Soil Microbes: An Introduction

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Microbes include:

- Fungi
- Protozoa
- Viruses
- Bacteria
- Archaea

A sense of scale

If a

Microbe
(5 microns)

were as big as

Person
(6ft tall)

Then a

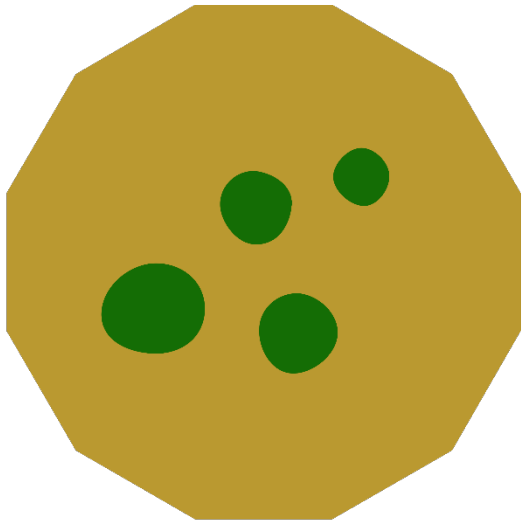
Silt/Clay Particle
(50 microns)

is like a

Semi Trailer
(60 feet)

Then a

Microaggregate
(250 microns)



is like the

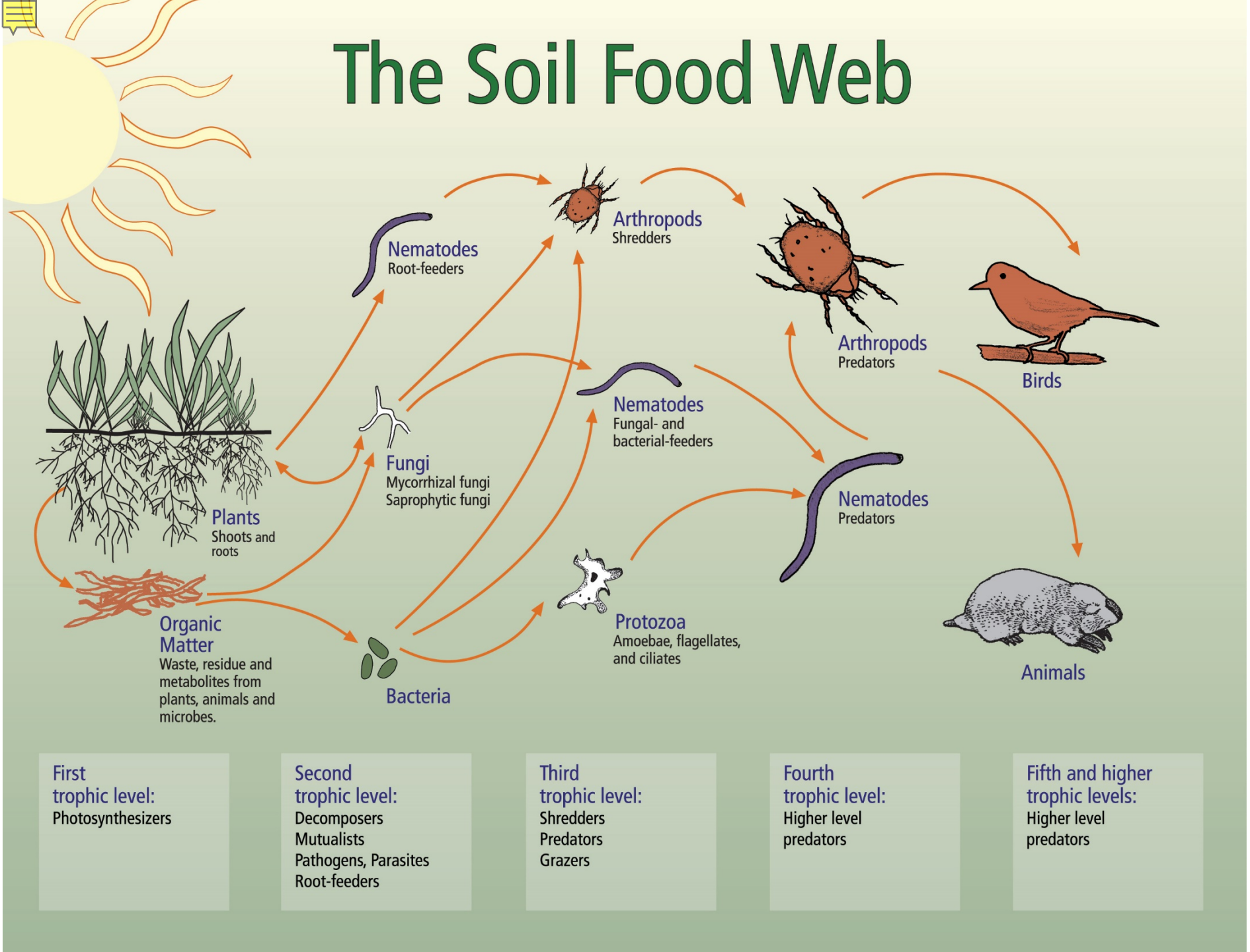
Statue of Liberty
(300 feet)

Then a

Clump
of soil (2in)

is like

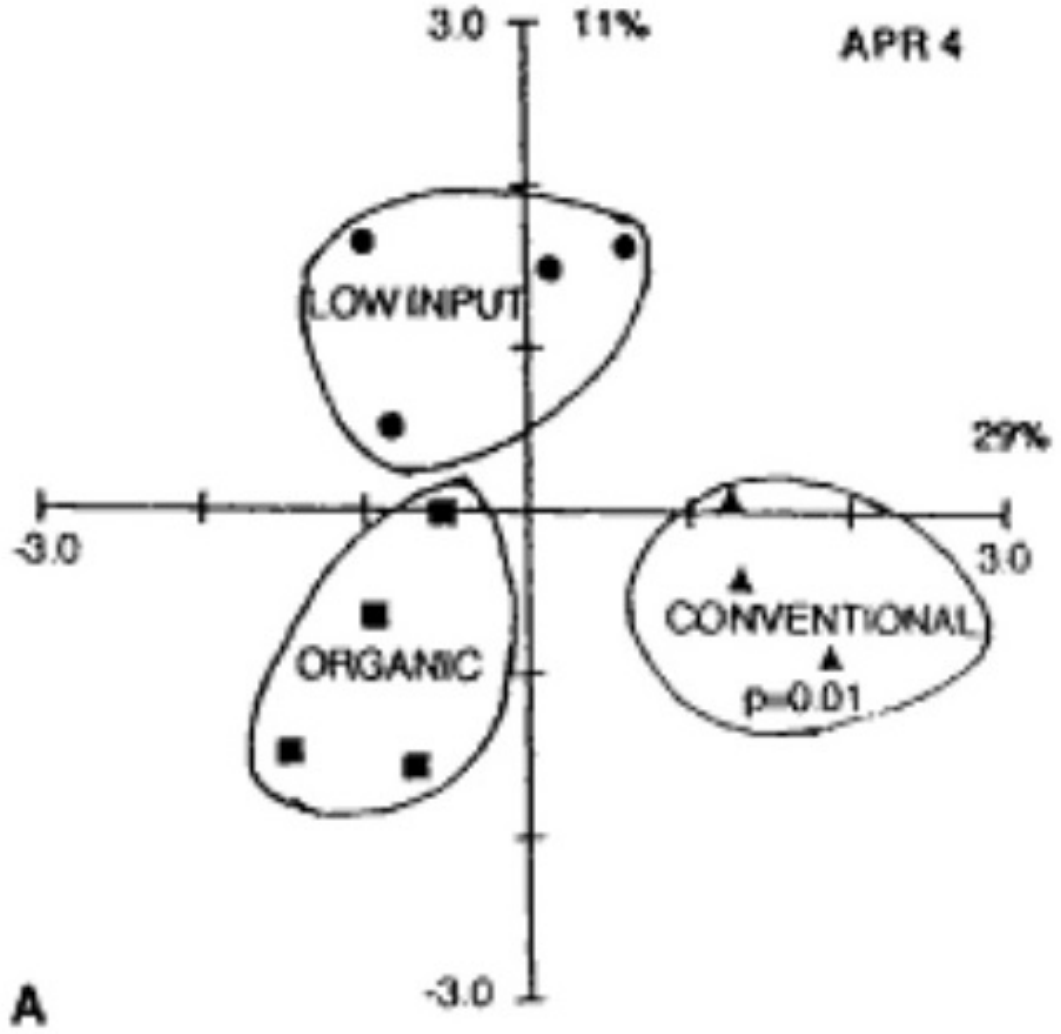
2 Mount
Everests on top
of each other
(11 miles)



There are a lot of microbes in a healthy soil. I'm sure we've all heard the saying that there are more microbes in a teaspoon of healthy soil than there are people on earth. But what does it mean that there are a lot of microbes?

Well, for one, it means that there is a lot of genetic diversity. As we learn more about genetics and DNA sequencing becomes more popular, scientists are increasingly turning to the soil to find new genes for disease resistance and antibiotics.

It also means that there are a lot of interactions between these microbes. Scientists are just starting to understand how microbes in the soil communicate with each other, how they work together to build soil structure, and how our activities affect them.

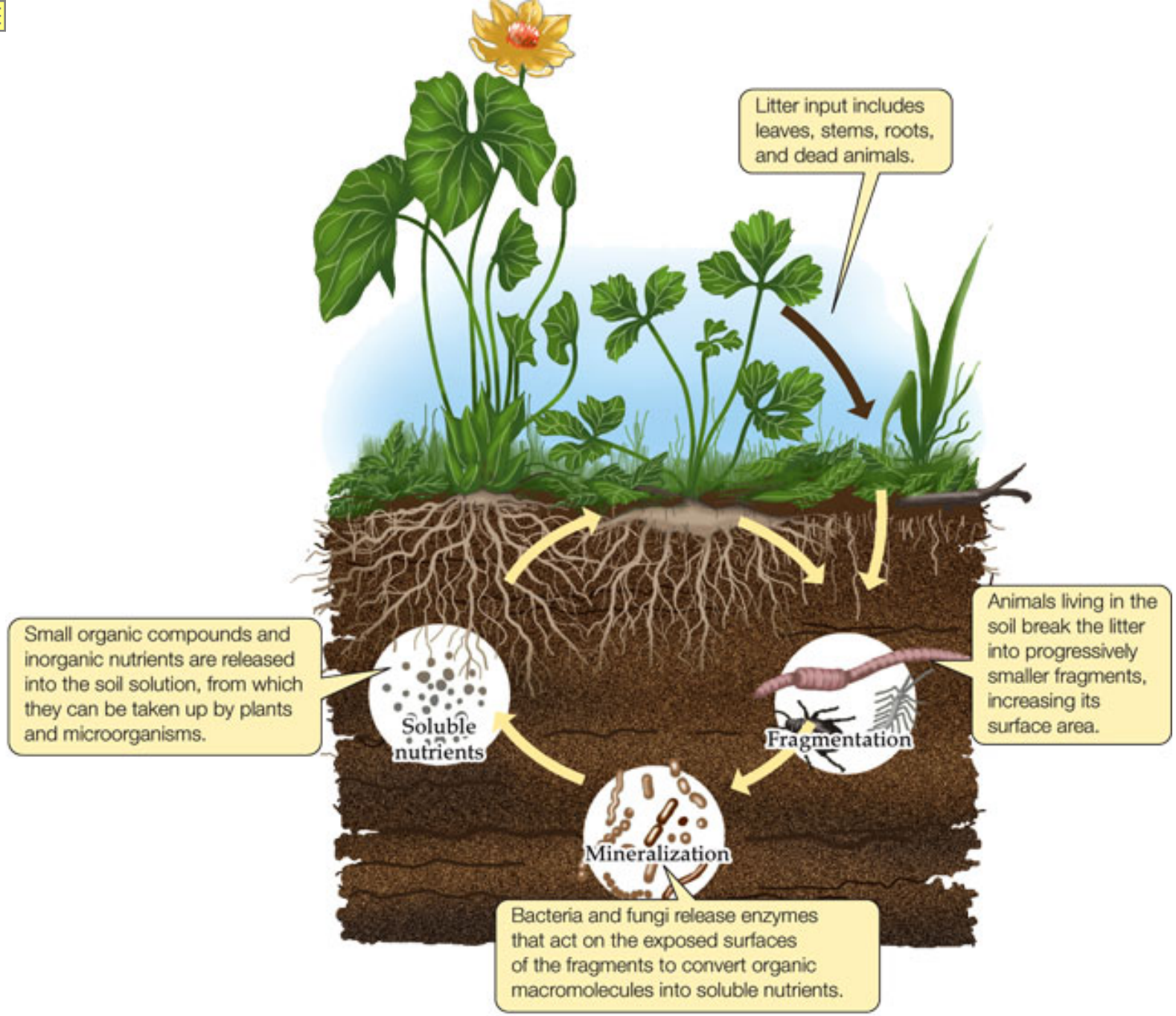


Taken from Bossio, D. A., Scow, K. M., Gunapala, N., & Graham, K. J. (1998). Determinants of soil microbial communities: effects of agricultural management, season, and soil type on phospholipid fatty acid profiles. *Microbial ecology*, *36*(1), 1-12.

We are like people looking in on a different culture, one in which we do not understand the language. We do not understand what microbes are saying to each other, but when we look at the communities, we can see that there is structure and communication. Soils that undergo different management practices will have different microbial communities. This is the only graph in my presentation, I promise. These circles are profiles of fatty acids extracted from soil samples on different dates that have undergone organic, conventional and low input treatments. If the microbial community in these samples were similar, the circles would overlap. What we see here is that the circles do not overlap. This means that the structure of the microbial communities in these samples is different.

As we learn more of the microbial language, and look at different soils, we can begin to link the “structure” of a community, and the “functions”, or what it actually does.

Microbes in the soil perform a number of functions.



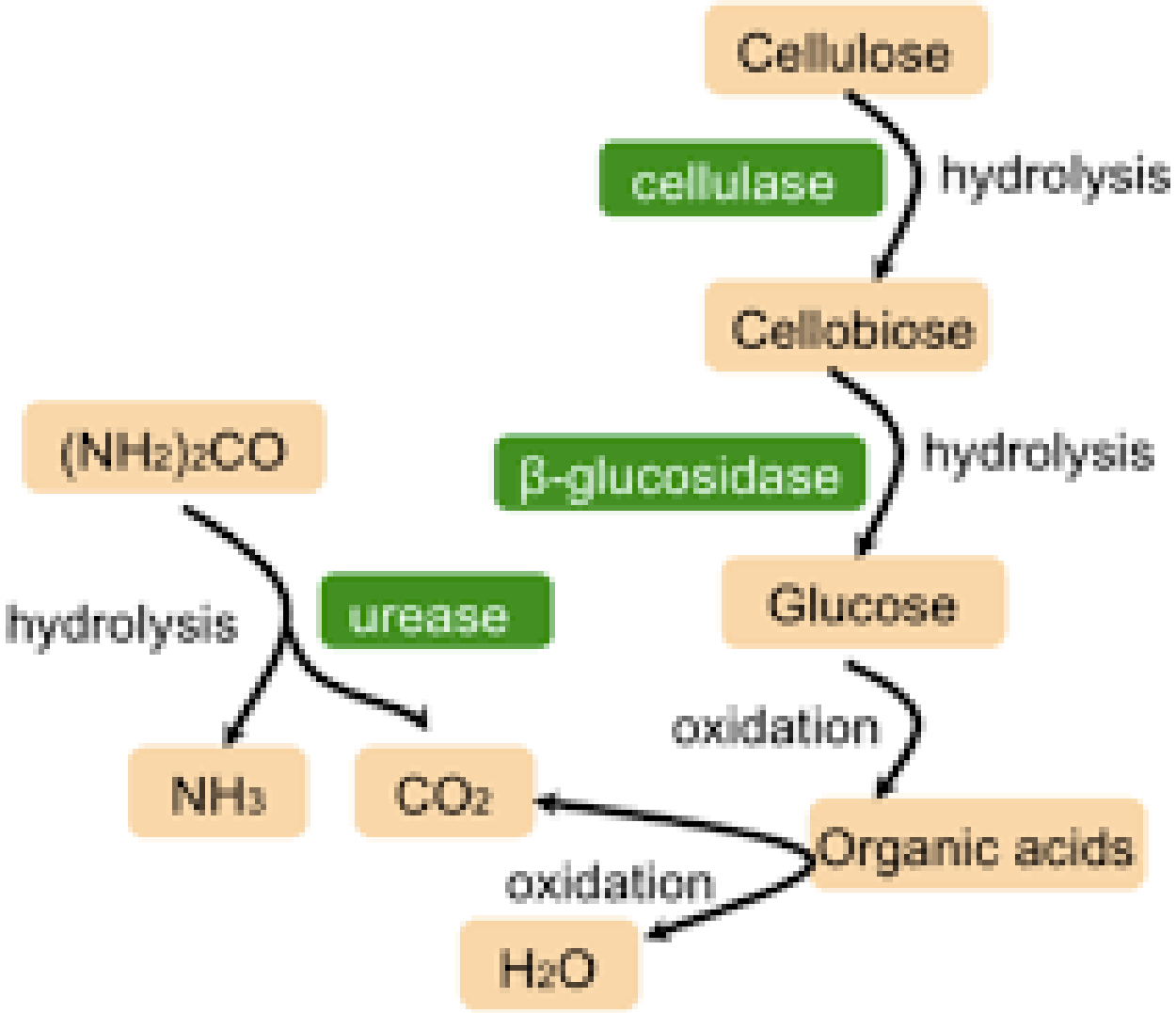
ECOLOGY 2e, Figure 21.6

Functions of Microbes

One of the most well known functions is **decomposition**, where plant roots and leaves are broken down and consumed.

Decomposition is important for releasing nutrients such as nitrogen and phosphorus that are trapped in plant and animal residues.

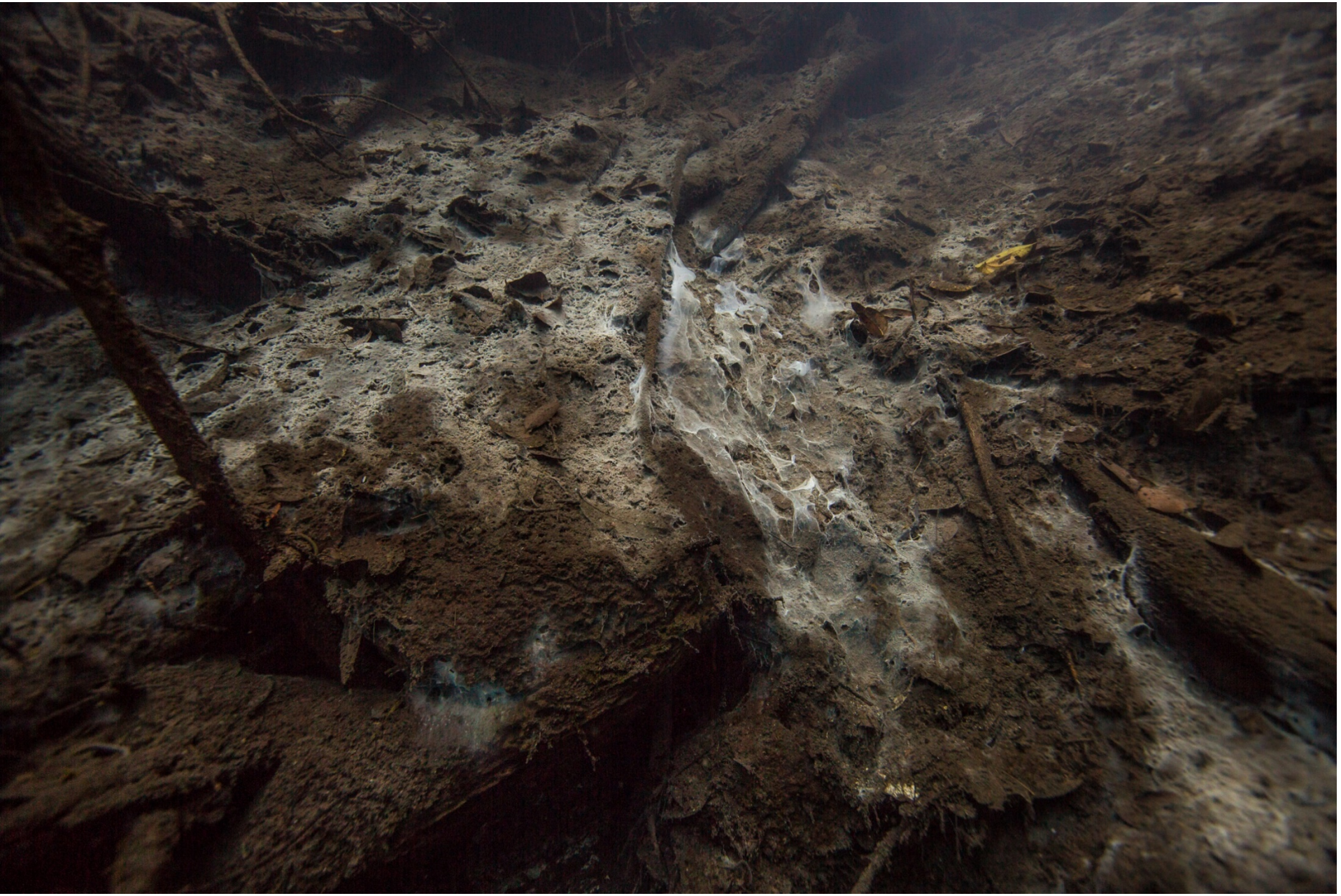
Functions of Microbes



Microbes use a variety of enzymes to break down complex compounds such as cellulose and lignin into simpler compounds, such as glucose.

Functions of Microbes

Fungi are particularly good at decomposition, as they are often the only ones capable of breaking down some of the tougher compounds found in plants, such as lignins.



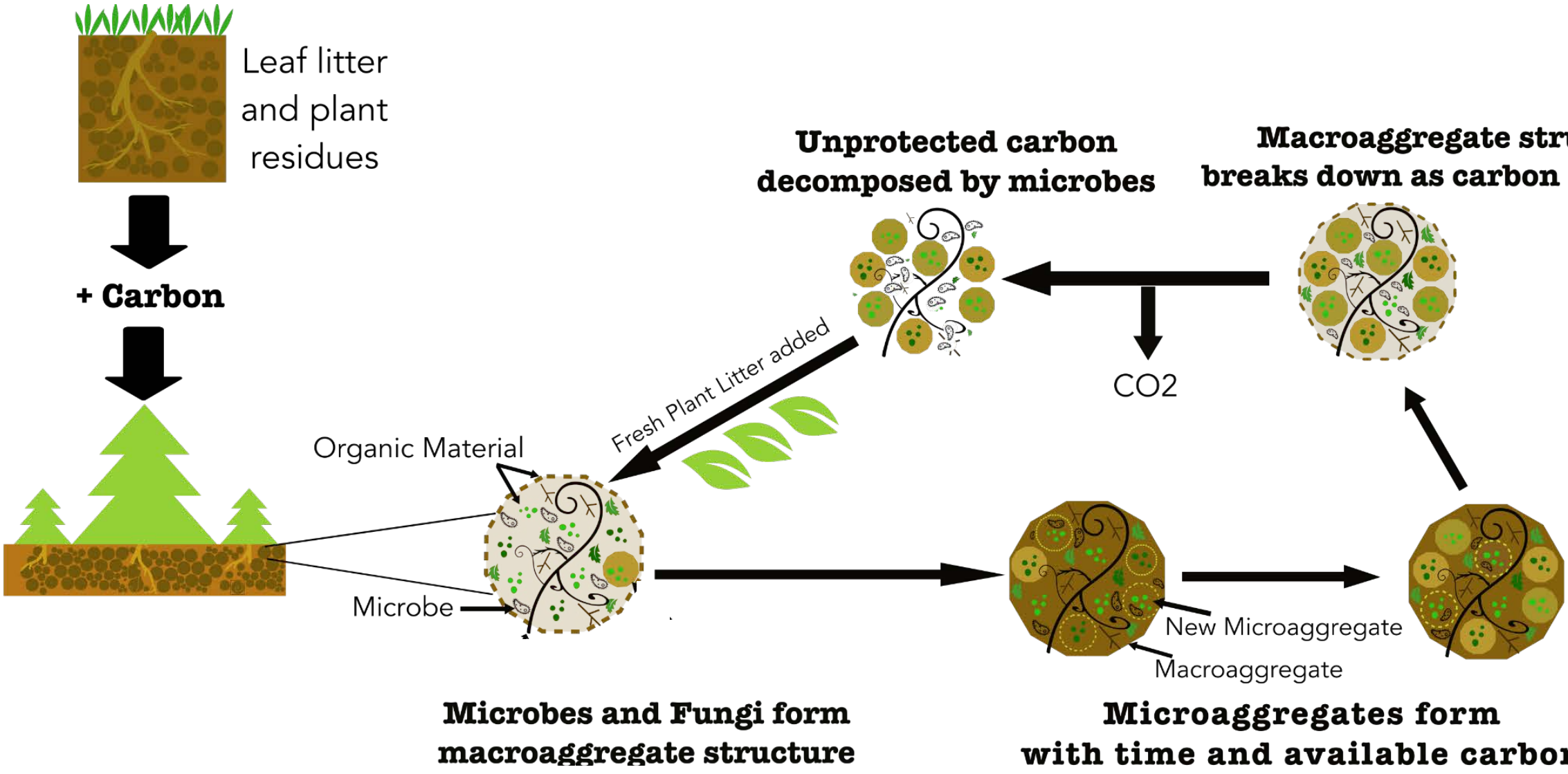
Functions of Microbes

If you would like to observe this in real time in the field, an amusing experiment you can do is to bury a pair of 100% cotton underwear in the field, and see how it looks after 2 months.

Functions of Microbes

Microbes are also responsible for the formation of soil structure, by contributing to the formation of soil aggregates.

Soil Aggregate Formation Process

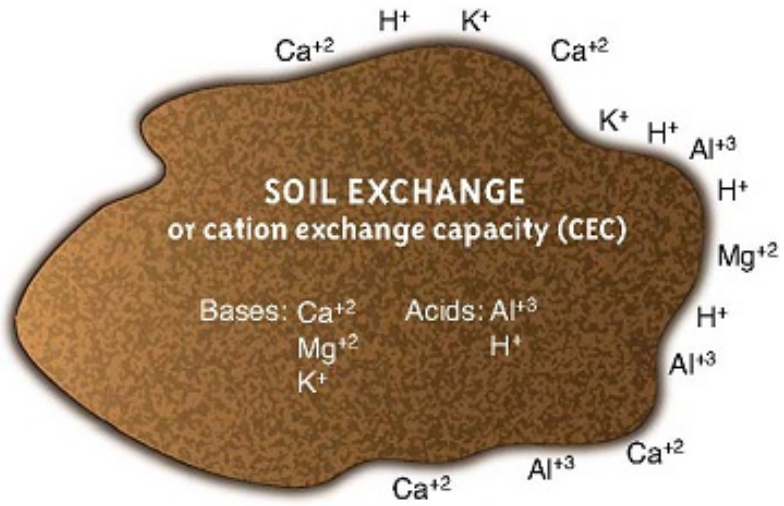


Macroaggregates (> 250 microns) and microaggregates (< 250 microns) form when microbes release EPS, sticky compounds or glues, around sources of organic carbon, which glue soil particles together.

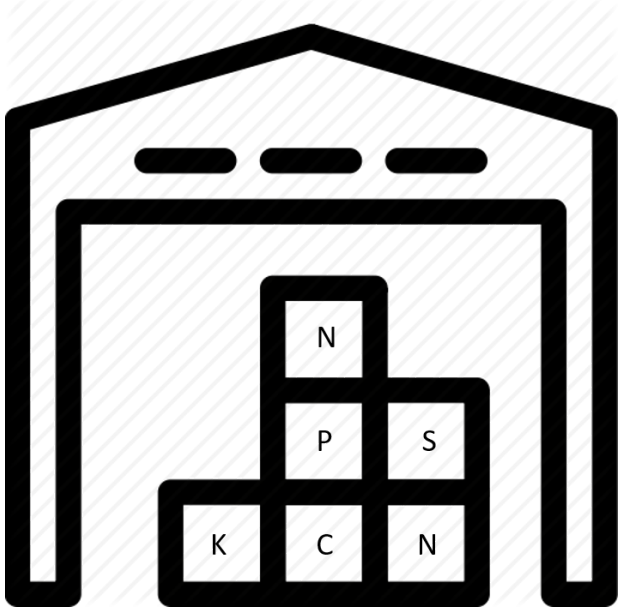
The functions of decomposition and soil structure formation by microbes are highly dependent on **soil organic matter**. Soil organic matter provides the “fuel” for microbial growth and reproduction, as well as providing a number of other benefits.

The Many Roles of Soil Organic Matter

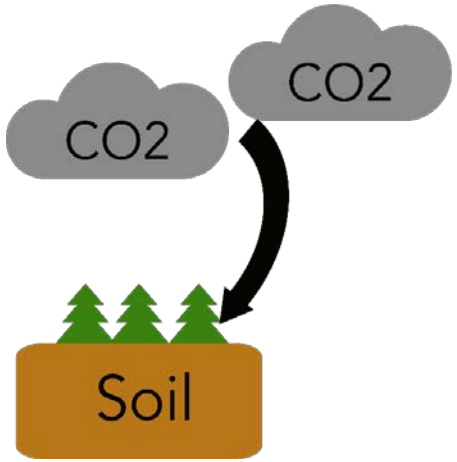
Structure Formation: facilitate root and water infiltration



Increase Cation Exchange Capacity: increases nutrient storage

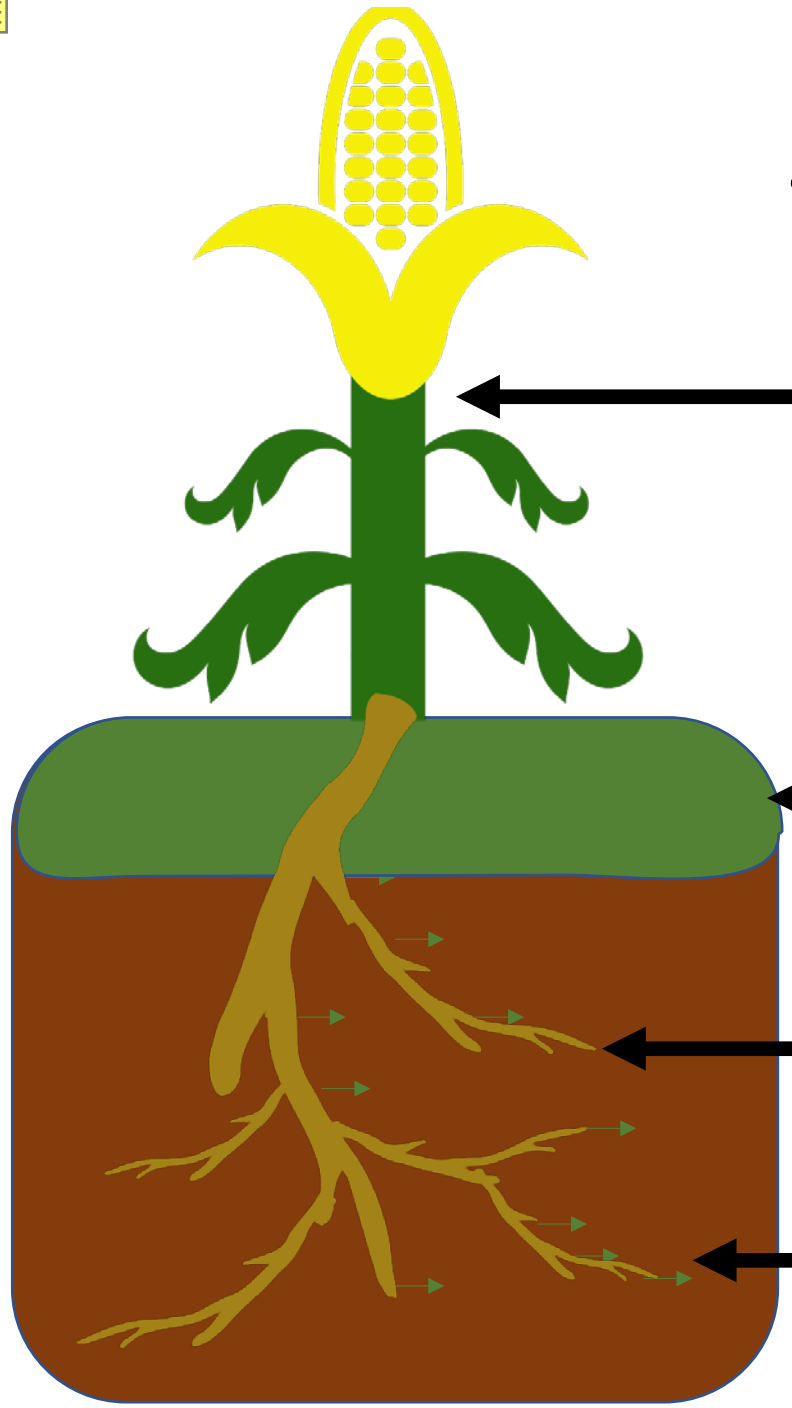


Nutrient Storage & Release Over Time



Sequester Carbon from the Atmosphere

Sources of Organic Carbon

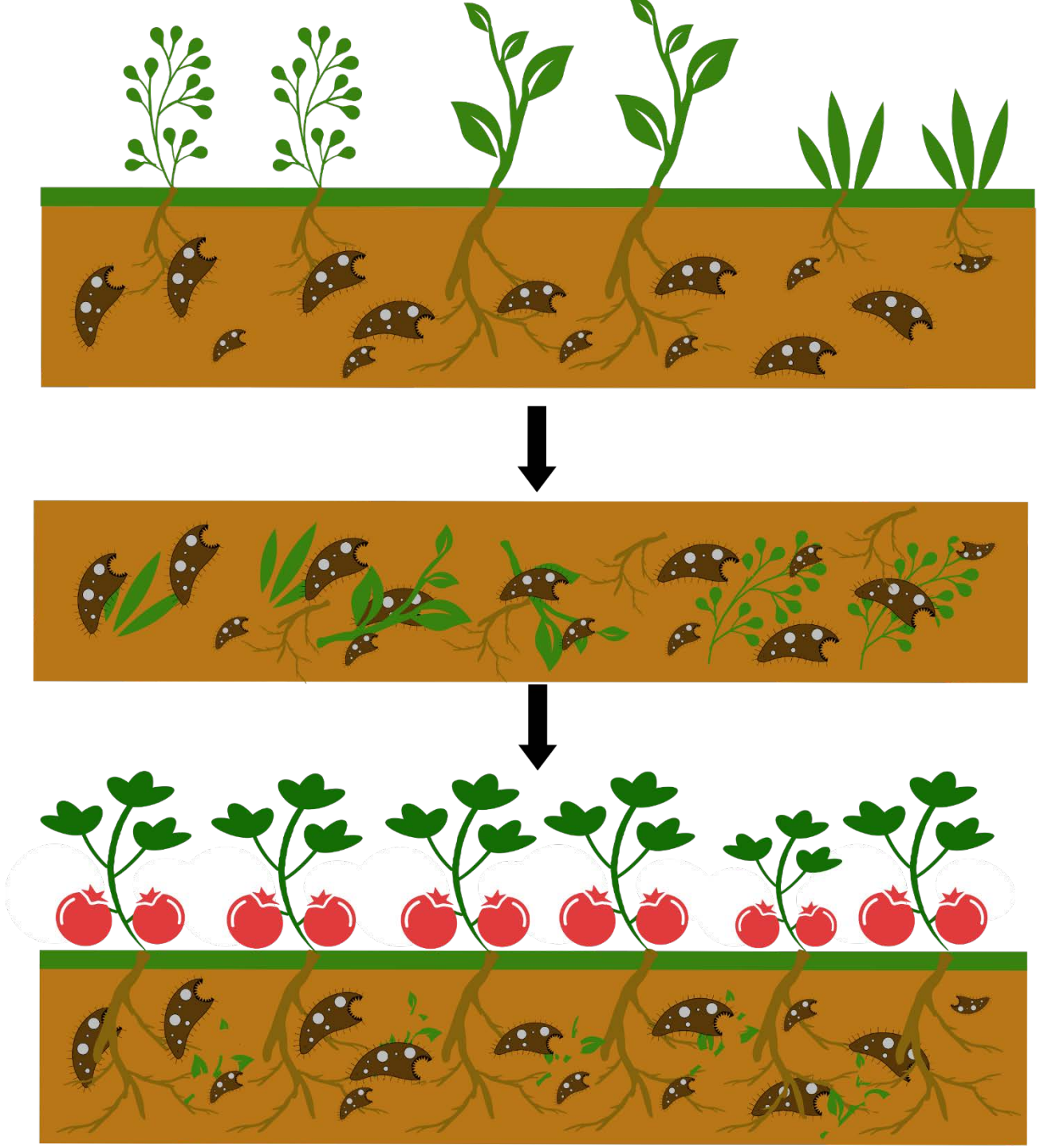


Aboveground biomass
Leaves, shoots, crop residue

Amendments
(manure, compost)

Belowground biomass
(Roots)

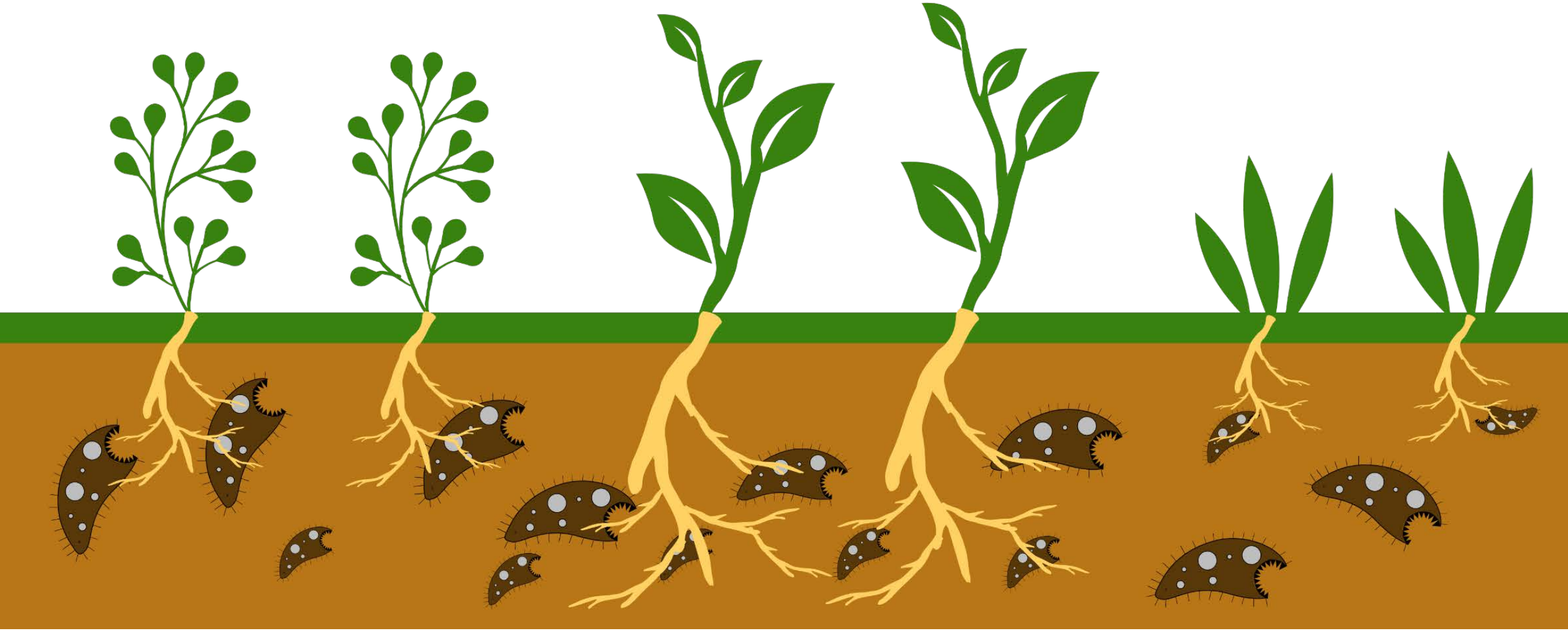
Root exudates Up to 1/3 of the carbon fixed by photosynthesis is by roots, representing a major energy source for microbes in the rhizosphere.



Traditional View of Soil Organic Matter:

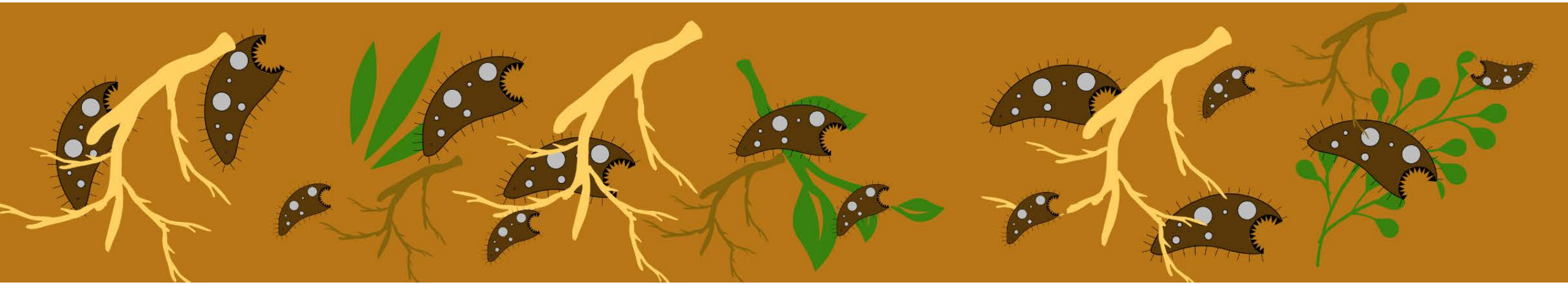
- Made up of recalcitrant leaf/root residues
- Decomposed by microbes

Revised View of Soil Organic Matter Formation



It starts with microbial community inhabiting the root zone (rhizosphere). The example here is of a cover cropped soil.

Revised View of Soil Organic Matter Formation



Then the cover crop is ploughed in, adding organic carbon in the form of leaves and roots to the soil.

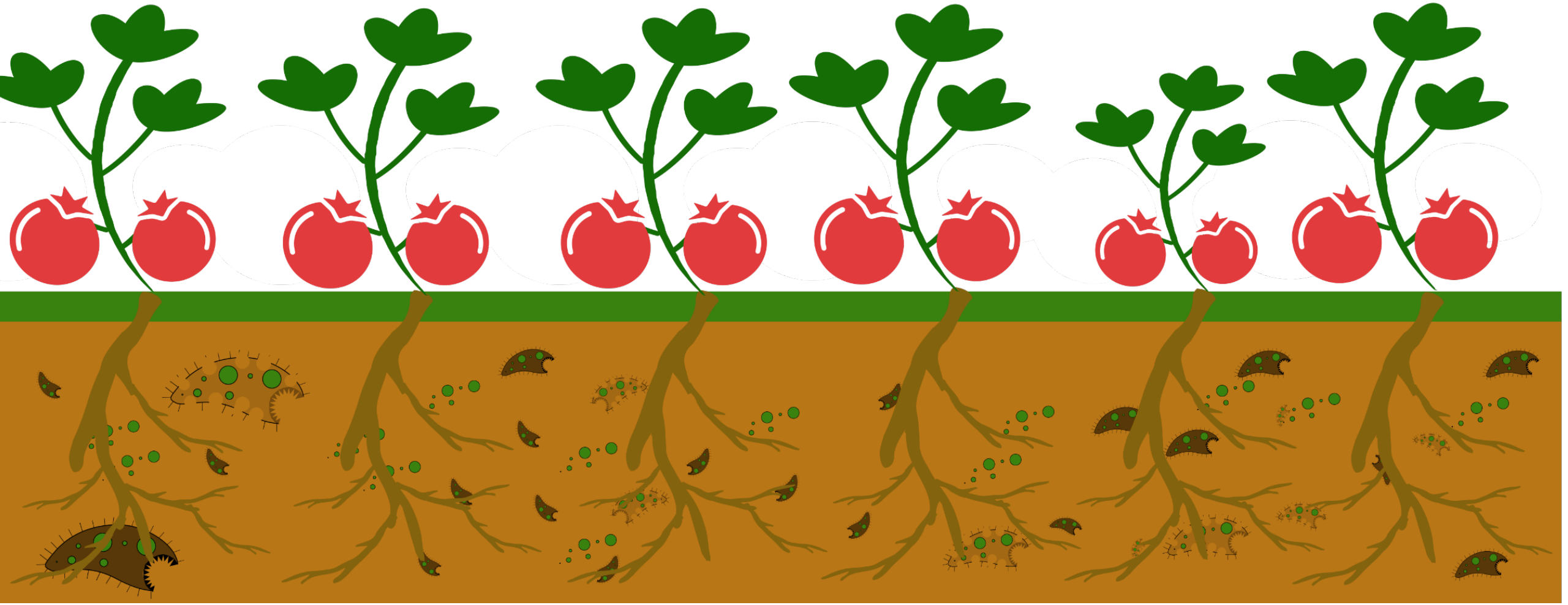
Revised View of Soil Organic Matter Formation

This new organic matter serves as fuel for the microbes, than can now start to consume it, metabolize it, and incorporate it into proteins and other structures in their cells, and ultimately, multiply.

Revised View of Soil Organic Matter Formation

As microbes die, their cells disintegrate, releasing their constituents into the soil. Some of these cellular constituents (such as peptidoglycan, tannins) will become associated with the minerals in the soil, and thus become stabilized and sequestered ("carbon sequestration"). This stabilized carbon can persist for a long time if it is not overly physically disturbed.

Revised View of Soil Organic Matter Formation



Organic material in the soil can now contribute to CEC, promote the formation of soil structure, and provide more fuel for microbial processes. Another important microbial contribution is formation and release of extracellular polymeric substances—eg. sticky polysaccharides are one kind—that help glue together small particles of soil into bigger clumps, or aggregates, that in turn are important “factories” for making soil organic matter. Microbes first make their houses and then live and work in them.

Soil health depends on soil microbes

What we have learned is that soil organic matter, and its associated benefits, owes most of its existence to the microbial biomass. A healthy soil, with an active microbial community, has a large store of organic material to draw on. As such, practices that encourage growth of the microbial community can encourage soil organic matter formation, and all the benefits that come along with that.

Principles for Managing Soil Health

- Feed the soil
- Keep it covered
- Disturb less
- Cultivate crop diversity