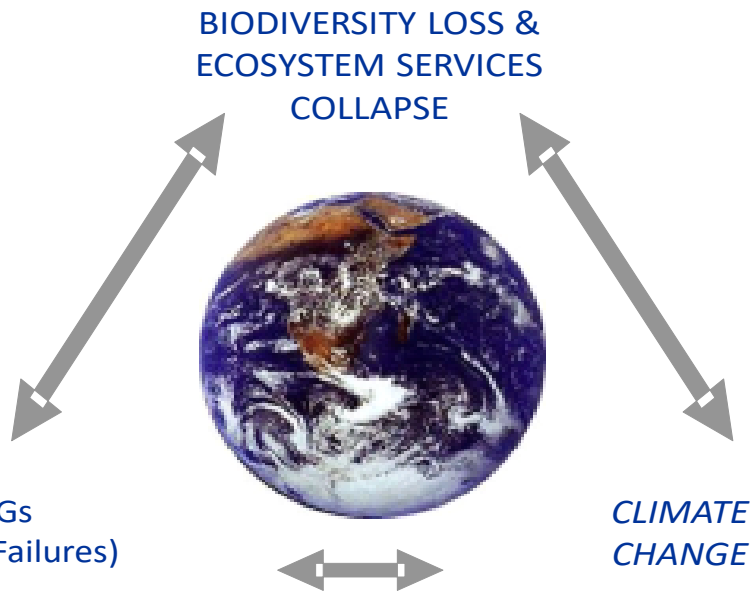
Climate Change

The Perfect Storm?

Biodiversity & MDG Targets already a huge challenge… - now add cumulative *Climate Change*….



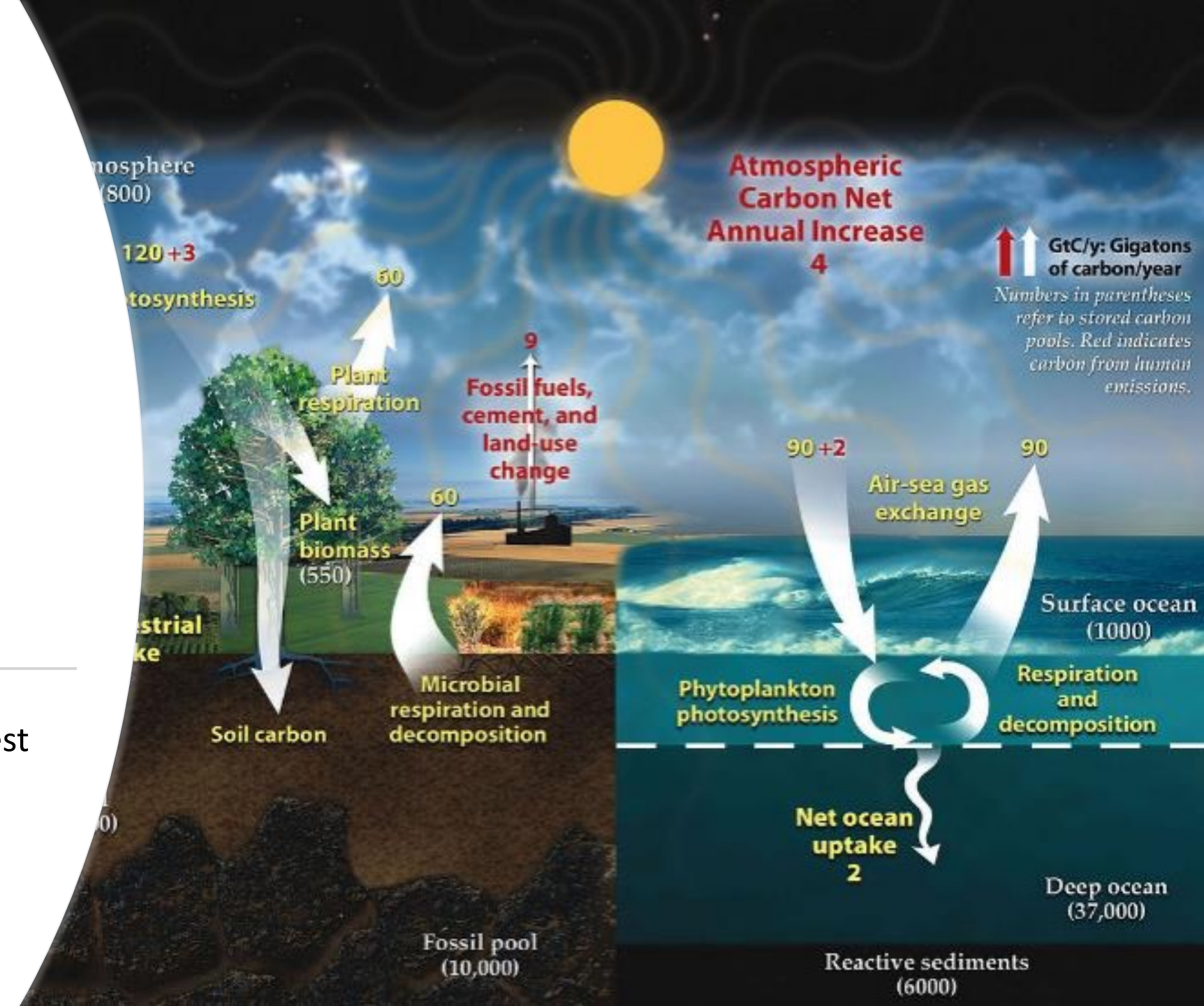
"…fixing carbon in soils is one of the few practical means we currently have to actually reduce global atmospheric CO2 levels. Building up soil organic matter is a win–win situation for the fight against climate change as well as soil health and crop yields, and must become the focus of farmers everywhere"

Rattal Lal

what we do as a society, in the next 5 years, will likely resonate for all life on earth over the next 10 000 years

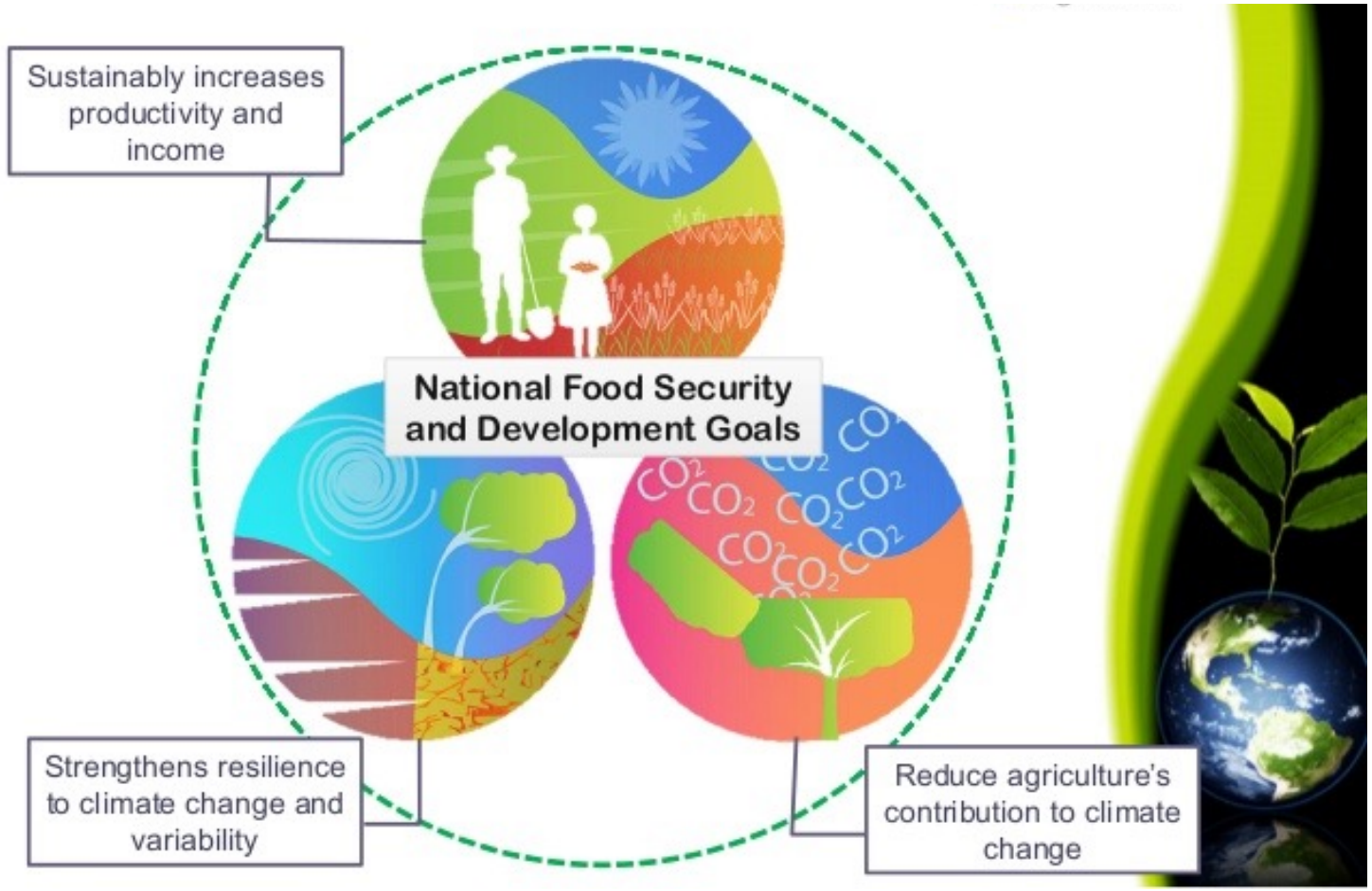
Carbon Cycle

The oceans and soil are the biggest carbon storage reserves



CCA and SCA/ CRA

- CSA is agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation) and enhances achievement of national food security and development goals (FAO 2010)
- It happens at multiple levels, global, national, regional and local.



Assessing CRA

Adaptation

Altering exposure	Reducing Sensitivity	Improving adaptive capacity
• Assess impacts and map hazard zones • Conduct proper land and wateruse planning • Protect watersheds and establish flood retention zones • Change cropping patterns	• Develop or adopt suitable crop, plant and animal varieties • Improve irrigation and drainage systems • Diversify cropping and agricultural activities • Adopt disaster-prevention	• Develop adaptive strategies and action plans • Diversify sources of household income • Improve water and other infrastructure systems • Establish disaster and crop insurance schemes

Mitigation

↘CO_2

↘ rate of deforestation and forest degradation,

↗ adoption of improved cropland management practices *(soil conservation)*

↘CH_4, N_2O

improved animal production and management of livestock waste,

more efficient management of irrigation water on rice paddies,

improved nutrient management on cropland

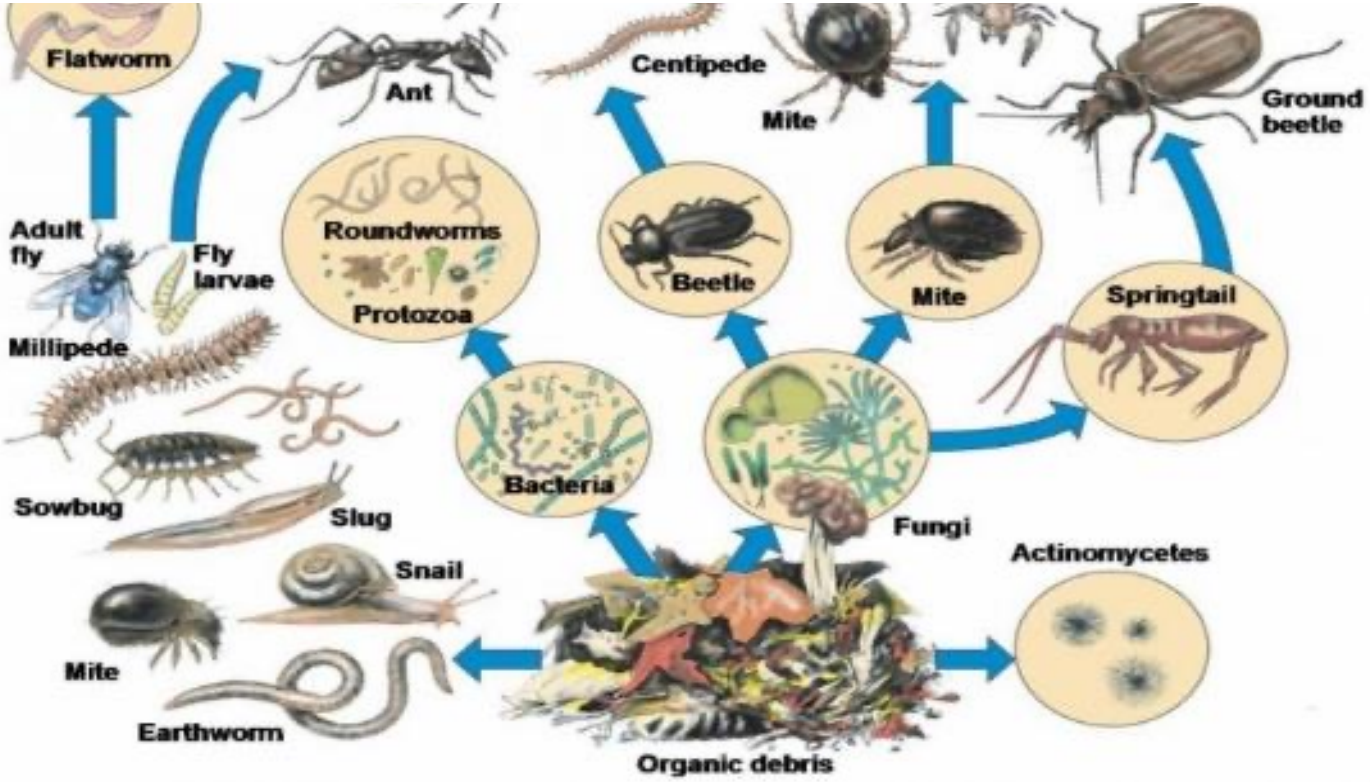
↗Sequestering carbon

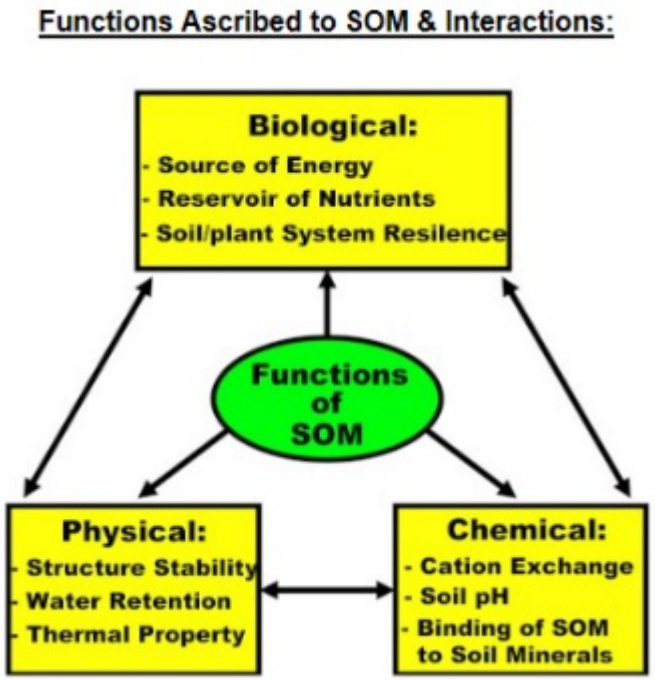
restoration of degraded soil, increased organic matter inputs to cropland, improved forest management practices, afforestation and reforestation, agro-forestry, improved grasslands management

Conventional Agricultural Intensification		Climate Smart Agriculture
Conversion of energy sources from human to fossil fuel dependent machinery.	•Energy	• Use of energy efficient technologies for agricultural power (irrigation or tillage).
Increased use of fertilizer, pesticides and herbicides (dependent on fossil fuels) generally very inefficiently applied.	•Inputs	• Increased efficiency of fertilizer /inputs and wider use of organic fertilizer.
Expansion of agricultural land area through deforestation and conversion from grasslands to cropland.	•Land use	• Intensification on existing land as main source of production increase rather than expansion to new areas.
Increased specialization in ag production and marketing systems.	•System	• Greater diversification in production, input and output marketing systems.
Emphasizing improved and hybrid crop varieties	•Varieties	• Valuing the resilience of traditional varieties

Soil Health:
The continued capacity of the soil to function as a **vital living ecosystem** that sustains plants, animals and humans.
Soil Renaissance Plan, USDA

Soils





These different types of organisms:

- Help to control insect pests, weeds and plant diseases
- Form beneficial ***symbiotic relationships*** with plant roots
- ***Recycle*** plant nutrients from soil organic matter and minerals back to roots and

Improve soil structure

SOM composition; Carbon = 42%, Oxygen = 42%, Hydrogen = 8%, Ash = 8%, Macronutrients (N, P, K, S, Ca, Mg), Micronutrients (Fe, Mn, B, Zn, Cu, Cl, Co, Mo, Ni)

Effects of Soil Organic Matter

- Improves soil biology
- Increase water holding capacity
- Improves soil fertility (cation exchange capacity)
- improves soil structure
  - provides crumb structure that resists compaction
- decreases bulk density
- increases pore space
- increases oxygen diffusion rate

How much organic matter is needed?

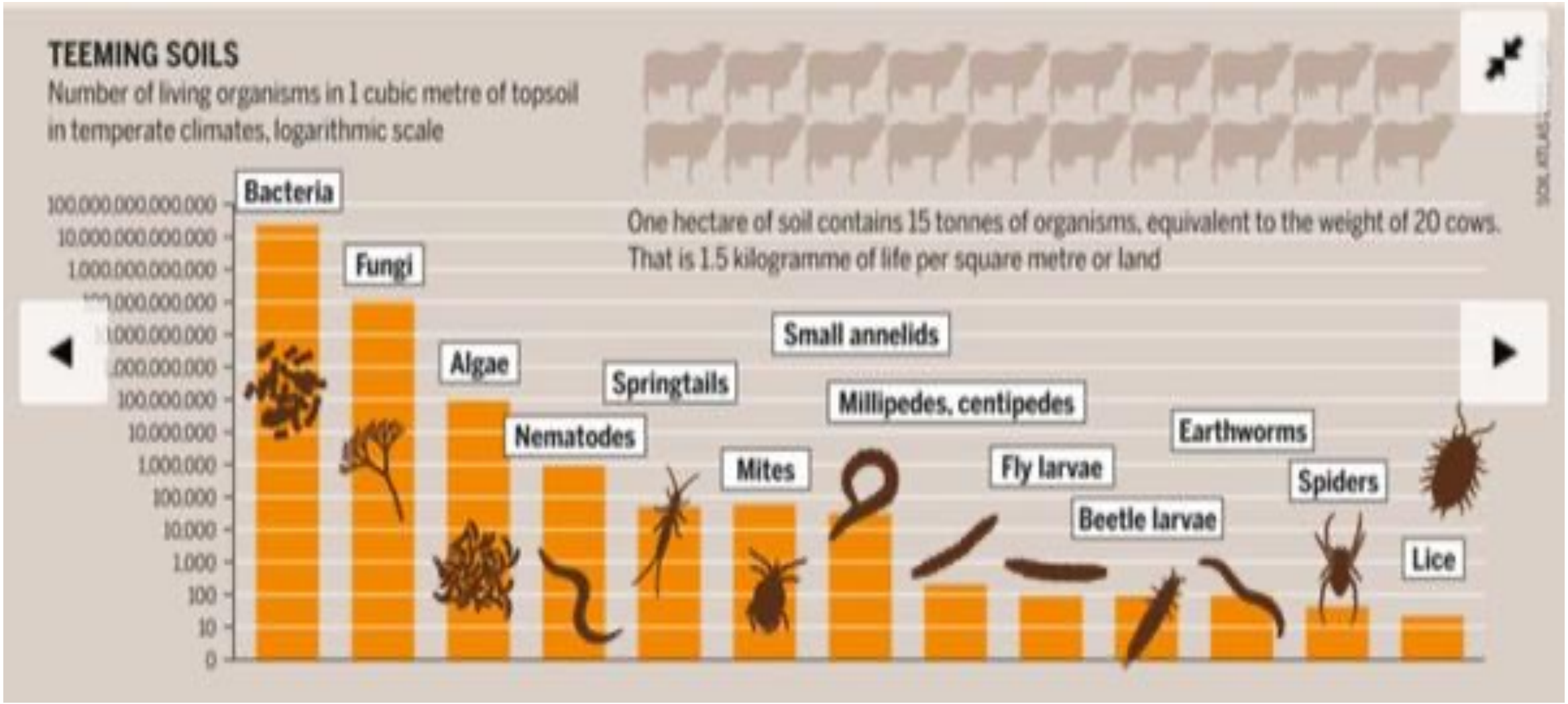
- As a guide, an additional 10 t/ha of organic matter would be required each year for 10 years to increase SOM by 1%,
- or more realistically in current farming systems - 2 t/ha each year for 20 years to achieve a 0.5% increase

Guide to Residue Cover.

Residue Cover %	20	30	40	50	60	70	80	90	95
Cereal Straw kg/ha	400	500	800	1000	1300	1700	2200	3000	4000

Table 5. Residue Cover and Residue Weight
Ontario Ministry of Agriculture and Food, 1992

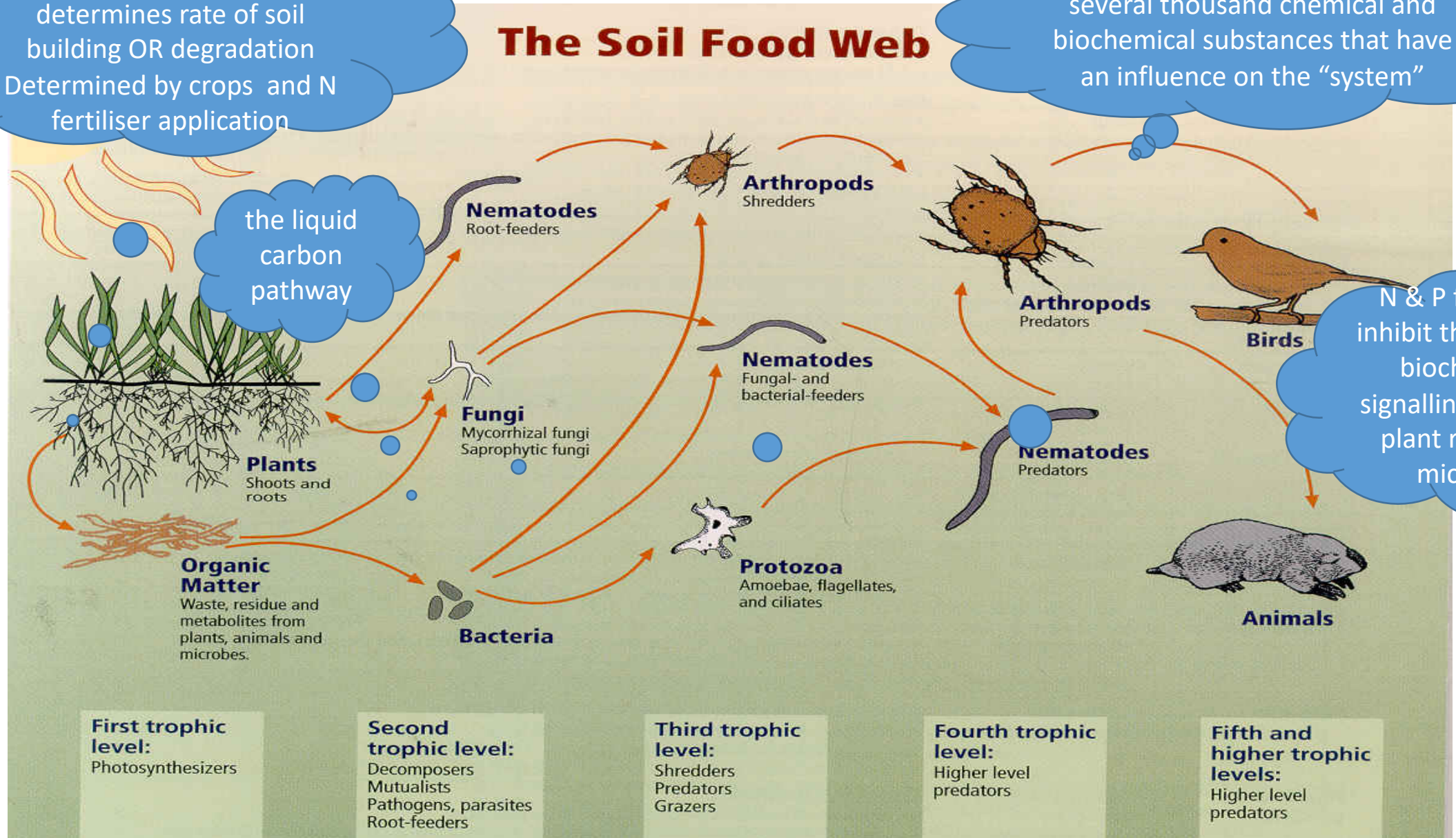
Who is living in 1 cubic meter of topsoil?



Who's living in the top 3 m3 of soil?

C:N Ratio of SOM determines rate of soil building OR degradation
Determined by crops and N fertiliser application

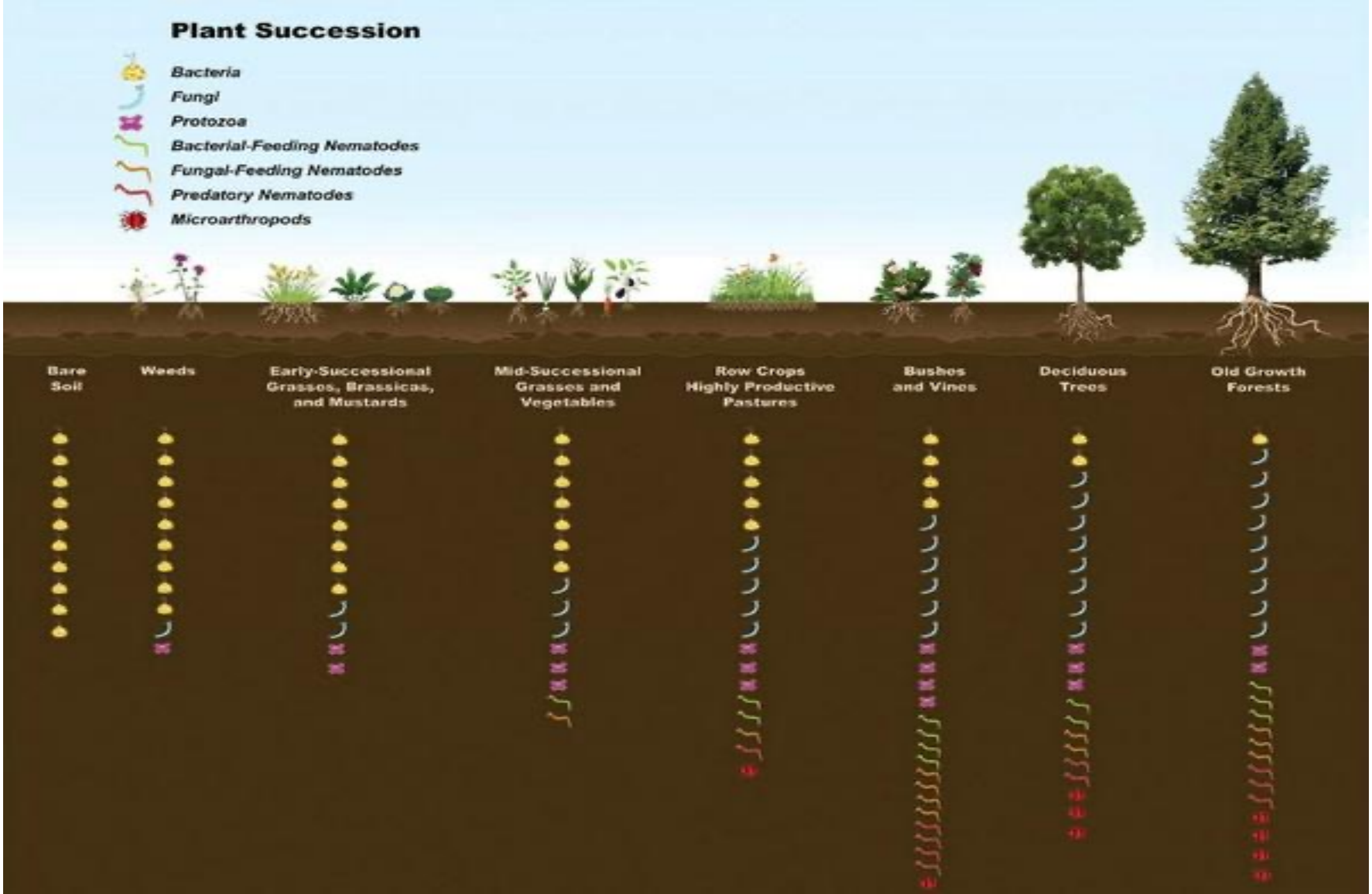
These interactions generate several thousand chemical and biochemical substances that have an influence on the "system"



N & P fertilisers inhibit the complex biochemical signalling between plant roots and microbes

Estimated Carbon-to-Nitrogen Ratios	
Browns = High Carbon	**C:N**
Ashes, wood	25:1
Cardboard, shredded	350:1
Corn stalks	75:1
Fruit waste	35:1
Leaves	60:1
Newspaper, shredded	175:1
Peanut shells	35:1
Pine needles	80:1
Sawdust	325:1
Straw	75:1
Wood chips	400:1
Greens = High Nitrogen	**C:N**
Alfalfa	12:1
Clover	23:1
Coffee grounds	20:1
Food waste	20:1
Garden waste	30:1
Grass clippings	20:1
Hay	25:1
Manures	15:1
Seaweed	19:1
Vegetable scraps	25:1
Weeds	30:1

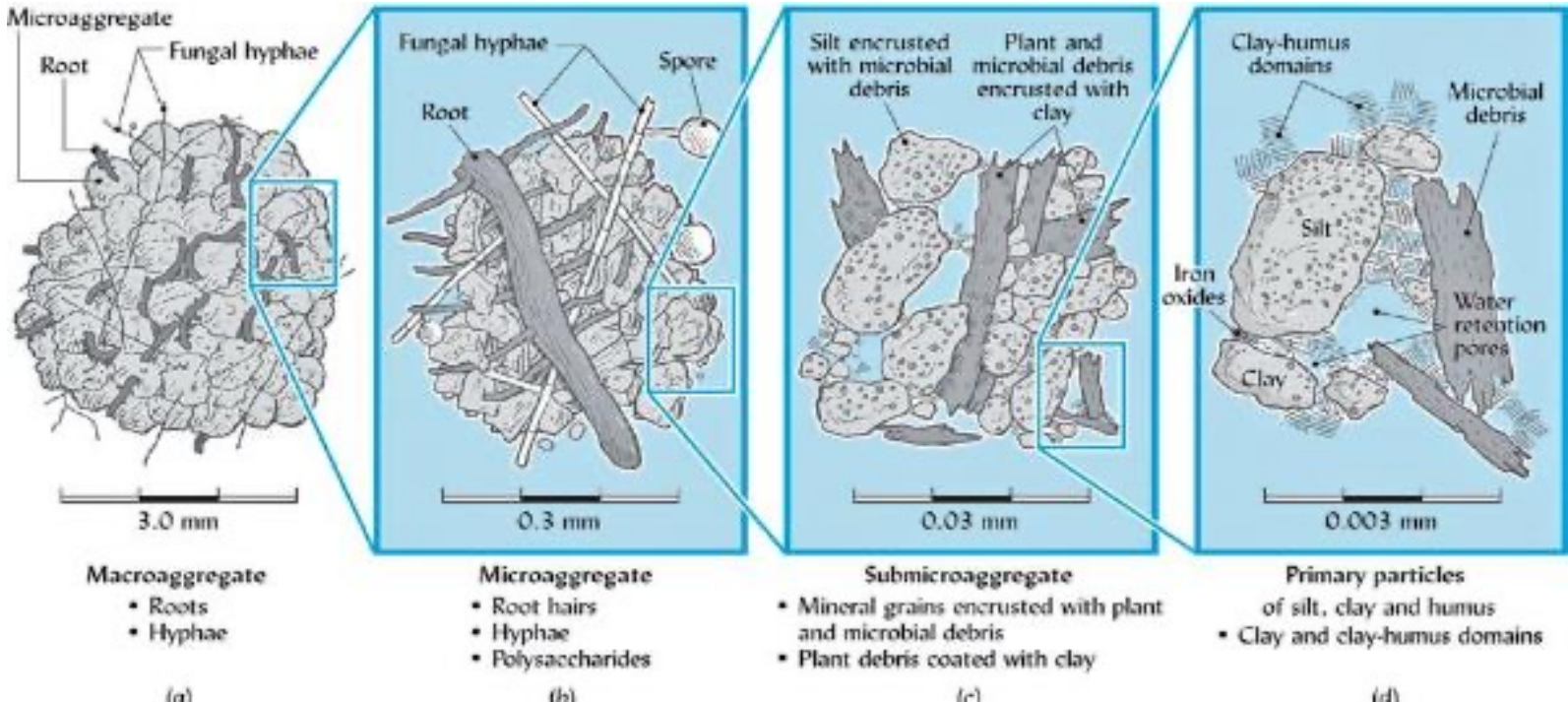
C:N ratio of compost is around 30:1


Plant Succession
Bacteria
Fungi
Protozoa
Bacterial-Feeding Nematodes
Fungal-Feeding Nematodes
Predatory Nematodes
Microarthropods
Bare Soil
Weeds
Early-Successional Grasses, Brassicas, and Mustards
Mid-Successional Grasses and Vegetables
Row Crops Highly Productive Pastures
Bushes and Vines
Deciduous Trees
Old Growth Forests


CROP RESIDUES EFFECTS and STRATIFICATION
ACTIVE ZONE OF DECOMPOSITION
ACTIVE ZONE OF AGGREGATION
AGGREGATES FORMATION
0 - 5 cm
Sá, 2001

Building soil Organic matter (Active and Stable Carbon)

- Although nutrients were more concentrated near the soil surface for millions of years, ecosystems didn't crash, and many became increasingly robust over millennia.
- *Stratification is normal*.



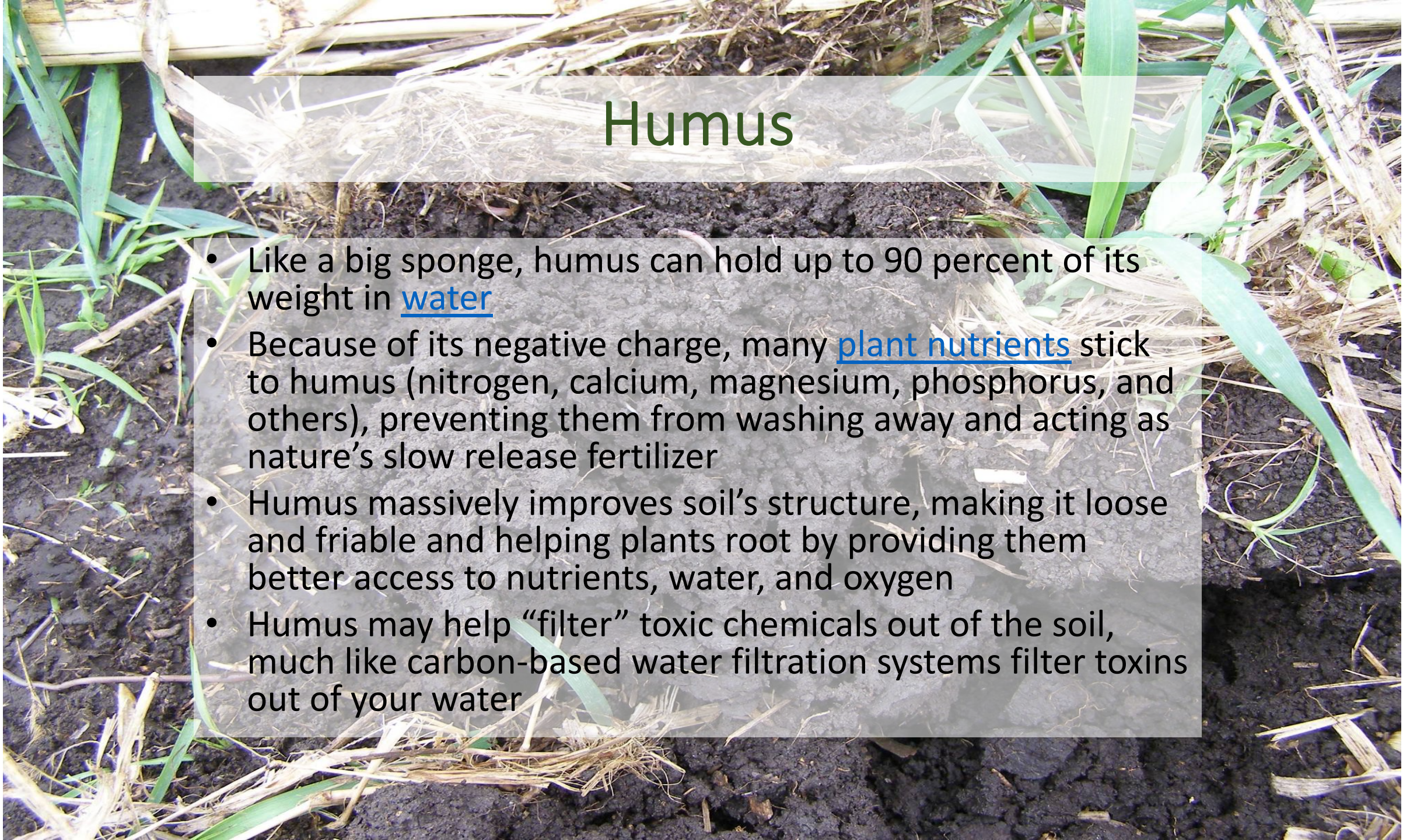
The root-hyphae net

An undisturbed soil covered by plant residues encourages the formation of **mycorrhizae**, the beneficial association of certain fungi with roots that enormously enhances the nutrient-gathering ability of many crop plants.

Roots, fungal hyphae, and their secretions stabilize soil aggregates and promote good soil structure, thus preventing compaction.

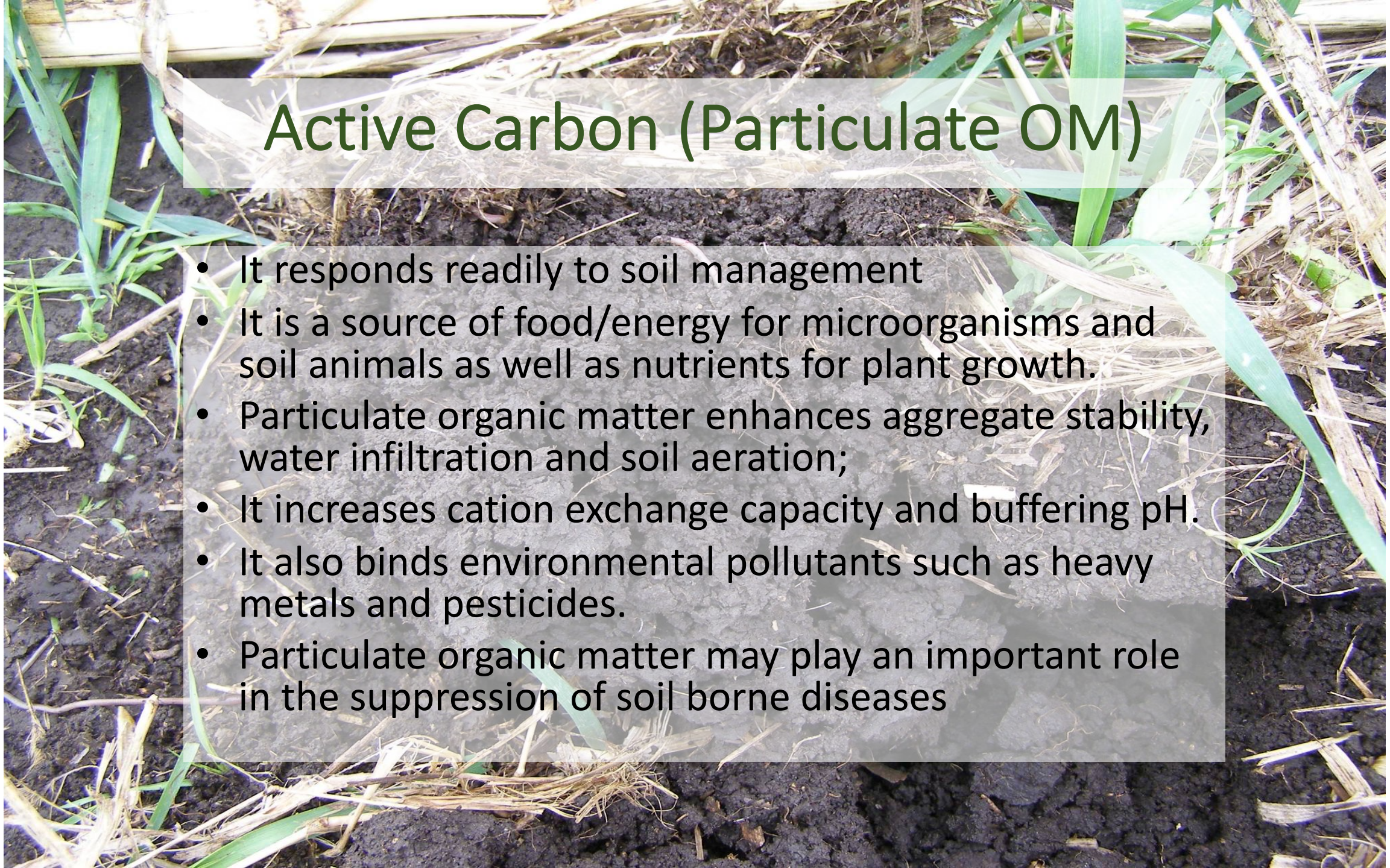
Active vs stable carbon

- **Active Organic Carbon** are the smaller carbon molecules like sugars that can be readily consumed by microbes and is regarded as microbial food. C:N Ratio important
- **Stable carbon** is for instance the final decomposed form of lignin – Humus & Humic substances. Can not be readily further decomposed.



Humus

- Like a big sponge, humus can hold up to 90 percent of its weight in water
- Because of its negative charge, many plant nutrients stick to humus (nitrogen, calcium, magnesium, phosphorus, and others), preventing them from washing away and acting as nature's slow release fertilizer
- Humus massively improves soil's structure, making it loose and friable and helping plants root by providing them better access to nutrients, water, and oxygen
- Humus may help "filter" toxic chemicals out of the soil, much like carbon-based water filtration systems filter toxins out of your water



Active Carbon (Particulate OM)

- It responds readily to soil management
- It is a source of food/energy for microorganisms and soil animals as well as nutrients for plant growth.
- Particulate organic matter enhances aggregate stability, water infiltration and soil aeration;
- It increases cation exchange capacity and buffering pH.
- It also binds environmental pollutants such as heavy metals and pesticides.
- Particulate organic matter may play an important role in the suppression of soil borne diseases