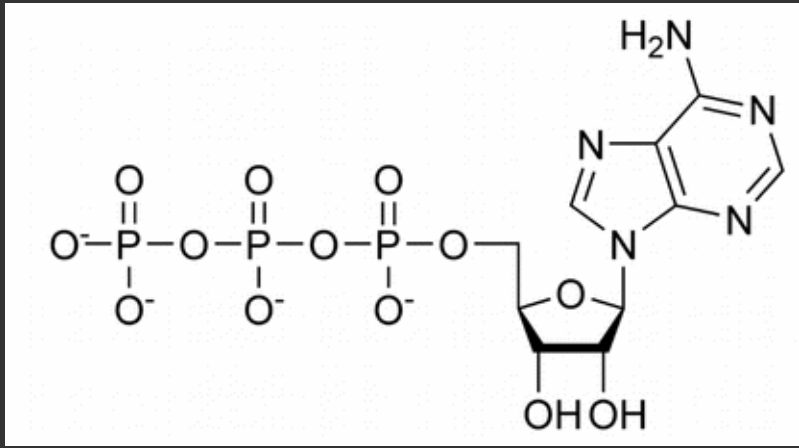

NONPOLAR
Glycine (Gly)
Alanine (Ala)
Valine (Val)
Leucine (Leu)
Isoleucine (Ile)
Methionine (Met)
Tryptophan (Trp)
Phenylalanine (Phe)
Proline (Pro)
POLAR
Serine (Ser)
Threonine (Thr)
Cysteine (Cys)
Tyrosine (Tyr)
Asparagine (Asn)
Glutamine (Gln)
Electrically Charged
Acidic
Aspartic Acid (Asp)
Glutamic Acid (Glu)
Lysine (Lys)
Basic
Arginine (Arg)
Histidine (His)

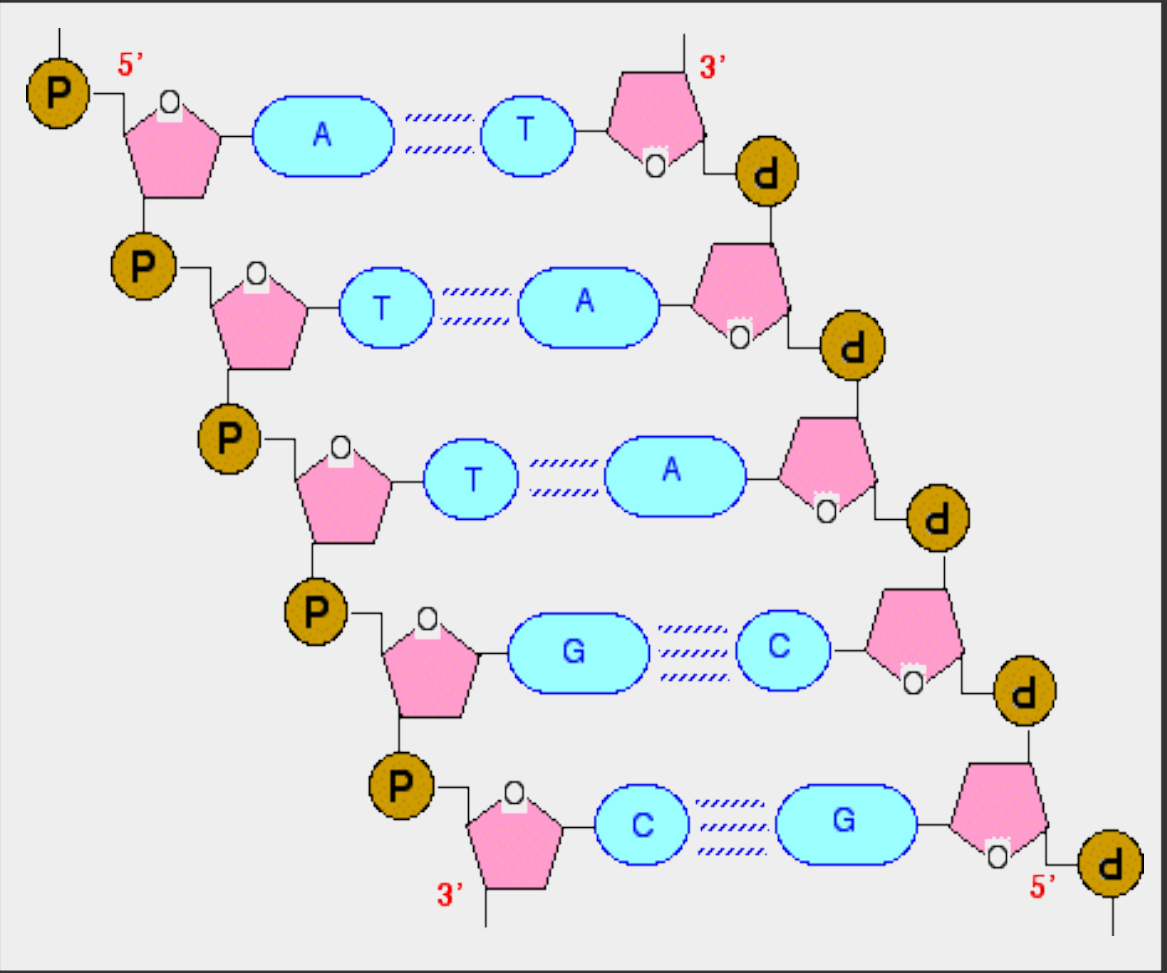

8 Active sites where CO_2 is fixed

Where does N come from?

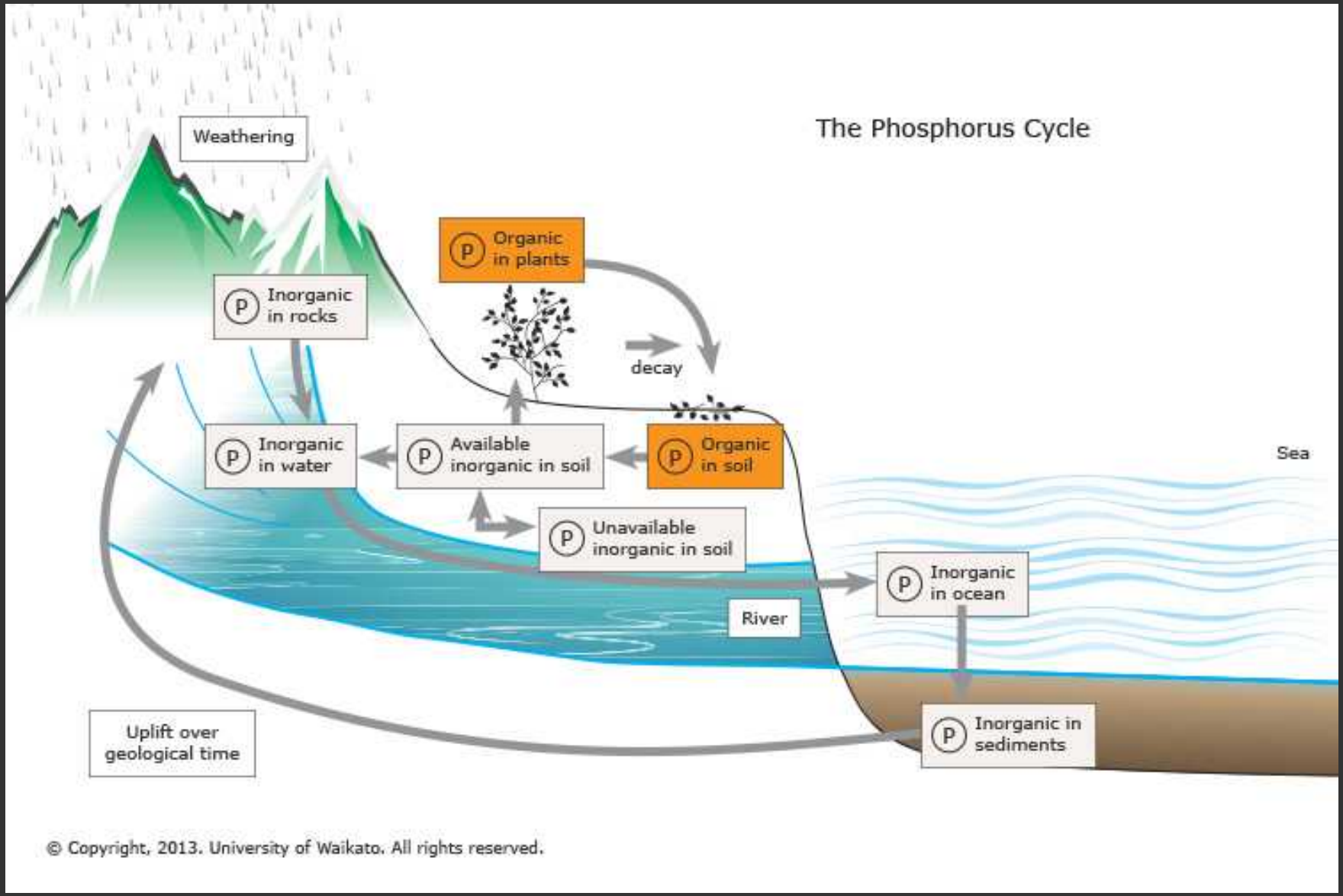


Phosphorus

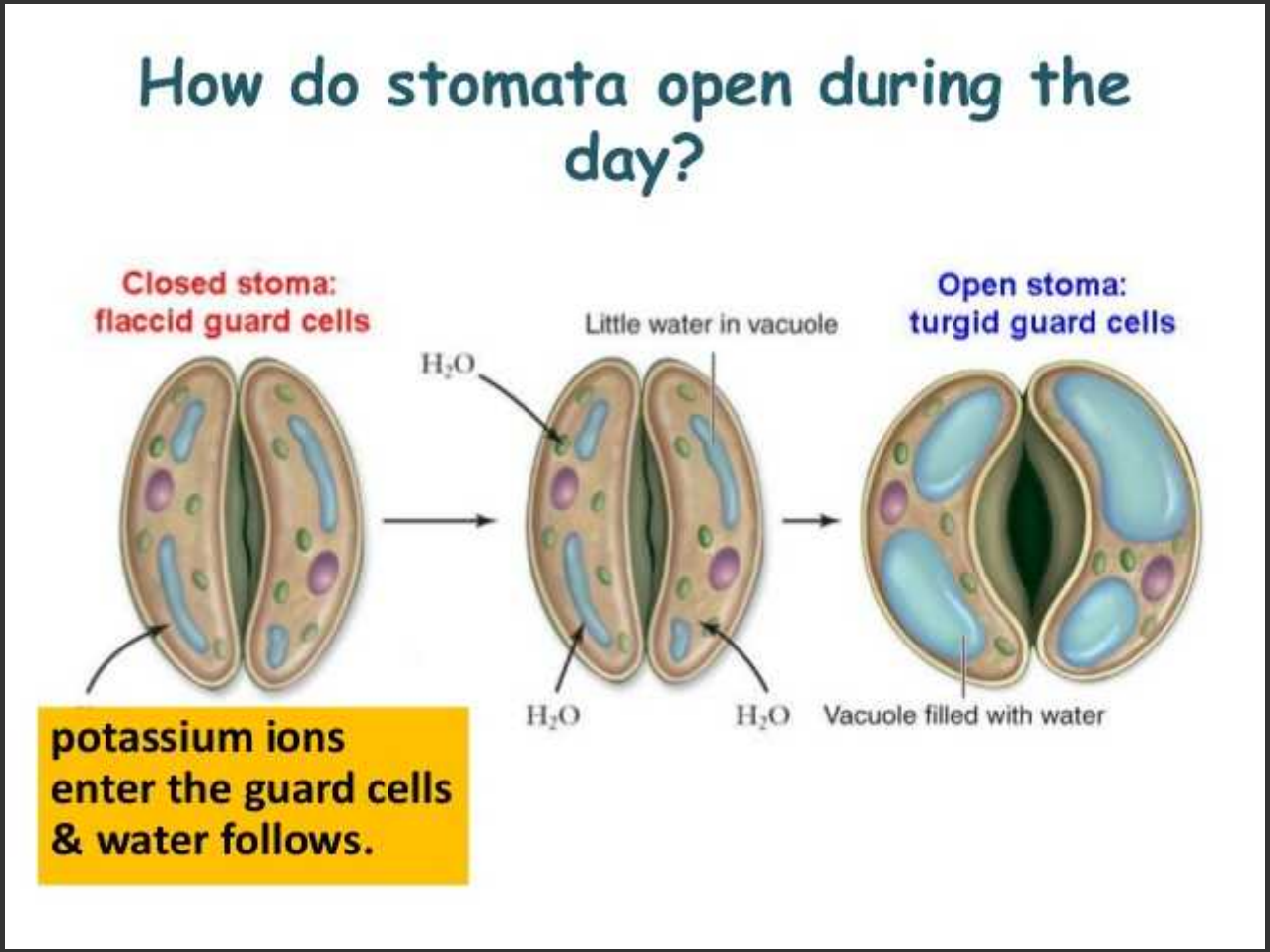




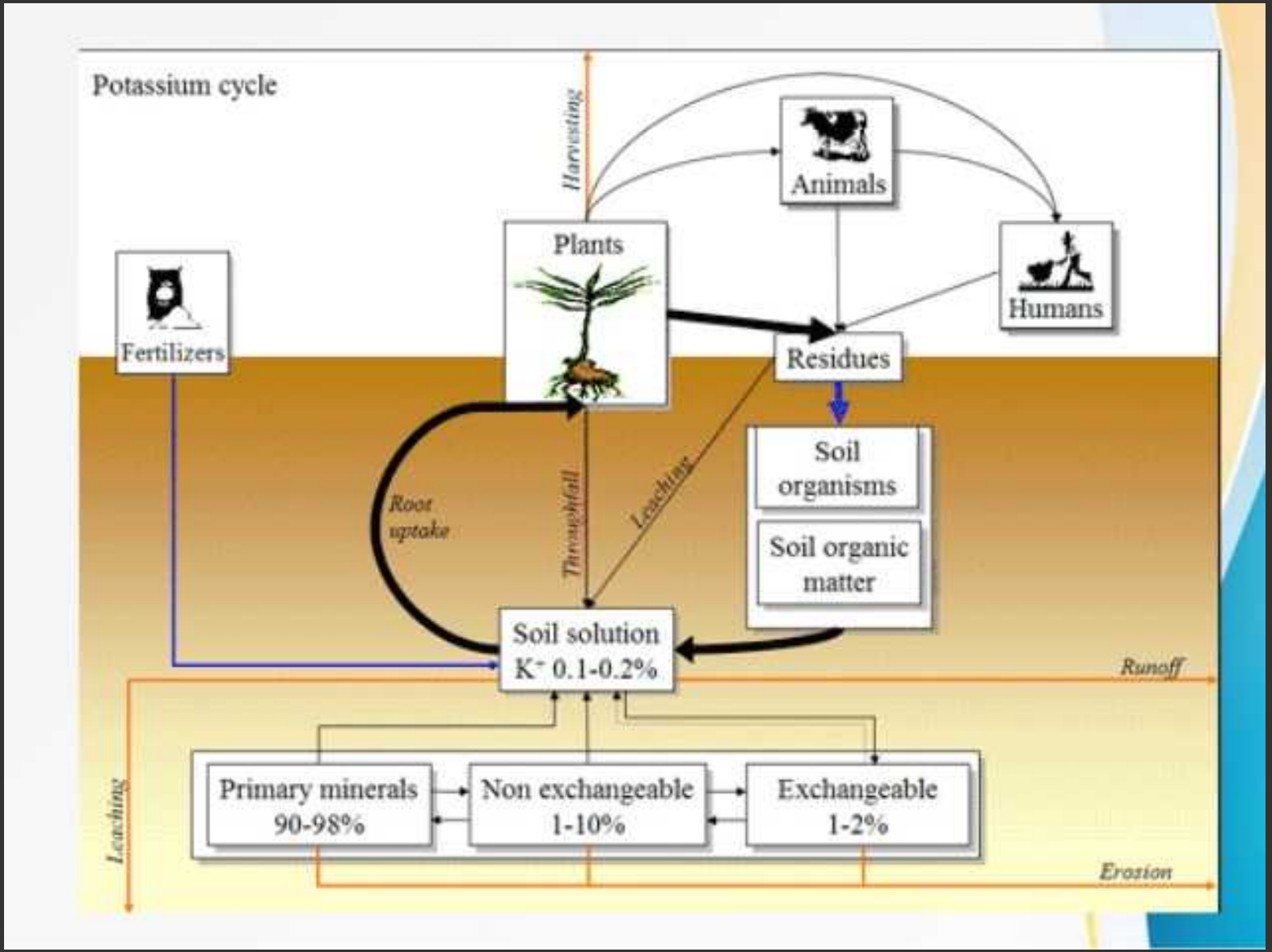
Where does phosphorus come from?



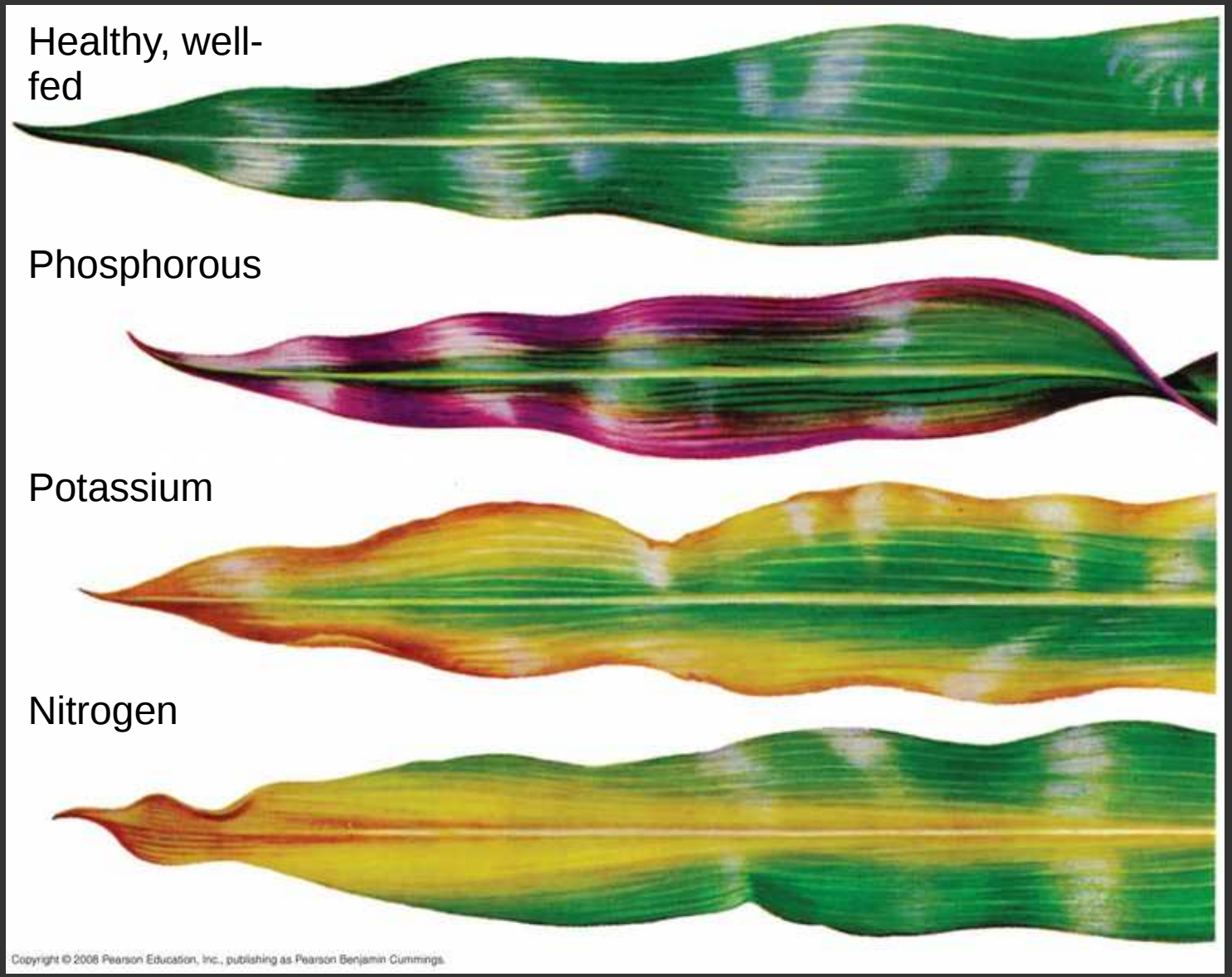
Potassium


How do stomata open during the day?
Closed stoma: flaccid guard cells
Little water in vacuole
Open stoma: turgid guard cells
H_2O
H_2O
H_2O
Vacuole filled with water
potassium ions enter the guard cells & water follows.

Where does potassium come from?



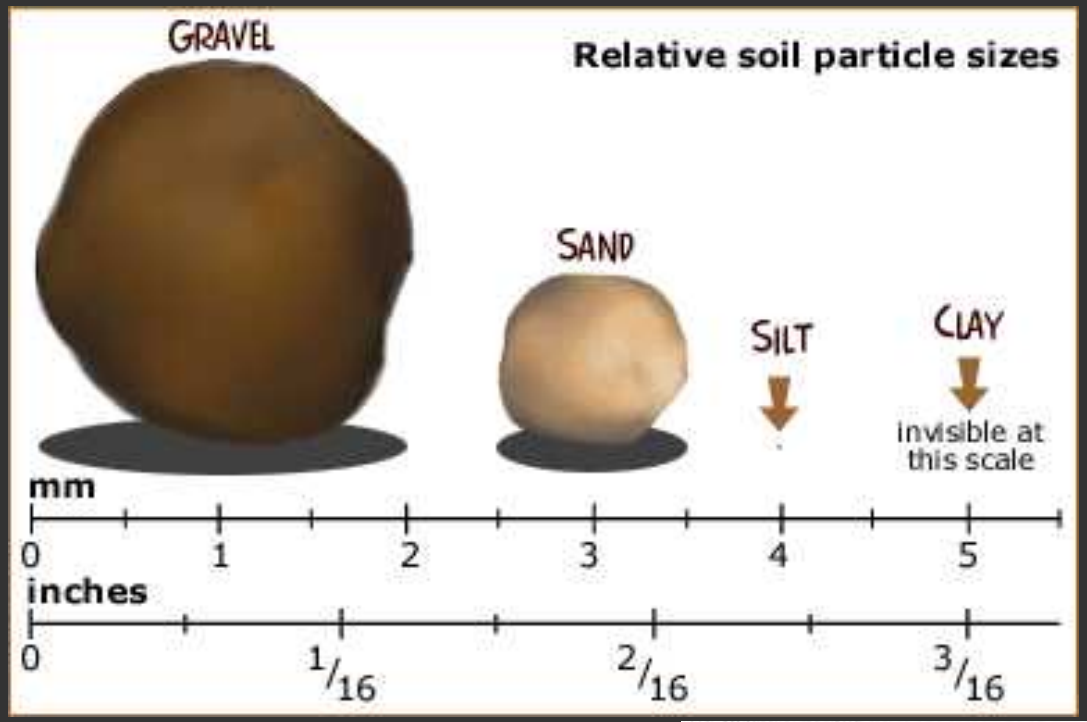
Nutrient deficiencies

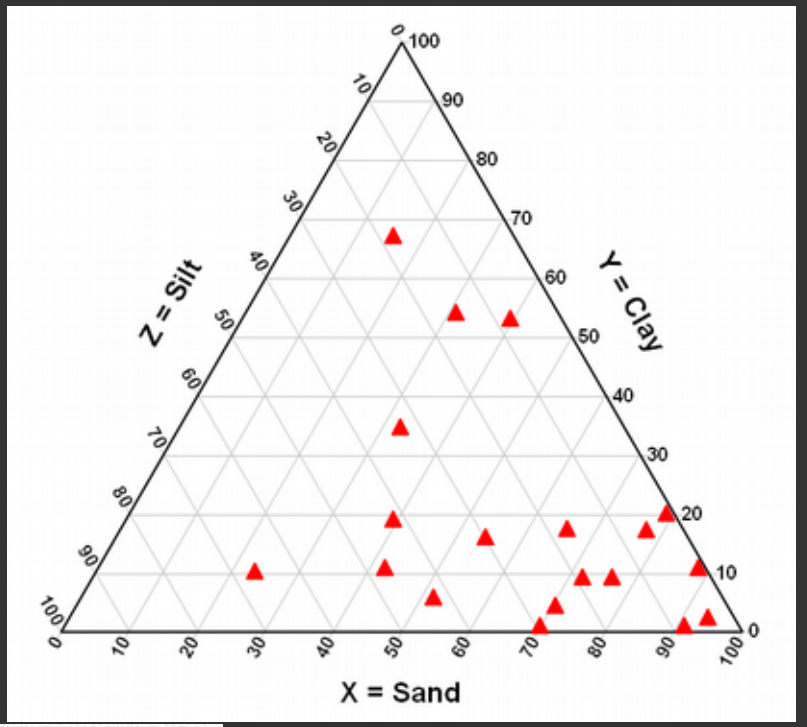


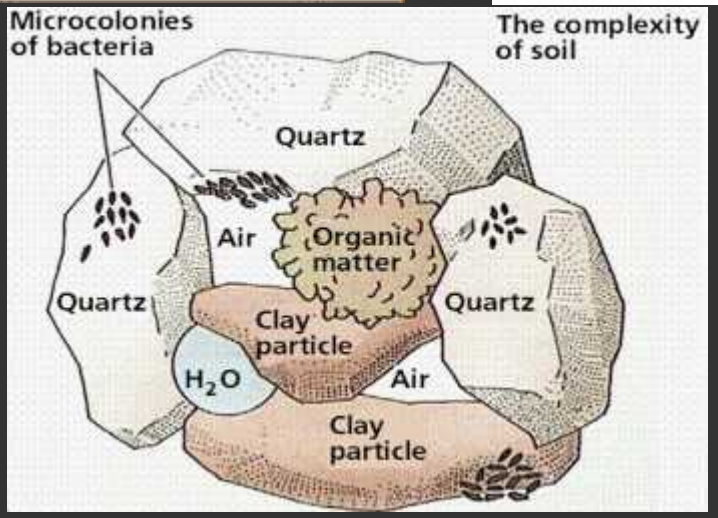
Plants can only use certain forms of NPK

Nitrogen	NO_3^-
Phosphorous	$H_2PO_4^-$
Potassium	K^+

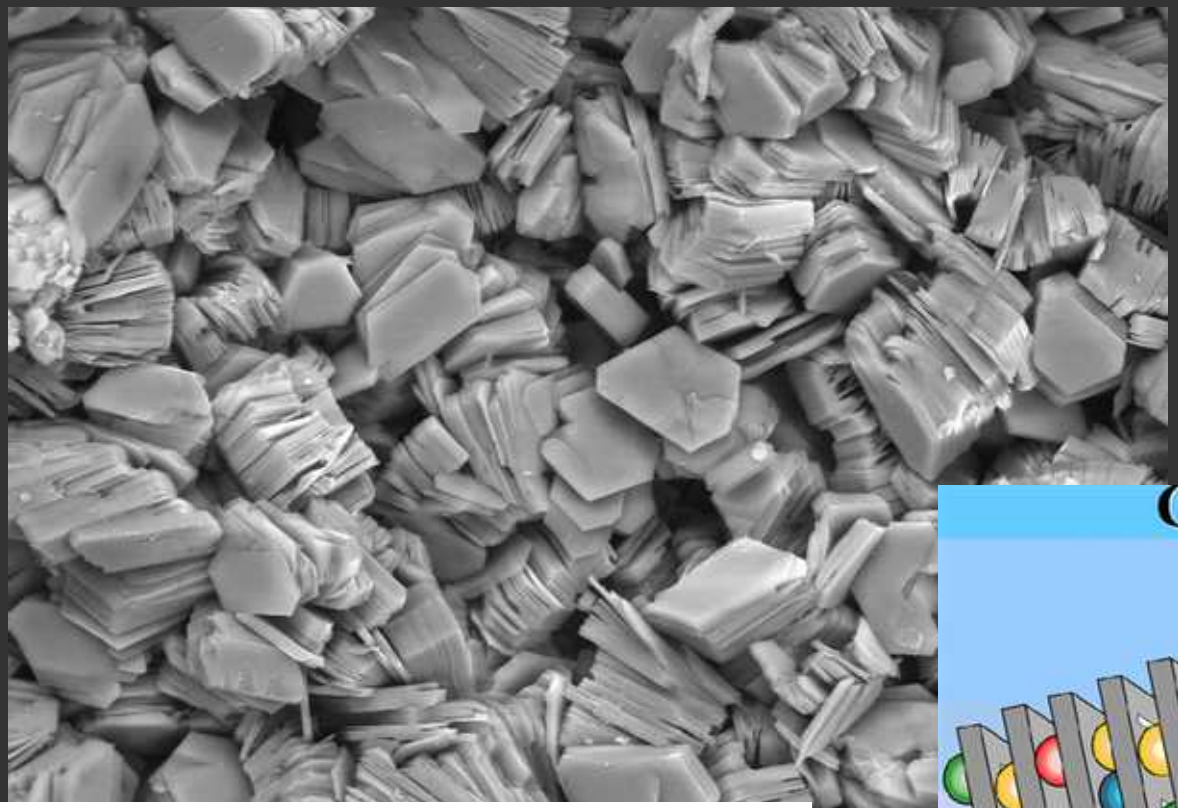
What is soil?

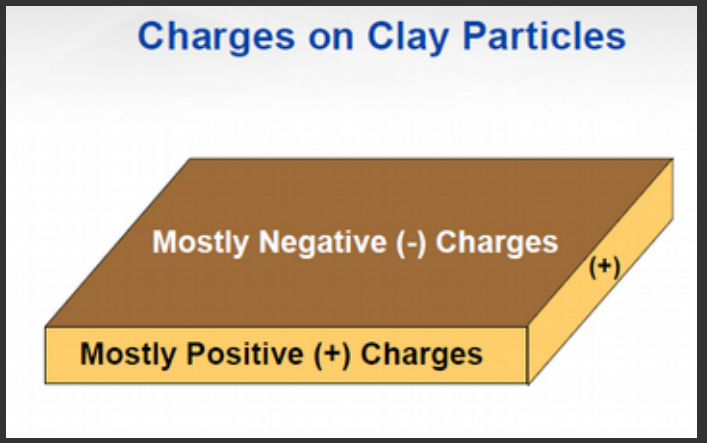

GRAVEL
Relative soil particle sizes
SAND
SILT
CLAY
invisible at this scale
mm
0
1
2
3
4
5
inches
0
1/16
2/16
3/16


Z = Silt
Y = Clay
X = Sand


Microcolonies of bacteria
The complexity of soil
Quartz
Air
Organic matter
Quartz
Quartz
Clay particle
H_2O
Air
Clay particle

Clay





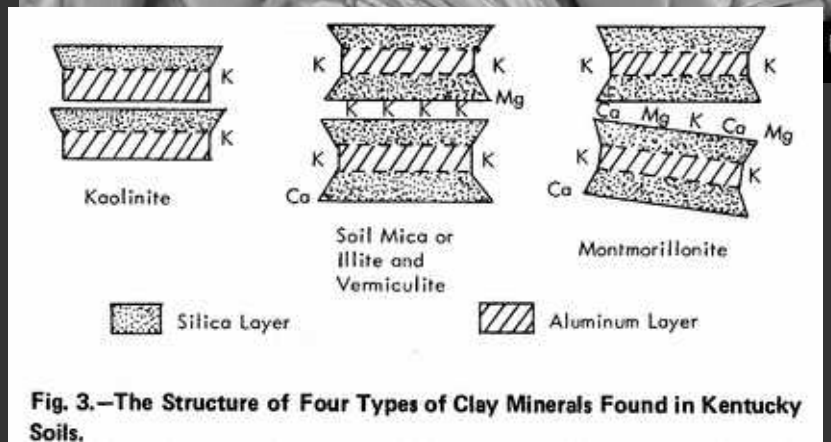
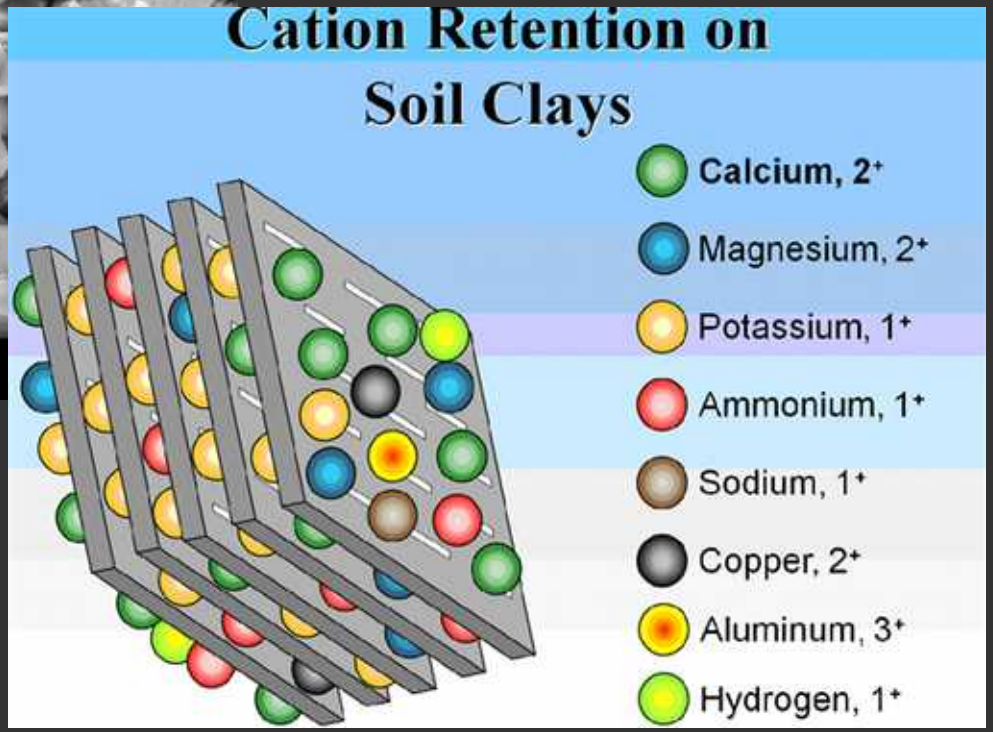
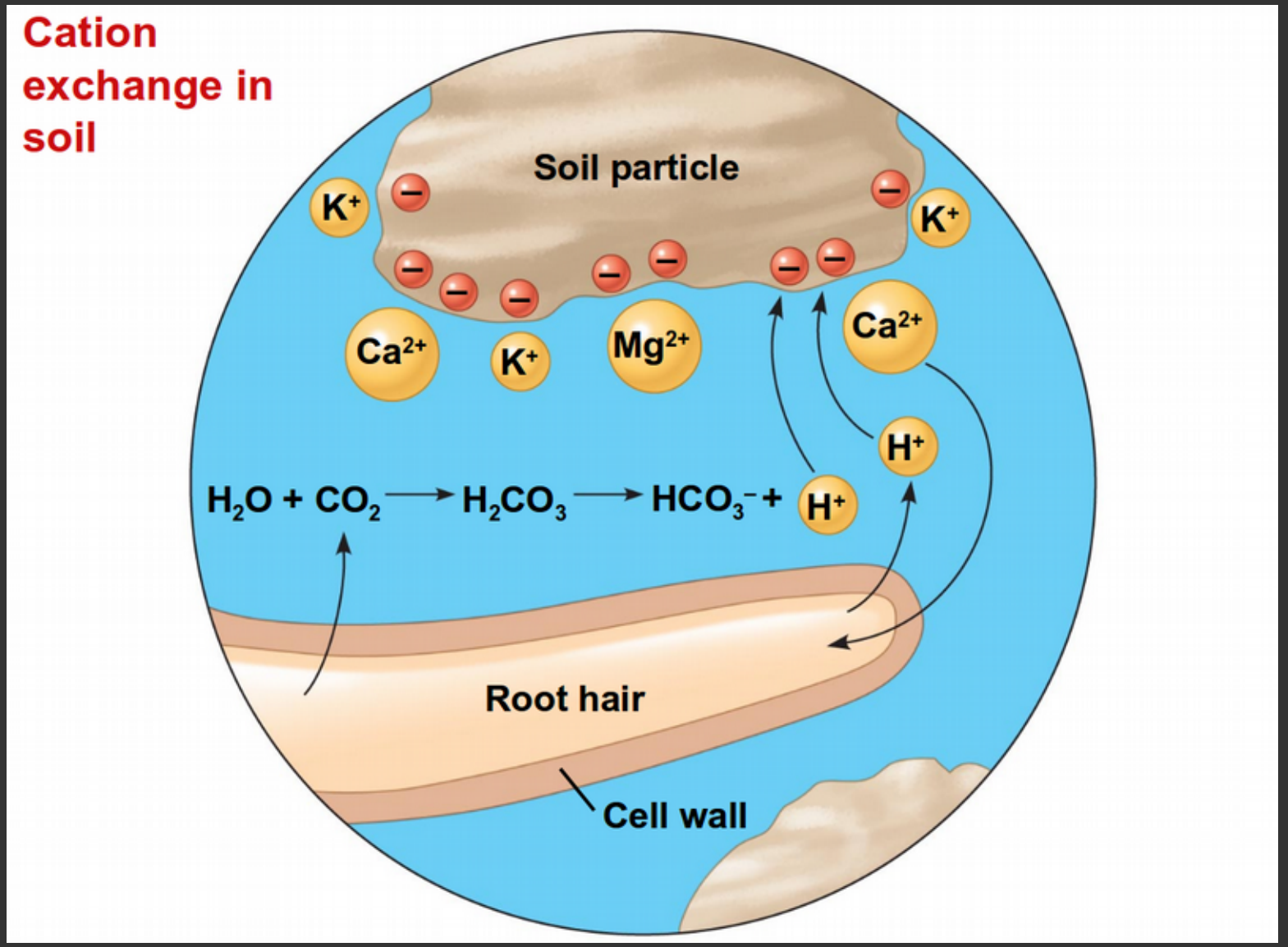


Fig. 3.—The Structure of Four Types of Clay Minerals Found in Kentucky Soils.

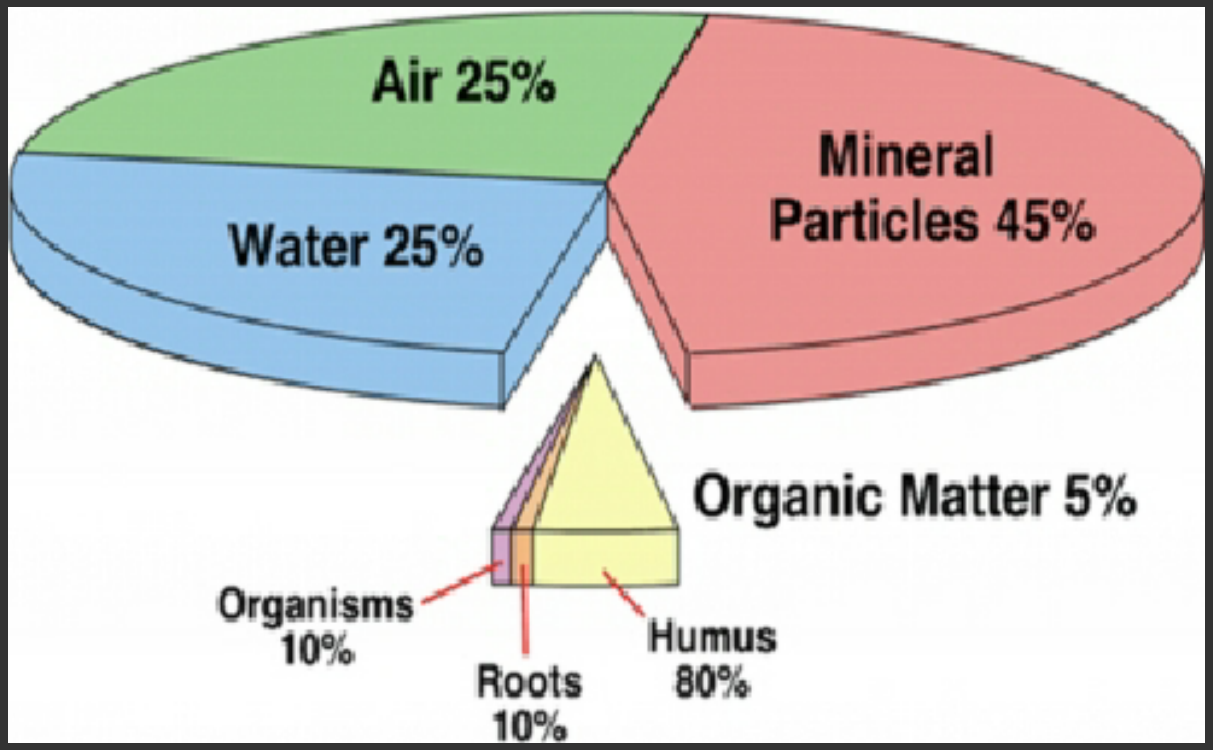
Pa



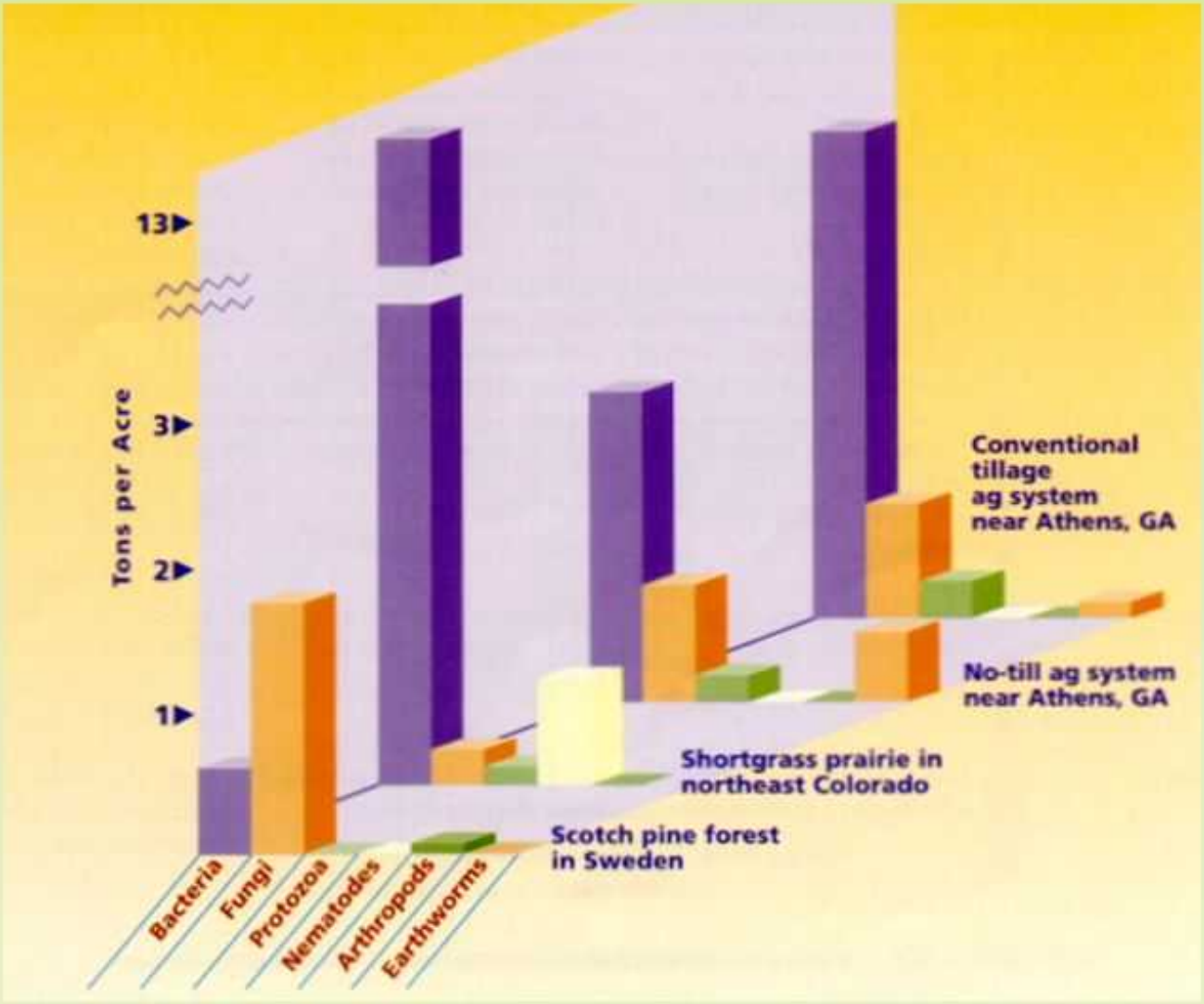
Hydrogen frees ions from soil adhesion



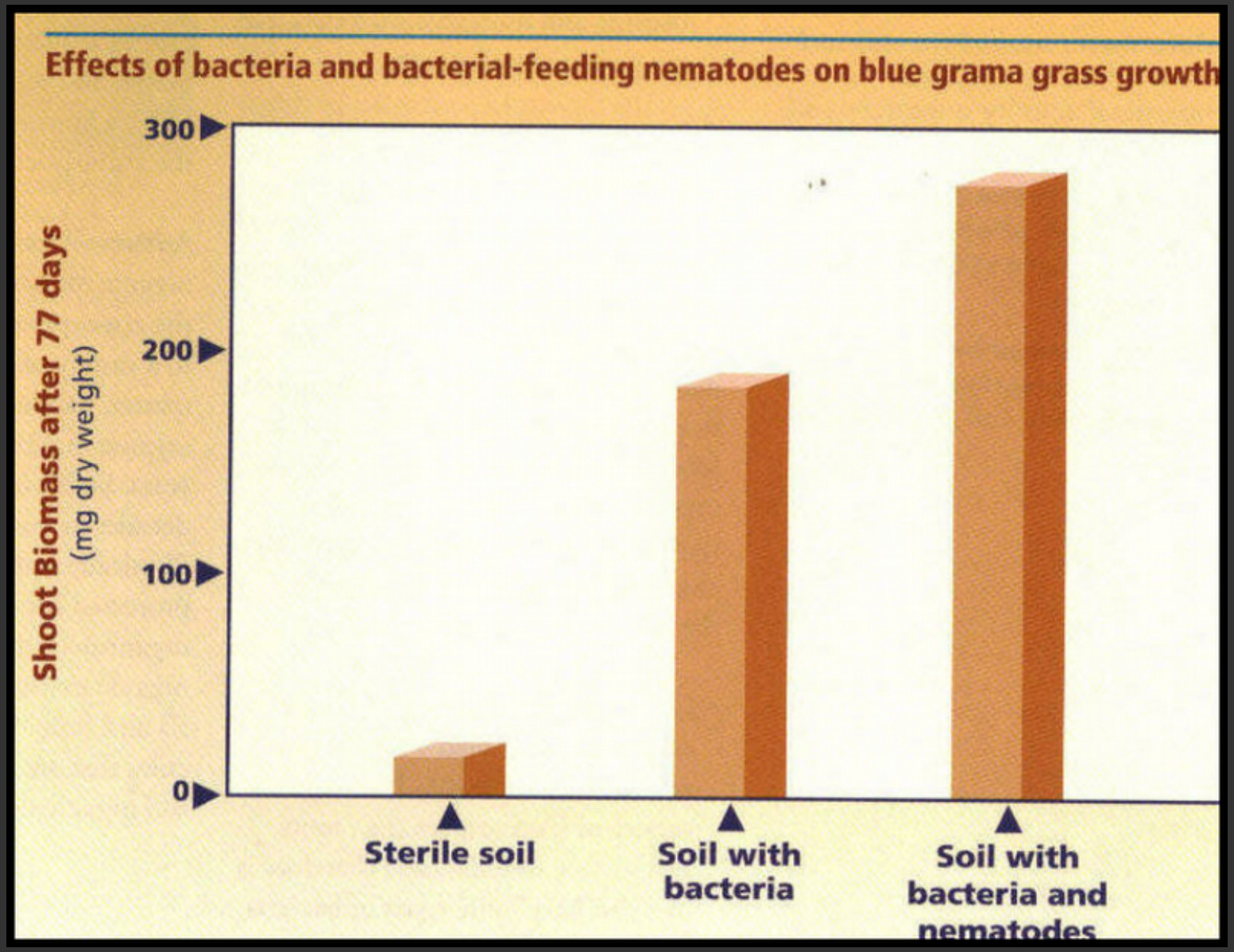
Soil composition by volume



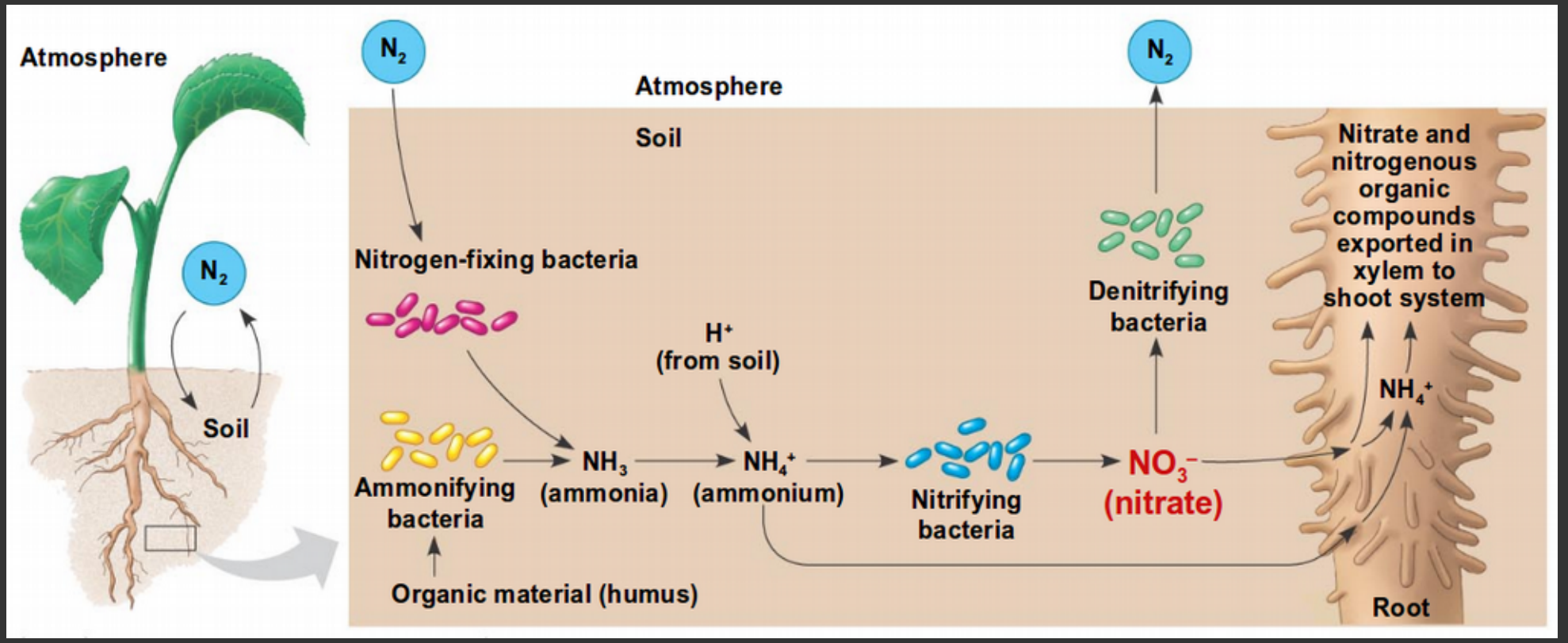
Biomass of Soil Organisms in Four Ecosystems



What is going on here?

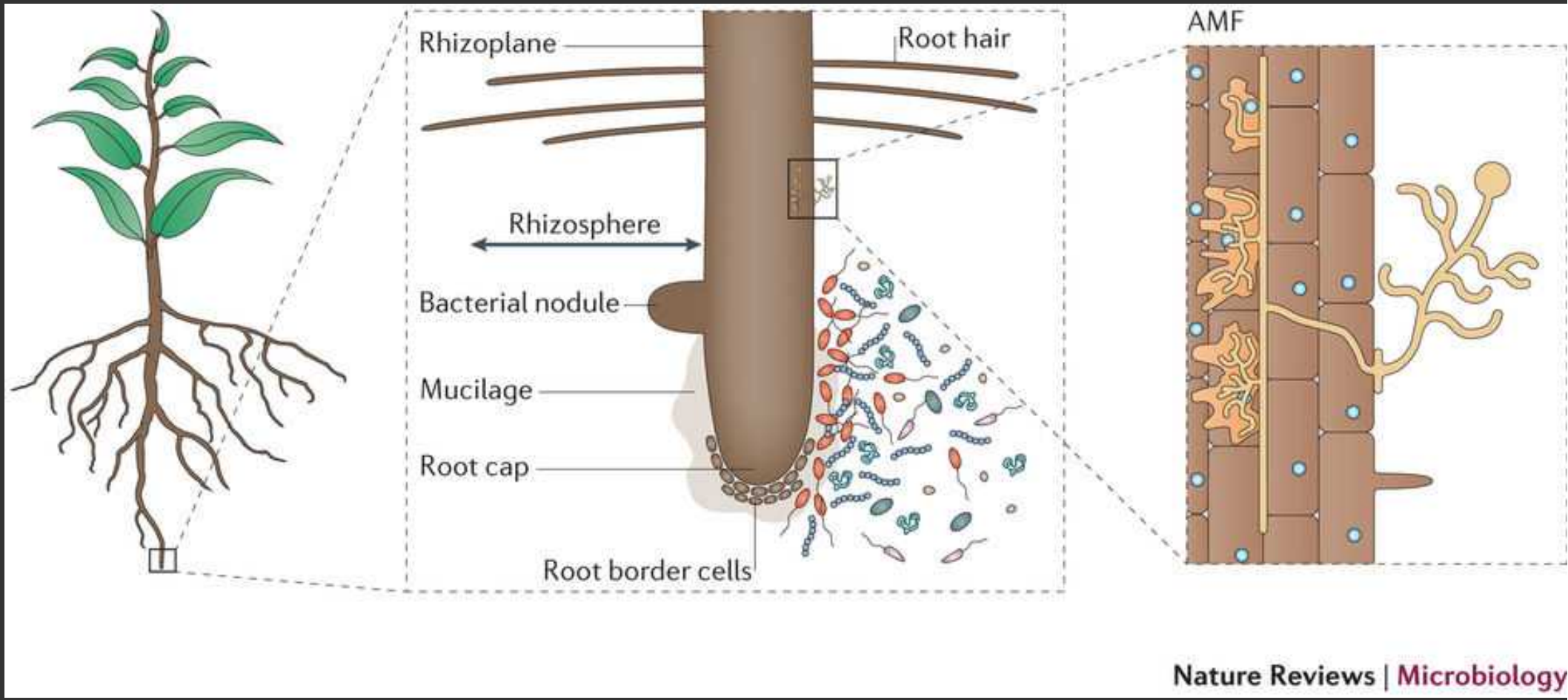


Role of bacteria in plant N acquisition

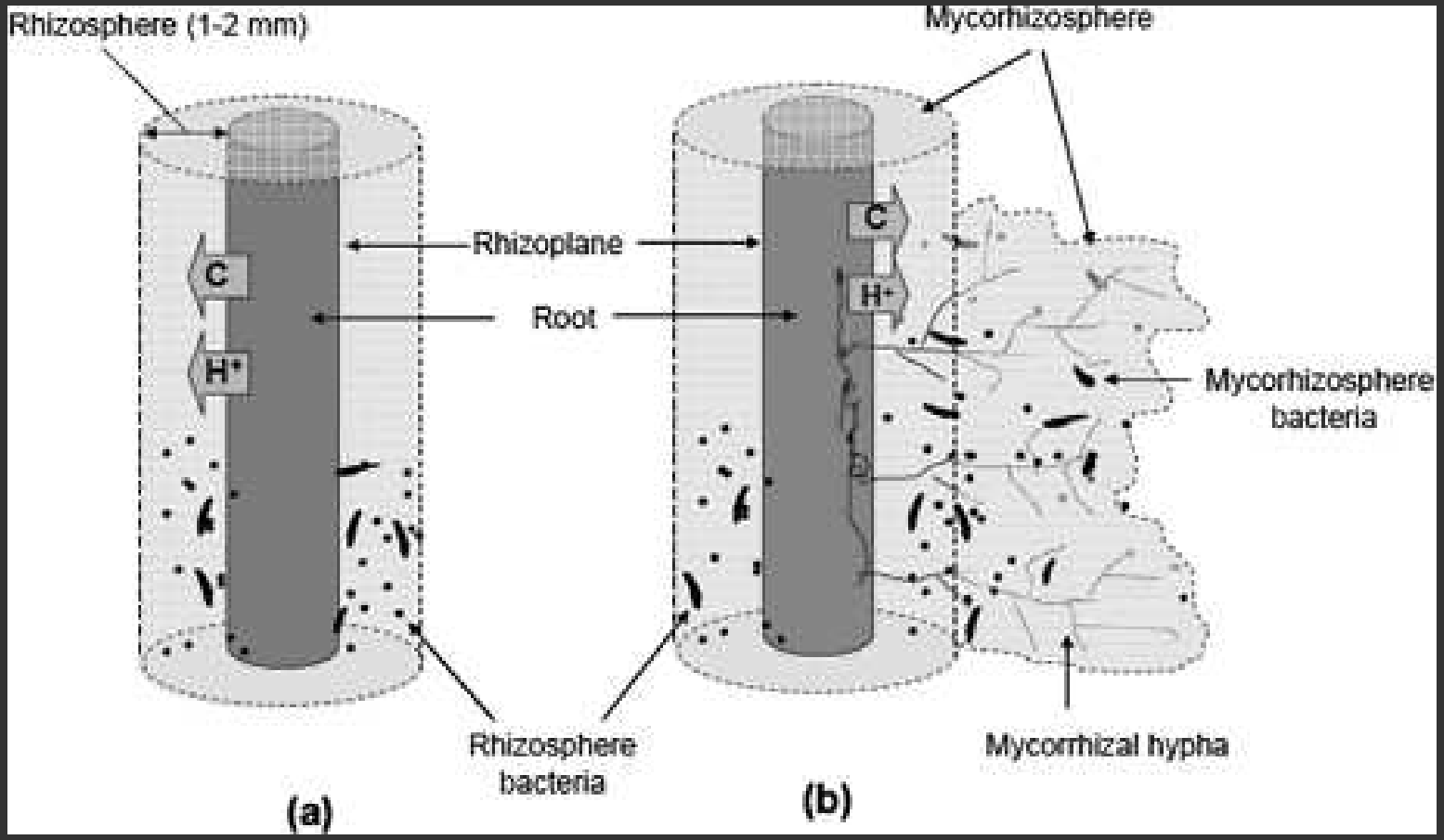


Soil is alive

Rhizosphere



"Mycorhizosphere"
(the extended rhizosphere)



Mycorhizosphere complexity

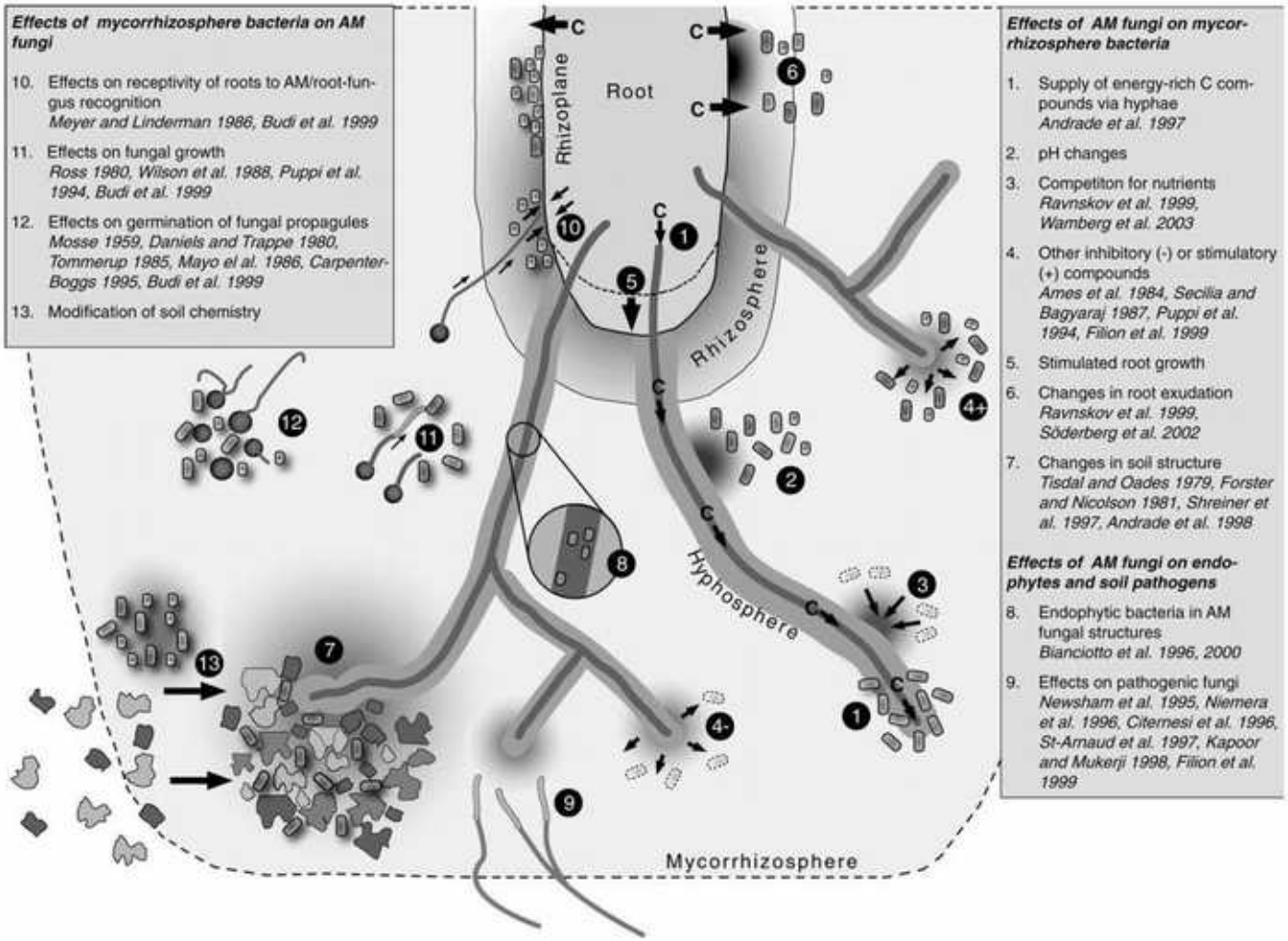
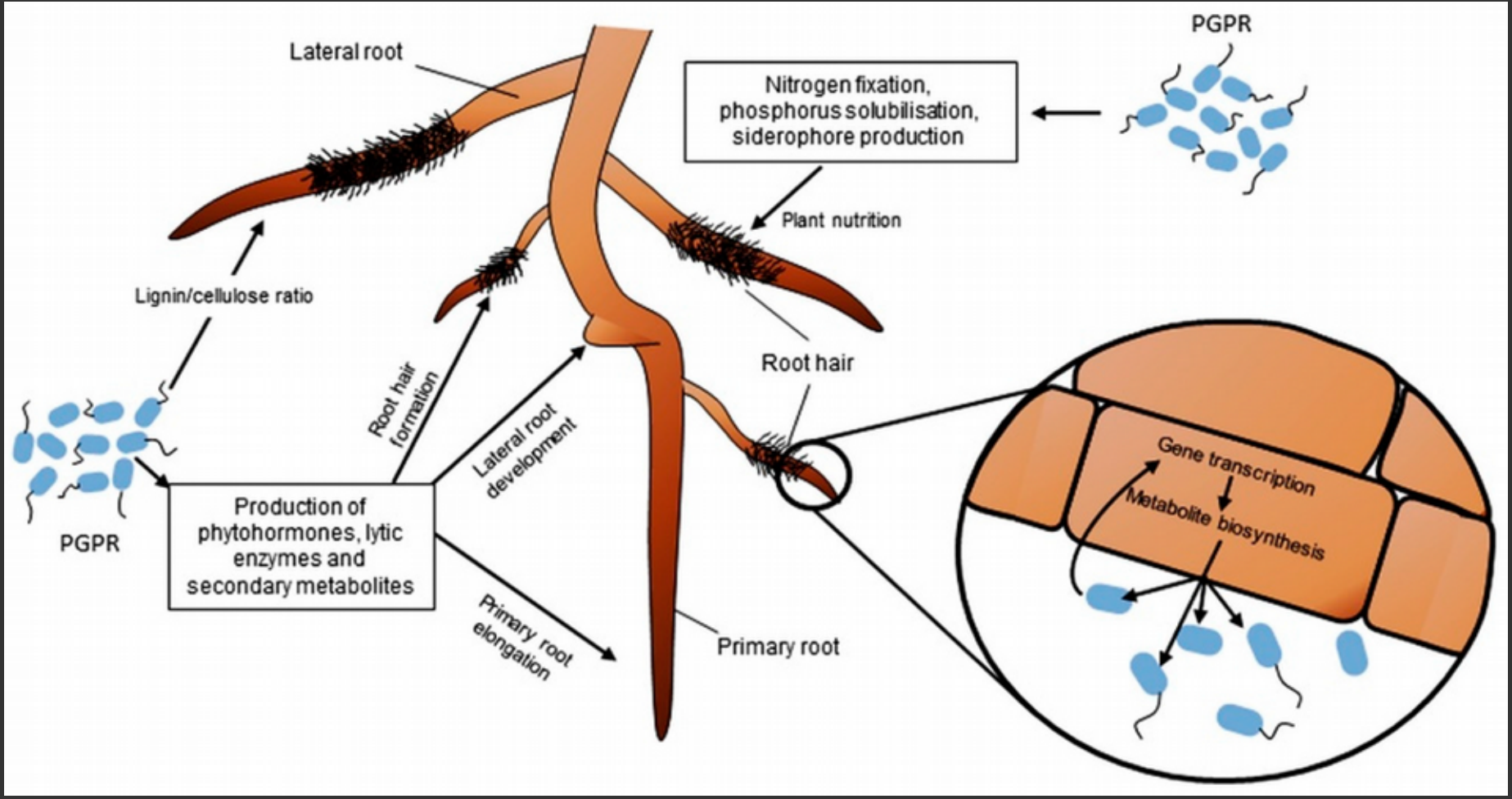
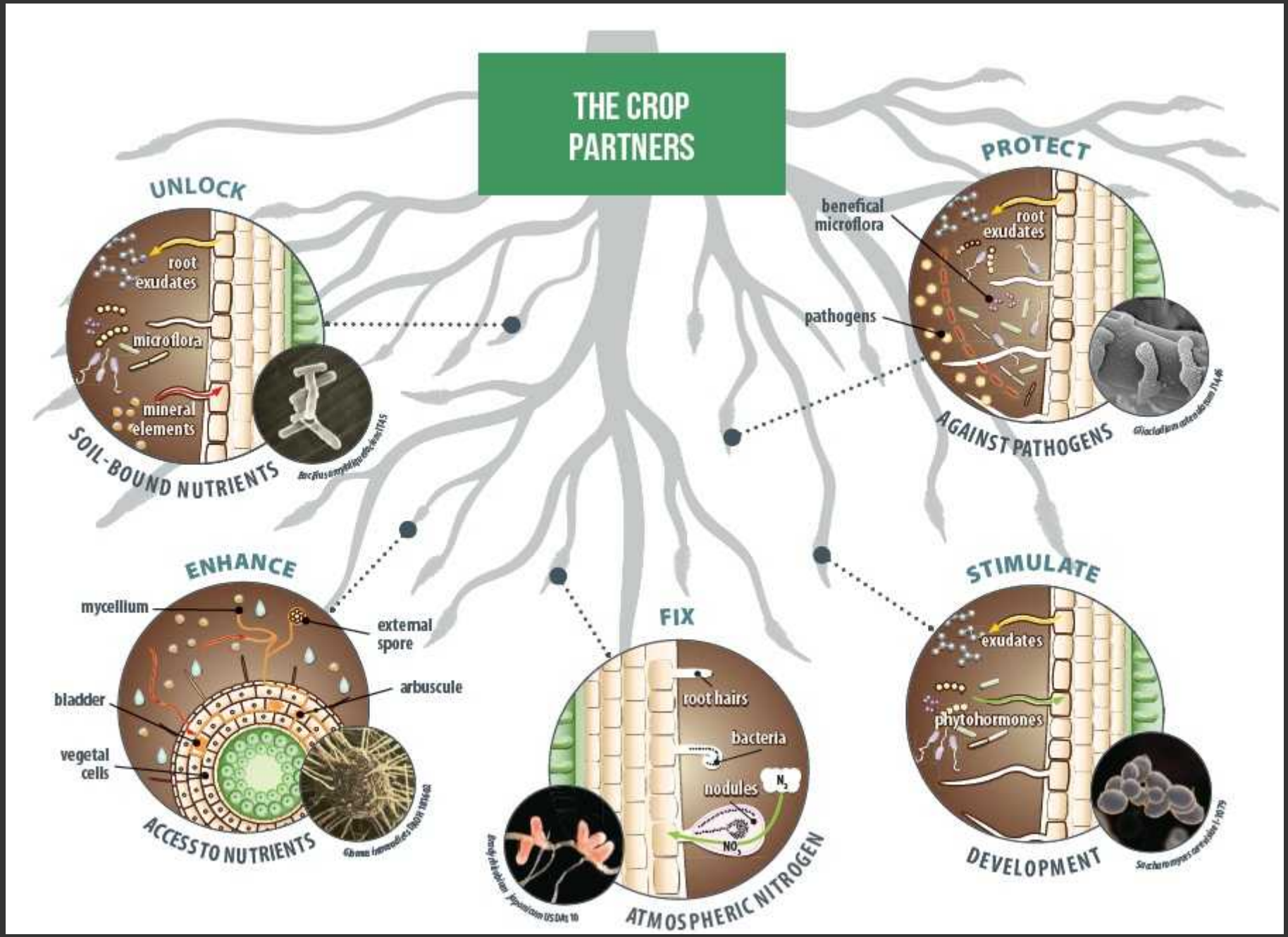


Fig. 1. Schematic view of possible interactions among different components of the mycorrhizosphere. The drawing is not to scale and underestimates the relative surface area of the external mycorrhizal mycelium.

Plant-growth promoting rhizobacteria

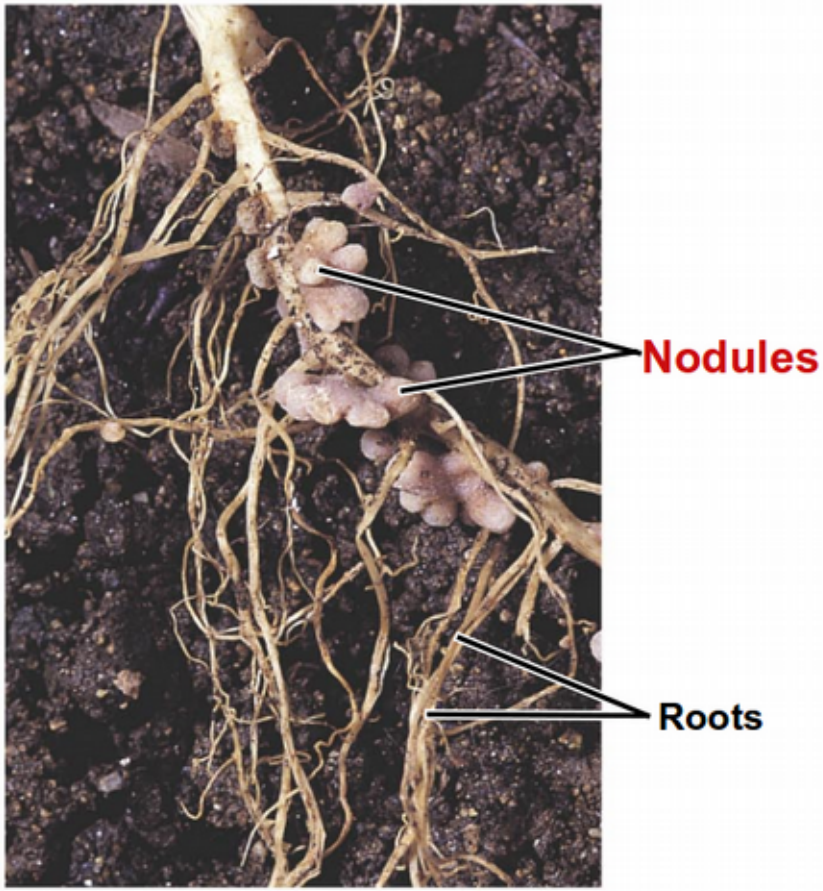


Some bacteria even make phytohormones

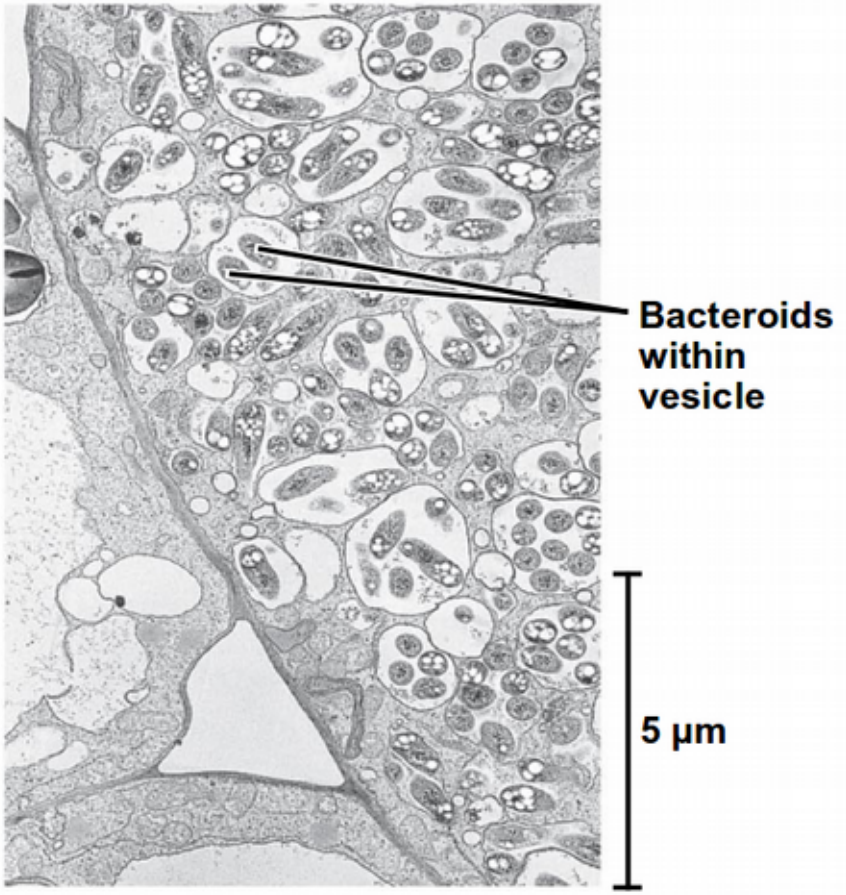

THE CROP PARTNERS
UNLOCK
root exudates
microflora
mineral elements
SOIL-BOUND NUTRIENTS
PROTECT
benefical microflora
root exudates
pathogens
AGAINST PATHOGENS
ENHANCE
mycelium
extemal spore
arbuscule
bladder
vegetal cells
ACCESS TO NUTRIENTS
FIX
root hairs
bacteria
nodules
N_2
NO_3
ATMOSPHERIC NITROGEN
STIMULATE
exudates
phytohormones
DEVELOPMENT

Rhizosphere bacteria

Root nodules on legume plants

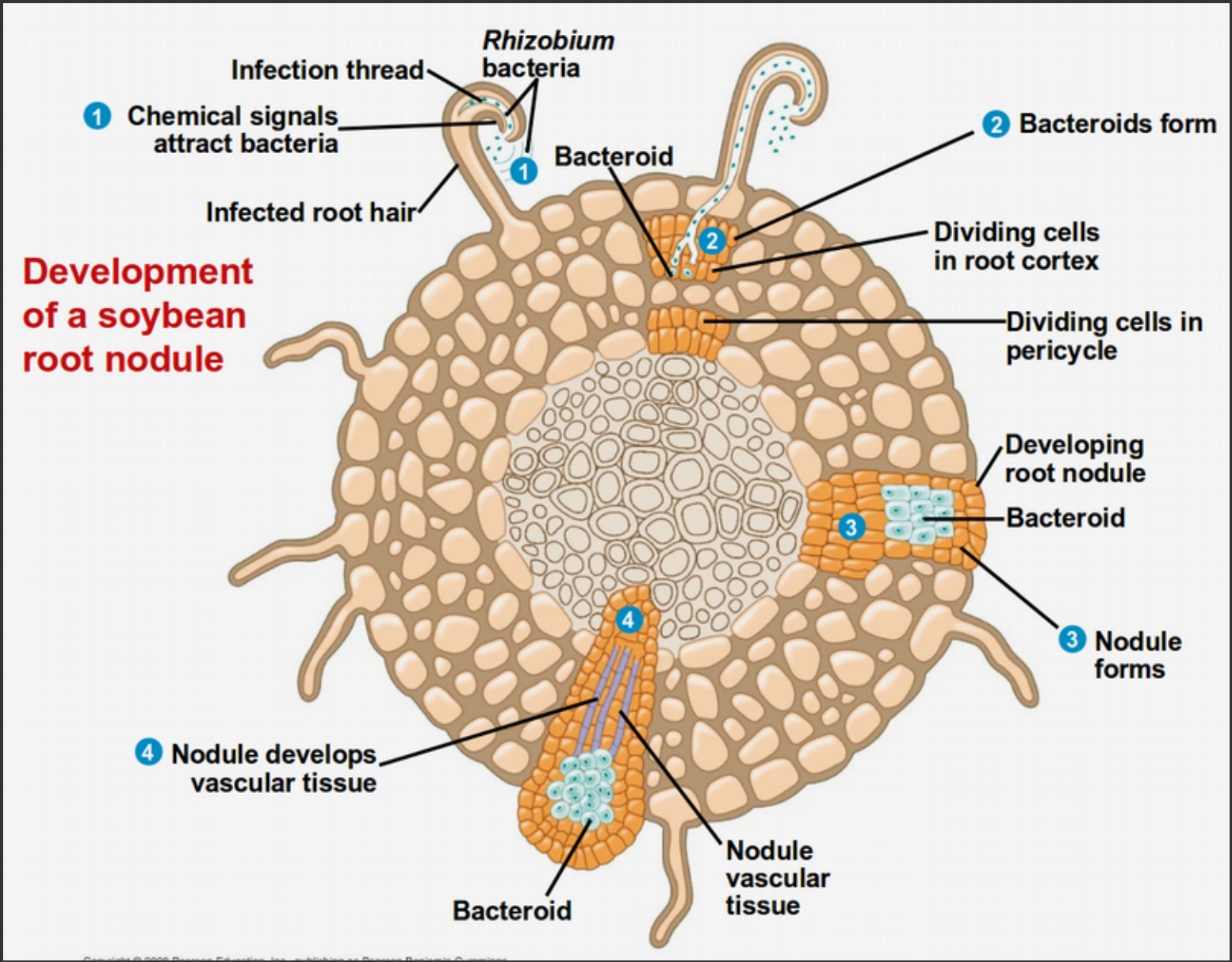


(a) Pea plant root



(b) Bacteroids in a soybean root nodule

Rhizobium infection of legume root

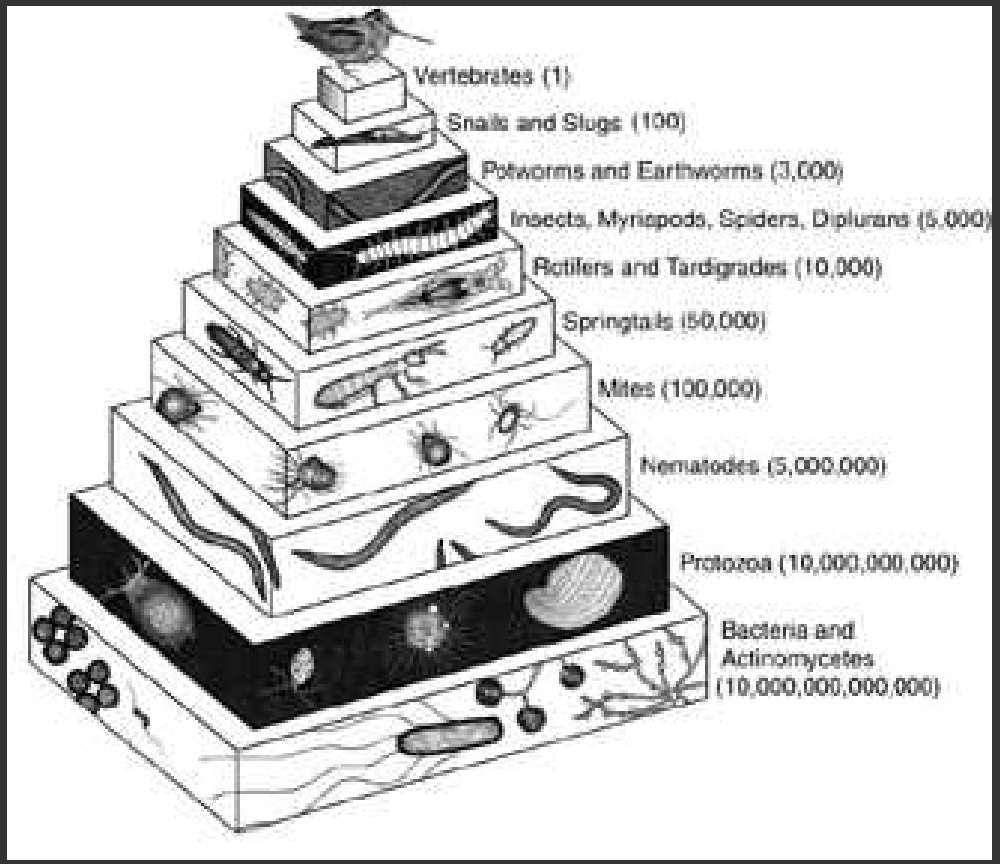


Soils are unbelievably complex

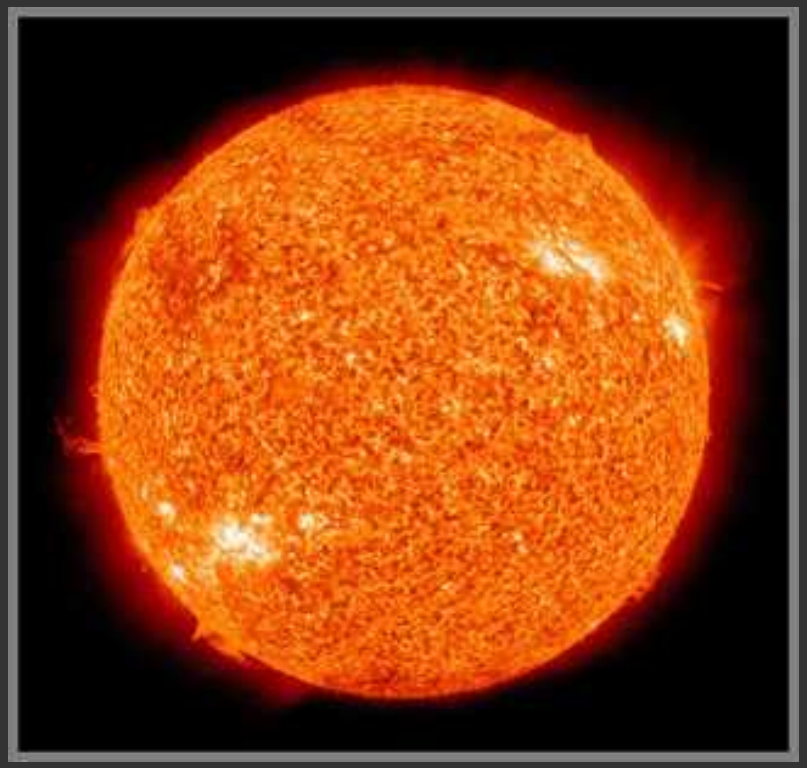
1 teaspoon of forest soil typically has:

- 40 MILES of fungal hyphae!
- 1 BILLION bacteria
- 100,000 protists
- 10,000 arthropods
- 100s of nematodes

10 m^2



We know more about the chemistry of this.....than we do about this



Utah's only carniverous plant

Utah's only carniverous plant

Bladderwort

Fastest plant on earth