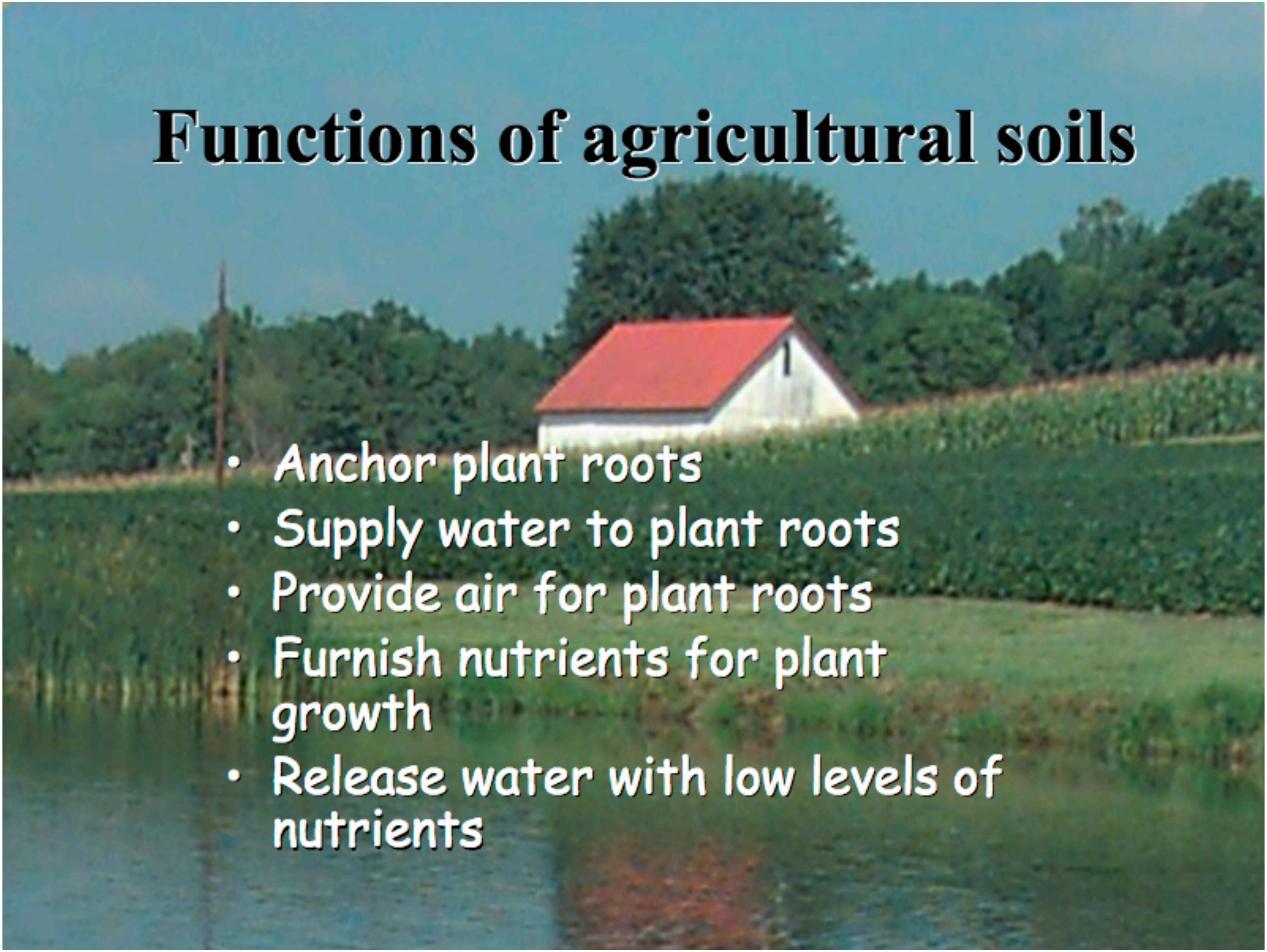
ADVANCE SOIL SCIENCE

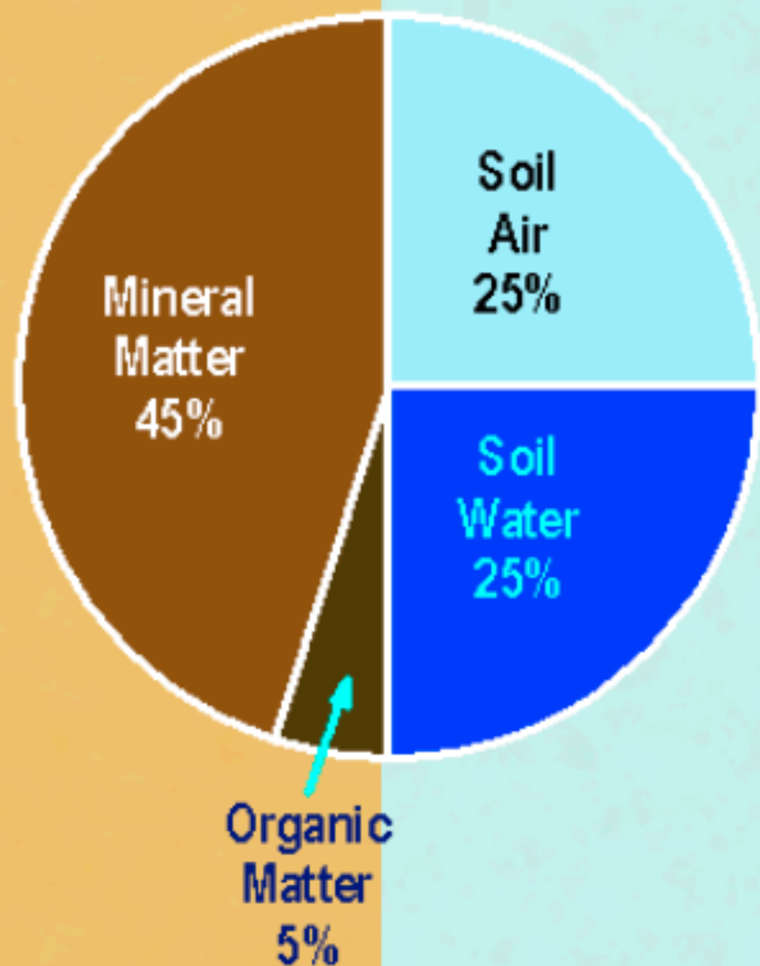
Presented by: Michael Trevizo


Functions of agricultural soils
• Anchor plant roots
• Supply water to plant roots
• Provide air for plant roots
• Furnish nutrients for plant growth
• Release water with low levels of nutrients

Soil Components

The 4 parts of soil

About ½ of the soil volume is solid particles



About ½ of the soil volume is pore space

Soil Texture

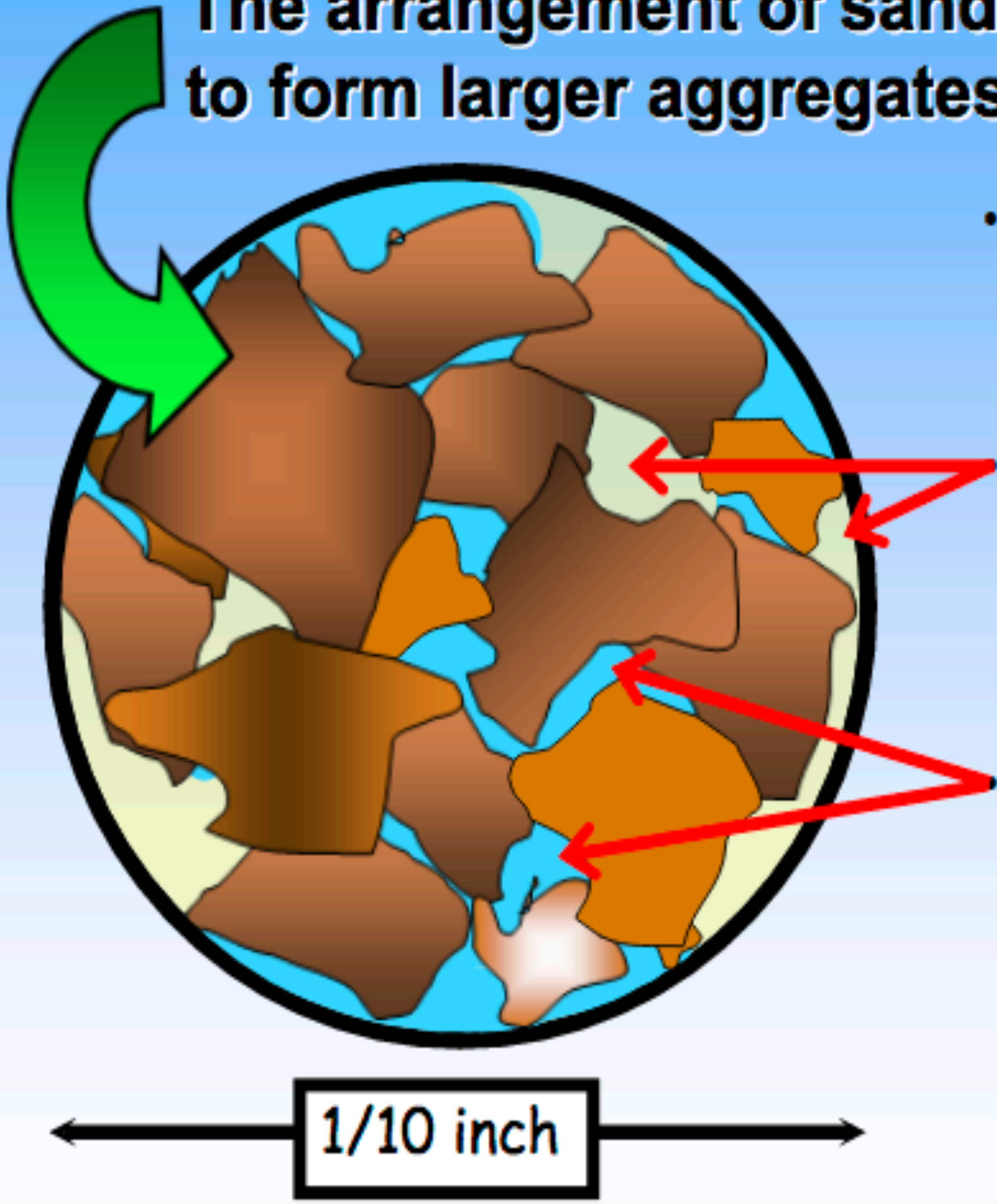
- The mineral part of soil consists of sand, silt, and clay particles

1/100 in		
Sand	**Silt**	**Clay**
0.1 – 0.002 in	0.002 – 0.0001 in	Less than 0.0001 in
2 – 0.05 mm	0.05 - 0.002 mm	Less than 0.002 mm

- The amounts of each size particle determines the textural property of the soil
  - **Coarse textured, loose (more sand, less clay)**
  - **Fine textured, heavy (more clay, less sand)**
  - **Loamy (more even mix of sand, silt and clay**

Soil Structure

The arrangement of sand, silt, and clay particles to form larger aggregates.



- <u>Organic matter</u> is the glue that holds the aggregates together

<u>Large pores (spaces)</u> between aggregates are filled with air in a moist soil.

<u>Small pores</u> are filled with water in a moist soil. Even smaller pores inside the aggregates (not shown) are also filled with water.

Supplying Plant Nutrients

Nutrients that plants obtain from the soil

Macronutrients:

(needed in large amounts)

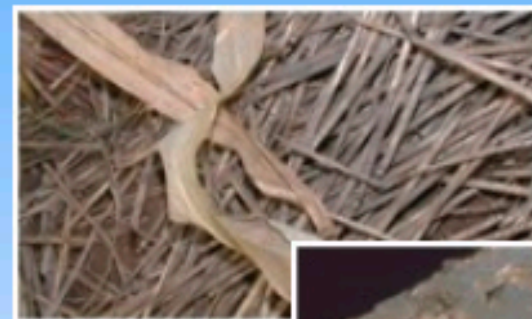
- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)
- Calcium (Ca)
- Magnesium (Mg)
- Sulfur (S)

Micronutrients:

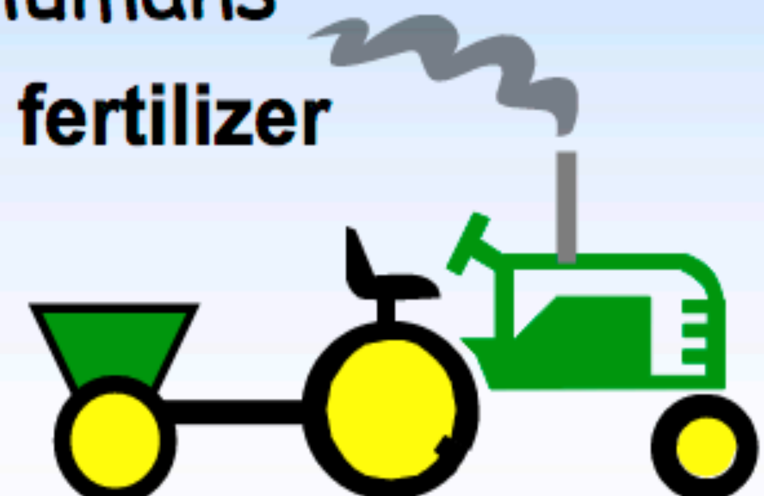
(needed in small amounts)

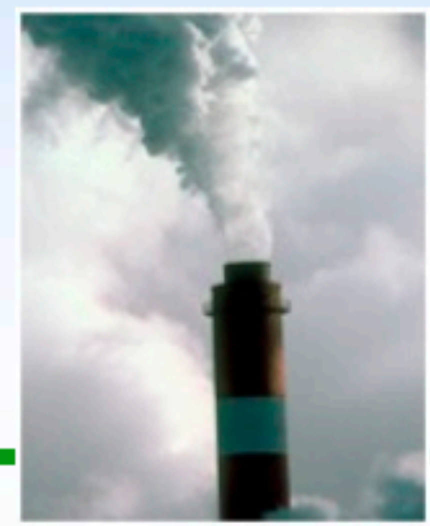
- Chlorine (Cl)
- Cobalt (Co)
- Copper (Cu)
- Iron (Fe)
- Manganese (Mn)
- Molybdenum (Mo)
- Nickel (Ni)
- Zinc (Zn)

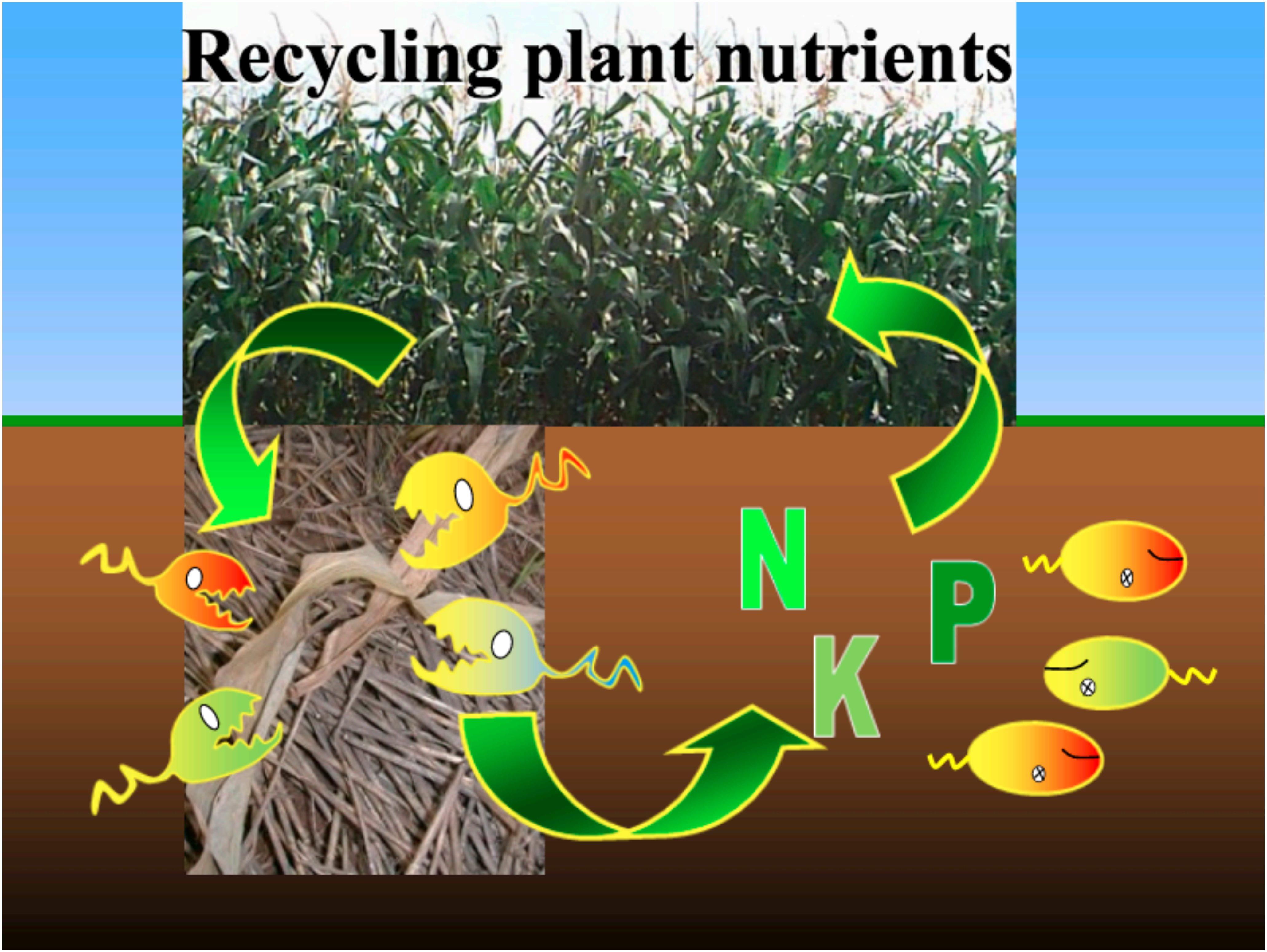
Where do plant nutrients come from?



- Decaying plant litter
- Breakdown of soil minerals
- Addition by humans
  - Commercial fertilizer
  - Manure
  - Lime
  - Other

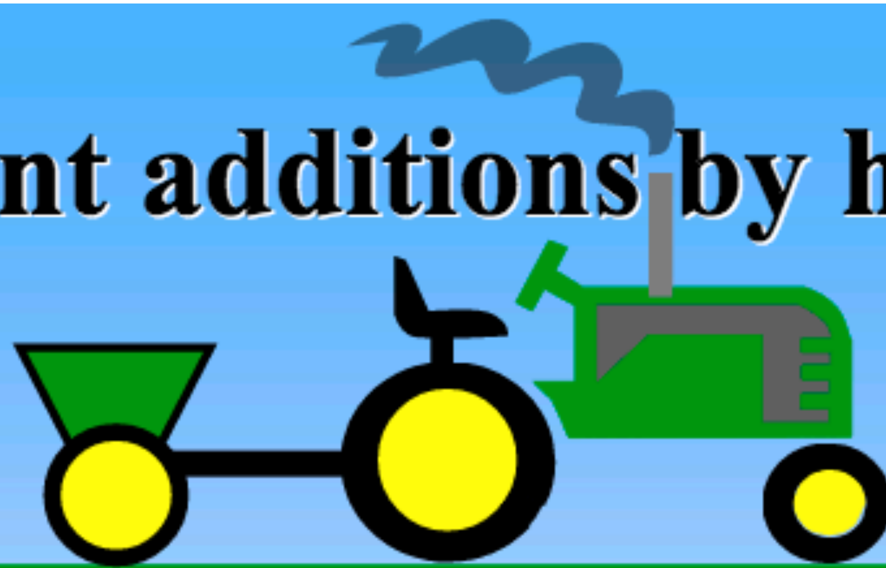





Recycling plant nutrients
N
P
K

Breakdown of soil minerals

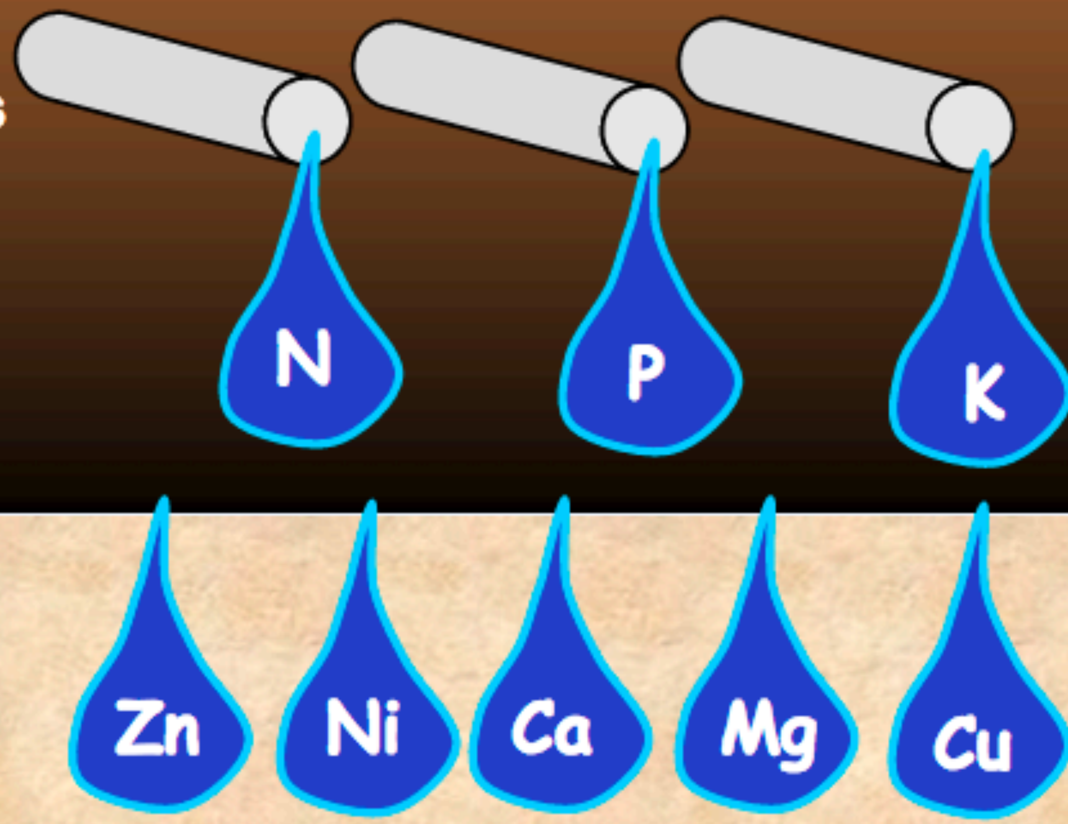
Nutrient additions by humans



- *Commercial fertilizers*
  - Nutrients are in a form that is available to plants
  - Dissolve quickly and nutrients go into soil water
- *Lime*
  - Dissolves slowly as it neutralizes soil acidity
  - Releases calcium and magnesium
- *Organic nutrient sources*
  - Manure, compost, sewage sludge
  - Decay and nutrient release is similar to crop litter

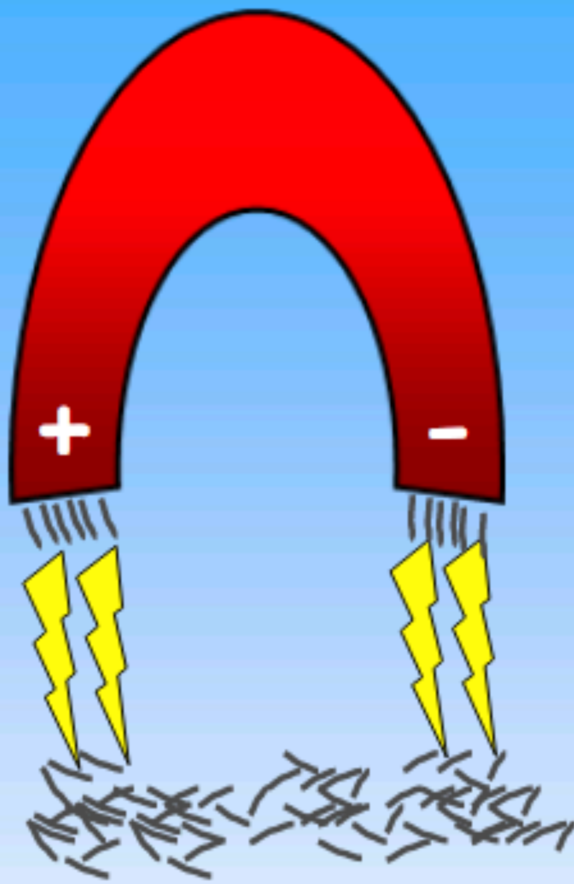
The soil solution

- Soil water is a complex solution that contains
  - Many types of nutrients
  - Other trace elements
  - Complex organic molecules
- Nutrients in the soil solution can be readily taken up by plant roots



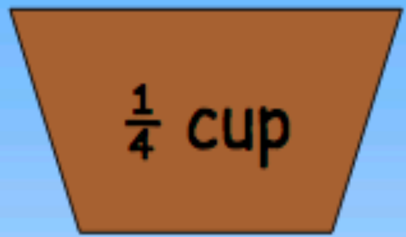
- If nutrients remained in solution they could all be quickly lost from the soil.

Adsorption

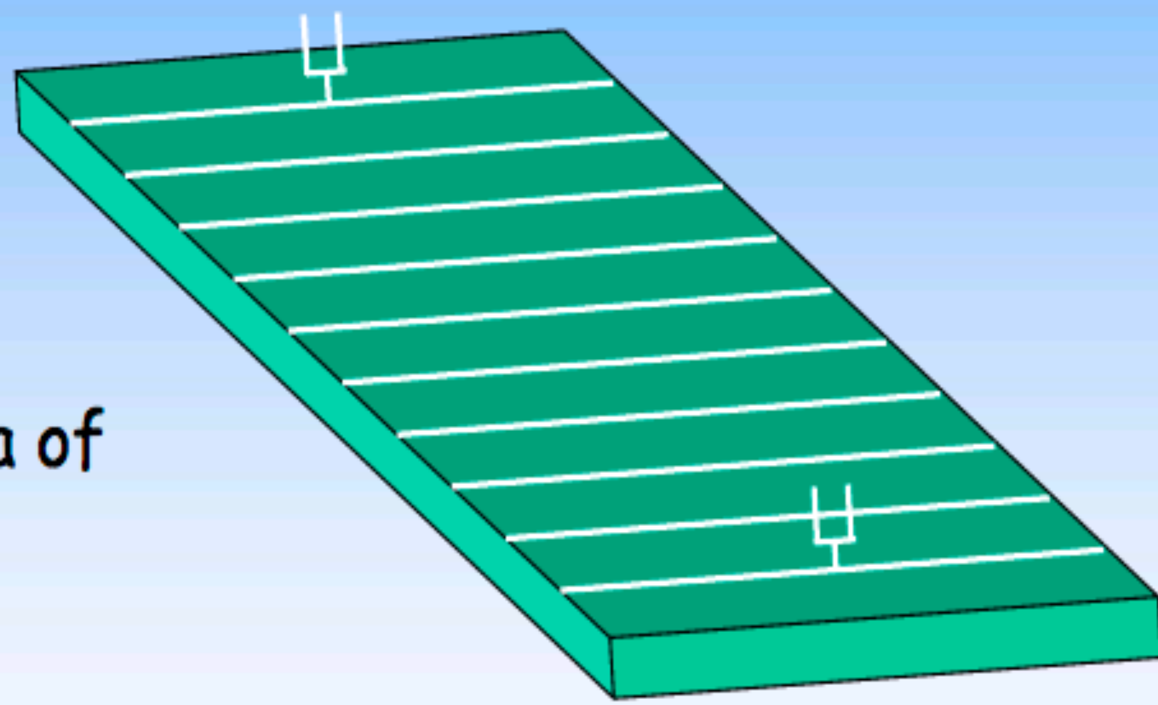


- Adsorption refers to the ability of an object to attract and hold particles on its surface.
- Solid particles in soil have the ability to adsorb
  - **Water**
  - **Nutrients and other chemicals**
- The most important adsorbers in soil are
  - **Clays**
  - **Organic matter**

Surface area of clay



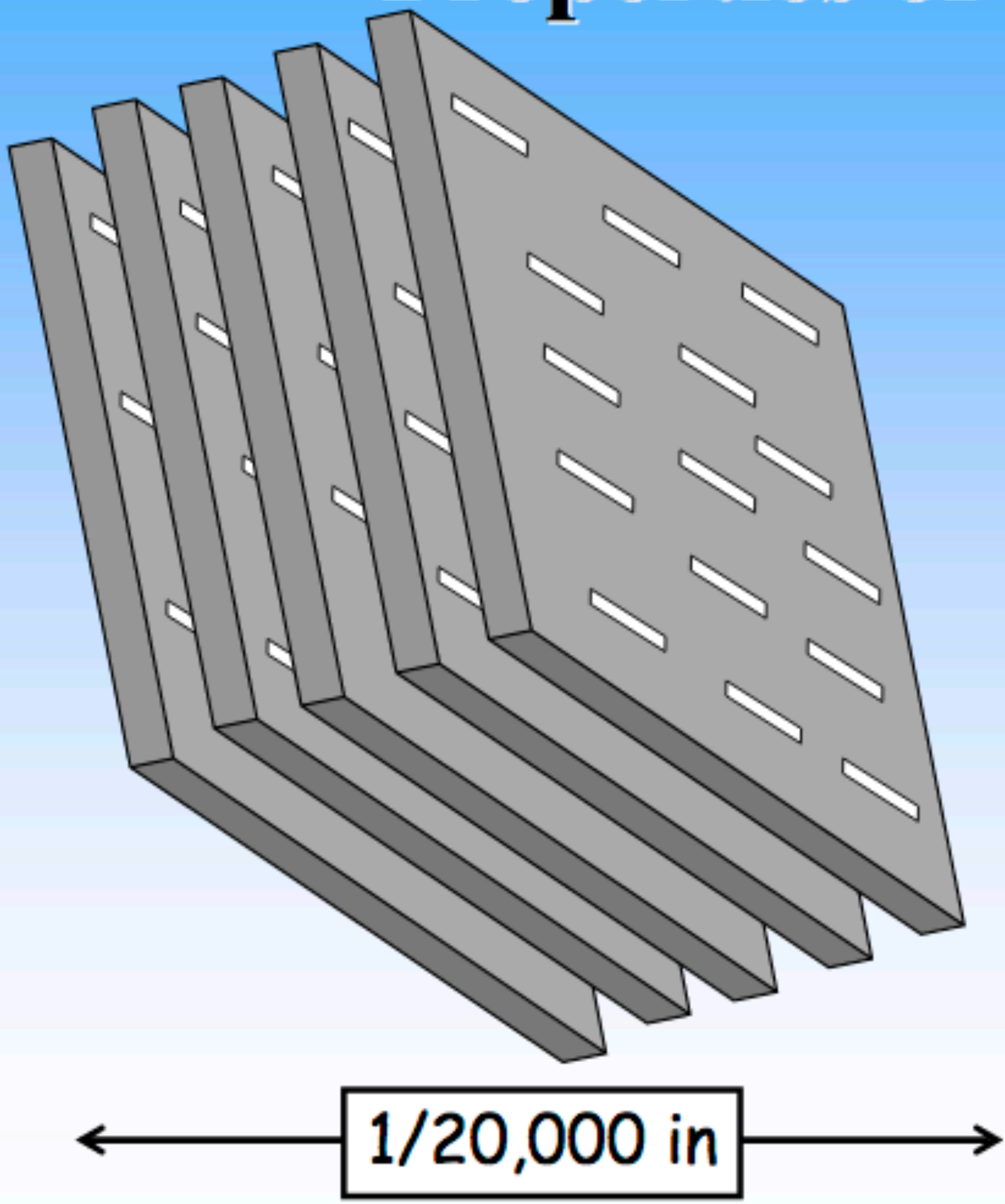
¼ cup of clay has more surface area than a football field



The large surface area of clay allows it to

- Adsorb a lot of water
- Retain nutrients
- Stick to other soil particles

Properties of Soil Clays



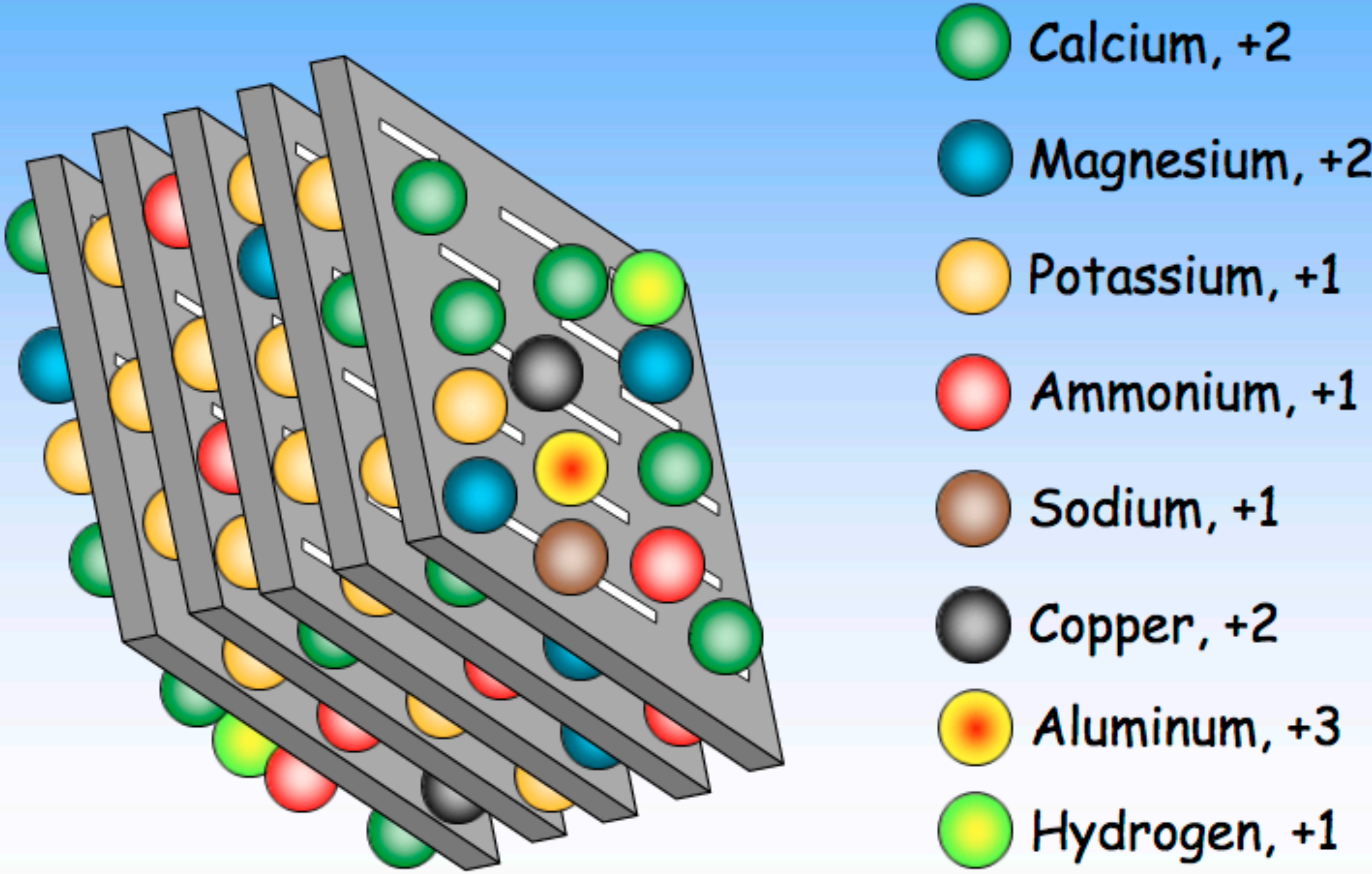
Clay particles are stacked in layers like sheets of paper.

Each clay sheet is slightly separated from those on either side.

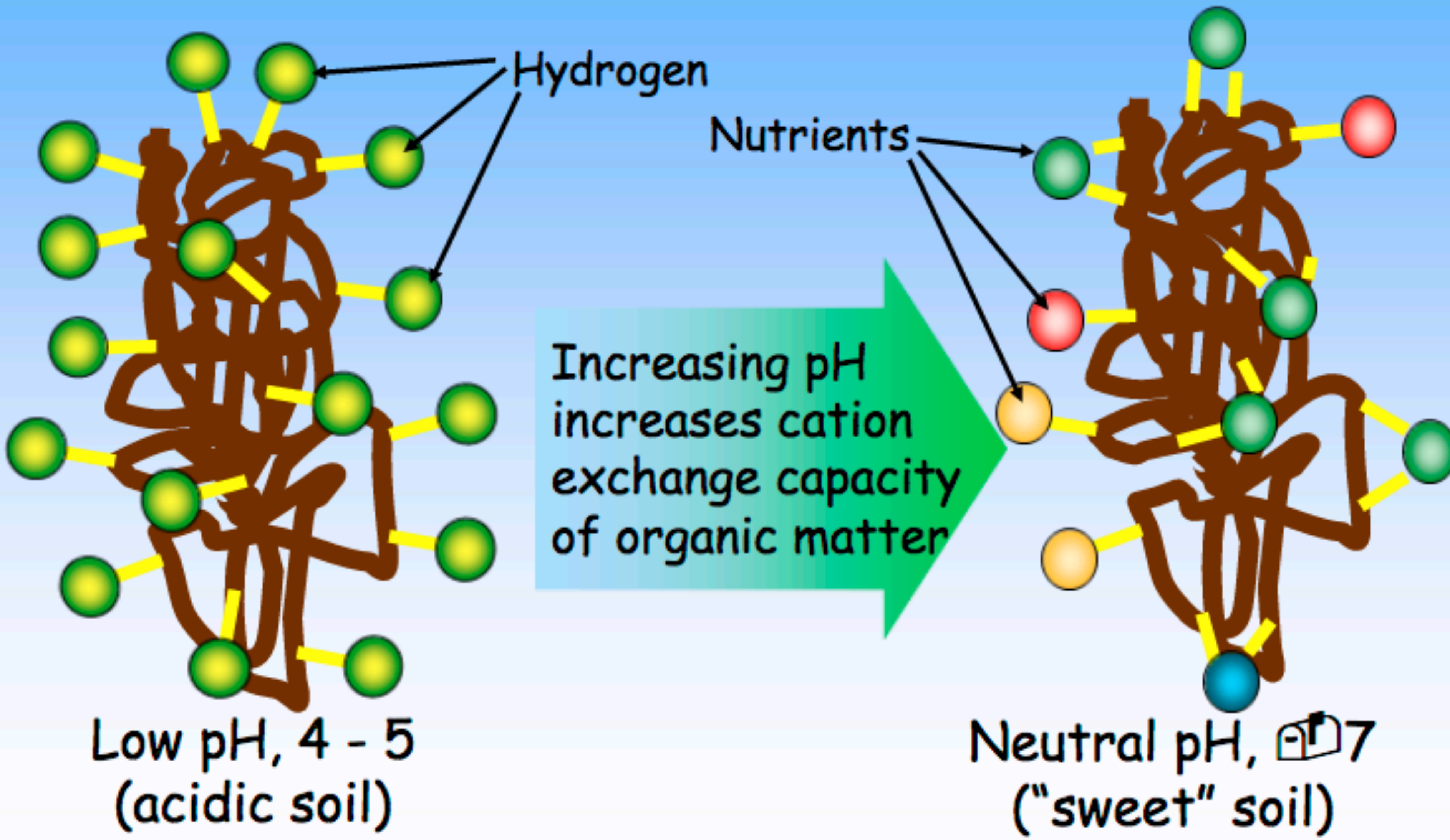
Each sheet has negative charges on it.

Negative charges have to be balanced by positive charges called cations.

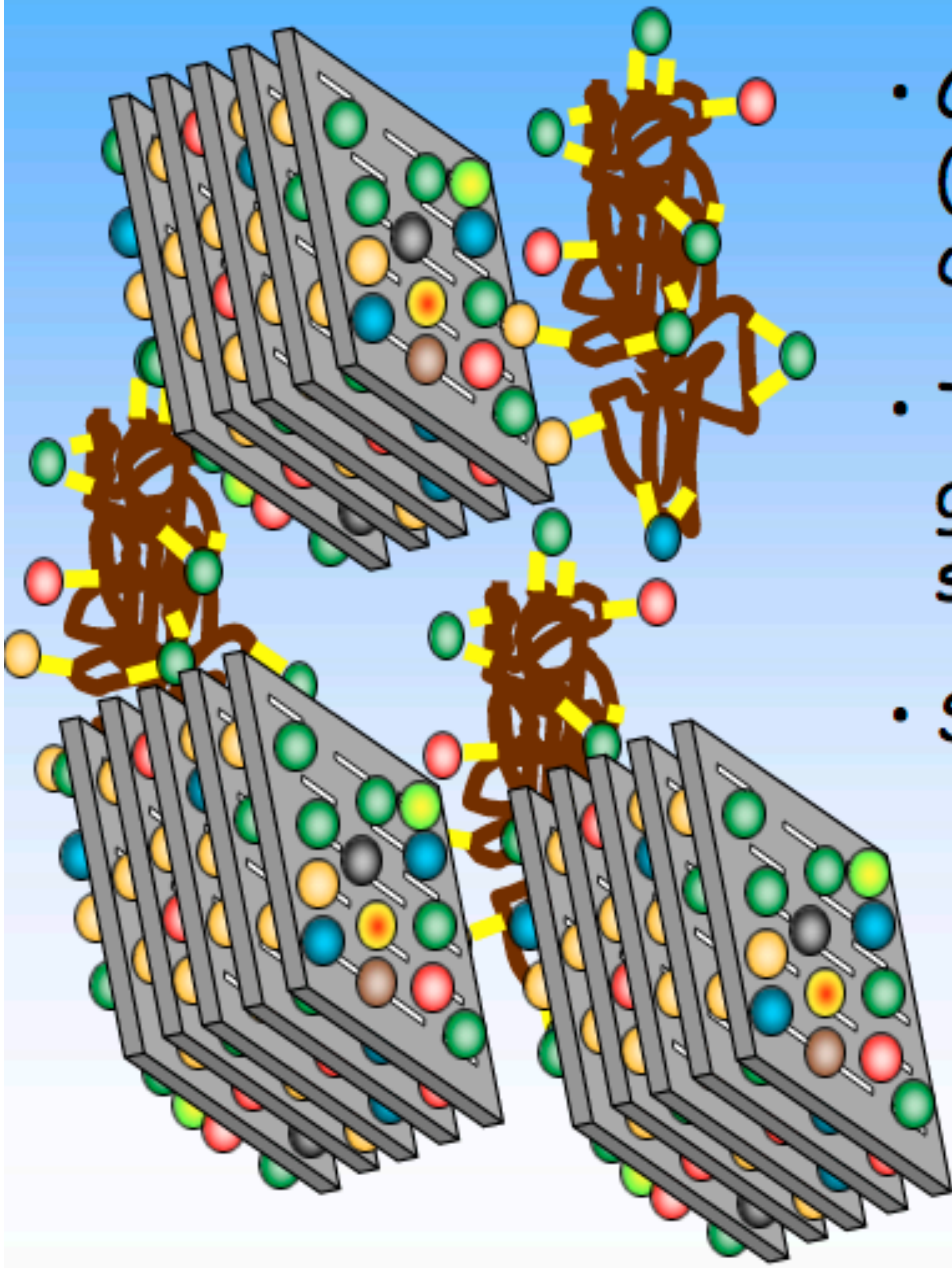
Cation Retention on Soil Clays



Cation Retention on Organic Matter



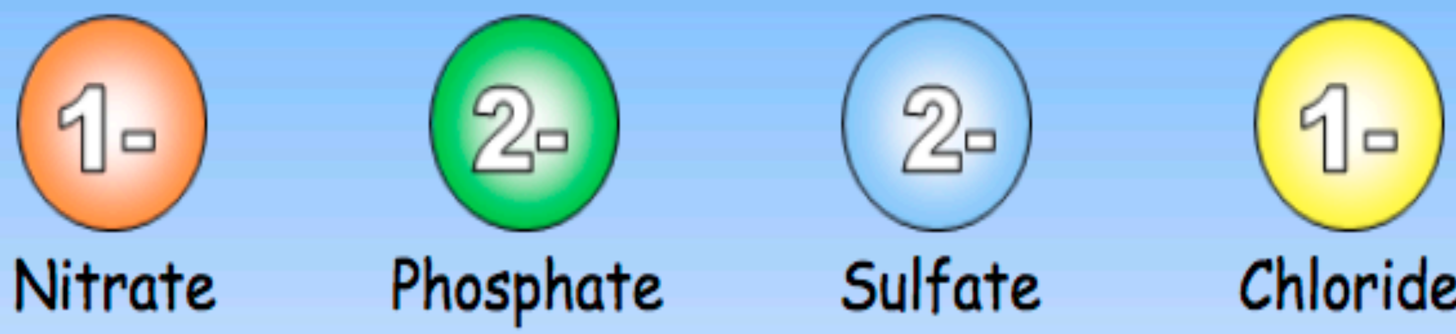
Cation Exchange Capacity



- Cation exchange capacity (CEC) is the total amount of cations that a soil can retain
- The higher the soil CEC the greater ability it has to store plant nutrients
- Soil CEC increases as
  - **The amount of clay increases**
  - **The amount of organic matter increases**
  - **The soil pH increases**

Negatively Charged Nutrients
(Anions)

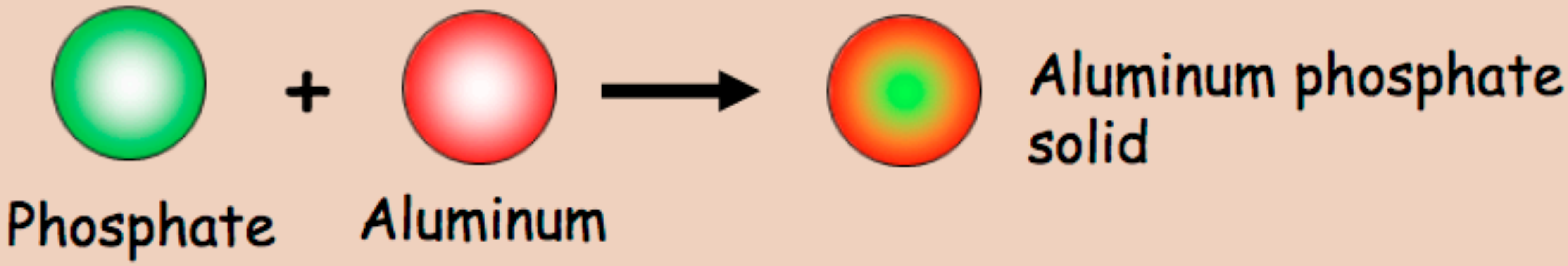
- Some very important plant nutrients are anions.



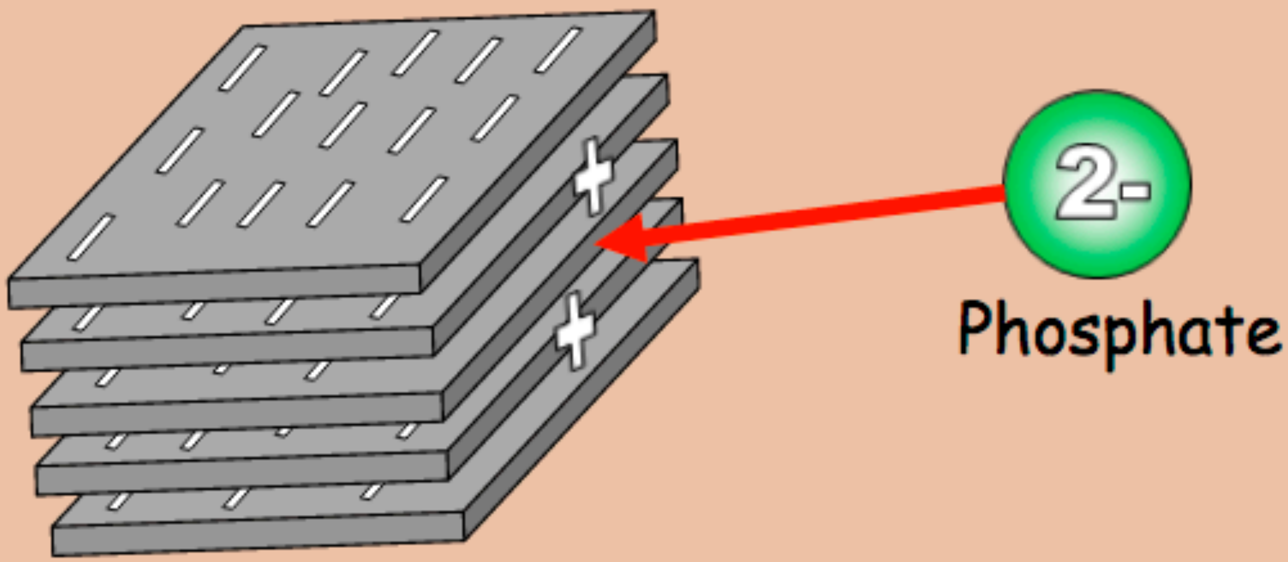
- Soils are able to retain some of these nutrient anions.
- Retention of nutrient anions varies from one anion to another

Phosphate retention in soil

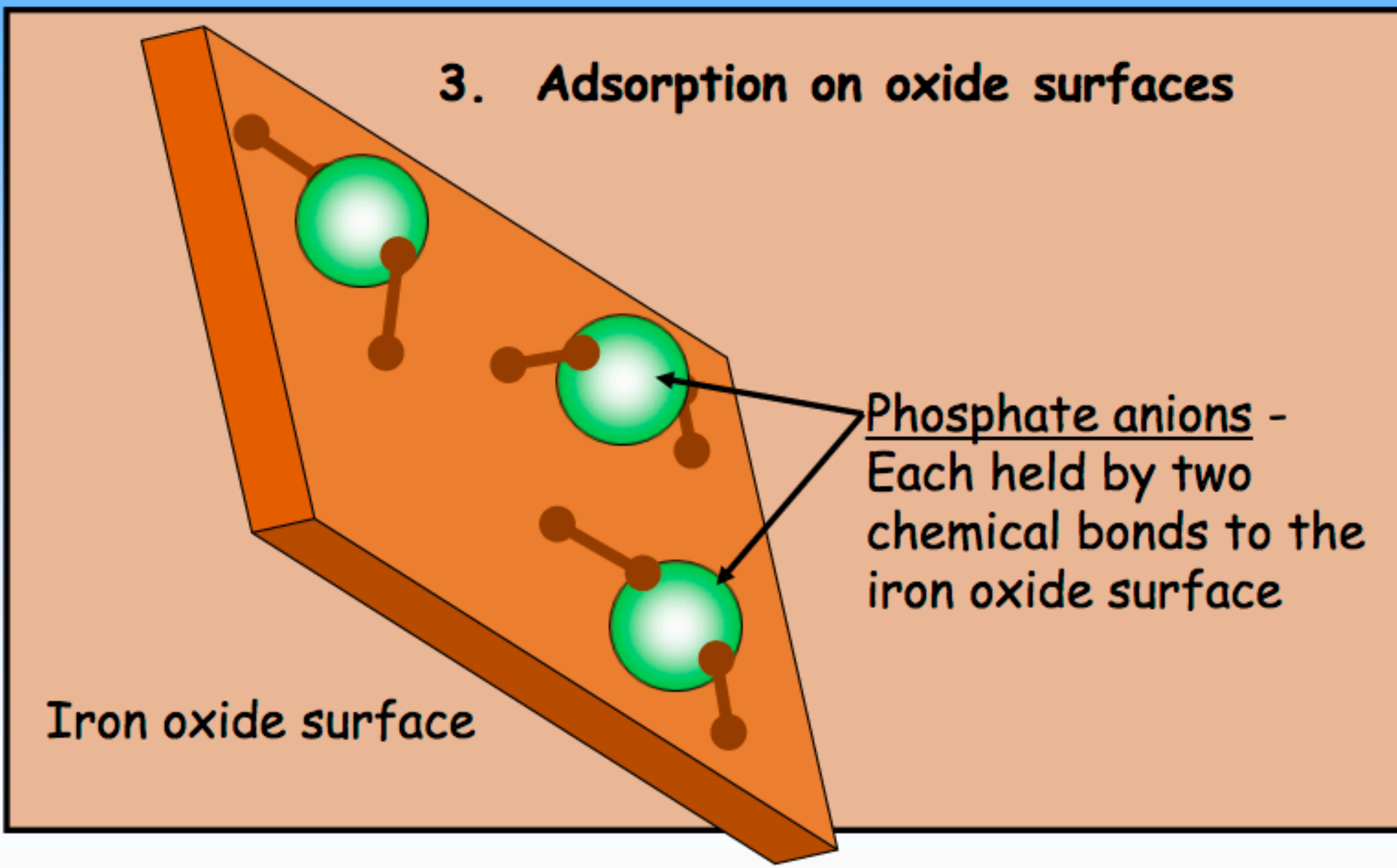
1. Formation of a new solid material



2. Anion exchange



Phosphate retention in soil



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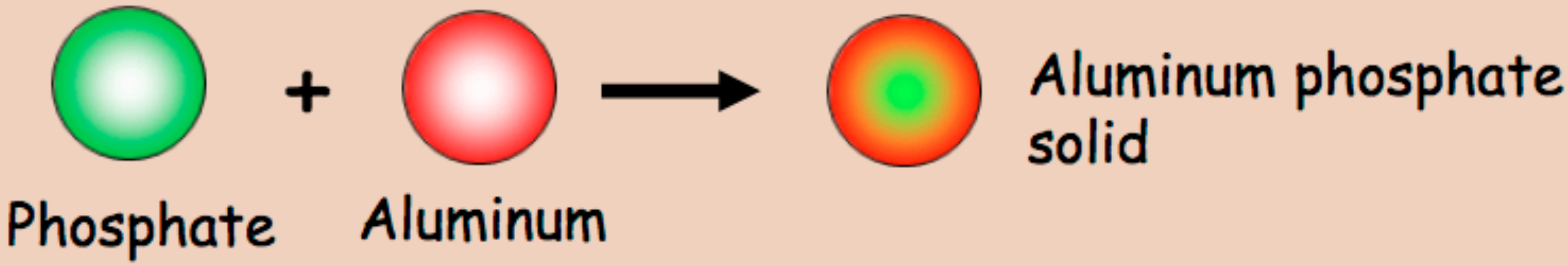

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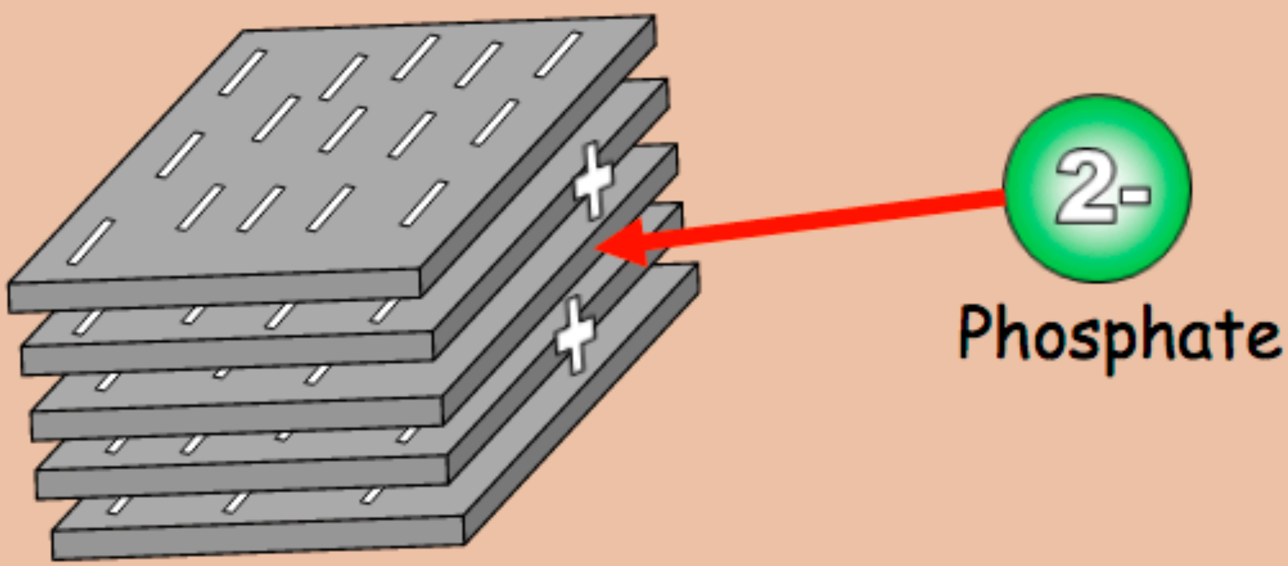
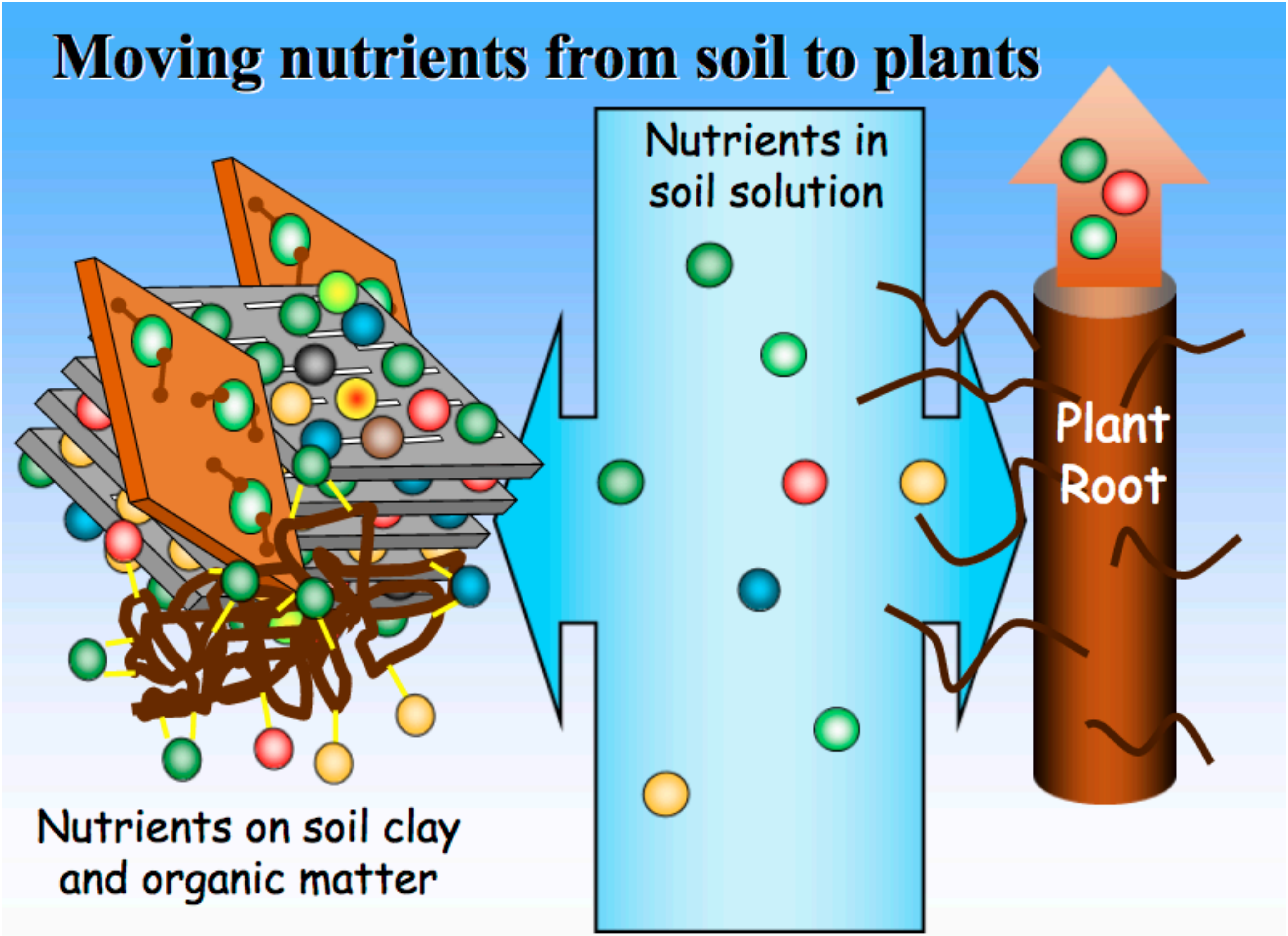
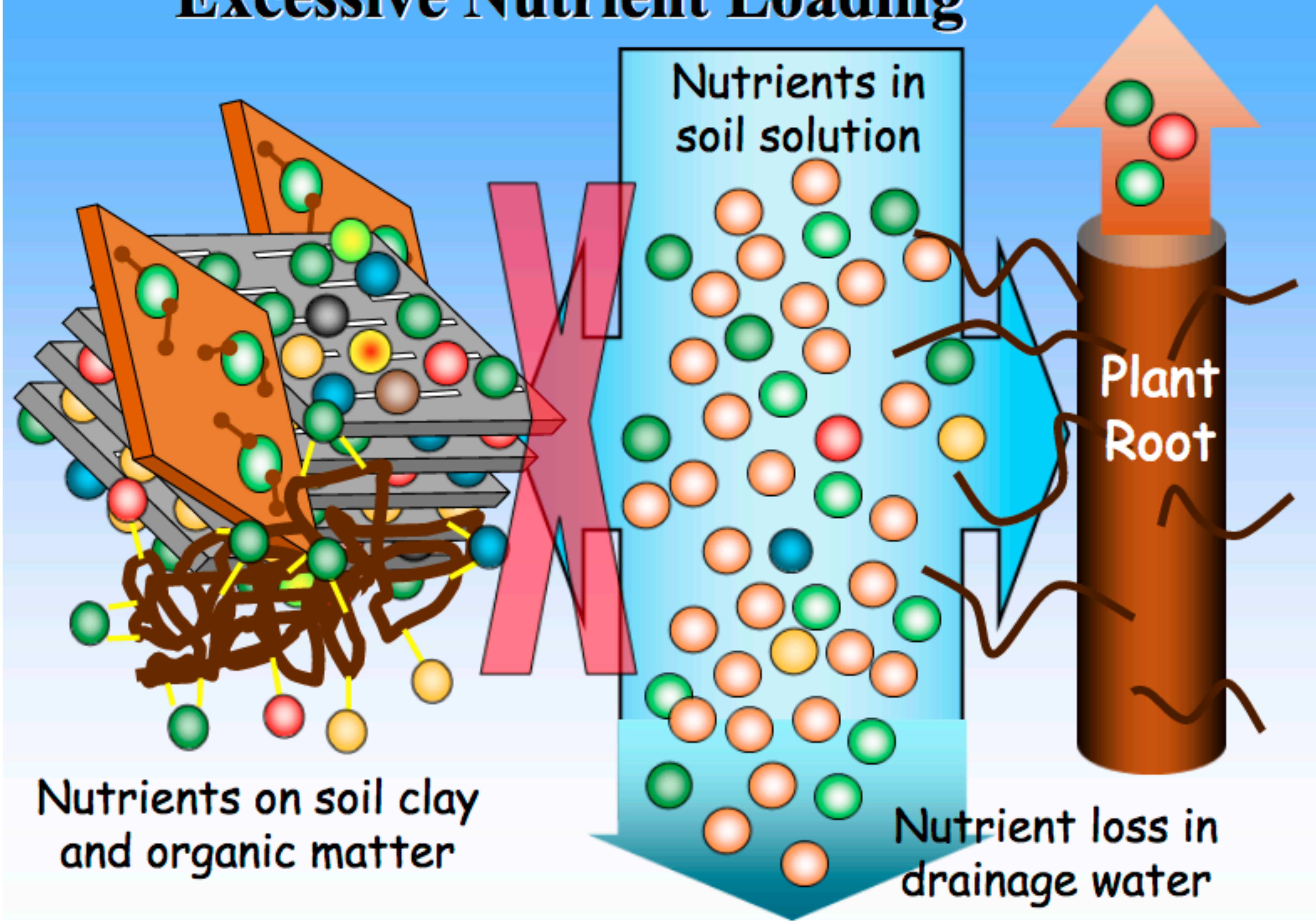



Moving nutrients from soil to plants
Nutrients in soil solution
Plant Root
Nutrients on soil clay and organic matter

Excessive Nutrient Loading



The black box is open

- Soil consists of mineral and organic matter, air and water
- Soils are able to adsorb nutrients and other chemicals
- The most important adsorbers are clay and organic matter
- Adsorbed nutrients are available to plants
- Adsorbed nutrients are not prone to loss in drainage water
- Soil adsorption capacity can be exceeded leading to greater nutrient loss

BASIC SOIL-PLANT RELATIONSHIPS

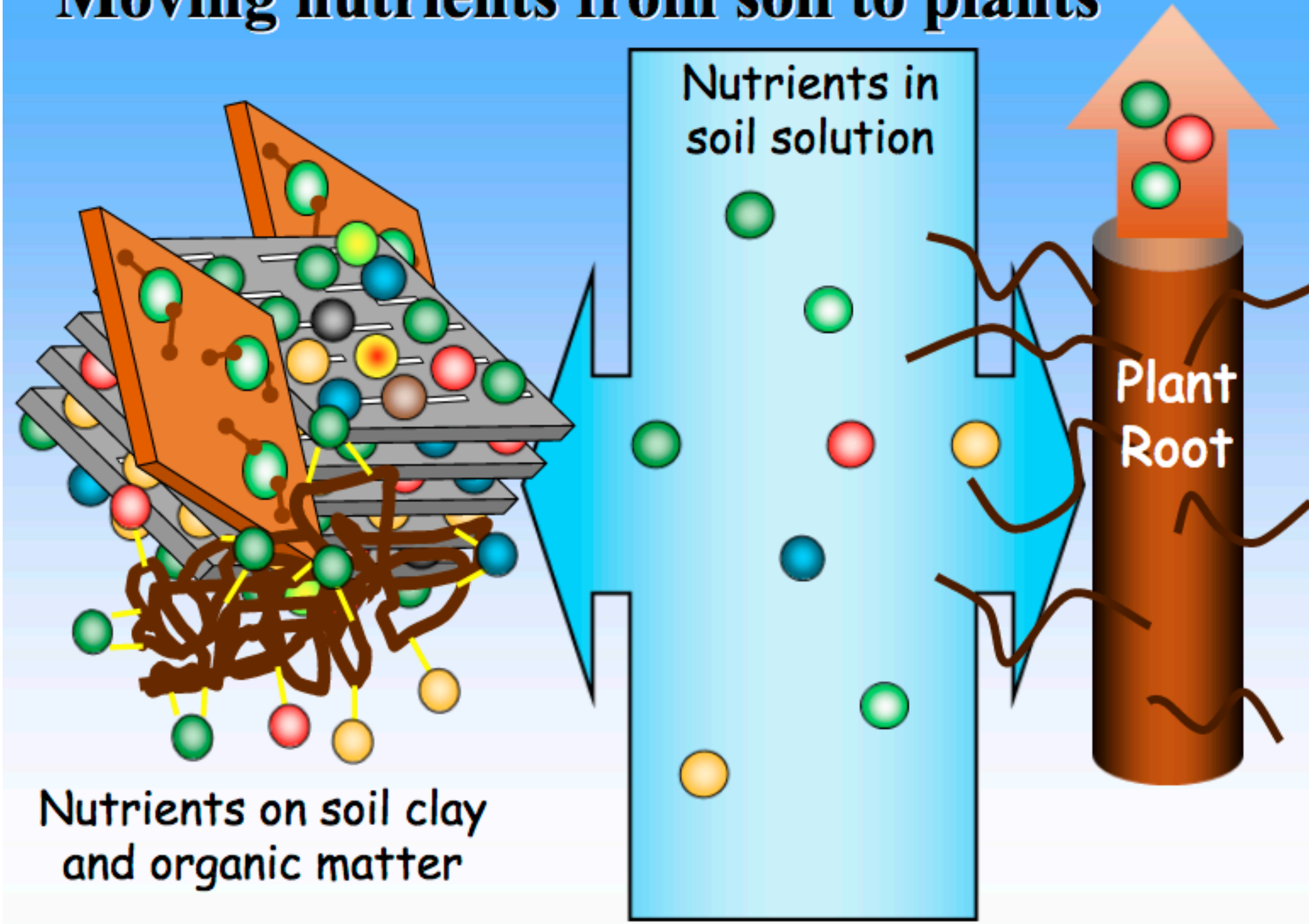
CATION EXCHANGE CAPACITY(CEC)

- https://www.youtube.com/watch?v=HmEyymGXOfI

SO… NOW YOU KNOW CEC

- Base Saturation?
- What is it?
- % base saturation
- Soil nutrient balancing

Moving nutrients from soil to plants



BASE SATURATION

- Base saturation is the measure of total “bases” in the soil
- %Base saturation, is the % of a soils CEC that is occupied by a given nutrient

Soils sample taken from a field

Soil Report

Job Name: **Five College Farms** Date: 7/29/2016

Company: Five College Farms Submitted By:

			RDW	RDS	RD276	RD258	
Sample Location			RDW	RDS	RD276	RD258	
Sample ID							
Lab Number			34	35	36	37	
Sample Depth in inches			8	8	8	8	
Total Exchange Capacity (M. E.)			6.24	4.94	5.27	3.95	
pH of Soil Sample			5.2	6.1	5.9	5.2	
Organic Matter, Percent			4.16	2.26	2.71	3.45	
ANIONS	**SULFUR:**	p.p.m.	21	15	15	22	
ANIONS	**Mehlich III Phosphorous:**	as (P_2O_5) lbs / acre	2114	1505	1317	1186	
EXCHANGEABLE CATIONS	**CALCIUM:** lbs / acre	Desired Value	2261	1793	1912	1431	
		Value Found	1404	1766	1723	957	
		Deficit	-857	-27	-189	-474	
	MAGNESIUM: lbs / acre	Desired Value	239	200	202	200	
		Value Found	184	184	224	73	
		Deficit	-55	-16		-127	
	POTASSIUM: lbs / acre	Desired Value	259	205	219	200	
		Value Found	119	101	59	81	
		Deficit	-140	-104	-160	-119	
	SODIUM:	lbs / acre	27	23	25	20	
BASE SATURATION %	Calcium (60 to 70%)		42.22	66.96	61.27	45.47	
	Magnesium (10 to 20%)		9.22	11.63	13.28	5.78	
	Potassium (2 to 5%)		1.84	1.96	1.08	1.97	
	Sodium (.5 to 3%)		0.69	0.75	0.76	0.82	
	Other Bases (Variable)		7.00	5.20	5.60	7.00	
	Exchangable Hydrogen (10 to 15%)		39.00	13.50	18.00	39.00	
TRACE ELEMENTS	Boron (p.p.m.)		0.37	0.37	0.37	0.37	
	Iron (p.p.m.)		256	166	212	206	
	Manganese (p.p.m.)		24	26	23	18	
	Copper (p.p.m.)		3.56	2.38	9.19	10.9	
	Zinc (p.p.m.)		9.01	3.45	6.49	3.33	
	Aluminum (p.p.m.)		1239	1281	1168	1289	
OTHER							

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OTHER						

Very low

Very High%

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Soils sample taken from a field

Low soil pH is inversely related the soils %Base Saturation of Hydrogen;
__Remember:__
pH is a unit used to measure the concentration of Hydrogen

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OTHER							

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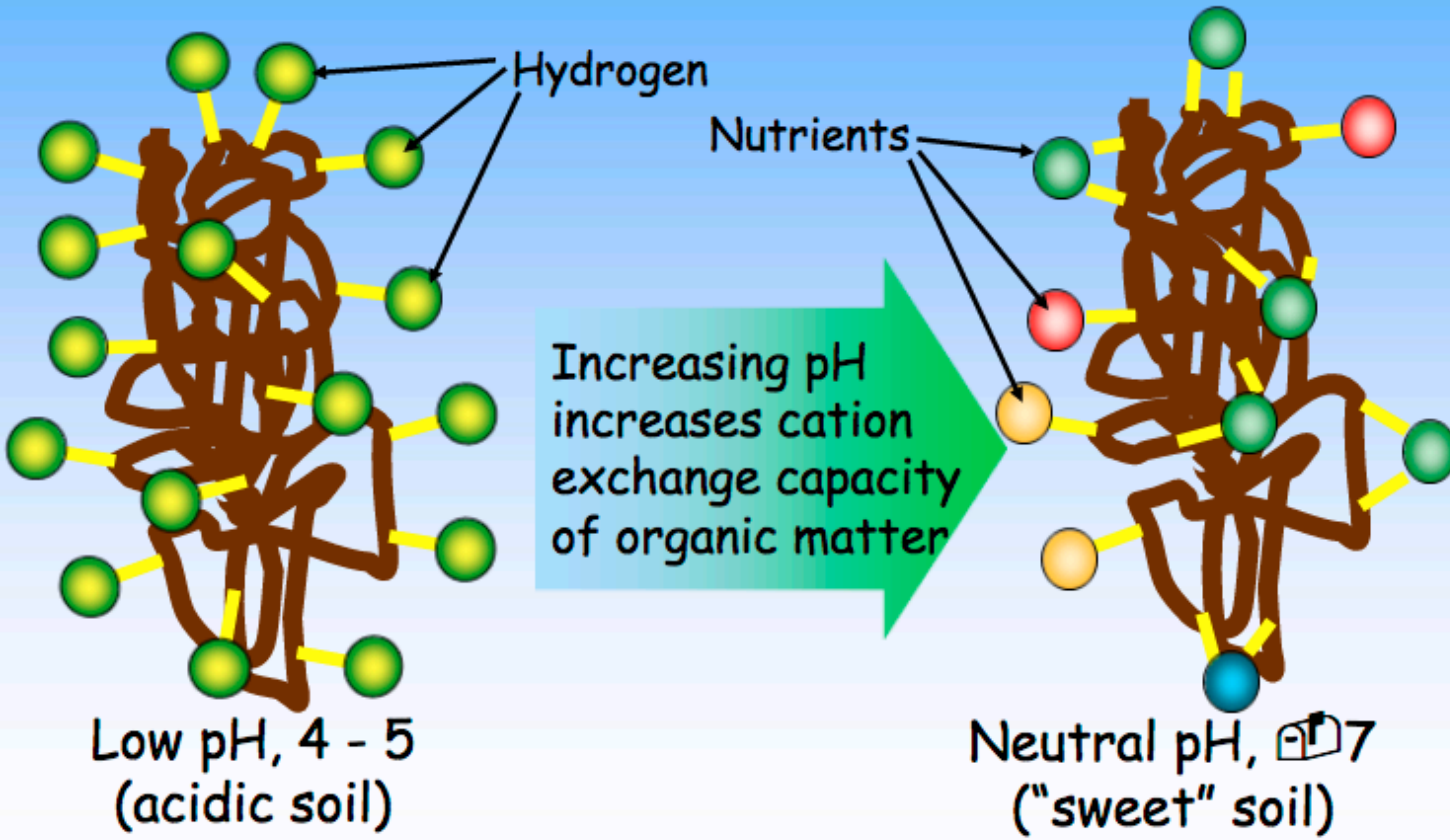
Soils sample taken from a field in the east coast with 40” annual precipitation

Extremely low pH on both fields

NOTE:
The two samples on the right where taken from the same field

Cation Retention on Organic Matter



Soil Report

Job Name: **Michael Rocky Trevizo** Date: 2/21/2018

Company: Michael Rocky Trevizo Submitted By:

Farmed → Hog; Virgin Ground → RCK, HTC

Sample Location		LG	LG	LG
Sample ID		Hog	RCK	HTC
Lab Number		158	159	160
Sample Depth in inches		6	6	6
Total Exchange Capacity (M. E.)		23.70	32.06	39.82
pH of Soil Sample		8.1	8.7	8.7
Organic Matter, Percent		0.70	1.09	1.00
ANIONS: SULFUR:	p.p.m.	14	16	30
ANIONS: Mehlich III Phosphorous:	as (P_2O_5) lbs / acre	100	297	173
EXCHANGEABLE CATIONS: CALCIUM: lbs / acre	Desired Value	6446	8720	10829
	Value Found	7838	10163	12917
	Deficit			
MAGNESIUM: lbs / acre	Desired Value	682	923	1146
	Value Found	643	1018	1152
	Deficit	-39		
POTASSIUM: lbs / acre	Desired Value	739	1000	1242
	Value Found	435	1146	1197
	Deficit	-304		-45
SODIUM:	lbs / acre	40	36	52
BASE SATURATION %: Calcium (60 to 70%)		82.68	79.24	81.11
Magnesium (10 to 20%)		11.30	13.23	12.06
Potassium (2 to 5%)		2.35	4.58	3.85
Sodium (.5 to 3%)		0.37	0.25	0.28
Other Bases (Variable)		3.30	2.70	2.70
Exchangable Hydrogen (10 to 15%)		0.00	0.00	0.00
TRACE ELEMENTS: Boron (p.p.m.)		0.39	0.69	0.94
Iron (p.p.m.)		51	30	19
Manganese (p.p.m.)		76	110	96
Copper (p.p.m.)		1.4	0.98	0.66
Zinc (p.p.m.)		3.05	1.77	1.2
Aluminum (p.p.m.)		92	49	31
OTHER				

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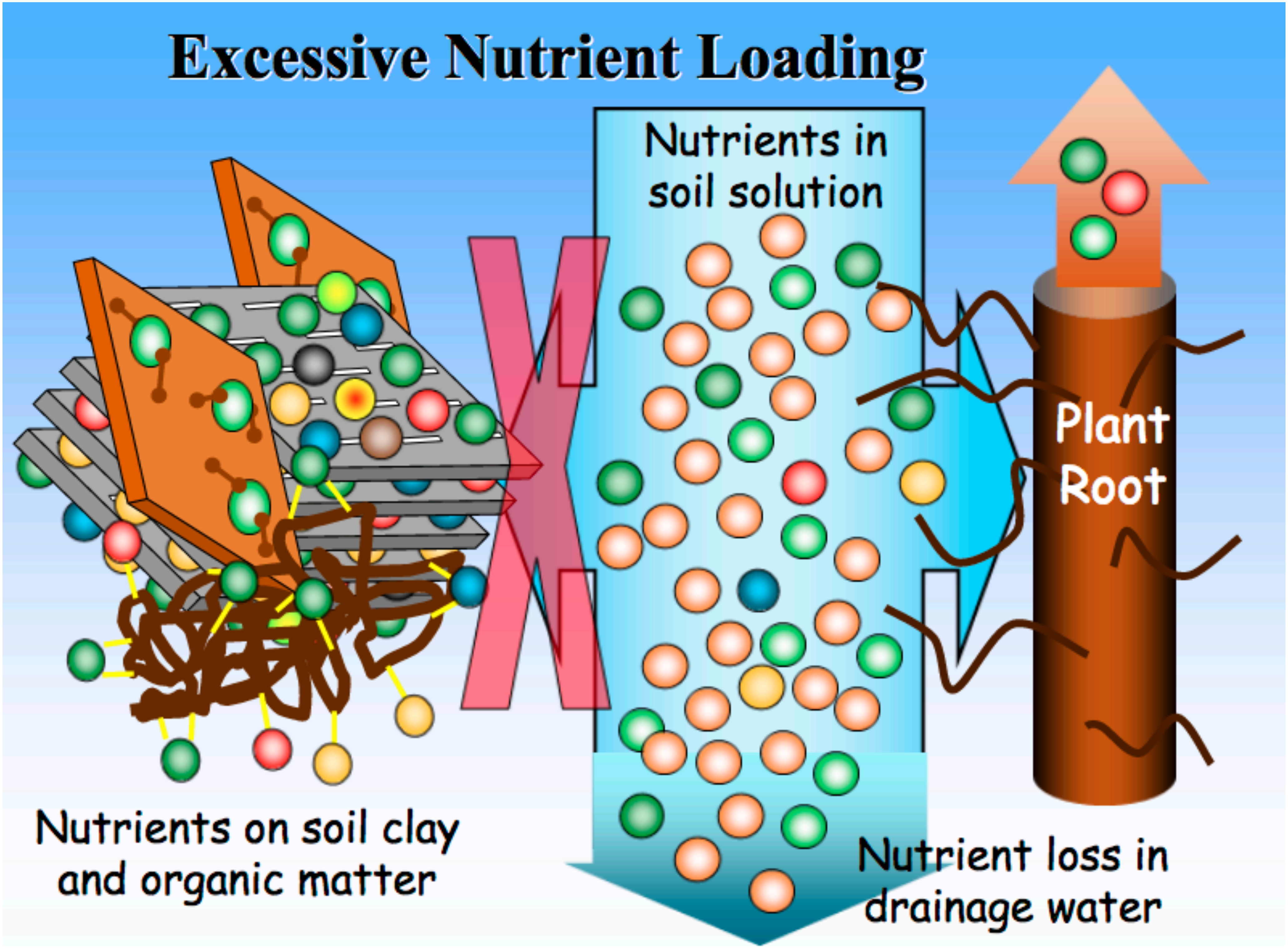
Soils sample taken from a field in the desert south west with 9" annual precipitation

This is a Sandy soil (80% Sand)

Why the high CEC?

High pH on all fields

NOTE:
The first sample has been farmed for some time; The two samples on the right where taken from virgin soil


Excessive Nutrient Loading
Nutrients in soil solution
Plant Root
Nutrients on soil clay and organic matter
Nutrient loss in drainage water

ORDER OF CATION AFFINITY

Table 4.3. Observed Order of Affinity of Divalent Metal Ions for Soil Organic Matter Related to Electronegativity

Affinity sequence	Cu	>	Ni	>	Pb	>	Co	>	Ca[a]	>	Zn	>	Mn	>	Mg
Electronegativity (Pauling)	2.0		1.91		1.87		1.88		1.00		1.65		1.55		1.31

[a]The affinity of humus for the essential macronutrients, Ca^{2+} and K^{+}, is (fortunately for plants and animals) higher than electronegativity would predict, suggesting that certain complexing or chelating groups in humus select for these metals on the basis of ionic size.

Al+3 and H+

BASIC SOIL-PLANT RELATIONSHIPS

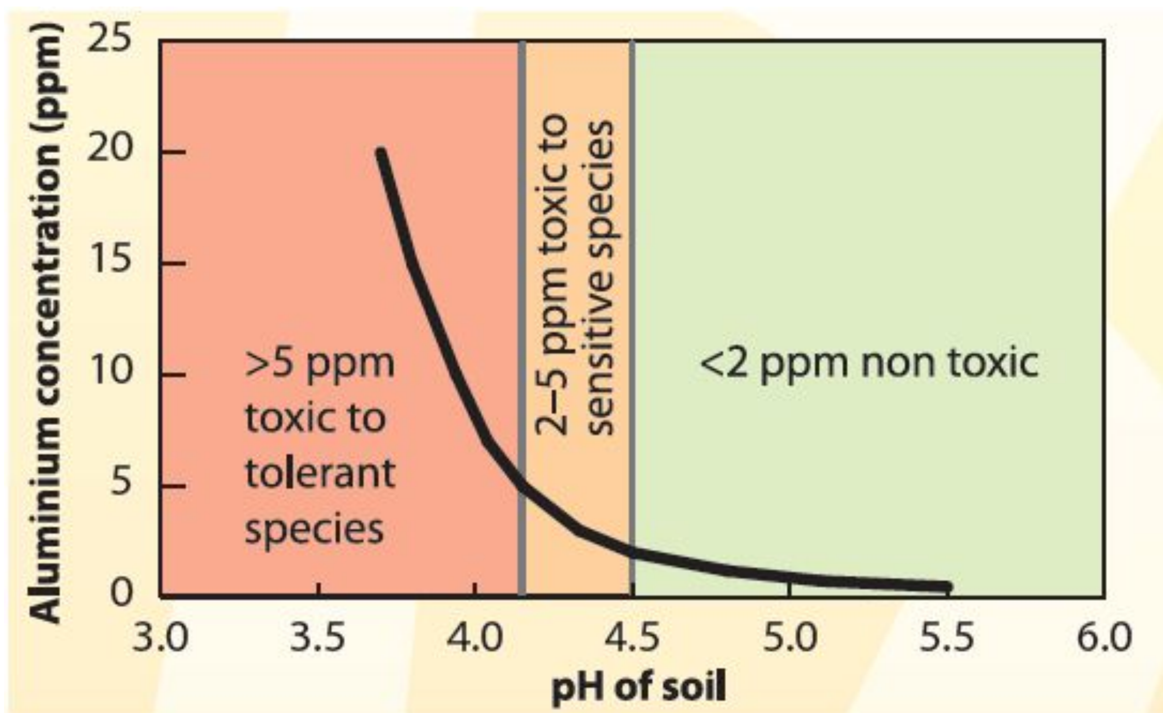
BUFFERING CAPACITY

- One of the most important chemical principles in soil chemistry and nutrient management is the soil buffer capacity (BC)
- However Cation Exchange Capacity (CEC) tells us how big the buffer is; and the %Base Saturation of a soil nutrient can provide an understanding of the soils ability to maintain the concentration of a nutrent in the soil solution.
- Far more important is the soils capacity to maintain the concentration of a nutrient in the soil solution.
- Example; Al^{+3} will desorb from the soil exchange sites when a soil is limed.

BASIC SOIL-PLANT RELATIONSHIPS

BUFFERING CAPACITY

- Far more important is the soils capacity to maintain the concentration of a nutrient in the soil solution.
- Example; Al^{+3} will desorb from the soil exchange sites when a soil is limed.



BASIC SOIL-PLANT RELATIONSHIPS

BUFFERING CAPACITY

- Al^{+3} has a +3 positive charge, however it is largely responsible for soil pH, as Al^{+3} drives soil acidity.

BASIC SOIL-PLANT RELATIONSHIPS

BUFFERING CAPACITY

THE TAKE HOME:

- Soil with high CEC and low pH will have a higher buffering capacity; and there fore will require more lime to raise the soil pH.
- Soils with low CEC and low pH will have a lower buffering capacity; and therefore will require less lime to the soil raise pH.

- Neither case really looks at %BS of any of the soil cations; and raising the pH alone will not provide optimal growing conditions

EXAMPLE

Most people would think your crazy for liming this soil!

Soil nutrient balancing is always more important then pH alone!

Soil Report

Job Name: **Rocky Trevizo** Date: 1/4/2019

Company: Five College Farms Submitted By:

	Sample Location		GH				
	Sample ID		4				
	Lab Number		71				
	Sample Depth in inches		6				
	Total Exchange Capacity (M. E.)		30.91				
	pH of Soil Sample		8.8				
	Organic Matter, Percent		27.71				
ANIONS	**SULFUR:**	p.p.m.	939				
ANIONS	**Mehlich III Phosphorous:**	as (P_2O_5) lbs / acre	1091				
EXCHANGEABLE CATIONS	**CALCIUM:** lbs / acre	Desired Value	8407				
		Value Found	4472				
		Deficit	-3935				
EXCHANGEABLE CATIONS	**MAGNESIUM:** lbs / acre	Desired Value	890				
		Value Found	1517				
		Deficit					
EXCHANGEABLE CATIONS	**POTASSIUM:** lbs / acre	Desired Value	964				
		Value Found	9180				
		Deficit					
EXCHANGEABLE CATIONS	**SODIUM:**	lbs / acre	385				
BASE SATURATION %	Calcium (60 to 70%)		36.17				
BASE SATURATION %	Magnesium (10 to 20%)		20.45				
BASE SATURATION %	Potassium (2 to 5%)		38.07				
BASE SATURATION %	Sodium (.5 to 3%)		2.71				
BASE SATURATION %	Other Bases (Variable)		2.60				
BASE SATURATION %	Exchangable Hydrogen (10 to 15%)		0.00				
TRACE ELEMENTS	Boron (p.p.m.)		4.29				
TRACE ELEMENTS	Iron (p.p.m.)		94				
TRACE ELEMENTS	Manganese (p.p.m.)		72				
TRACE ELEMENTS	Copper (p.p.m.)		4.3				
TRACE ELEMENTS	Zinc (p.p.m.)		52.77				
TRACE ELEMENTS	Aluminum (p.p.m.)		75				
OTHER	Media Density g/cm3		0.43				
OTHER							
OTHER							
OTHER							

K^{+2} 10 X Greater then desired

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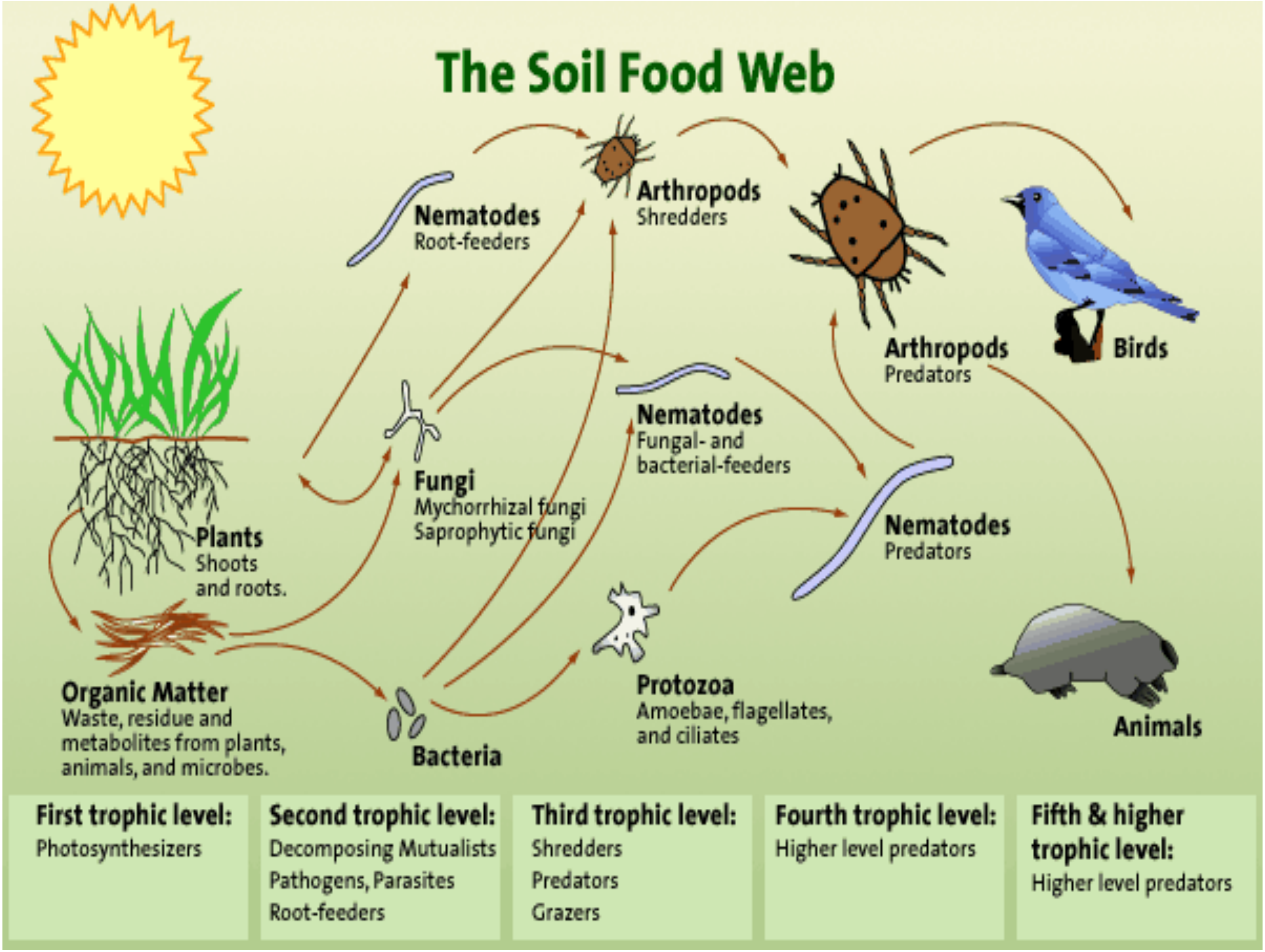
BASIC SOIL-PLANT RELATIONSHIPS

SUPPLY OF NUTRIENTS FROM ORGANIC MATTER

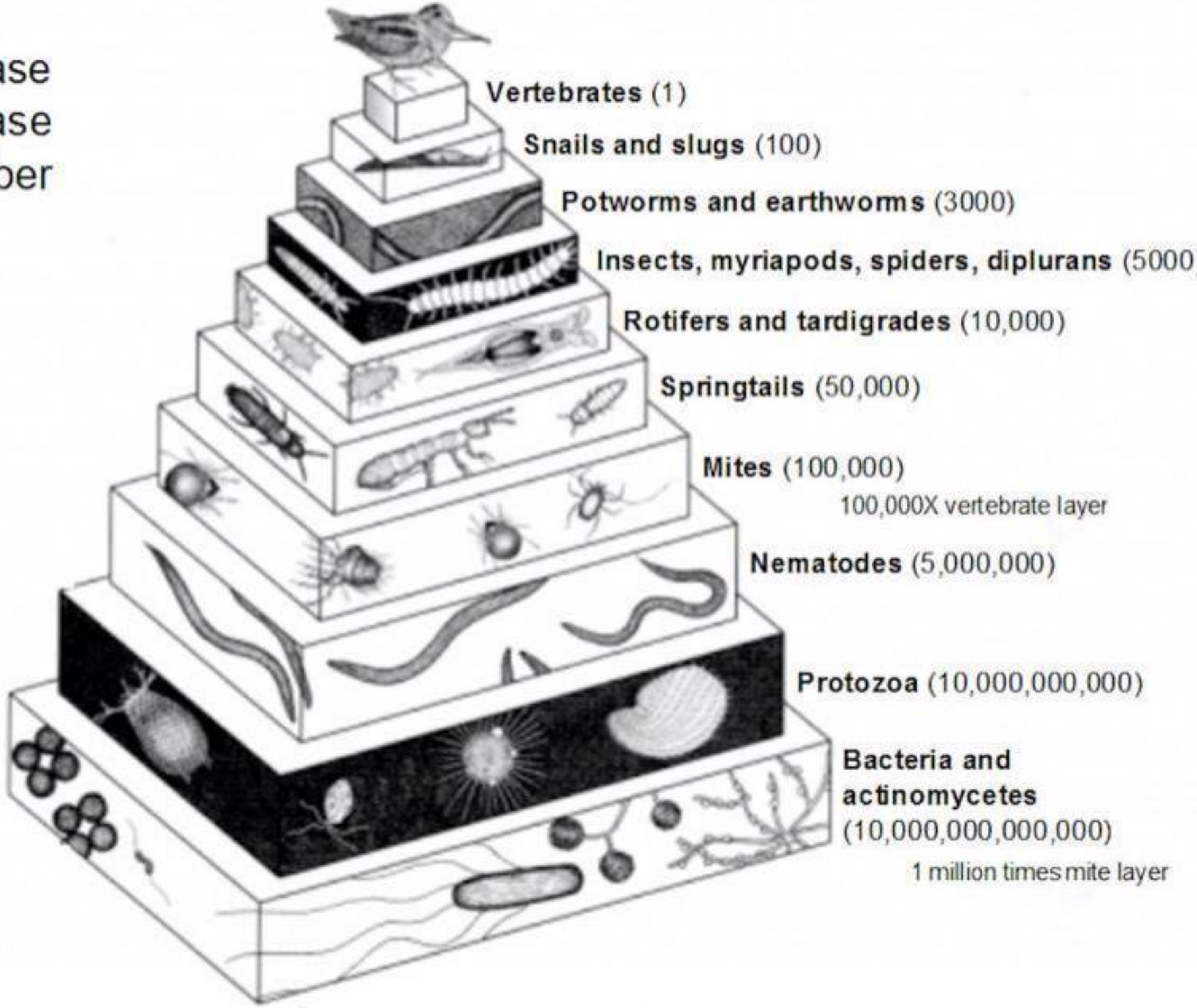
- Microbial activity and nutrient cycling through soil OM substantially impacts plant nutrient availability.
- Soil solution concentration of N, S, P, and several other micronutrients is intimately related to the microbial (organic) fraction in the soil



The Soil Food Web
Nematodes
Root-feeders
Arthropods
Shredders
Arthropods
Predators
Birds
Fungi
Mychorrhizal fungi
Saprophytic fungi
Nematodes
Fungal- and
bacterial-feeders
Nematodes
Predators
Plants
Shoots
and roots.
Organic Matter
Waste, residue and
metabolites from plants,
animals, and microbes.
Bacteria
Protozoa
Amoebae, flagellates,
and ciliates
Animals
First trophic level:
Photosynthesizers
Second trophic level:
Decomposing Mutualists
Pathogens, Parasites
Root-feeders
Third trophic level:
Shredders
Predators
Grazers
Fourth trophic level:
Higher level predators
Fifth & higher
trophic level:
Higher level predators

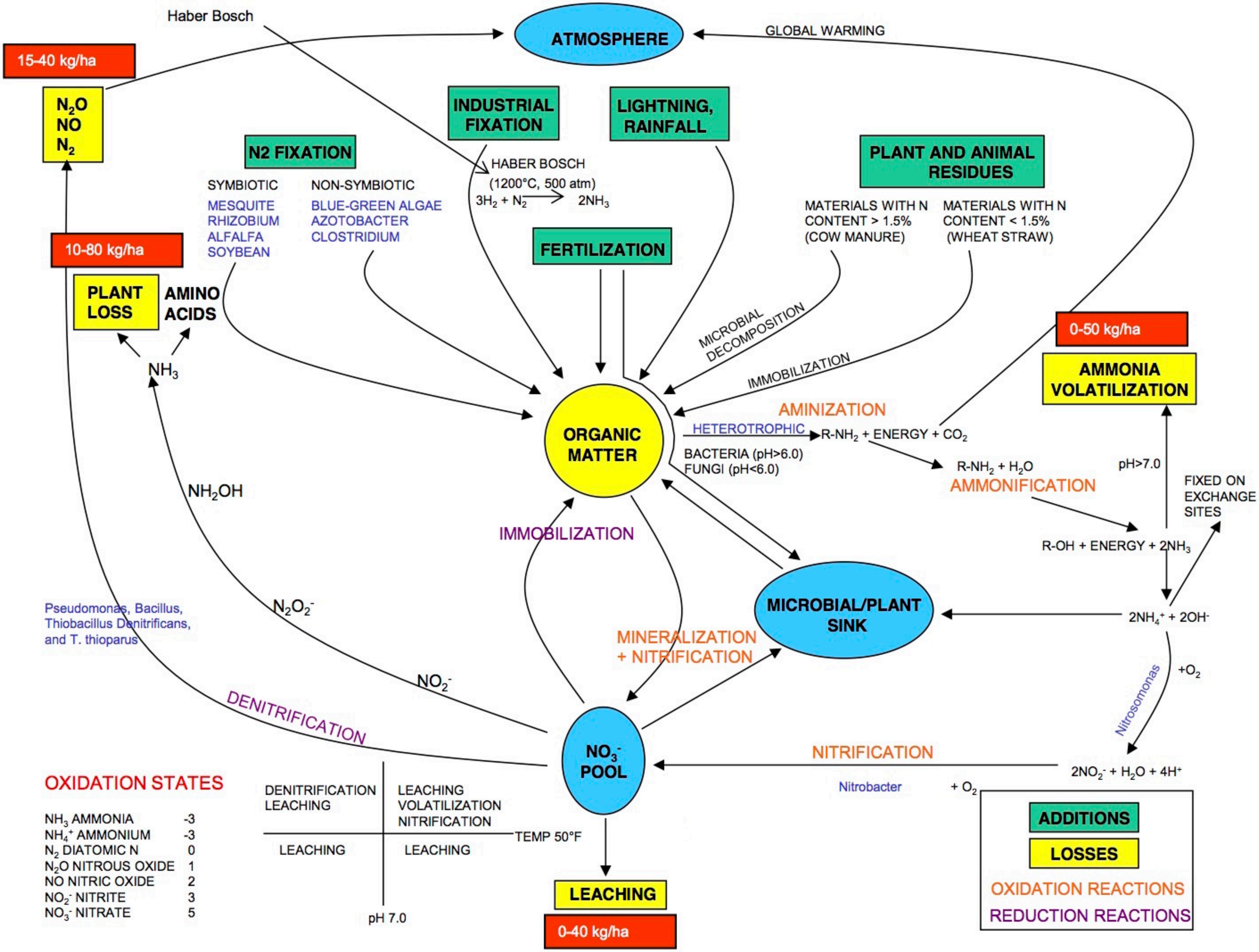
In one square meter of soil....

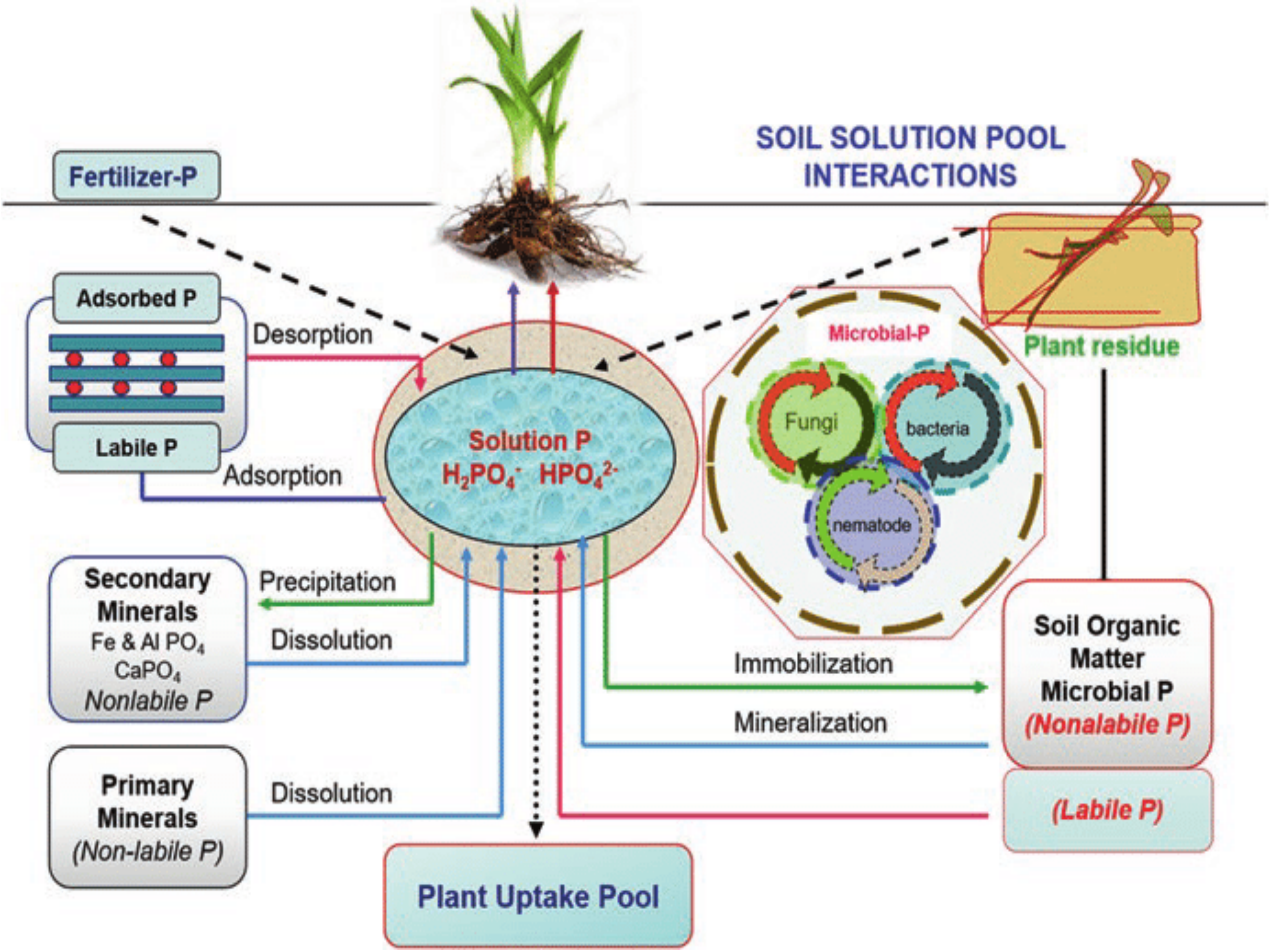
Organisms decrease
in size and increase
in number

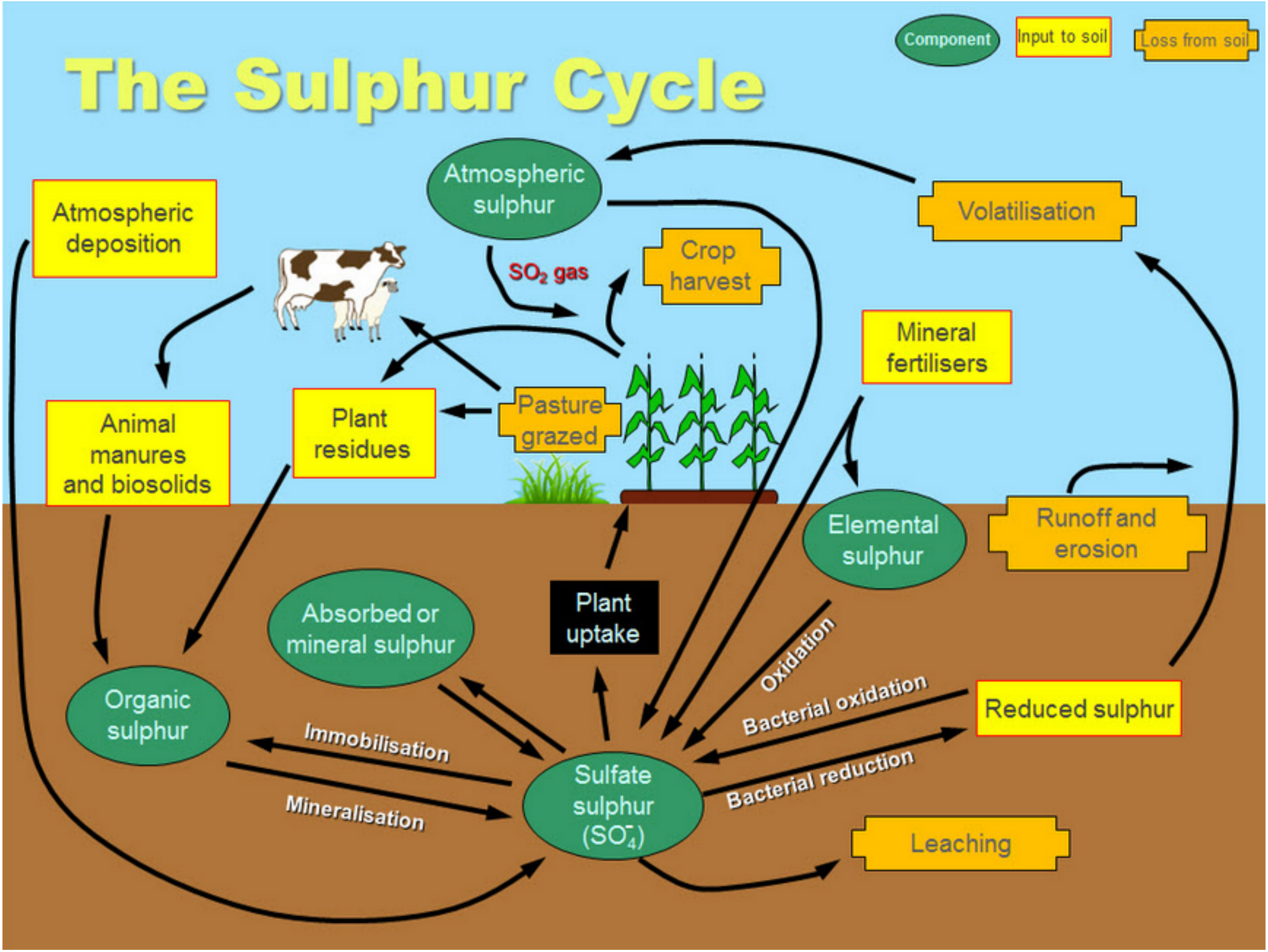


TWO MAJOR NUTRIENT CYCLES AND THE PREDOMINATE SOURCE OF THESE ANIONS

- Nitrogen cycle
- Phosphorus cycle
- Sulfur cycle


Haber Bosch
ATMOSPHERE
GLOBAL WARMING
15-40 kg/ha
N_2O
NO
N_2
INDUSTRIAL FIXATION
LIGHTNING, RAINFALL
N2 FIXATION
PLANT AND ANIMAL RESIDUES
HABER BOSCH
(1200°C, 500 atm)
$3H_2 + N_2 \rightarrow 2NH_3$
SYMBIOTIC
MESQUITE
RHIZOBIUM
ALFALFA
SOYBEAN
NON-SYMBIOTIC
BLUE-GREEN ALGAE
AZOTOBACTER
CLOSTRIDIUM
MATERIALS WITH N CONTENT > 1.5% (COW MANURE)
MATERIALS WITH N CONTENT < 1.5% (WHEAT STRAW)
10-80 kg/ha
FERTILIZATION
PLANT LOSS
AMINO ACIDS
MICROBIAL DECOMPOSITION
IMMOBILIZATION
0-50 kg/ha
AMMONIA VOLATILIZATION
NH_3
ORGANIC MATTER
AMINIZATION
HETEROTROPHIC
$R\text{-}NH_2$ + ENERGY + CO_2
BACTERIA (pH>6.0)
FUNGI (pH<6.0)
$R\text{-}NH_2 + H_2O$
AMMONIFICATION
pH>7.0
FIXED ON EXCHANGE SITES
NH_2OH
IMMOBILIZATION
R-OH + ENERGY + $2NH_3$
Pseudomonas, Bacillus, Thiobacillus Denitrificans, and T. thioparus
$N_2O_2^-$
MICROBIAL/PLANT SINK
$2NH_4^+ + 2OH^-$
MINERALIZATION + NITRIFICATION
$+O_2$
Nitrosomonas
NO_2^-
DENITRIFICATION
NITRIFICATION
NO_3^- POOL
$2NO_2^- + H_2O + 4H^+$
Nitrobacter
$+ O_2$
OXIDATION STATES
DENITRIFICATION LEACHING
LEACHING VOLATILIZATION NITRIFICATION
TEMP 50°F
LEACHING
LEACHING
pH 7.0
NH_3 AMMONIA -3
NH_4^+ AMMONIUM -3
N_2 DIATOMIC N 0
N_2O NITROUS OXIDE 1
NO NITRIC OXIDE 2
NO_2^- NITRITE 3
NO_3^- NITRATE 5
LEACHING
0-40 kg/ha
ADDITIONS
LOSSES
OXIDATION REACTIONS
REDUCTION REACTIONS

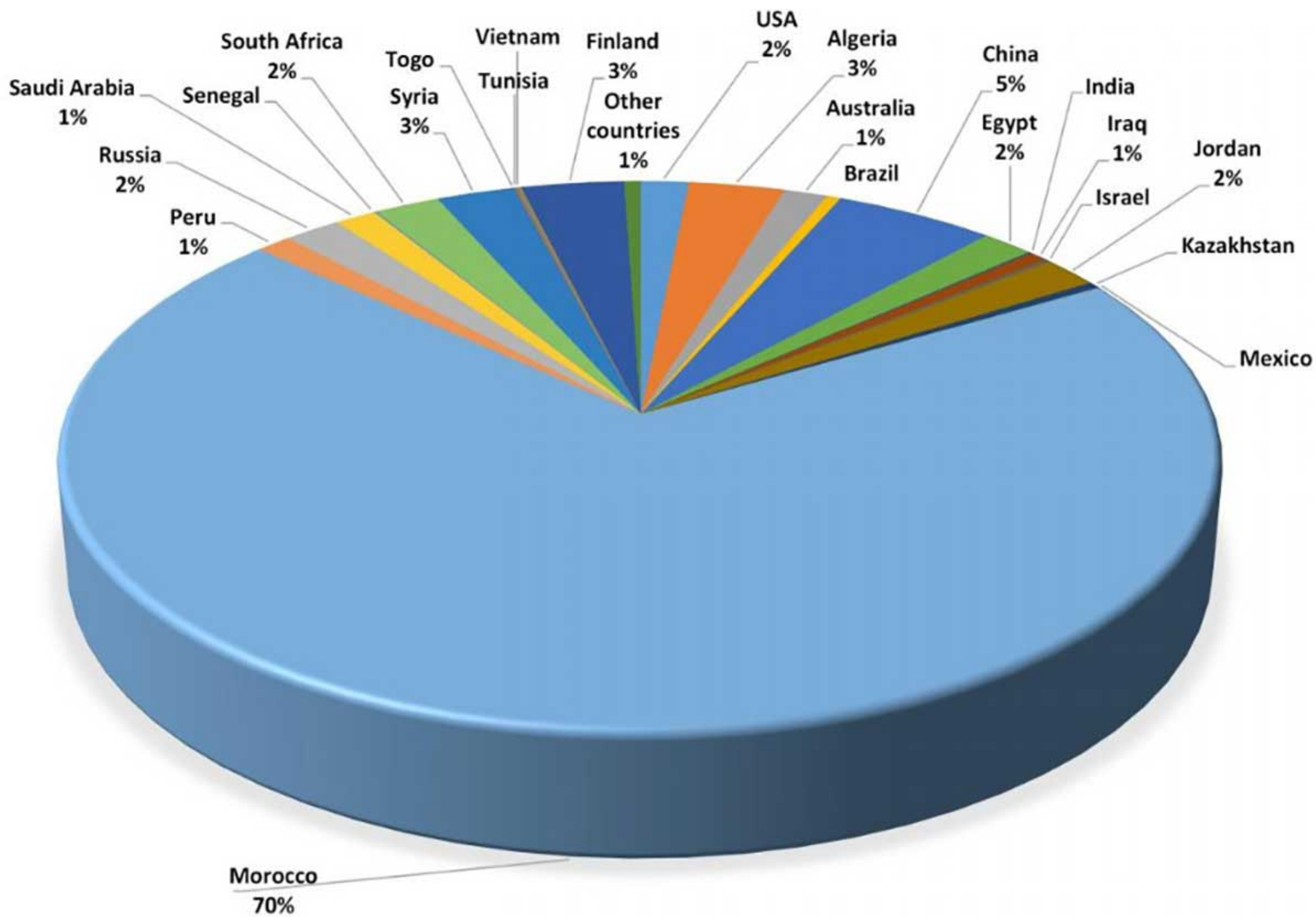

SOIL SOLUTION POOL
INTERACTIONS
Fertilizer-P
Adsorbed P
Labile P
Desorption
Adsorption
Solution P
$H_2PO_4^-$ HPO_4^{2-}
Microbial-P
Fungi
bacteria
nematode
Plant residue
Secondary
Minerals
Fe & Al PO_4
$CaPO_4$
Nonlabile P
Precipitation
Dissolution
Immobilization
Mineralization
Soil Organic
Matter
Microbial P
(Nonalabile P)
(Labile P)
Primary
Minerals
(Non-labile P)
Dissolution
Plant Uptake Pool


Component
Input to soil
Loss from soil
The Sulphur Cycle
Atmospheric sulphur
Volatilisation
Atmospheric deposition
SO2 gas
Crop harvest
Mineral fertilisers
Animal manures and biosolids
Plant residues
Pasture grazed
Elemental sulphur
Runoff and erosion
Absorbed or mineral sulphur
Plant uptake
Oxidation
Bacterial oxidation
Organic sulphur
Reduced sulphur
Immobilisation
Bacterial reduction
Mineralisation
Sulfate sulphur (SO4-)
Leaching

EXCESSIVE USE OF SYNTHETIC FERTILIZERS

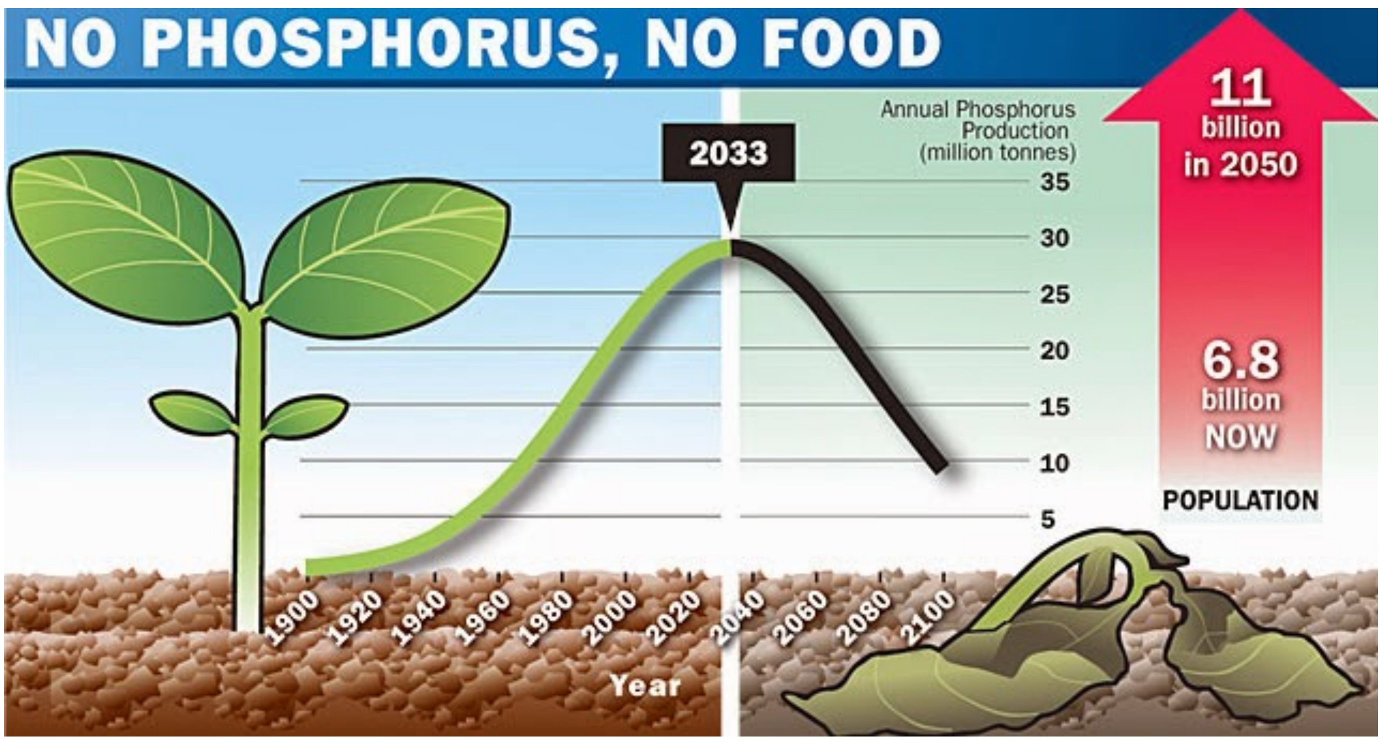
- The two nutrients of most concern
- Nitrate and Ammonium
- Phosphorus

THE WOULD IS RUNNING OUT OF PHOSPHORUS, WHICH THREATENS GLOBAL FOOD SUPPLIES



PHOSPHORUS FERTILIZER RESTRICTIONS

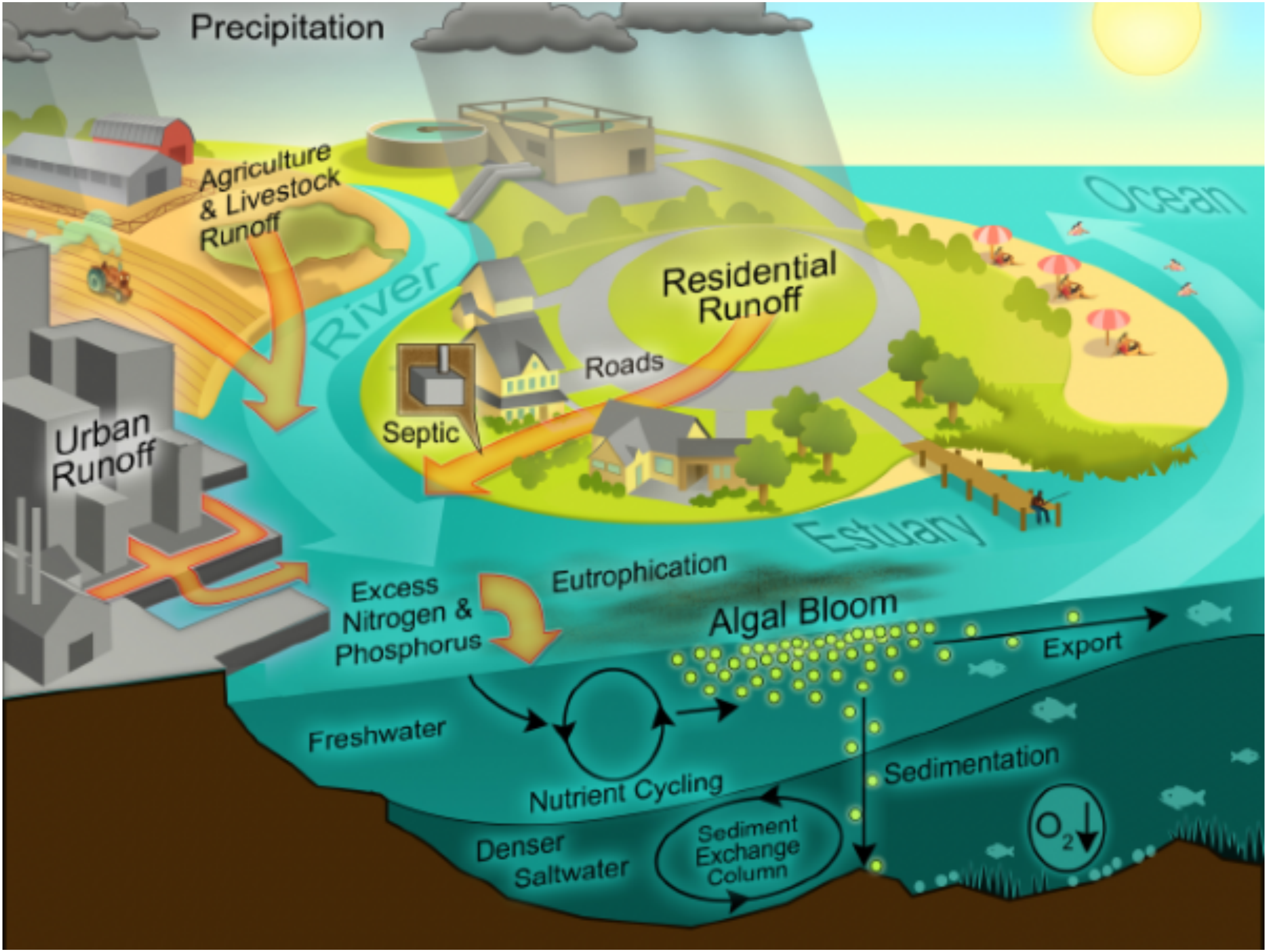
- World supply of Phosphorus is running out!!!
- This will lead to restricted use of phosphorus for future farming

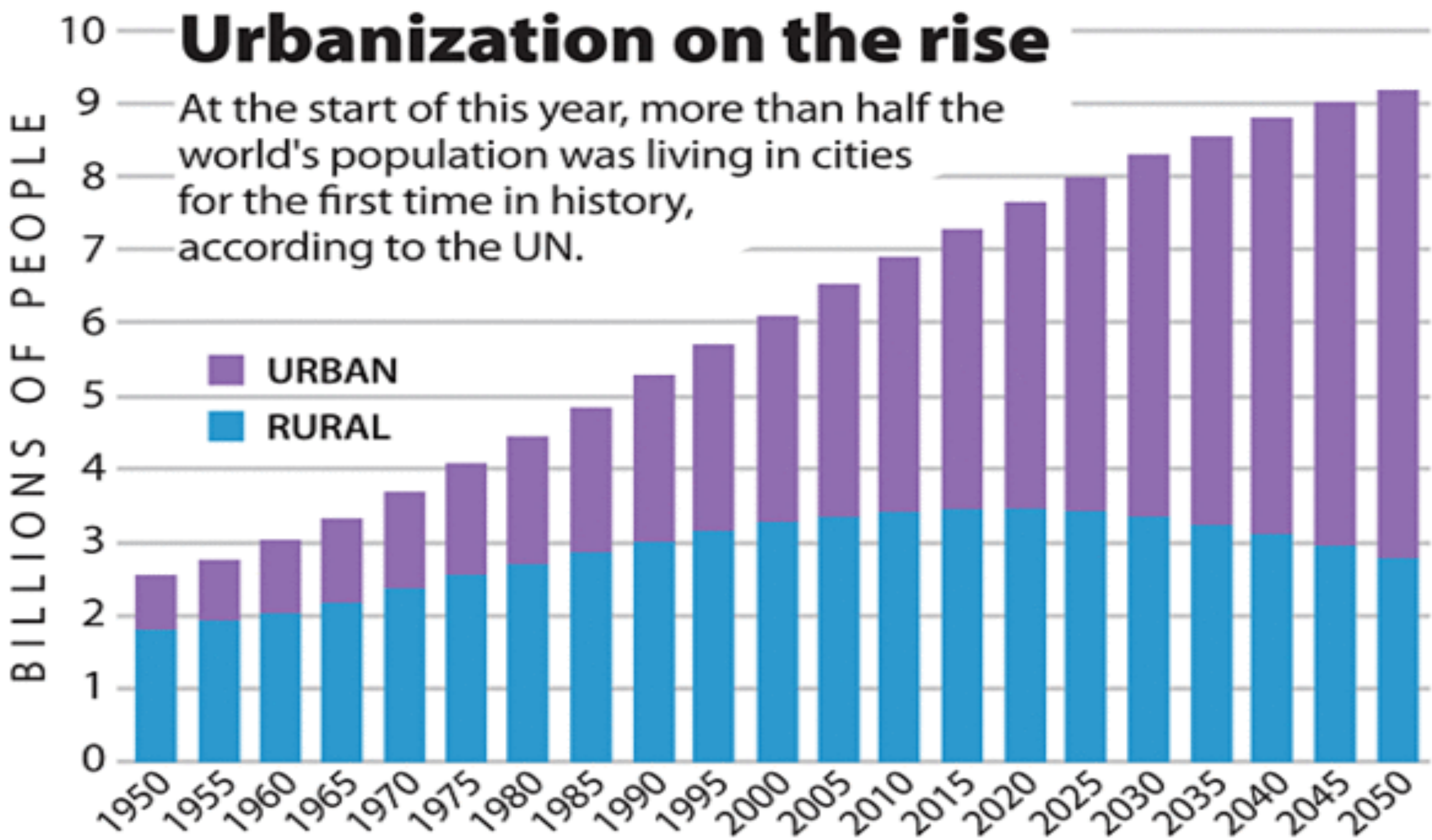


A GOOD WAY TO SCARE YOURSELF IS BY GOOGLING "PHOSPHORUS SHORTAGE."

- Agriculture requires lots of phosphorus for fertilizer, and after it's spread on crops, most of it gets washed into the ocean, where it is irrecoverable. Without phosphorus, food production will plummet, unless people come up with new ways to grow food.

- *Again and again the Lord has instructed that our people are to take their families away from the cities, into the country, where they can raise their own provisions, for in the future the problem of buying and selling will be a very serious one. We should now begin to heed the instruction given us over and over again: Get out of the cities into rural districts, where the houses are not crowded closely together, and where you will be free from the interference of enemies.—Selected Messages 2:141 (1904). LDE 99.4*


Precipitation
Agriculture
& Livestock
Runoff
River
Residential
Runoff
Roads
Septic
Ocean
Urban
Runoff
Estuary
Eutrophication
Excess
Nitrogen &
Phosphorus
Algal Bloom
Export
Freshwater
Nutrient Cycling
Sedimentation
Denser
Saltwater
Sediment
Exchange
Column
O_2



"Properties will be offered for sale in the rural districts at a price below the real cost, because the owners desire city advantages, and it is these rural locations that we desire to obtain for our schools." PH012 13.1

GOD INTENDED A BETTER WAY

Ignorance is doing its baleful work. Slothful servants are increasing the evil by their lazy habits. ***<u>Many are unwilling to earn their bread by the sweat of their brow, and they refuse to till the soil</u>***. But the earth has blessings hidden in her depths for those who have courage and will and perseverance to gather her treasures. Fathers and mothers who possess a piece of land and a comfortable home are kings and queens. {CL 18.2}

PEOPLE IN CITIES NEED TO EAT

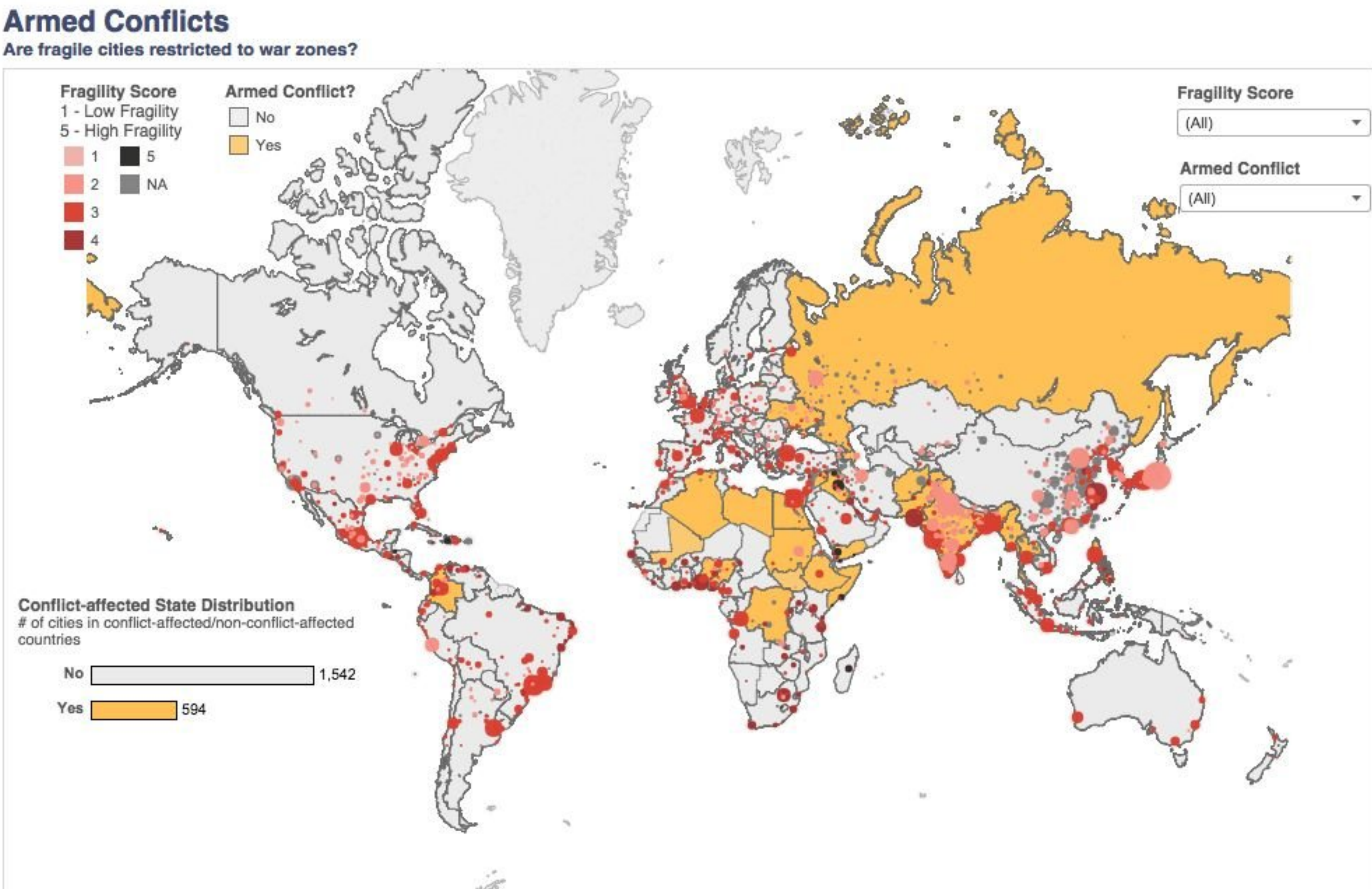
- As the population in Urban areas increases, so will the pressure on the worlds agro ecosystems

- Global mass consolidation of agricultural production is on the rise
- The “lone wolf” farmer is almost extent!

WHAT SAITH THE LORD

God does not design that men shall appropriate all that the earth produces for their own selfish purposes. He calls upon them to bring their tithes and offerings into His storehouse, that there may be meat in His house.

In India, China, Russia, and the cities of America, thousands of men and women are dying of starvation. The monied men, because they have the power, control the market. They purchase at low rates all they can obtain, and then sell at greatly increased prices. *This means starvation to the poorer classes, and will result in a civil war.* 5MR 305.3



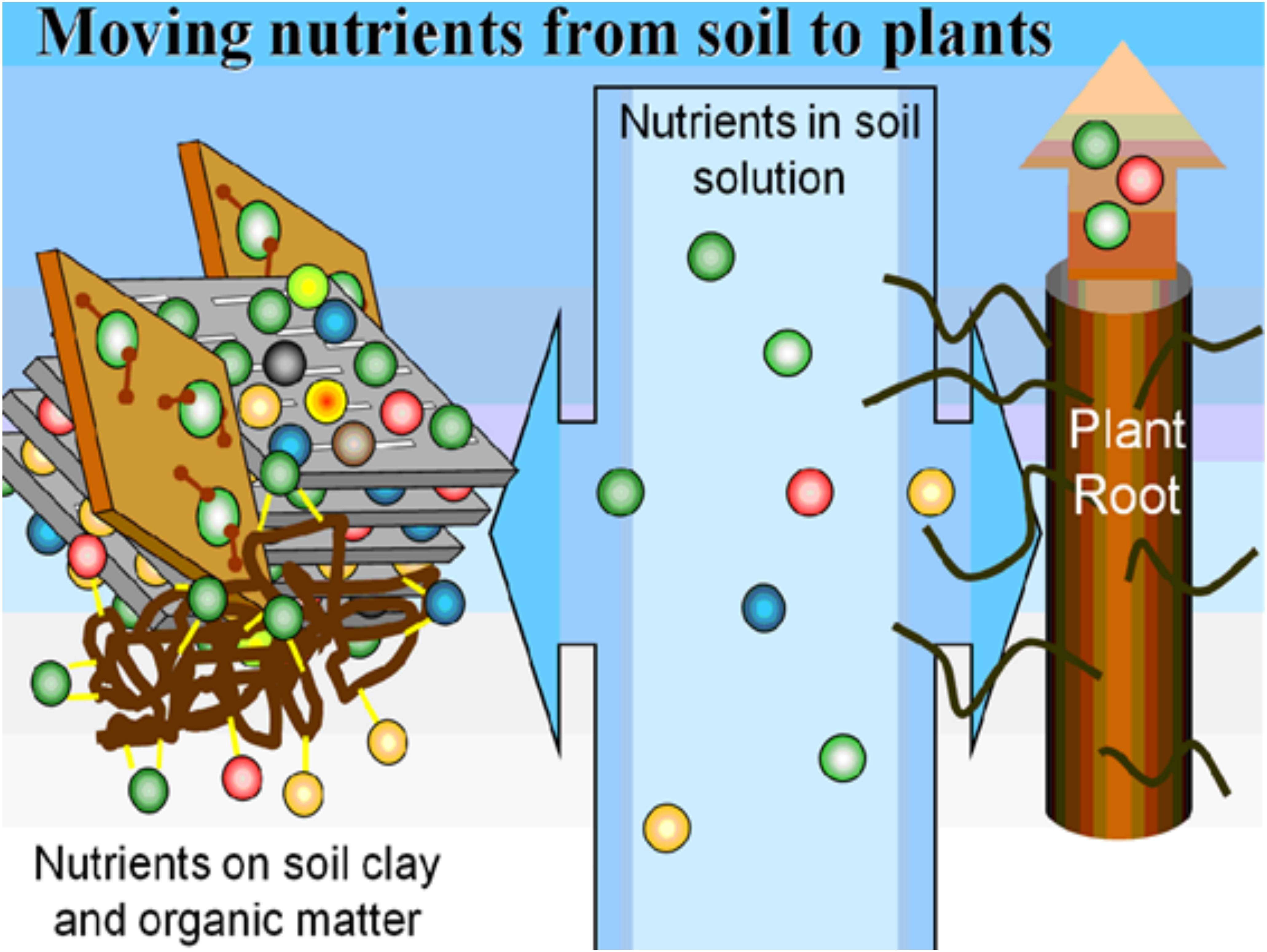
https://www.opencanada.org/features/how-cities-youve-never-heard-will-shape-future/

WHAT IS NEEDED?

- In the cultivation of the soil the thoughtful worker will find that treasures little dreamed of are opening up before him. No one can succeed in agriculture or gardening without attention to the laws involved. The special needs of every variety of plant must be studied. Different varieties require different soil and cultivation, and **compliance with the laws governing each is the condition of success**. Ed pg111

BASIC SOIL-PLANT RELATIONSHIPS

MOVEMENT OF IONS FROM SOILS TO ROOTS


Moving nutrients from soil to plants
Nutrients in soil solution
Plant Root
Nutrients on soil clay and organic matter

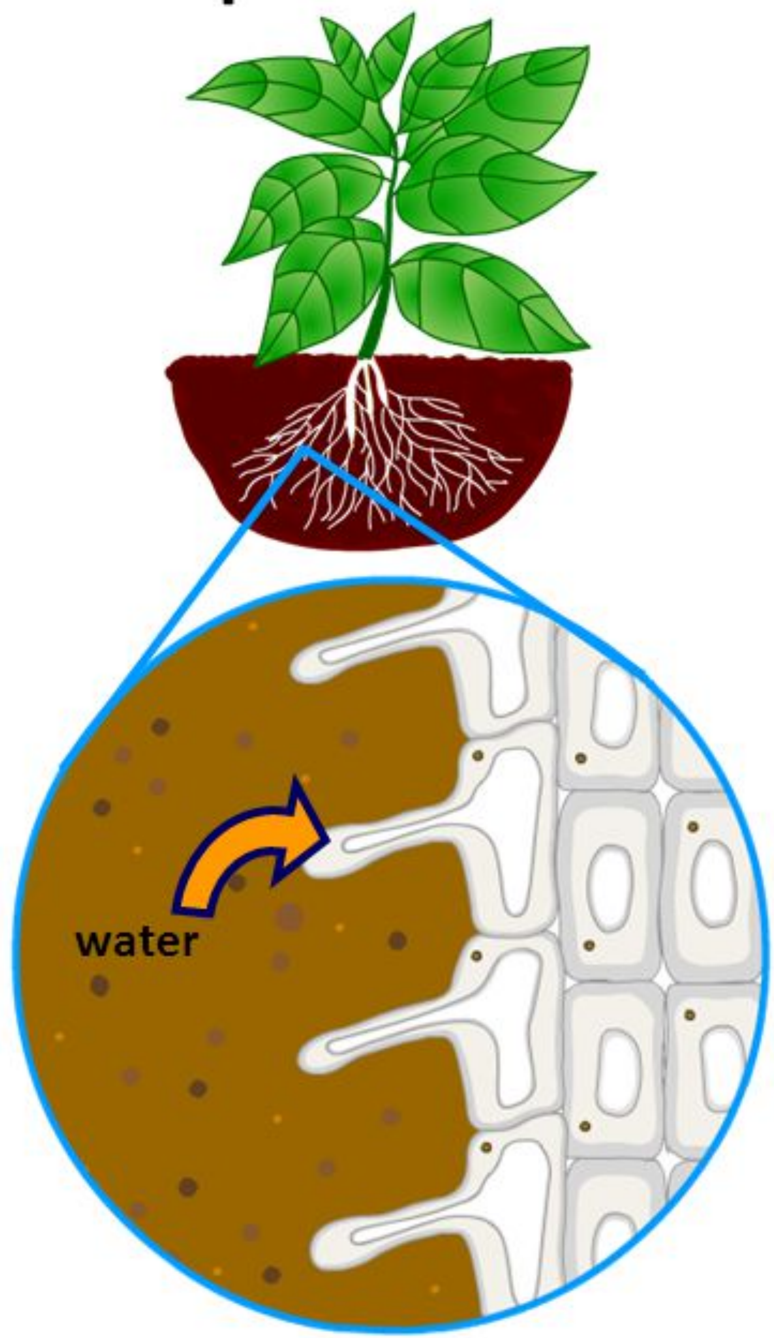
How are roots adapted?

- Roots are branched and spread out for two reasons:
  - to absorb water (and mineral salts) from a large amount of soil.
  - to anchor the plant in the soil.

- Taking a closer look, roots are covered in **root hair cells**.

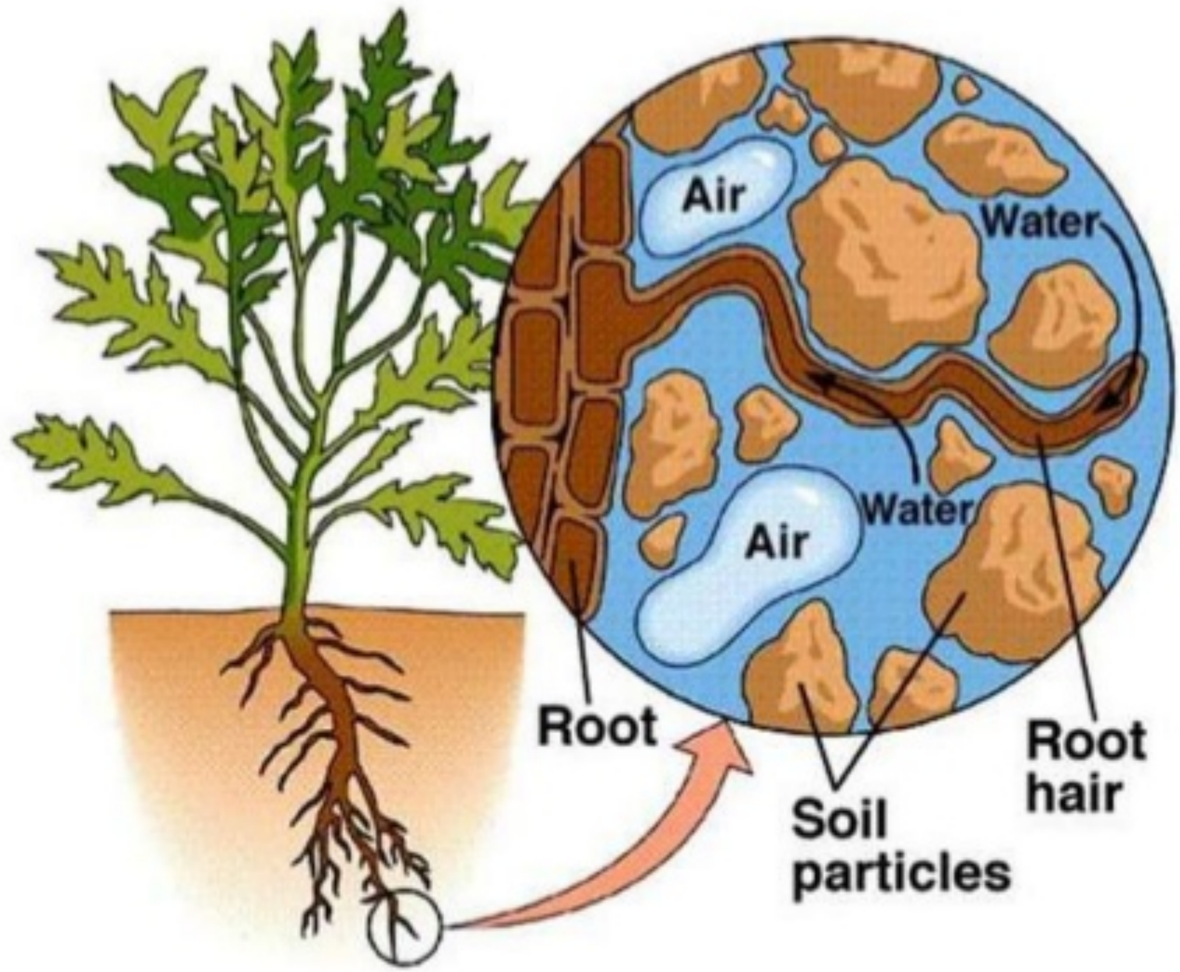
  Root hair cells have **thin walls** and a **large surface area** to help them absorb lots of water.

  How are roots adapted to their job?



How are root hairs adapted for absorption?

1. are long and provide a large surface area
2. have a thin cell wall



How do minerals enter plants?

Like water, minerals enter plants through the roots. However, they do this by different methods.

Water passively diffuses **with a concentration gradient** from the soil into the roots and up the stem.

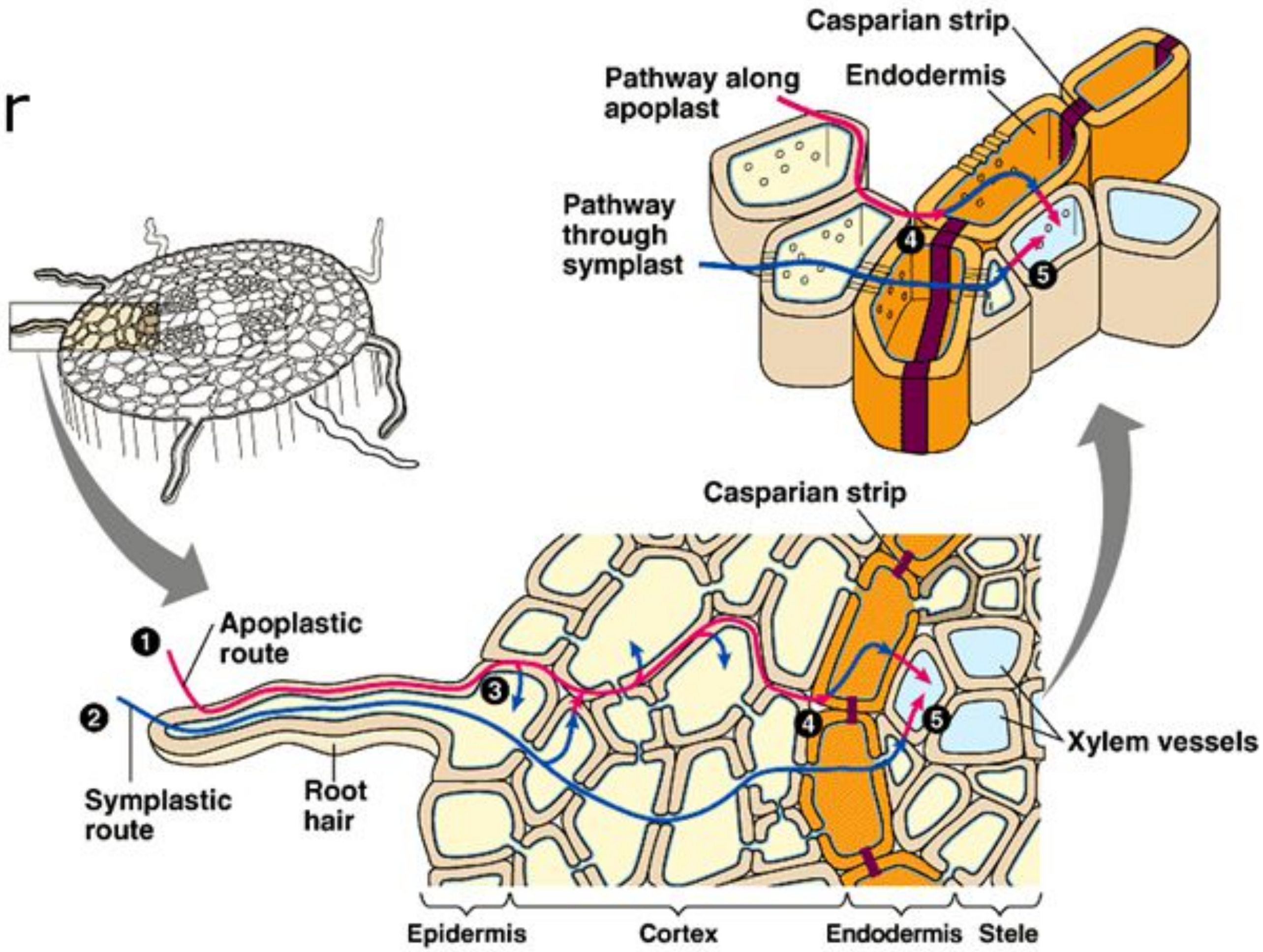
Minerals are usually found in the soil in lower concentrations than they occur in the plant. Why can they not be transported by diffusion?

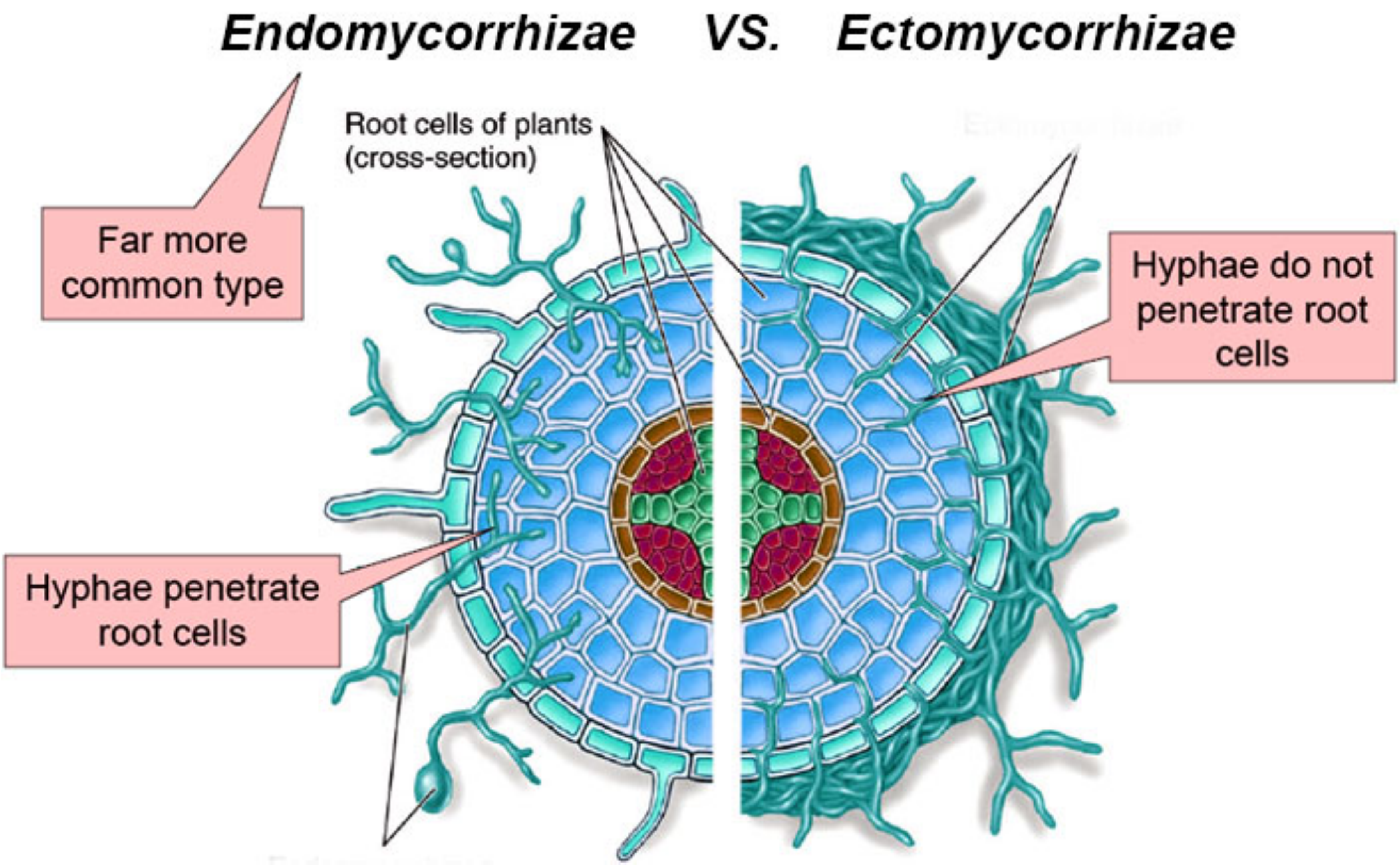
Diffusion cannot take place against a concentration gradient.

Instead, minerals enter the roots by **active transport**.

Water and Mineral Absorption – Water Transport in Roots

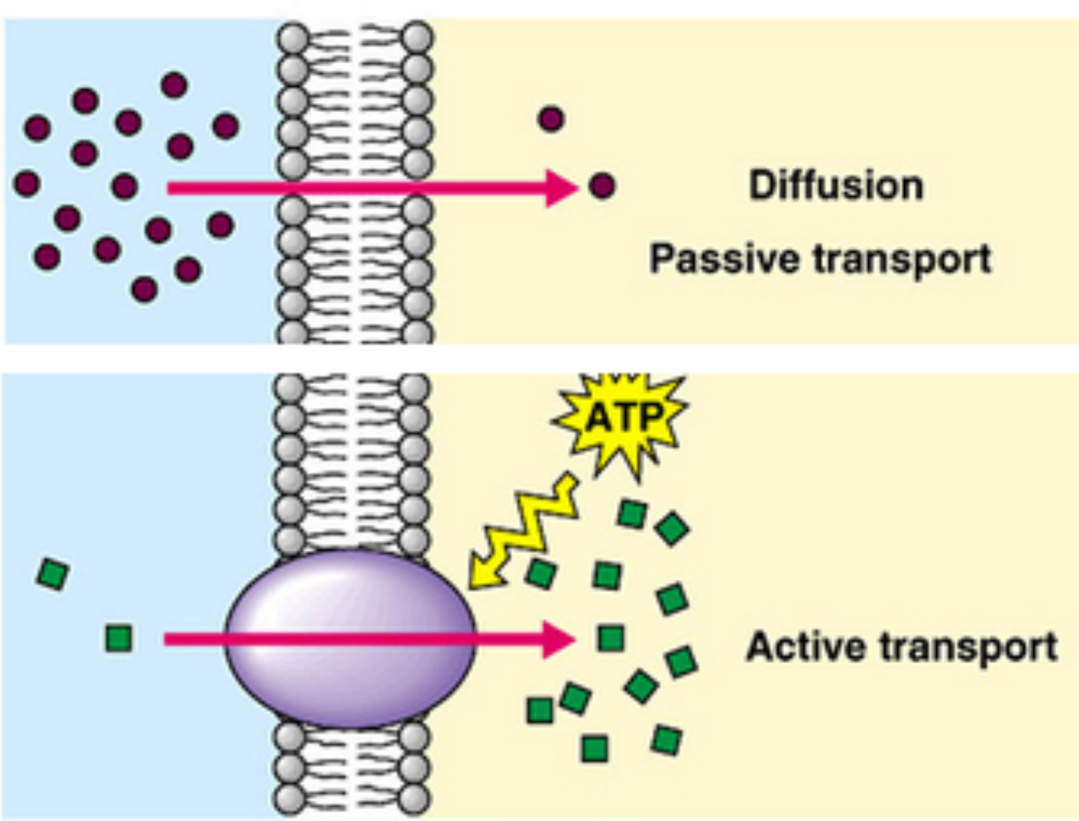
Apoplastic or
symplastic
Until the
endodermis
Is reached!!

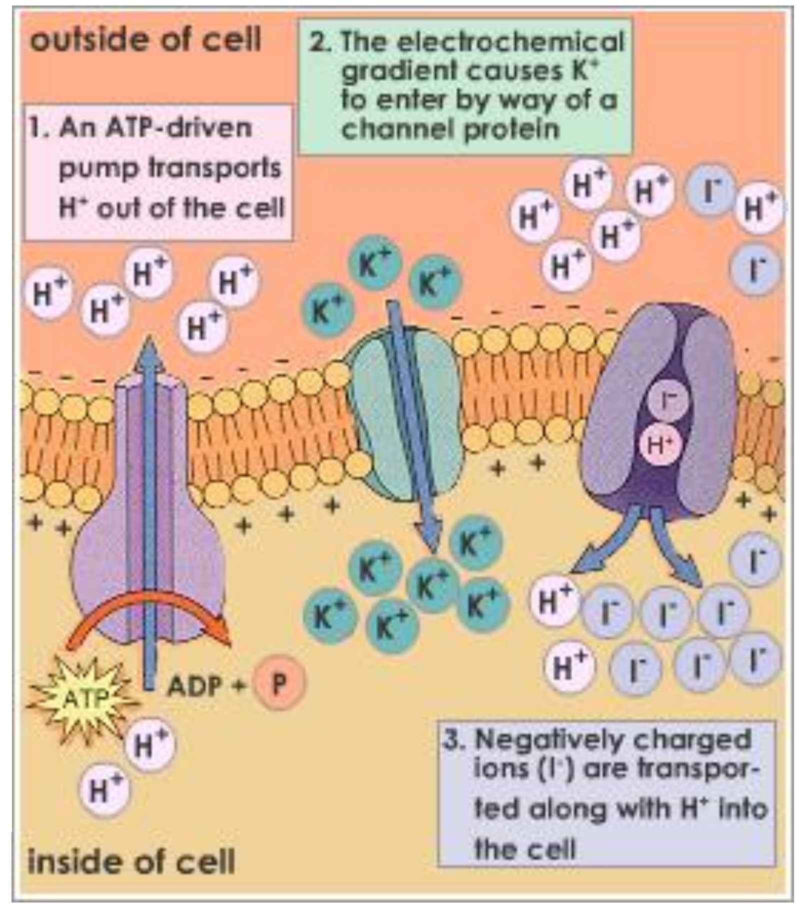




- Well established mycorrchizae colonies on roots will work to prevent fungal pathogens from forming on plant root systems

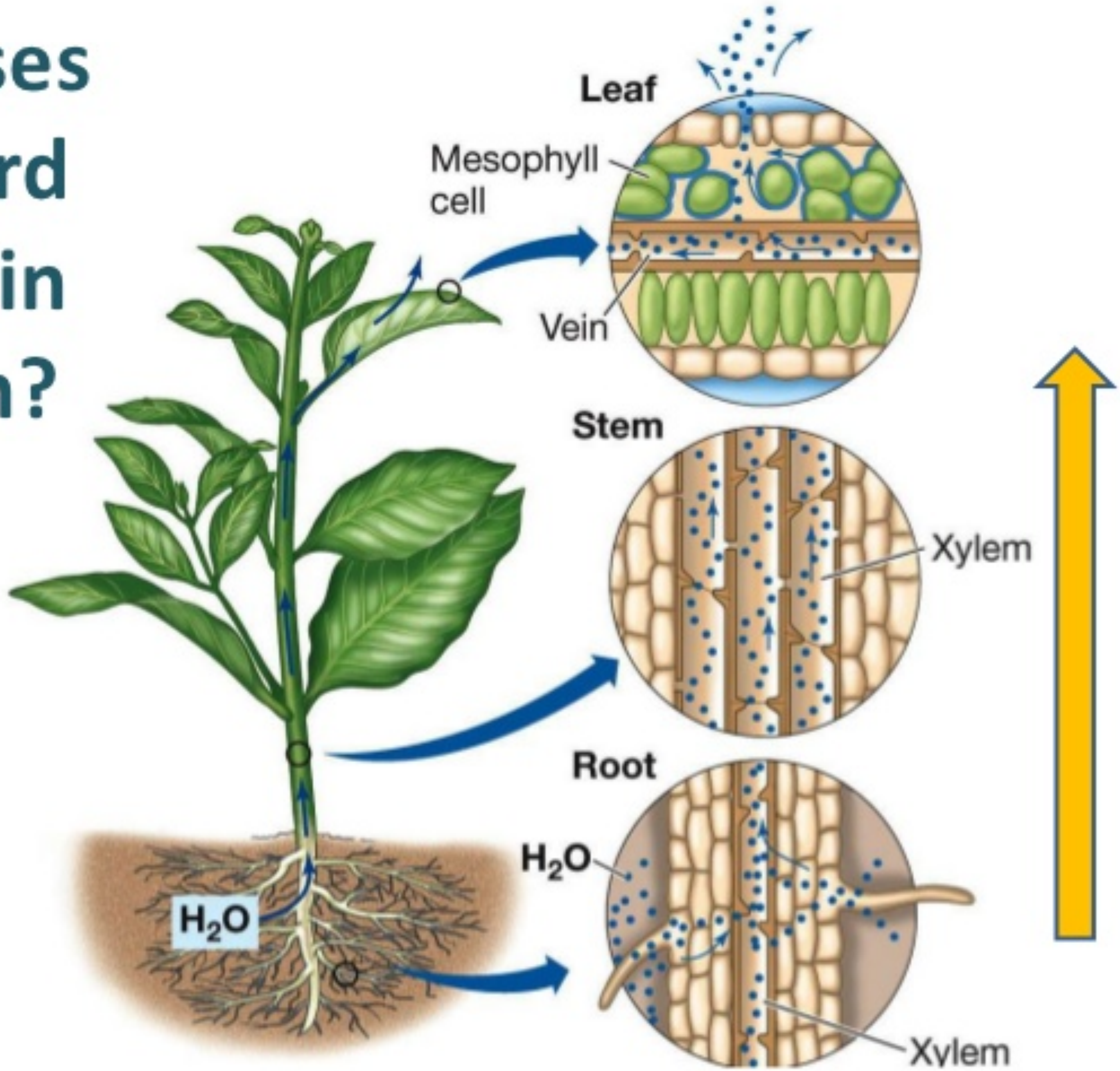
ACTIVE AND PASSIVE TRANSPORT





To learn more watch this video
https://www.youtube.com/watch?v=KfvYQgT2M-k

What causes the upward flow within the xylem?



Mostly, evaporation of water by the sun.

BASIC SOIL-PLANT RELATIONSHIPS

ION ABSORPTION BY PLANTS

NITROGEN N

- Taken up by plants in two main forms
- Nitrate NO_3^-
  an anion that is taken up by plants easily; readily leaches from the soil and needs to be managed carefully in both organic and conventionally production systems.
- Ammonium NH_4^+
  a cation that can be held on the the soil colloids however its not very stable and will be converted to nitrogen gas(NO_2) via microbial activity(nitrosomonas). Ammonium can be taken up by plants however plants prefer to uptake nitrate, and will have to convert ammonium to nitrate in the plant, if excesses ammonium is used this can lead to sudden pH drop in hydroponic production system. Ammonium will lower the pH of a soil and is preferred over nitrate in alkaline soils.

PHOSPHORUS P

- Plants uptake phosphorus in the form of Orthophosphate ($H_2PO_4^-$) & (HPO_4^{-2})
- Important for DNA/RNA and energy production in plants(ATP)
- Visual deficiency symptoms include overall stunting of the plant and a darker green coloration of leaves. Some times in some crops a purples color will appear.
- Soils deficient in P should be amended to correct deficiency; annual plants should be inoculated with Endomycorrhizae and Ectomycorrhizae.

EFFECT OF ENDOMYCORRHIZA ON P NUTRIENT CONTENT IN CORN SHOOTS

TABLE 2-7
EFFECT OF INOCULATION OF ENDOMYCORRHIZA AND P ON NUTRIENT CONTENT IN CORN SHOOTS

	Content in Shoots (μg)			
	No P		*25 ppm P Added*	
Nutrient	*No Mycorrhiza*	*Mycorrhiza*	*No Mycorrhiza*	*Mycorrhiza*
P	750	1,340	2,970	5,910
K	6,000	9,700	17,500	19,900
Ca	1,200	1,600	2,700	3,500
Mg	430	630	990	1,750
Zn	28	95	48	169
Cu	7	14	12	30
Mn	72	101	159	238
Fe	80	147	161	277

Source: Adapted from Lambert et al., 1979, *SSSAJ*, 43:976.

POTASSIUM K

- 7th most abundant element ~2.5% in the earths crust
- Generally absorb by plants in amounts larger then any other nutrient except Nitrogen
- High weather soils are generally low in K
- Low K levels in crop are seen as small fruit sets and reduction in yields
- K is essential for photosynthesis through several functions including:
  ATP synthesis
  production and activity of specific photosynthetic enzymes
  CO2 absorption through leaf stomates
  maintenance of electroneutrality during photophosphorylation in chloroplasts

CALCIUM CA

- Ca^{+2} in plants ranges from 0.2% to 1.0%; is essential to cell wall membrane structure and permeability.
- Low Ca^{+2} weakens cell membranes, resulting in increase permeability, loss of cell contents, and failure of nutrient-uptake mechanisms.
- Ca^{+2} and other cations neutralize organic acids formed during normal cell metabolism.
- Ca^{+2} is important to N metabolism and protein formation by enhancing NO_3^- uptake
- Ca^{+2} also provides some regulation of cation uptake; e.g. K^+ and Na^+ uptake are equivalent in absence of Ca+2, but in its presence K^+ uptake greatly exceeds Na^+ uptake.

SULFUR S

- Plant absorbable S is an anion in the from of SO_4^-
- Most soil SO_4^- is associated with OM decay and the Sulfur cycle
- S and Mg are taken up by plants in similar quantity as P; but in lower quantities then Ca^{+2}
- Ca^{+2} and Mg^{+2} behave in similar ways as K^+
- S^0 is a form of elemental sulfur, and is used to amend soil sulfur deficiencies; and for lowering soil pH

MAGNESIUM MG

- Like other cations, is available in ion Mg^{+2} and should represent around 10% to 20% of the soils base saturation
- Needed for chlorophyll (15%-20% of total Mg^{+2} in plants)
- Deficient plats will see protein N decreases while non-protein N increases. (inviting phloem feeding insects; e.g. aphids)
- Very important for plant metabolism (Krebs cycle, cellular respiration photosynthesis, glycolysis)

MICRONUTRIENTS

▪ Iron	Fe
▪ Zinc	Zn
▪ Copper	Cu
▪ Manganese	Mn
▪ Boron	B
▪ Chloride	Cl
▪ Molybdenum	Mo
▪ Nickel	NI

Soil Report

Job Name: **Five College Farms** Date: 7/29/2016

Company: Five College Farms Submitted By:

				RDW	RDS	RD276	RD258	
Sample Location				RDW	RDS	RD276	RD258	
Sample ID								
Lab Number				34	35	36	37	
Sample Depth in inches				8	8	8	8	
Total Exchange Capacity (M. E.)				6.24	4.94	5.27	3.95	
pH of Soil Sample				5.2	6.1	5.9	5.2	
Organic Matter, Percent				4.16	2.26	2.71	3.45	
ANIONS	**SULFUR:**		p.p.m.	21	15	15	22	
	Mehlich III Phosphorous:		as (P_2O_5) lbs / acre	2114	1505	1317	1186	
EXCHANGEABLE CATIONS	**CALCIUM:**	lbs / acre	Desired Value	2261	1793	1912	1431	
			Value Found	1404	1766	1723	957	
			Deficit	-857	-27	-189	-474	
	MAGNESIUM:	lbs / acre	Desired Value	239	200	202	200	
			Value Found	184	184	224	73	
			Deficit	-55	-16		-127	
	POTASSIUM:	lbs / acre	Desired Value	259	205	219	200	
			Value Found	119	101	59	81	
			Deficit	-140	-104	-160	-119	
	SODIUM:		lbs / acre	27	23	25	20	
BASE SATURATION %	Calcium (60 to 70%)			42.22	66.96	61.27	45.47	
	Magnesium (10 to 20%)			9.22	11.63	13.28	5.78	
	Potassium (2 to 5%)			1.84	1.96	1.08	1.97	
	Sodium (.5 to 3%)			0.69	0.75	0.76	0.82	
	Other Bases (Variable)			7.00	5.20	5.60	7.00	
	Exchangable Hydrogen (10 to 15%)			39.00	13.50	18.00	39.00	
TRACE ELEMENTS	Boron (p.p.m.)			0.37	0.37	0.37	0.37	
	Iron (p.p.m.)			256	166	212	206	
	Manganese (p.p.m.)			24	26	23	18	
	Copper (p.p.m.)			3.56	2.38	9.19	10.9	
	Zinc (p.p.m.)			9.01	3.45	6.49	3.33	
	Aluminum (p.p.m.)			1239	1281	1168	1289	
OTHER								

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Soils sample taken from a field

GOAL FOR THIS EXAMPLE

- %65 BS for Ca
- %15 BS for Mg
- %4 BS for K
- %2 BS for Na
- %10 BS for H
- %5 BS for other Cations

MATH REQUIRED

I need to know total CEC
Pounds of each cation needed to fully saturate a CEC of 1

MATH REQUIRED

- Fe and Mn tend to complex in the soil and at not necessarily occupying space in the soil colloids.
- Mo is taken up by plants as a anion and is there for not on the CEC
- Co was not test so I will not account for it
- Al drives acidity and is need by plants in only small quantities
- Anion Exchange Capacity is negligible and is not accounted for through this means.

WHAT WE KNOW

- A cation exchange capacity (CEC) of 1 mmol/100g of soil simply telling us:

  .001 moles of – ionic charges per ever 100g of soil
  moles is Avogadro's number(6.03 X 10^{24} – ions)
  This number can also be express as .00001 mols/g of soil

- 1 acre 6" deep on average weighs 2,000,000 lbs or 907,200,000g/acre X .00001 moles/g of soil = 9072 mol/acre of – ion charges
- Now we need to know how many grams of a given cation can be held onto the colloids for each

CALCULATING CATIONS NEEDED

- 907,200,000g/acre X .00001 moles/g of soil = 9072 mol/acre of – ion charges
- 9072 mol/acre of – anion charges can be neutralized with the same amount of + cation charges

$$\frac{40\frac{g}{mol}\ Ca^{+2}\ x\ 9072\frac{mol}{acre}}{+2/Ca} = \frac{90720 g Ca^{+2}}{453.6\frac{g}{lbs}} = 400\frac{lbs\ Ca}{acre}$$

$$\frac{40\,\frac{g}{mol}\;Ca^{+2}\;x\;9072\,\frac{mol}{acre}}{+2/Ca} = \frac{90720gCa^{+2}}{453.6\,\frac{g}{lbs}} \quad = \;400\,\frac{lbsCa^{+2}}{acre}$$

$$\frac{24.3\,\frac{g}{mol}\;Mg^{+2}\;x\;9072\,\frac{mol}{acre}}{+2/\mathrm{Mg}} = \frac{220{,}449gMg^{+2}}{453.6\,\frac{g}{lbs}} \quad = 486\,\frac{lbsMg^{+2}}{acre}$$

$$\frac{39\,\frac{g}{mol}\;K^{+}\;x\;9072\,\frac{mol}{acre}}{+1/K} = \frac{353808gK^{+}}{453.6\,\frac{g}{lbs}} \quad = \;780\,\frac{lbs\;K^{+}}{acre}$$

$$\frac{23\,\frac{g}{mol}\;Na^{+}\;x\;9072\,\frac{mol}{acre}}{+1/Na} = \frac{208656gNa^{+}}{453.6\,\frac{g}{lbs}} \quad = \;460\,\frac{lbs\;Na^{+}}{acre}$$

UNDERSTANDING THE CALCULATIONS

- CEC X lbs of desired cation x desired %BS = lbs/acre of element cations desired
- e.g. CEC 10 x 400 lbs of Ca^{+2} X 65% BS Ca^{+2} = 2600lbs/acre of Ca^{+2}
- Subtract our value found… say 1000lbs/acre = 1600lbs/acre needed

Soil Report

Job Name: **Five College Farms**   Date: 7/29/2016

Company: Five College Farms   Submitted By:

			RDW	RDS	RD276	RD258	
Sample Location			RDW	RDS	RD276	RD258	
Sample ID							
Lab Number			34	35	36	37	
Sample Depth in inches			8	8	8	8	
Total Exchange Capacity (M. E.)			6.24	4.94	5.27	3.95	
pH of Soil Sample			5.2	6.1	5.9	5.2	
Organic Matter, Percent			4.16	2.26	2.71	3.45	
ANIONS	**SULFUR:**	p.p.m.	21	15	15	22	
ANIONS	**Mehlich III Phosphorous:**	as (P_2O_5) lbs / acre	2114	1505	1317	1186	
EXCHANGEABLE CATIONS	**CALCIUM:** lbs / acre	Desired Value	2261	1793	1912	1431	
		Value Found	1404	1766	1723	957	
		Deficit	-857	-27	-189	-474	
	MAGNESIUM: lbs / acre	Desired Value	239	200	202	200	
		Value Found	184	184	224	73	
		Deficit	-55	-16		-127	
	POTASSIUM: lbs / acre	Desired Value	259	205	219	200	
		Value Found	119	101	59	81	
		Deficit	-140	-104	-160	-119	
	SODIUM:	lbs / acre	27	23	25	20	
BASE SATURATION %	Calcium (60 to 70%)		42.22	66.96	61.27	45.47	
	Magnesium (10 to 20%)		9.22	11.63	13.28	5.78	
	Potassium (2 to 5%)		1.84	1.96	1.08	1.97	
	Sodium (.5 to 3%)		0.69	0.75	0.76	0.82	
	Other Bases (Variable)		7.00	5.20	5.60	7.00	
	Exchangable Hydrogen (10 to 15%)		39.00	13.50	18.00	39.00	
TRACE ELEMENTS	Boron (p.p.m.)		0.37	0.37	0.37	0.37	
	Iron (p.p.m.)		256	166	212	206	
	Manganese (p.p.m.)		24	26	23	18	
	Copper (p.p.m.)		3.56	2.38	9.19	10.9	
	Zinc (p.p.m.)		9.01	3.45	6.49	3.33	
	Aluminum (p.p.m.)		1239	1281	1168	1289	
OTHER							

Logan Labs, LLC

Soils sample taken from a field

We will attempt to balance this soil with

%BS Ca 65%
%BS Mg 15%
%BS K 4%
%BS Na 2%

NOW WE CALCULATE OUR DESIRED SOIL NUTRIENT LEVELS

CEC 6.24 x (8/6) x 400lbs/A Ca X 65%	=	2157.8lbs/A
Value found	=	1404 lbs/A
Needed		754 lbs/A
CEC 6.24 x (8/6) x 243lbs/A Mg x 15%	=	302.5 lbs/A
Value found	=	184 lbs/A
Needed		118.5 lbs/A
CEC 6.24 x (8/6) x 780lbs/A K x 4%	=	258.9 lbs/A
Value found	=	119 lbs/A
Needed		140 lbs/A
CEC 6.24 x (8/6) x 480lbs/A Na x 2%	=	79.7 lbs/A
Value found	=	27 lbs/A
Needed		53 lbs/A

AGRICULTURAL MISSIONARIES

- God would be glorified if men from other countries who have acquired an intelligent knowledge of agriculture, would come to this land, and by precept and example teach the people how to cultivate the soil, that it may yield rich treasures. Men are wanted to educate others how to plow, and how to use the implements of agriculture. Who will be missionaries to do this work, to teach proper methods to the youth, and to all who feel willing and humble enough to learn? FE 324.1