Chapter 1
Understanding Soil

Lecture 2 – Understanding the Components of Soil

Why be concerned with soil life?

Healthy plants

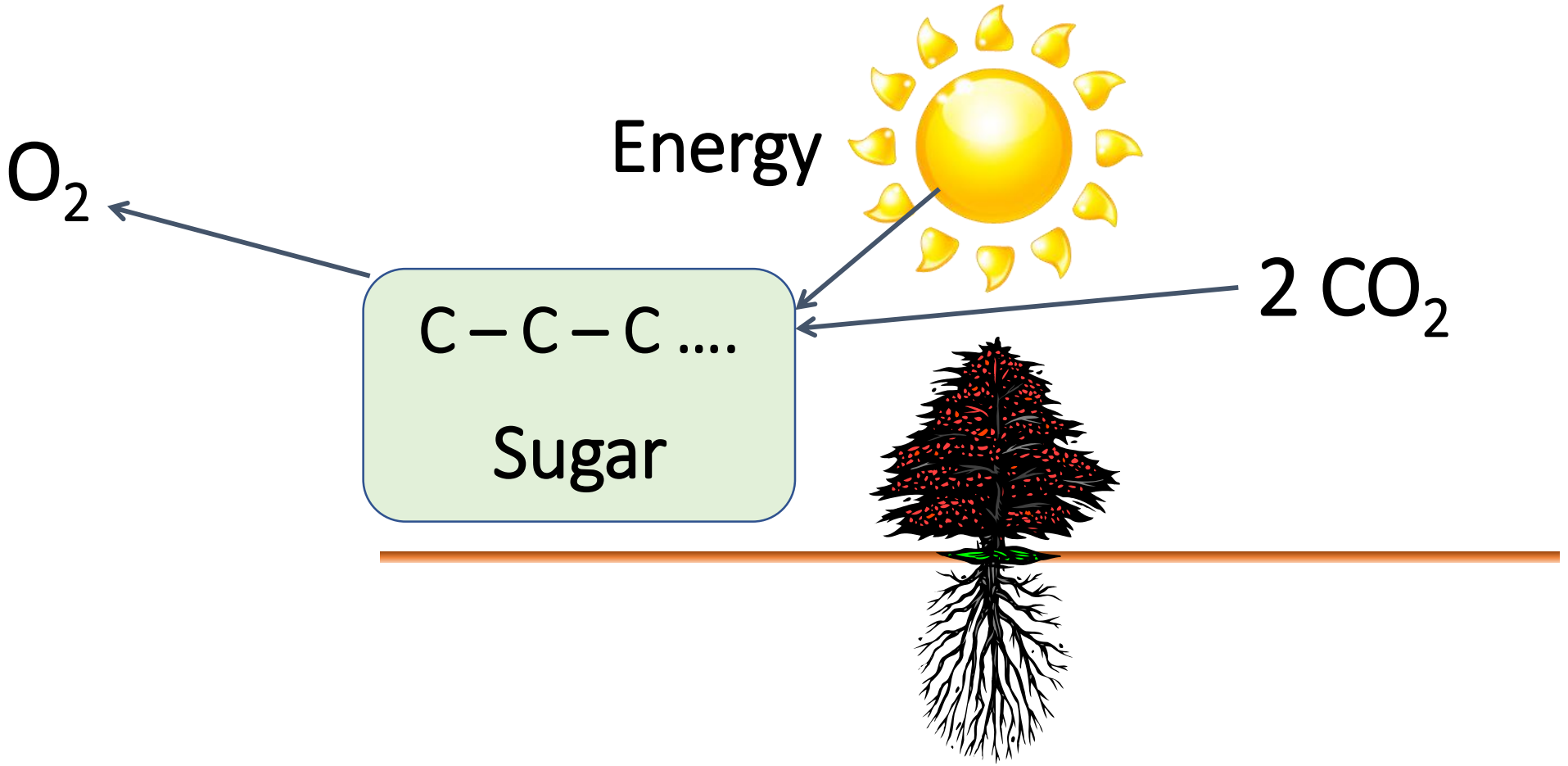
- Don’t need toxic chemicals to grow
- Have the proper balance of nutrients
- So they taste good and satisfy hunger

Flavor depends on the balance of ALL nutrients

Where do plants get their nutrients?

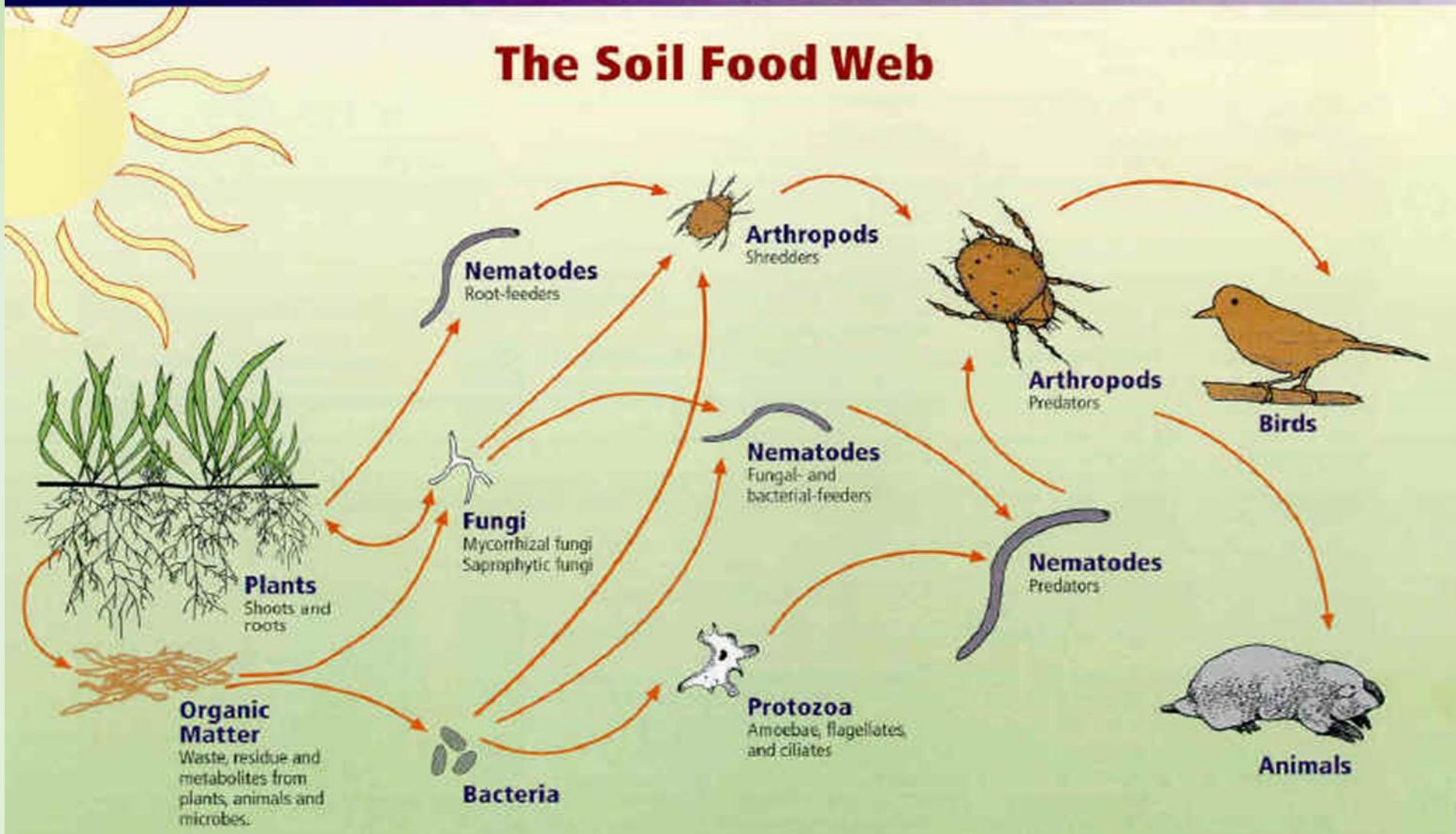
- All but two nutrients come from the soil
- So, human nutrition comes from soil

Photosynthesis



Sugar is made by the plant. What does your plant do with sugar?

The Soil Food Web



First trophic level:
Photosynthesizers

Second trophic level:
Decomposers
Mutualists
Pathogens, parasites
Root-feeders

Third trophic level:
Shredders
Predators
Grazers

Fourth trophic level:
Higher level predators

Fifth and higher trophic levels:
Higher level predators

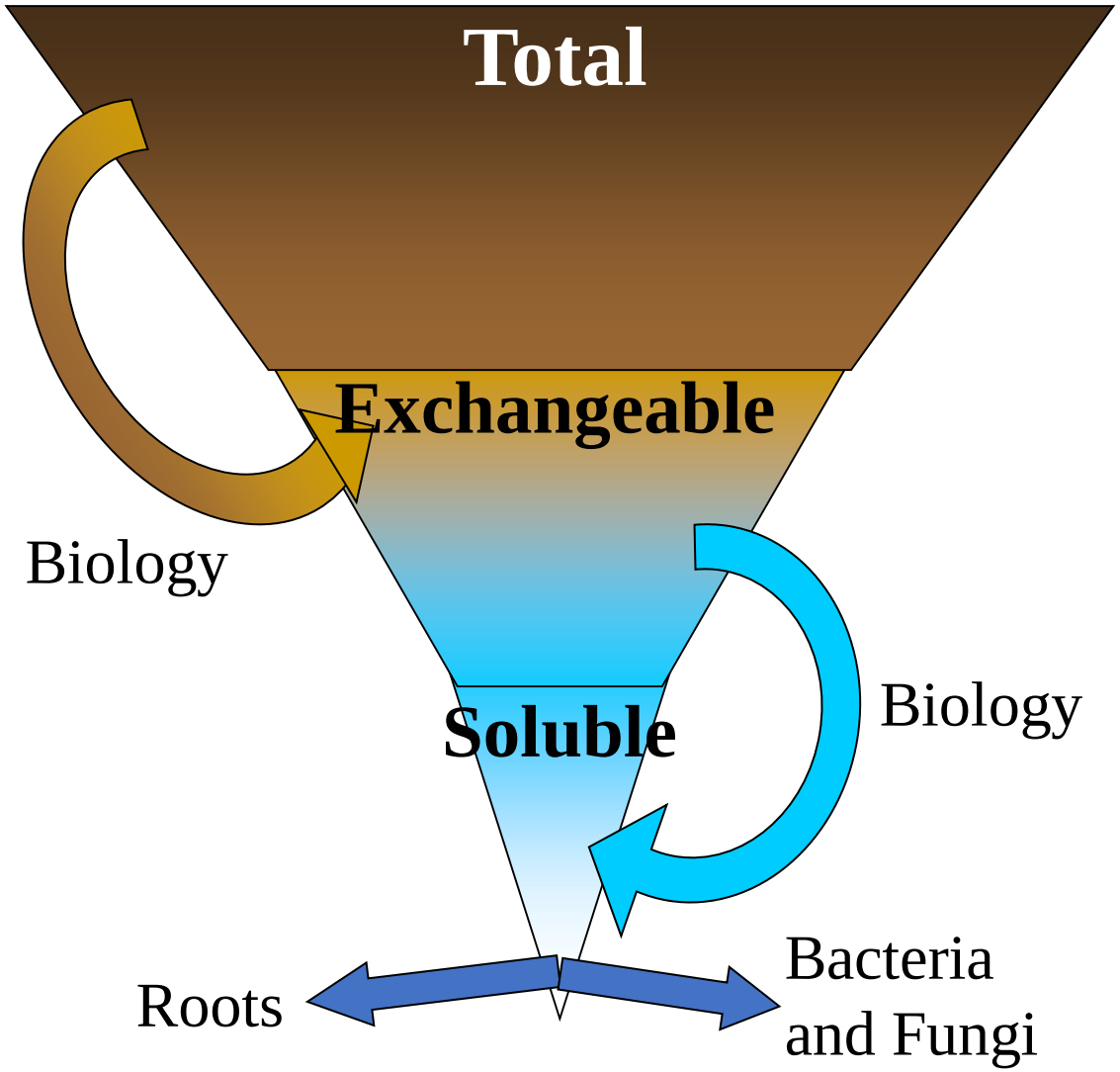
Soil Nutrient Pools

Tests used for the different pools

Grind; Conc. Nitric acid, combustion
10% HCl, H2NO3

Melich III
Bray 2
Amm. Cl / BaCl

Colwell
Olsen, Bray 1
Melich I
Morgan (Reams)
1 M KCl, Universal



Soil Chemistry: Nutrient Pools

Total Soil Nutrients – not normally reported

- Grind, digest using strong acids, combust

Exchangeable Nutrients – ions bound on surfaces of OM, sand, silt, clay, organisms

- Medium strength extracting agents (Melick 3, Ammonium Acetate 1N)

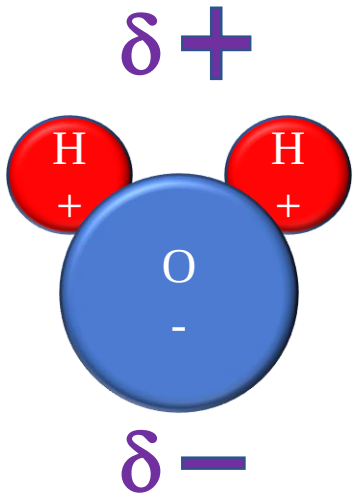
Soluble Nutrients – dissolved in water

- Plant Available nutrients

Plant Tissue Tests

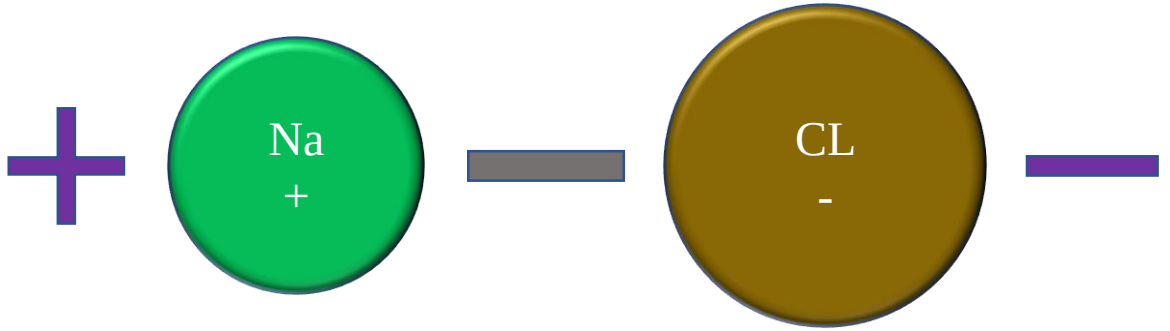
- Same extraction as for total soil nutrients

Water molecule has a polar positive and negative charge (partial charge – δ)



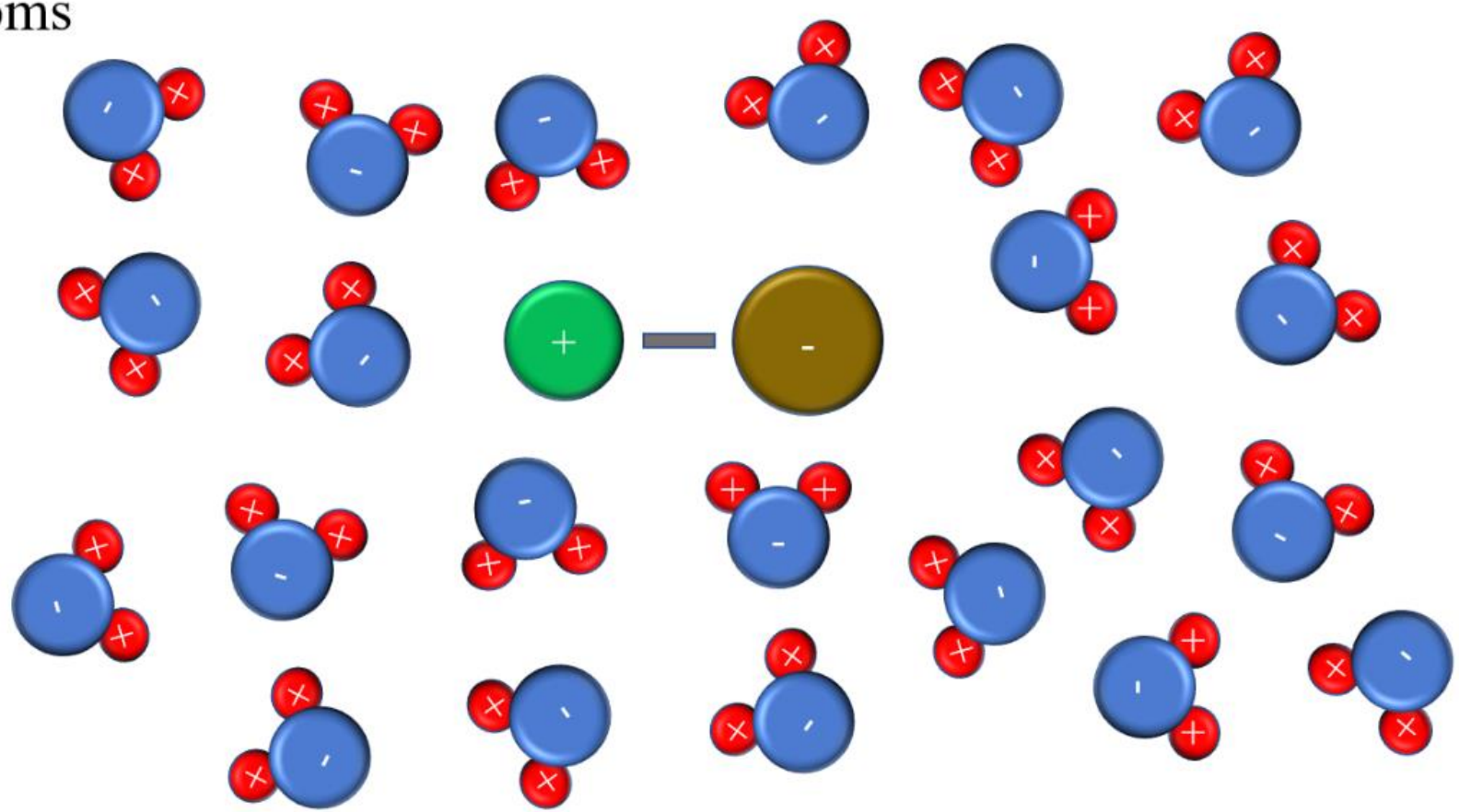
Water molecule

Salt molecule has a ionic positive and negative charge

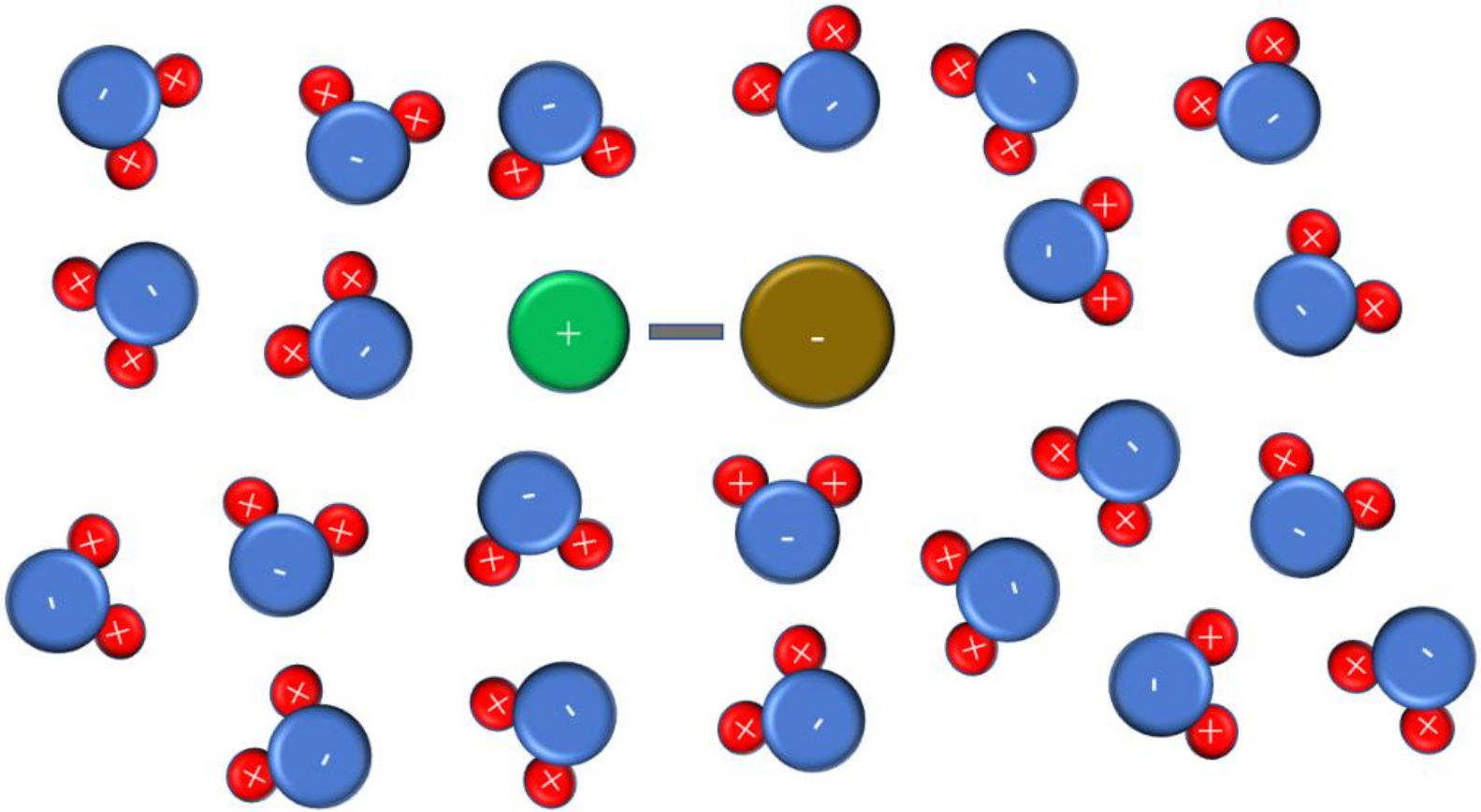


Salt molecule – sodium chloride

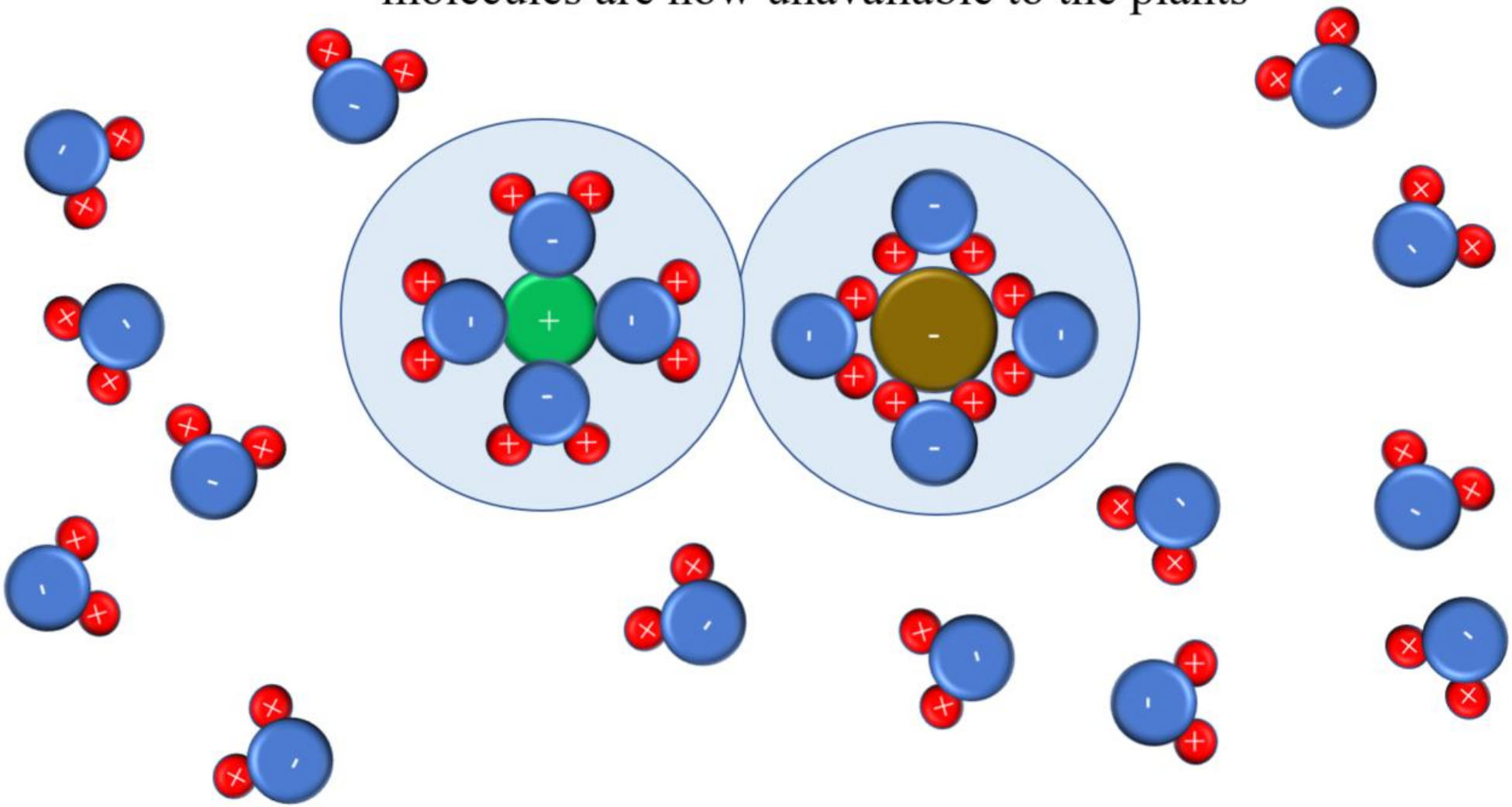
Water molecules will bind with the positive charged sodium and negative charged chloride atoms



The ionic bond between the sodium and chloride is broken



The water molecules have bonded with sodium and chloride atoms. The water molecules are now unavailable to the plants



Agronomist Optimum Element Levels (soluble nutrients)

Nutrient	Limit in PPM	Avg. PPM	Old Growth
Major Elements			(added)
Nitrogen	150-1000	250	0.1 (0.5)
Phosphorus	50-100	80	0.1
Potassium	100-400	300	0.2
Minor Elements			
Calcium	100-500	200	1.0
Magnesium	50-100	75	0.5
Sulfur	200-1000	400	0.4
Trace Elements			
Copper	0.1-0.5	0.7	0.5
Iron	2-10	5	0.1
Boron	0.5-5.0	1.0	0.1
Manganese	0.5-5	2.0	0.2
Molybdenum	0.01-.05	0.02	0.02
Zinc	0.5-1.0	0.5	0.04

What is soil?

As defined by Hans Jenny, the Father of Soil Science:

1. Mineral: Sand, silt, clay - All minerals properly balanced

2. Organic matter

3. (Aerobic) Organisms

Soil Organic Matter

1. **Where does it come from?**
   a. Dead plant material
   b. Plant exudates
   c. Modified by bacterial and fungal decomposition
   d. Wastes released by one organism is food for another species

2. **Types of Organic Matter**

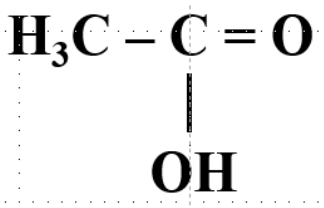
Simple to Complex Organic Matter

Bacterial	**Sugar**	Unbranched carbon chains
	Amino Acids	Unbranched sugars with N ($NH_{2)}$
Bacterial and Fungal	**Protein**	1 – 10,000 amino acids, branched, plus other nutrients
	Lipo-polysaccharides	Branched, PO_4
	Hormones	Long protein chains, cyclical
Fungal	**Ulmic acids**	Highly branched, rings
	Fulvic acids	More highly branched; tan
	Humic acids	Extremely branched, complex brown color

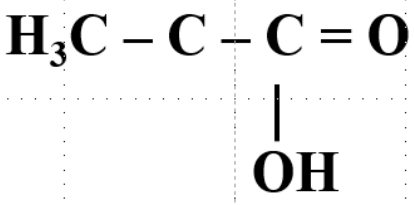
Simple Organic Matter

Simplest Sugar

Two carbons



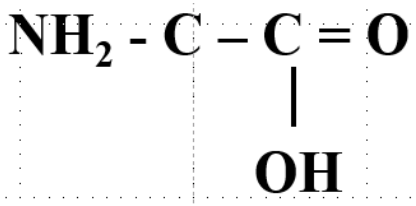
Three carbons



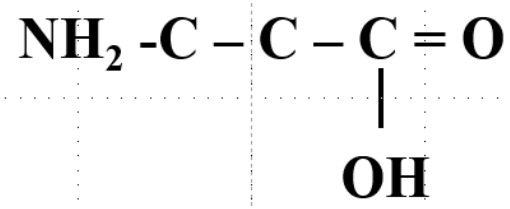
and so on

Simplest Amino Acids (add NH_2 or amide group)

Two carbon

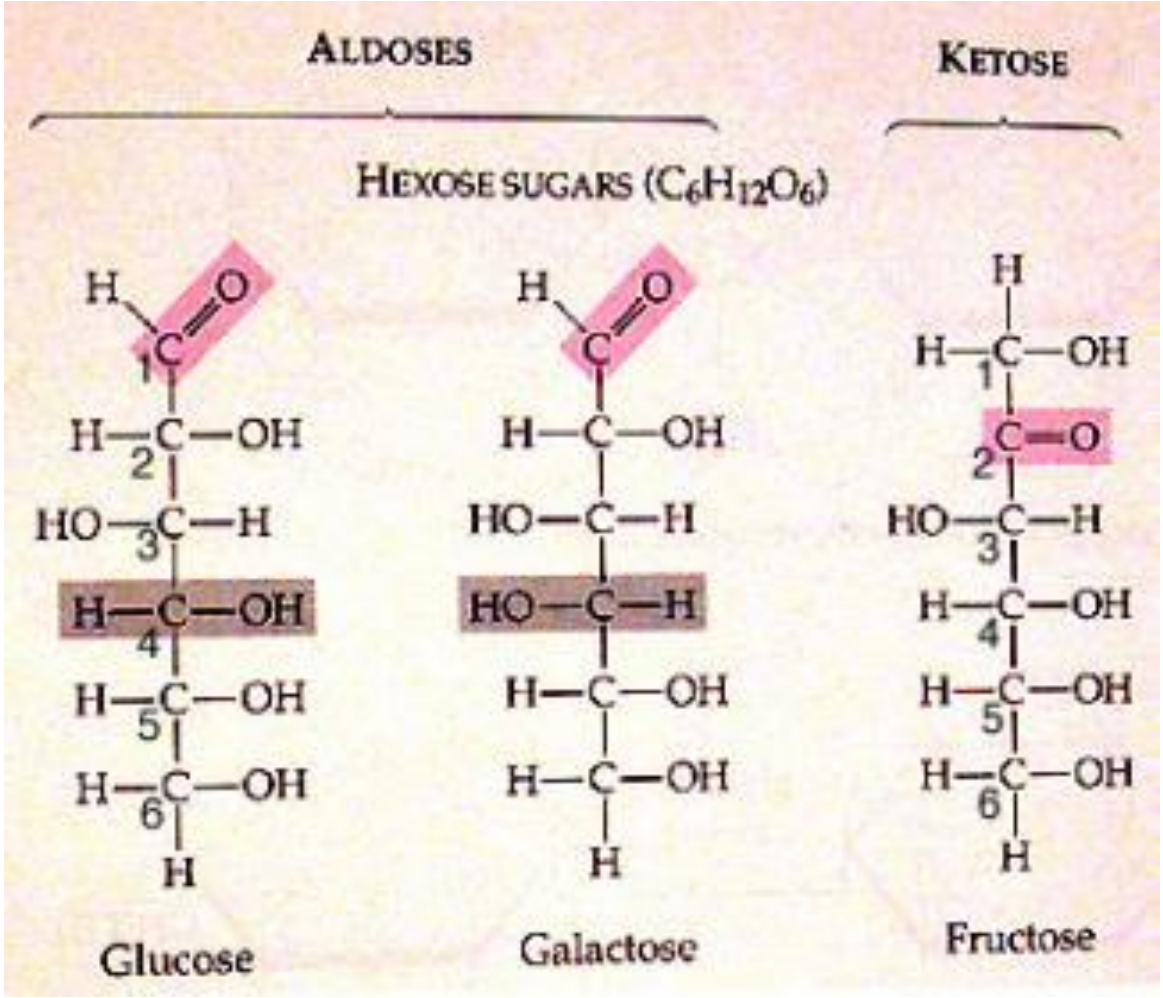


Three carbons

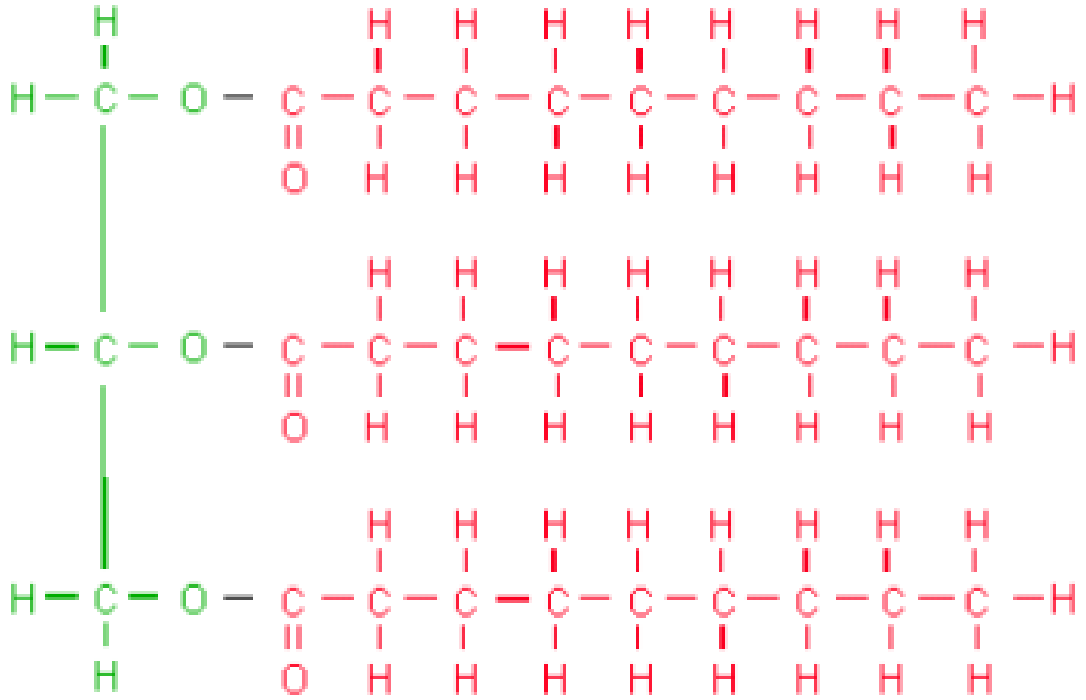


and so on

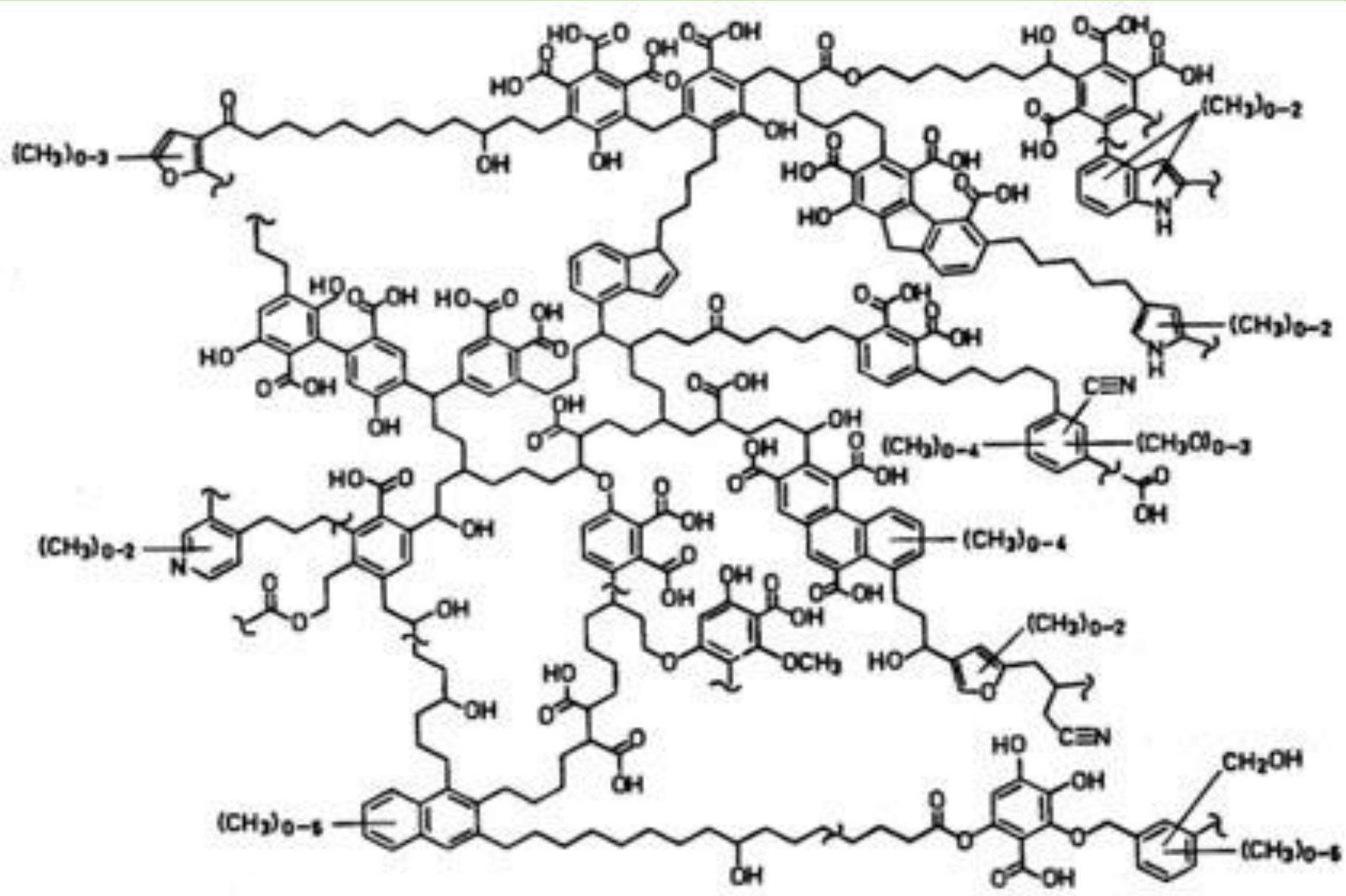
More Sugars


ALDOSES
KETOSE
HEXOSE SUGARS ($C_6H_{12}O_6$)
Glucose
Galactose
Fructose

Complex Branched Structures



A small part of a humic acid molecule



Carbon to Nitrogen Ratios: C:N

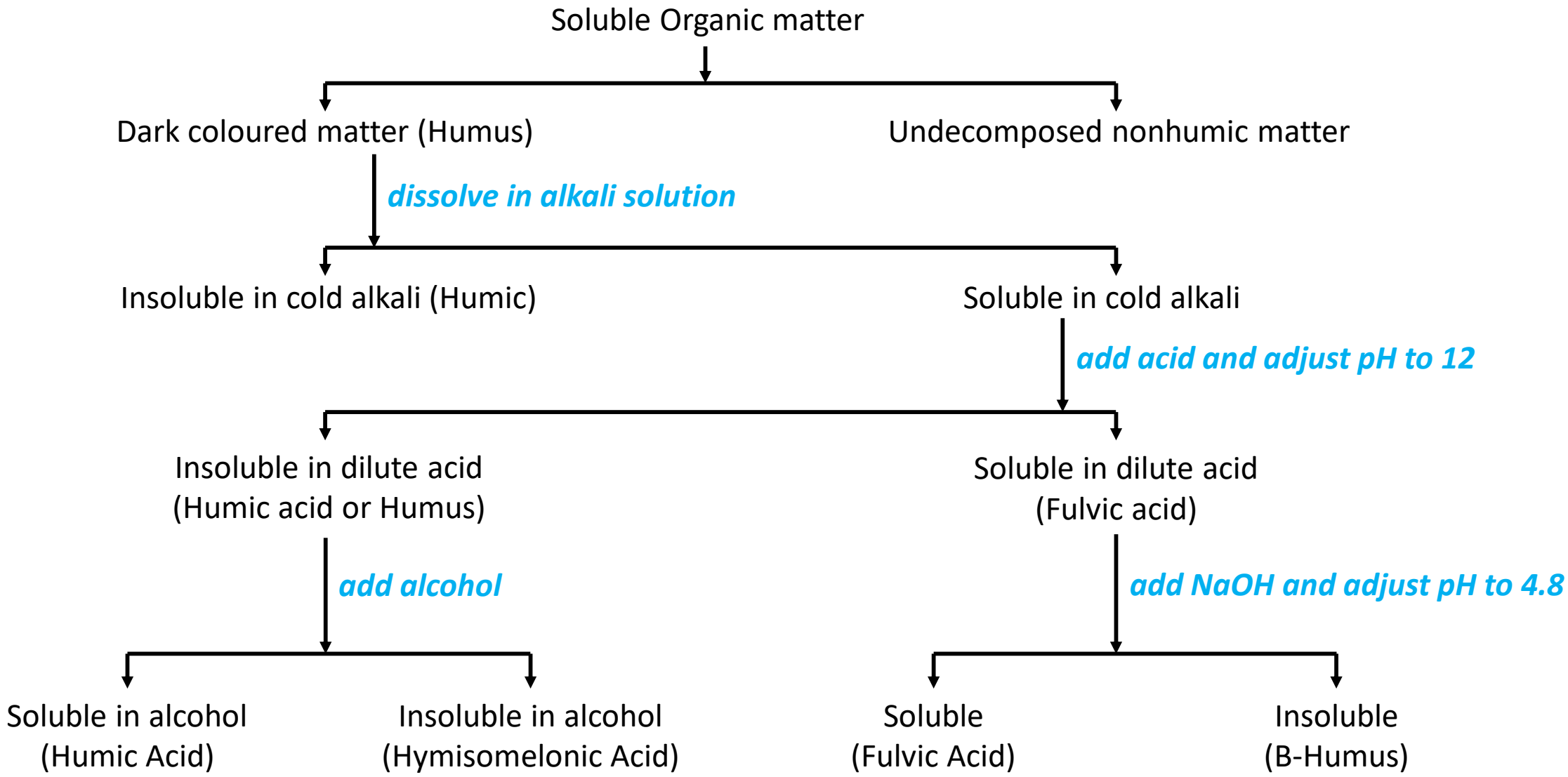
The ratio of the number of carbon atoms relative to the number of nitrogen atoms gives a good clue to several important factors in growing plants.

For example:

1. Is balance of C and N within the plant tissue correct?
2. Is the plant stressed?
3. Is the organic matter better fungal food, or bacterial food?
4. How rapidly will the organic matter decompose, if the correct bacterial and fungal species are present? If the predators are present to release soluble nutrients?

The plant itself will strongly influence C:N ratios by the exudates it releases and the root cells it sloughs.

Soil Organic Matter



Food Sources for Soil Organisms

Bacterial Foods

- Molasses
- Sugars
- Simple Amino Acids
- Simple Proteins
- Simple Carbohydrates

Fungal Foods

- Humic Acids
- Complex Proteins
- Oatmeal
- Bran
- Fish Hydrolysate
- Wide C:N ratio Foods

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Microorganisms: Appearance & Function

Morphology

Deciding characteristics

Function

What each group does

Total vs Active

Active: Actively metabolizing organisms (respiring, making enzymes, producing wastes) that meet criteria for ID of that group.

Total: All the organisms that meet the criteria, includes: Extremely to Not-very active, Moribund, Dead but ID can still be made. No dormant stages included.

Species or Individuals

Why do we need to know:

The number of species present
and
The number of individuals of each species

A high number of species means all the functions of that group will be performed; a low number means the plant will suffer. ALSO need lots of individuals of each species active, to do their jobs

Numbers versus Biomass

One elephant versus one mouse?

One fungus versus one bacterium?

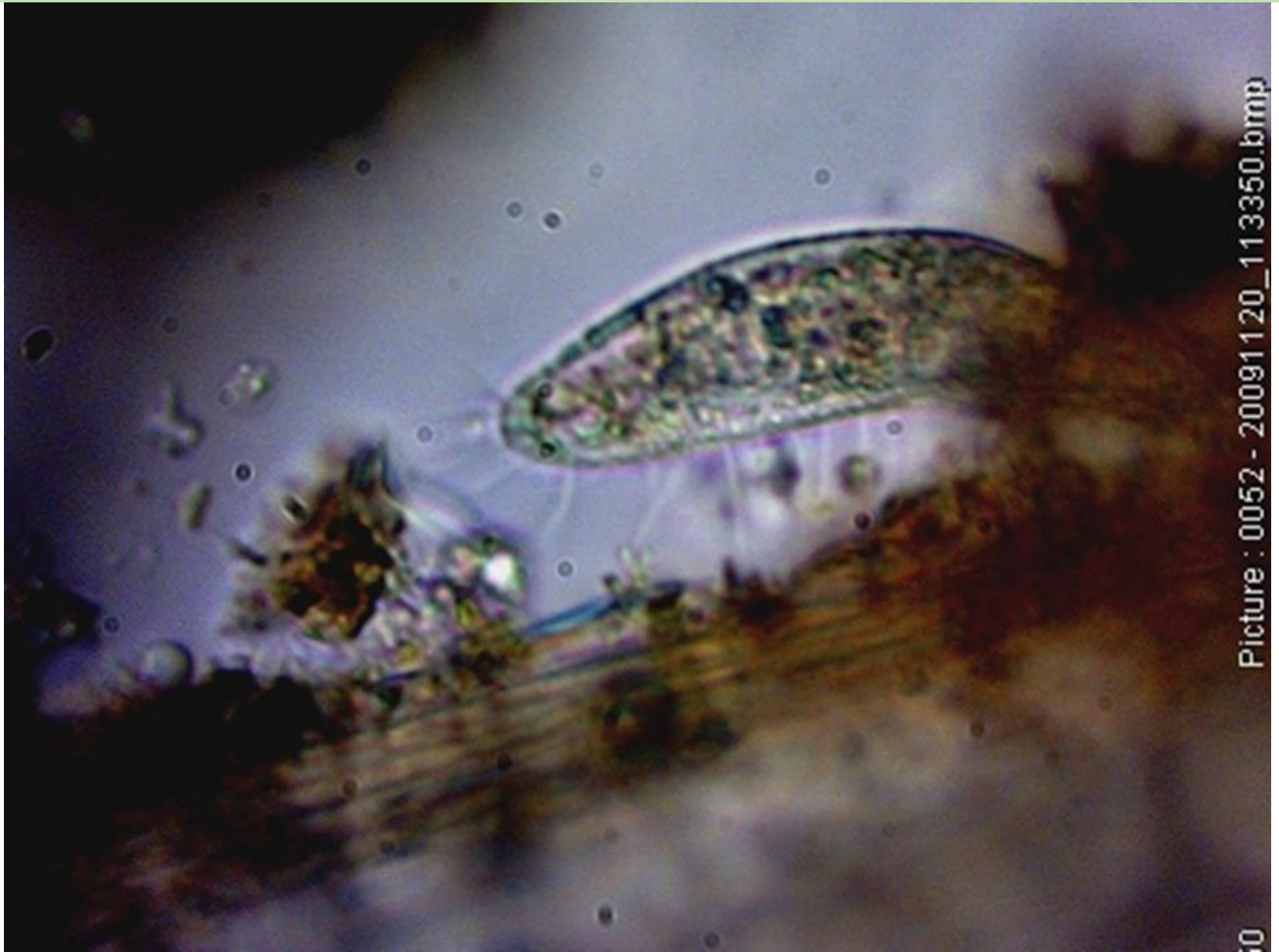
How do we decide importance?

The largest organisms on this planet are fungi.

Bacteria are among the smallest organisms.

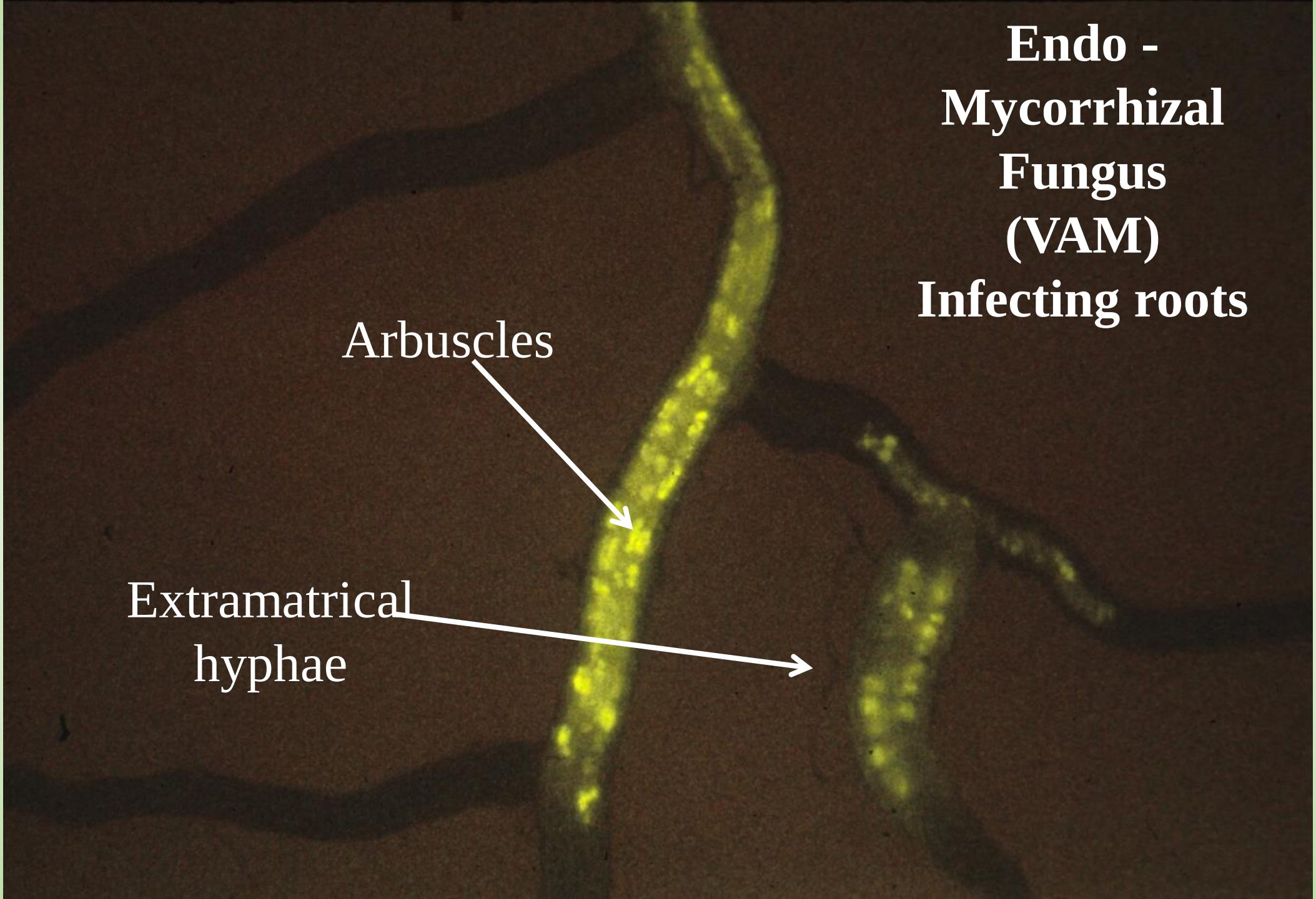
So, we need to know biomass, not numbers

Bacteria, Aggregates, Roots, Ciliate (Protozoan)



Bacteria, fungi, humus, aggregates: 400X total magnification

Josh Webber: Portmore Golf Course North Devon, UK

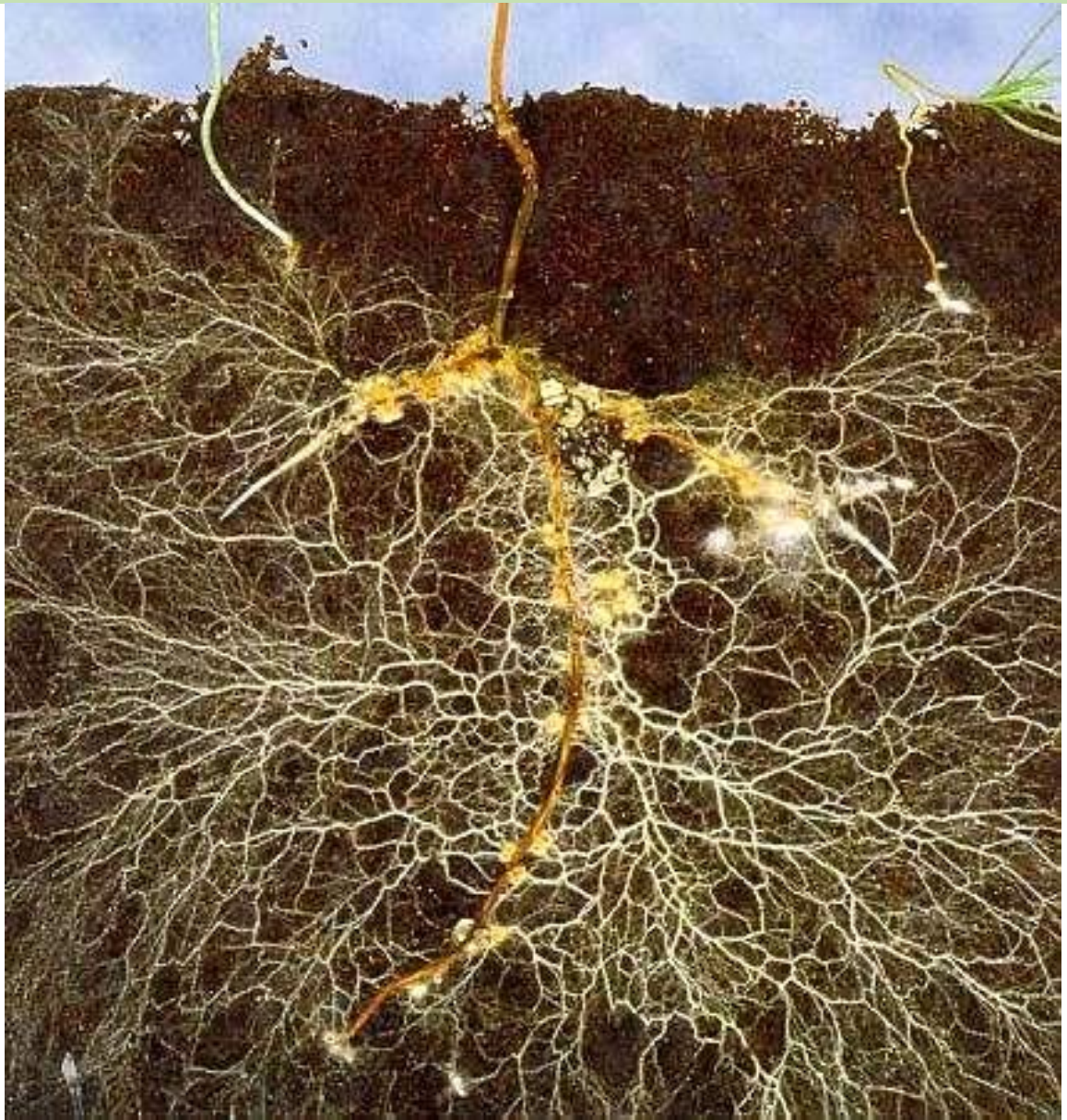

Endo -
Mycorrhizal
Fungus
(VAM)
Infecting roots
Arbuscles
Extramatrical
hyphae

Ecto-Mycorrhizal Example

David Reid

Ecto-
Mycorrhizal fungi
on pine seedling

How much more of the soil can the plant get nutrients from?

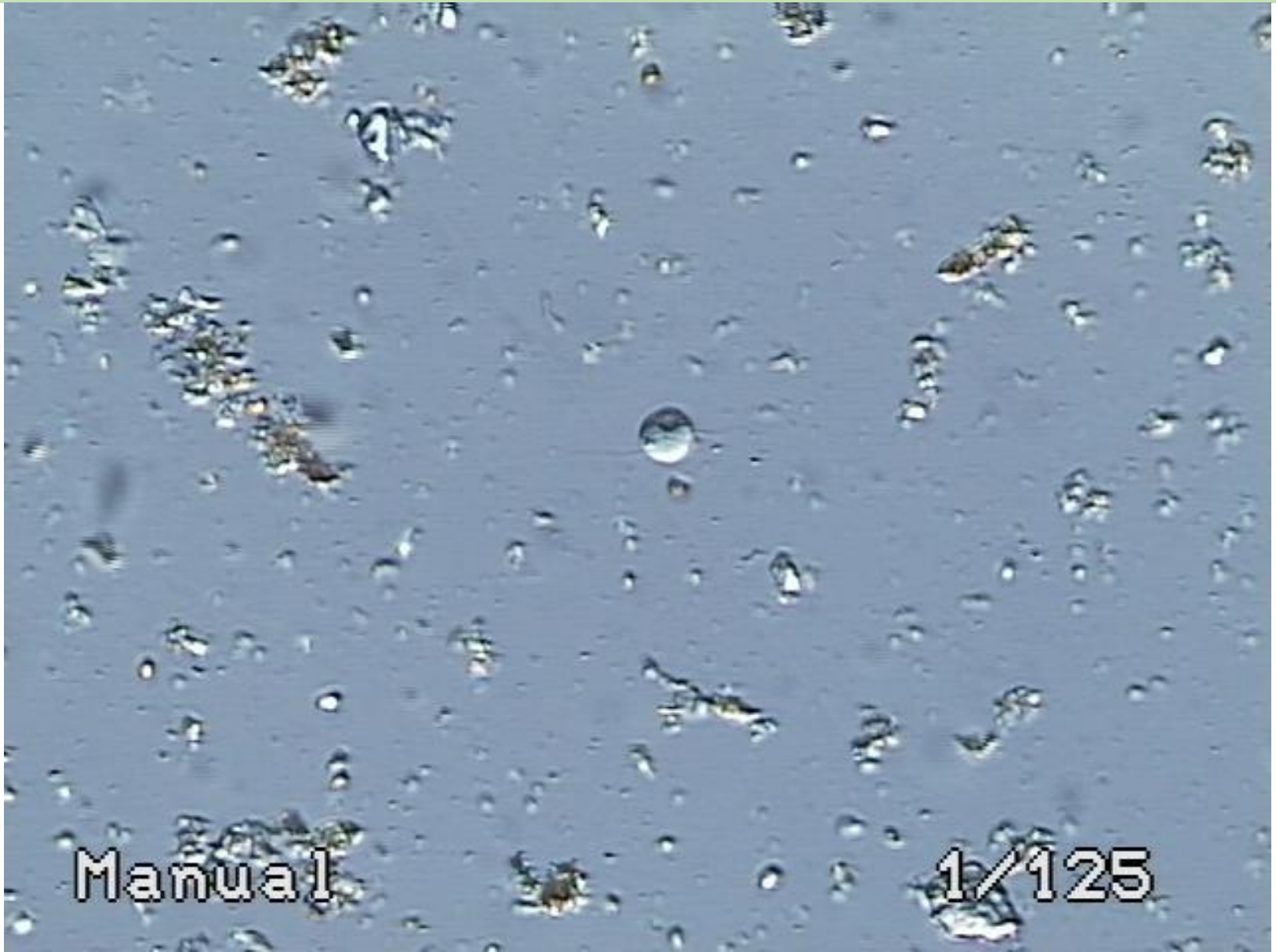


Predator Morphology

Protozoa

Nematodes

Flagellates, Soil Bacteria – 400x mag



Beneficial Nematodes

Hi! I’m Alaimus!

My mouth and lip hairs let you know who I am

I live in the town of Vegetable Roots and eat aerobic bacteria the plant grows around its roots

If bad-tasting anaerobic bacteria start growing or things get too disturbed, I leave

My job is turning excess nutrients in bacteria into plant-available forms of those nutrients

Plant-Available Nutrients

Bacteria and fungi form a massive wall around roots, because plants feed them

Protozoa and nematodes are attracted to the large number of their prey

Because nutrients are so much higher in bacteria and fungi than in their predators, excess nutrients are released, but in plant available forms

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