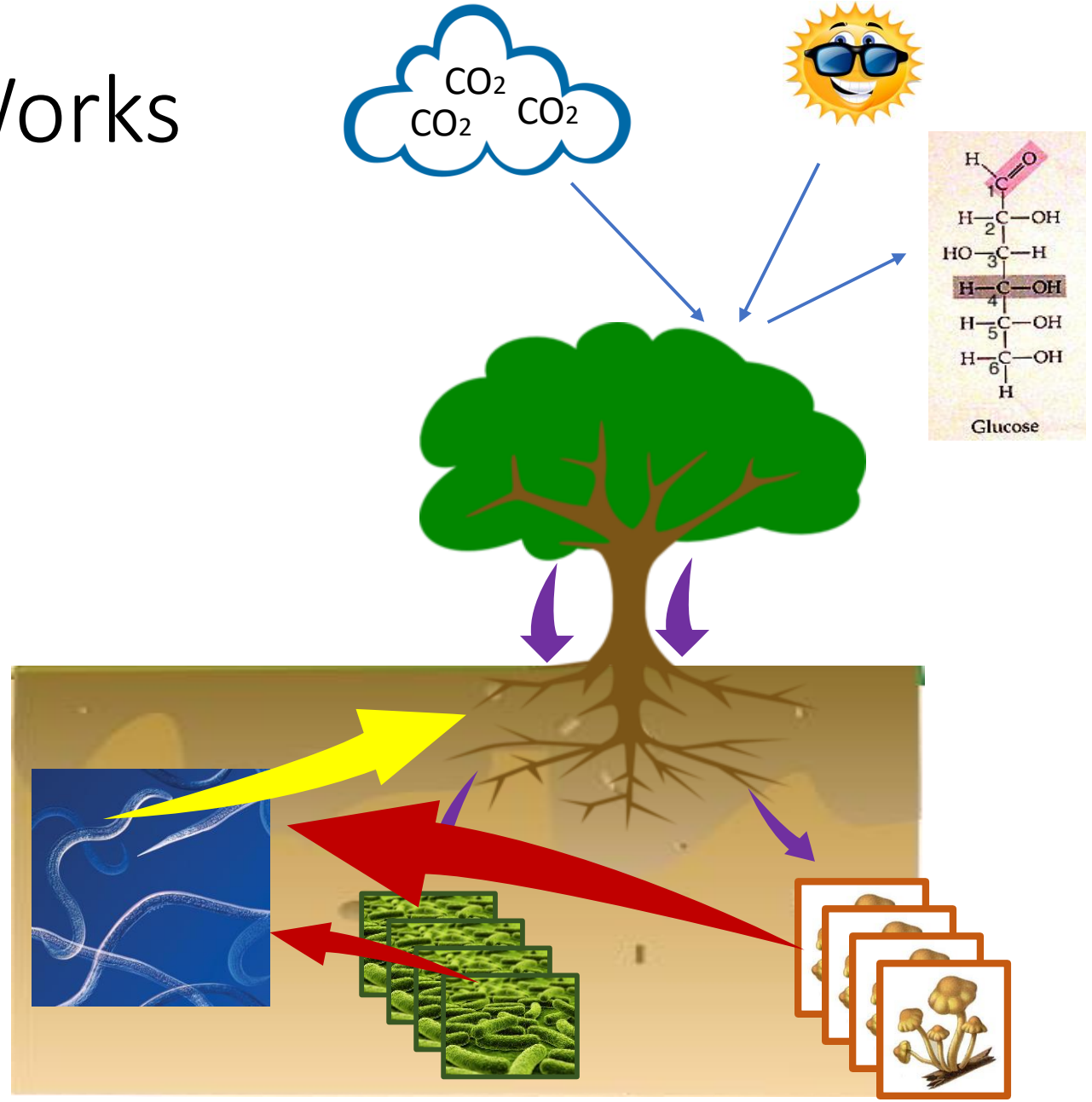
Chapter 2
The Benefits of the Soil Food Web

Lecture 7 – Compaction and Anaerobic Conditions

How Nutrient Cycling Works

- Plants produce simple sugars through photosynthesis
- But they need more than this. They need Mg, Fe, Cu, P, K, Na etc…
- Plants ***invest*** *30-40%* of their sugars into the soil – exuding them from their roots in the form of *exudates.*
- Exudates get consumed by *Bacteria & Fungi* which makes the breed and grow – populations explode.
- Bacteria & Fungi consume Organic Matter and *Mineral Particles* – so they become *Nutrient-Rich*
- Predators eat Bacteria & Fungi
- Predator poop – soluble nutrients
- Plants love soluble nutrients!!! So they get a great return on their investment!!



A Healthy Food Web Will:

- Make Nutrients Available at rates plants require (eliminate fertilizer) leading to flavor and nutrition for animals and humans
- Retain Nutrients (stop run-off, leaching)
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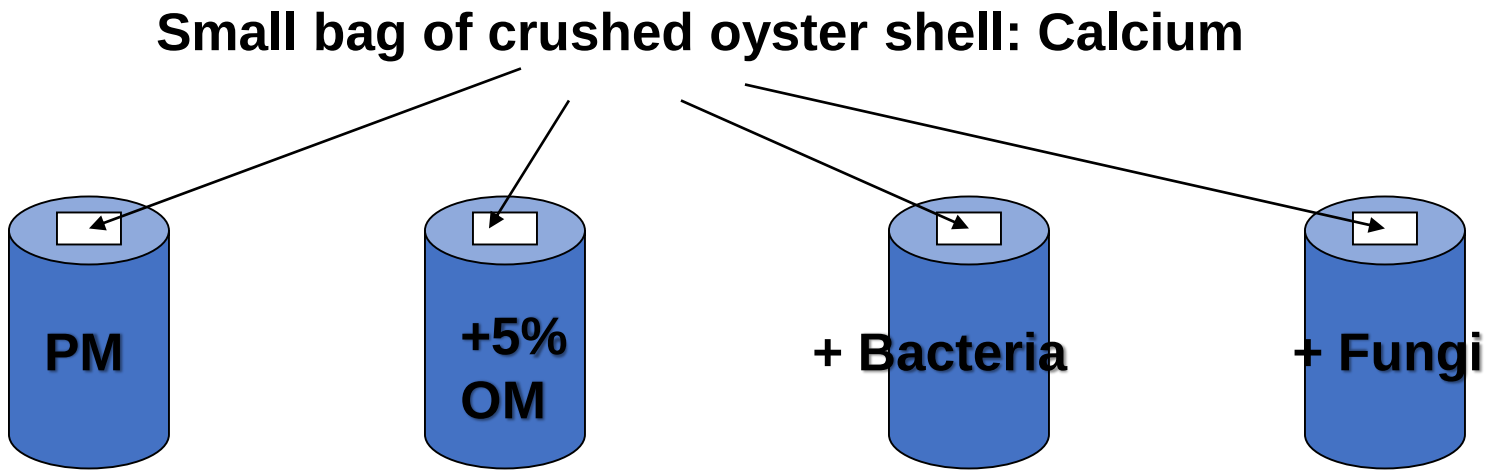
- Decompose Toxins

Where Are Nutrients Retained?

Sandy loam soil, no OM, sterile, re-packed to same bulk density

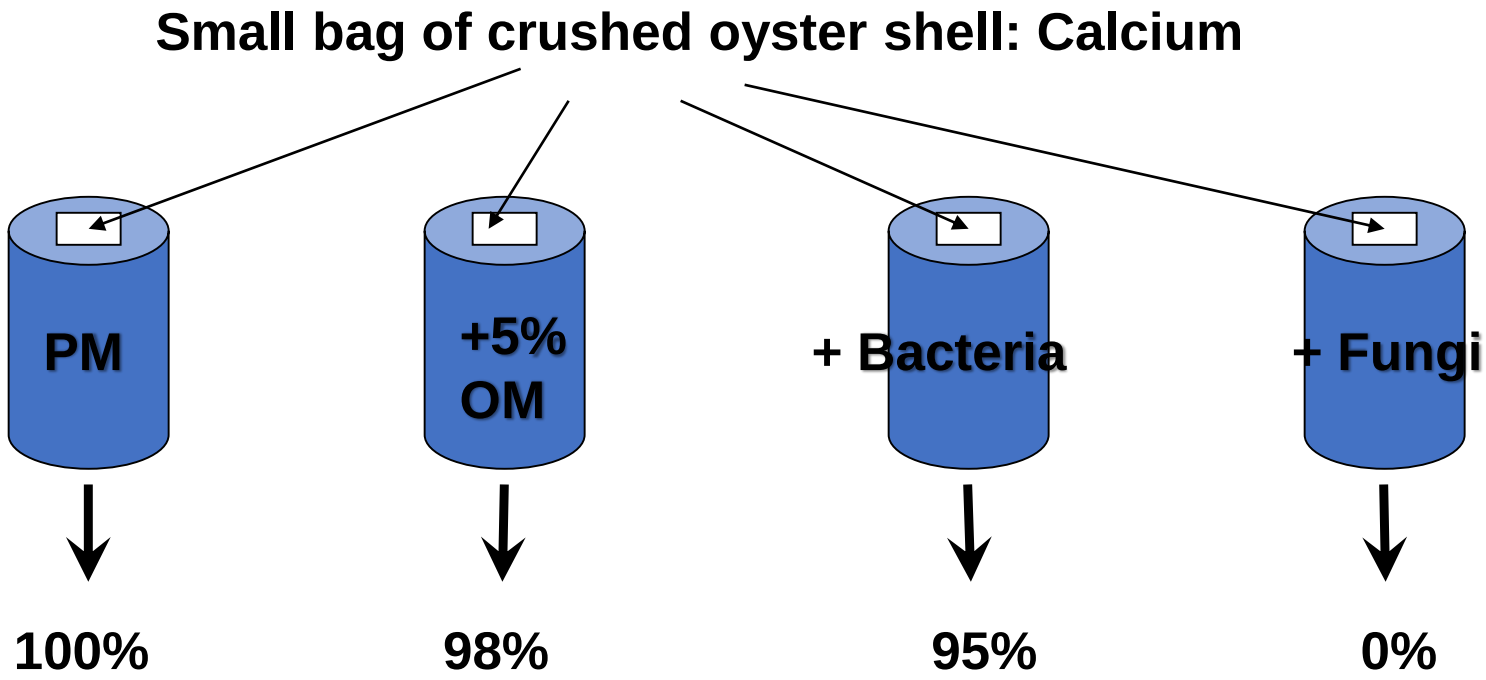
Bag with oyster shell on surface of each replicate of the following treatments; 1 L water passed through, 300 micrograms of Ca leached into soil



Applied 1 liter of water through oyster shell, measured Ca in leachate

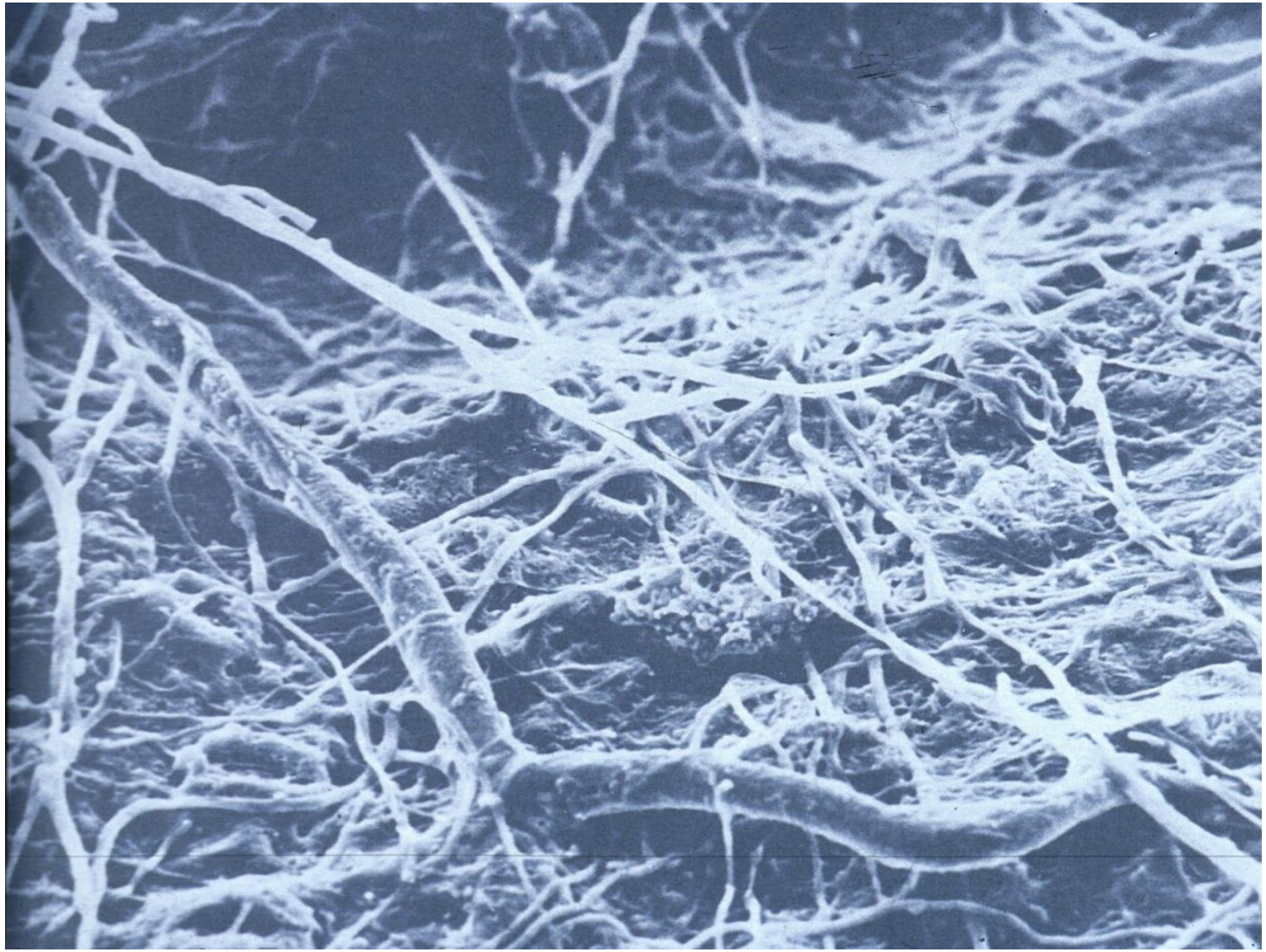
Where Are Nutrients Retained?

Parent material held no Ca. Sterile OM held only 2% of the leachable Ca, bacteria and OM held 5% of Ca, when fungi present, **ALL CALCIUM held**.

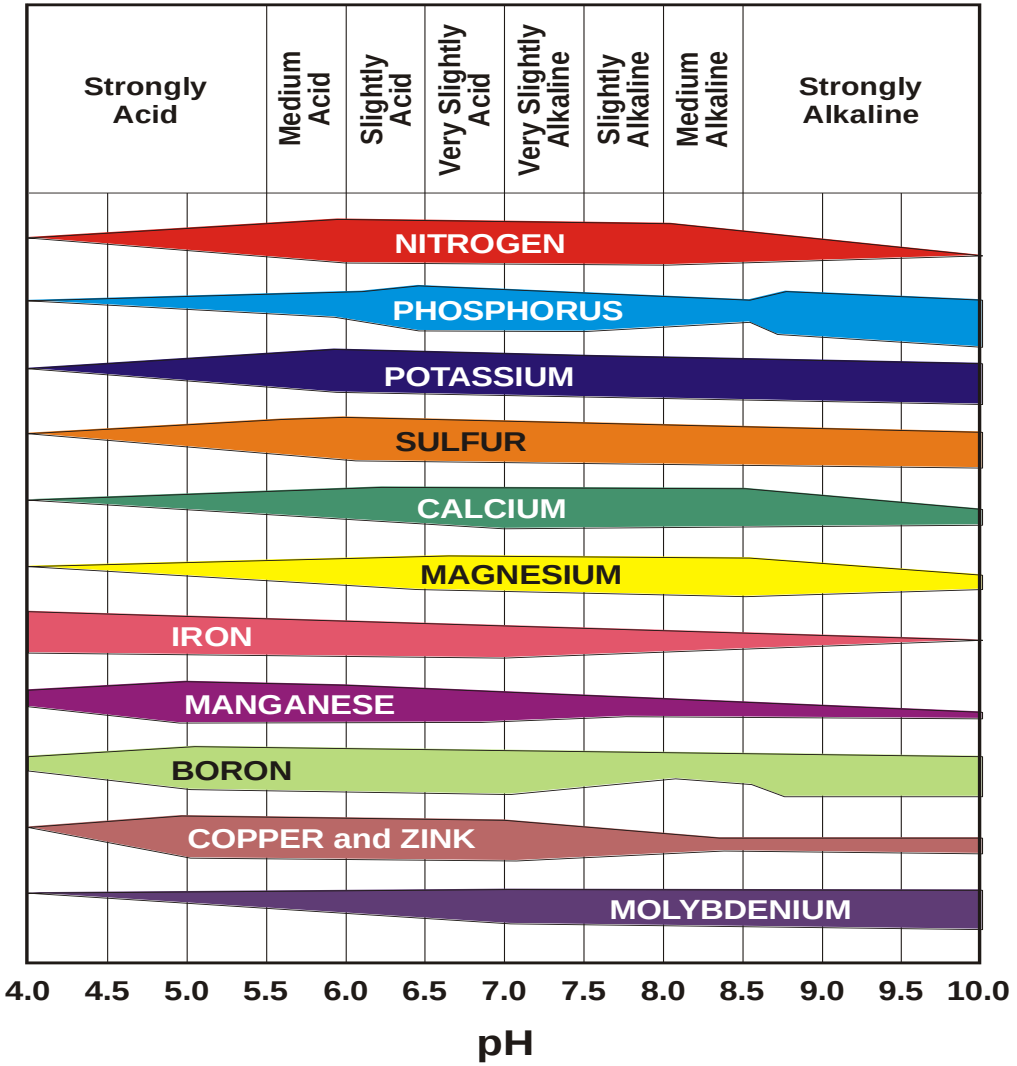


Percentage of the 300µg Ca leached from the oyster shell

Why don’t Bacteria and Fungi get washed away?



Availability of Minerals Relative to pH



Can soil organisms affect pH and thus CEC?

Yes! But only if the plant is feeding the organisms.

Nutrient Retention

Bacteria and fungi are more concentrated in N than any other organism.

That means they hold (or retain) N

Also true for P, S, K, etc.

Do bacteria or fungi release N?

Only when they are consumed

Nutrient Retention

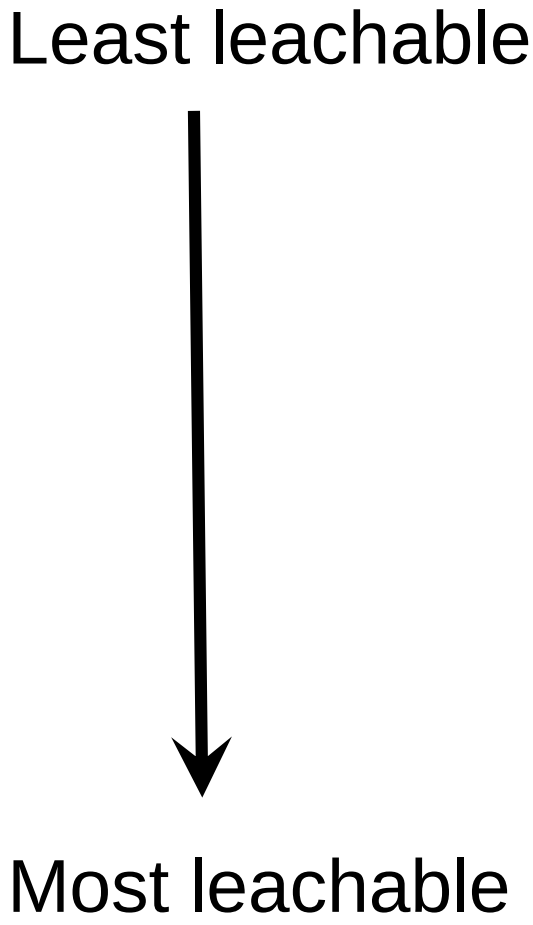
Most leachable forms of N:

- NO_3^-
- NO_2^- The Inorganic Forms of N!!!
- NH_4^+
- NH_3 (anaerobic and stinks!)

Least leachable is N

Least Leachable form of N (aerobic or anaerobic)

- Bacteria
- Fungi
- Protozoa
- Nematodes
- Microarthropods
- Roots
- Organic matter



Compaction

Effects on Nutrient Retention

Aerobic versus Anaerobic Effects on Roots

Soil Structure

How Compaction Affects Roots

Just because we see this in urban areas all the time, does it means this is how trees grow?

Peter M. Wild, Boston Tree Preservation

The Causes of Compaction

- **Rainfall** on bare soil
  - Bare soil is an enormously bad thing
  - Soil needs protection from the pressure from each raindrop. Plant cover!
- **Heavy equipment -** How far down will compaction form?
  - Most heavy machinery will produce a compaction layer at approx. 18”
- **Tillage -** How far down is the compaction imposed
- **Lack of biology** to re-build soil
- **Toxic chemicals** produced in anaerobic, compacted soil

The Effects of Compaction

How does compaction effect plants?

- Roots can’t grow deep – no structure
- Lack of oxygen
- Plant toxic compounds

What happens to soil when compaction occurs?

- Aerobic bacteria, fungi, protozoa and nematodes will be killed or go dormant.
- Soil structure cannot be maintained and will be lost; compaction will increase
- Loss of N, S, P as gasses; leaching and erosion

Anaerobic Conditions in a Compost Pile

Compaction in Grasslands

Lawns , trees, gardens or crops, the story is the same. Soil biology is being destroyed by human mismanagement. Roots are not going as deep as they should, and water, fertility and disease protection are lost.

Aerobic……Anaerobic

Predominant N form in soil

- OM, protein……Remains as organisms

Inorganic forms

(leach, plant available?)

- NO_3 (nitrate)
- NO_2 (nitrite)
- NH_4 (ammonium)

NH_3

(ammonia)

Oxidized

Reduced

Aerobic……Anaerobic

Predominant S form in soil

- OM, protein……..……Remains as organisms

Inorganic forms
(leach, plant available?)

- SO_4 (sulfate)
- SO_3 (sulfite)
- SO_2 (sulfur dioxide)
- S_2 (Elemental S)

H_2S
(hydrogen sulphide)

Oxidized

Reduced

Aerobic……Anaerobic

Predominant P form in soil

- OM, membranes……..Remains as organisms and OM

Inorganic forms

(leach, plant available?)

- Rock P
- PO_4 (phosphate)  Phosphine gas

Oxidized Reduced

Anaerobic Organic Acids

- Only produced under anaerobic conditions, smells indicate anaerobic conditions

- Acetic acid common name?
- Butyric acid
- Valeric acid pH of 2.0 or lower
- Putrescine

- Mix these with organic matter and what pH ?

Toxic Materials only produced in Anaerobic conditions

Alcohol

- 1 ppm alcohol solubilizes any plant cell wall
- anaerobic soil/compost produces 25 ppm alcohol

Formaldehyde

Phenols

Surface Compaction Caused by Rain

Unprotected soil surfaces means evaporation and salt accumulation which form crusts. Soil organisms work to immobilize those salts instead, incorporating them into OM, into biomass.

Extremely Anaerobic Conditions

Compaction can prevent oxygen from moving into the soil for a long time and the copper in the soil can become completely reduced, giving soil this blue color. The rusty lines are where iron was fully reduced, oxygen started to seep back into the soil, causing the rusty color along those cracks. Unfortunately, that form of iron is not usable by plants. Biology is required to convert it back into a plant available form

Compaction Inhibits Drainage

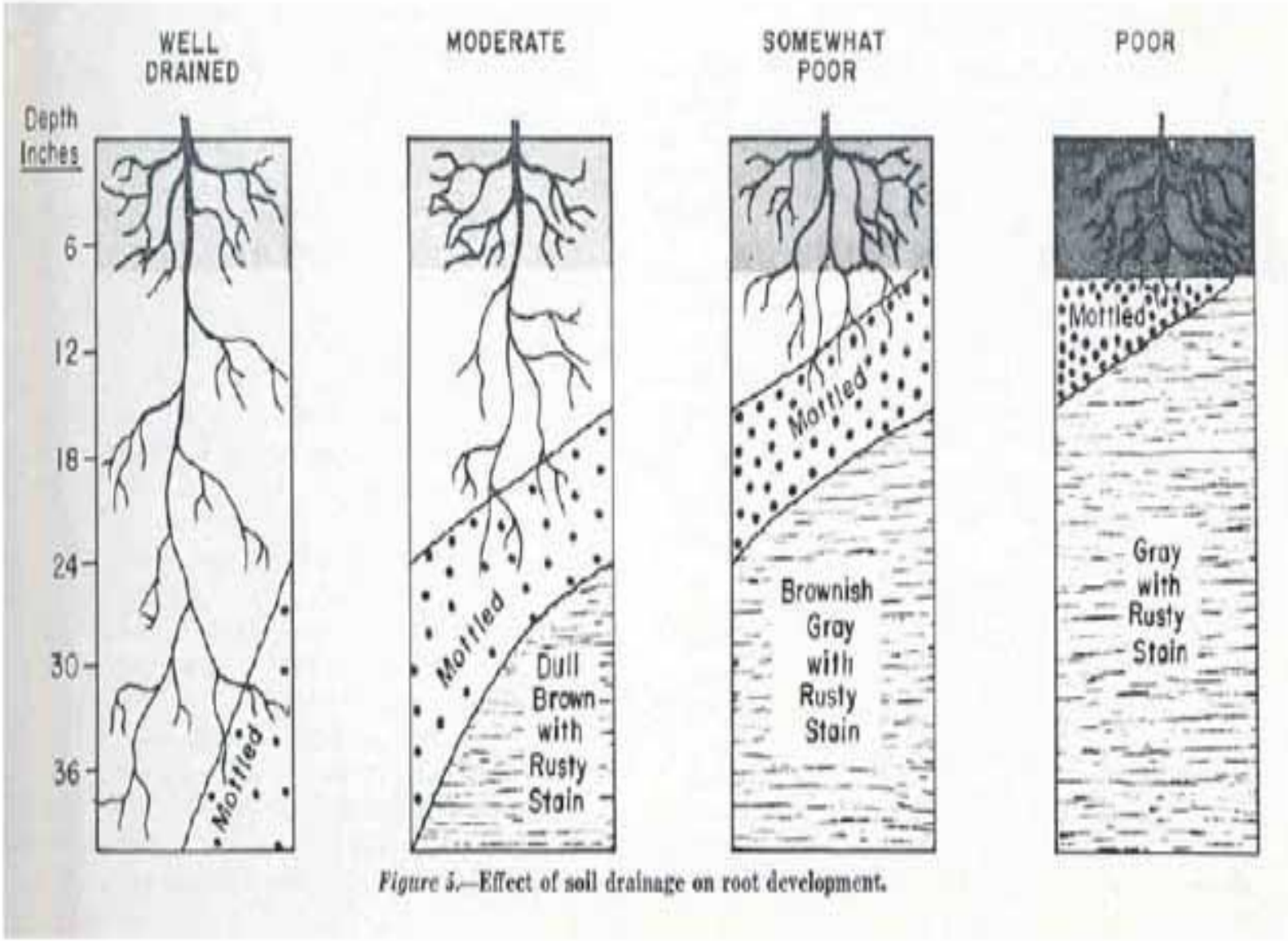
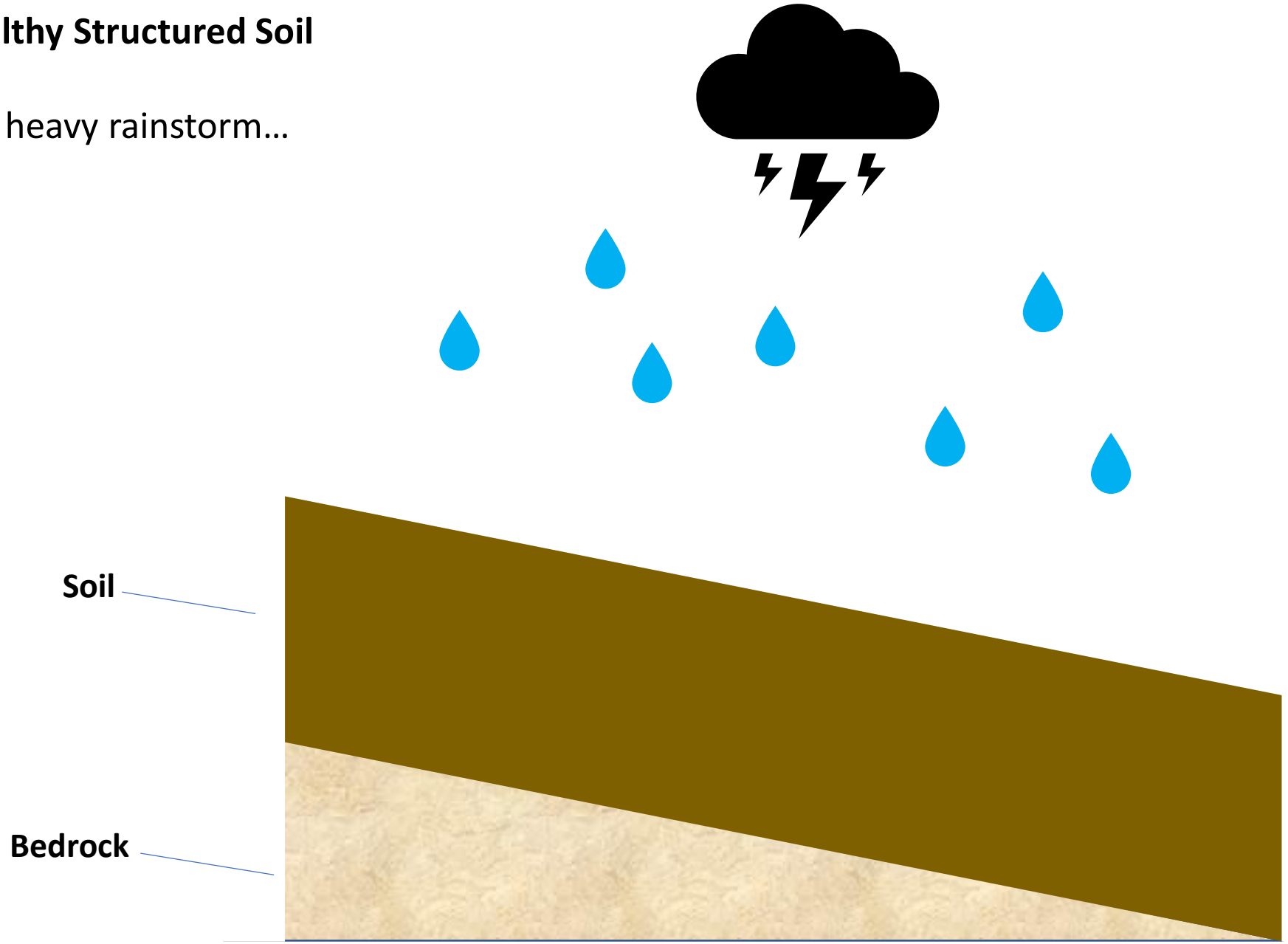


Figure 5.—Effect of soil drainage on root development.

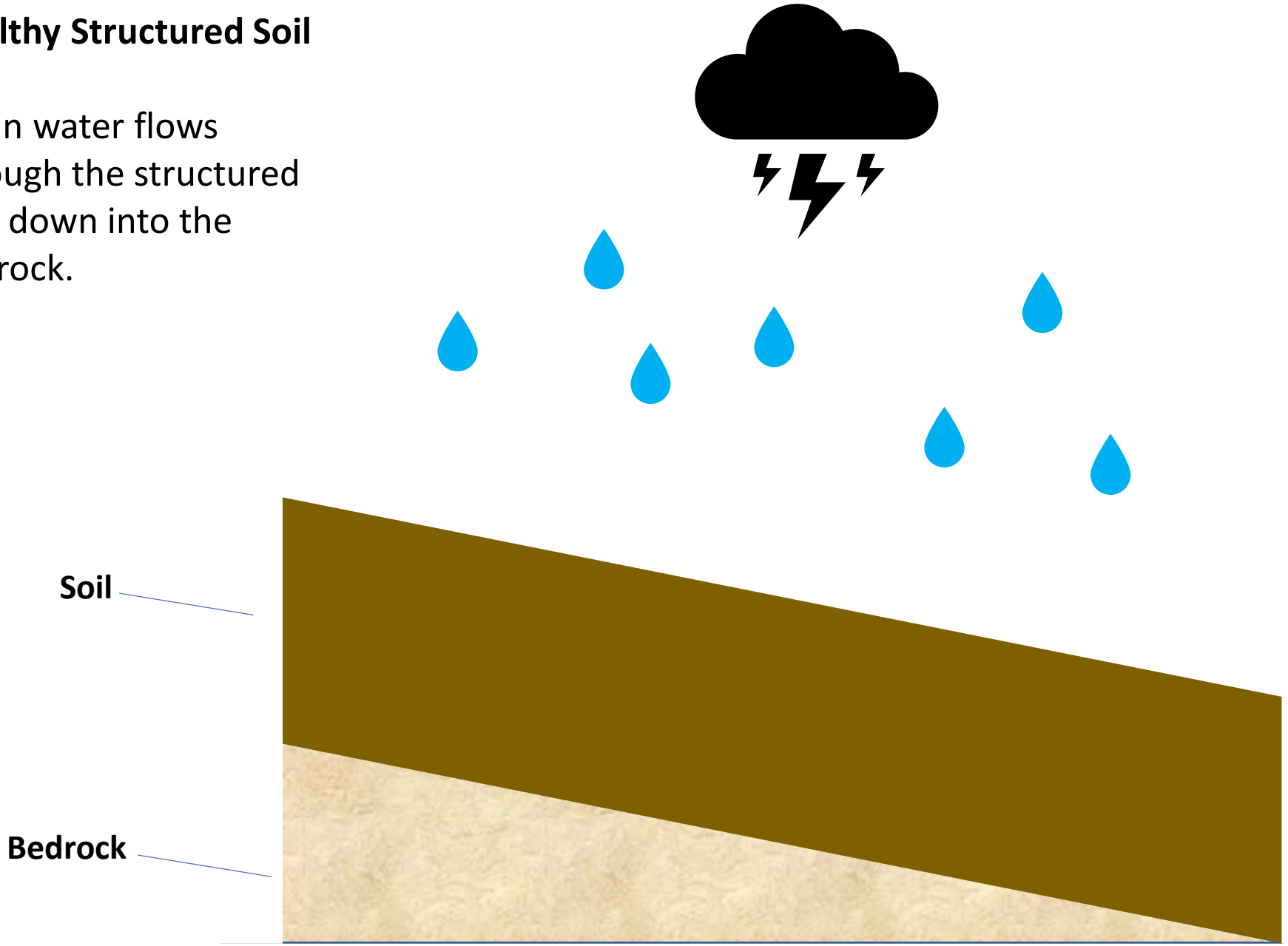
Healthy Structured Soil

In a heavy rainstorm…



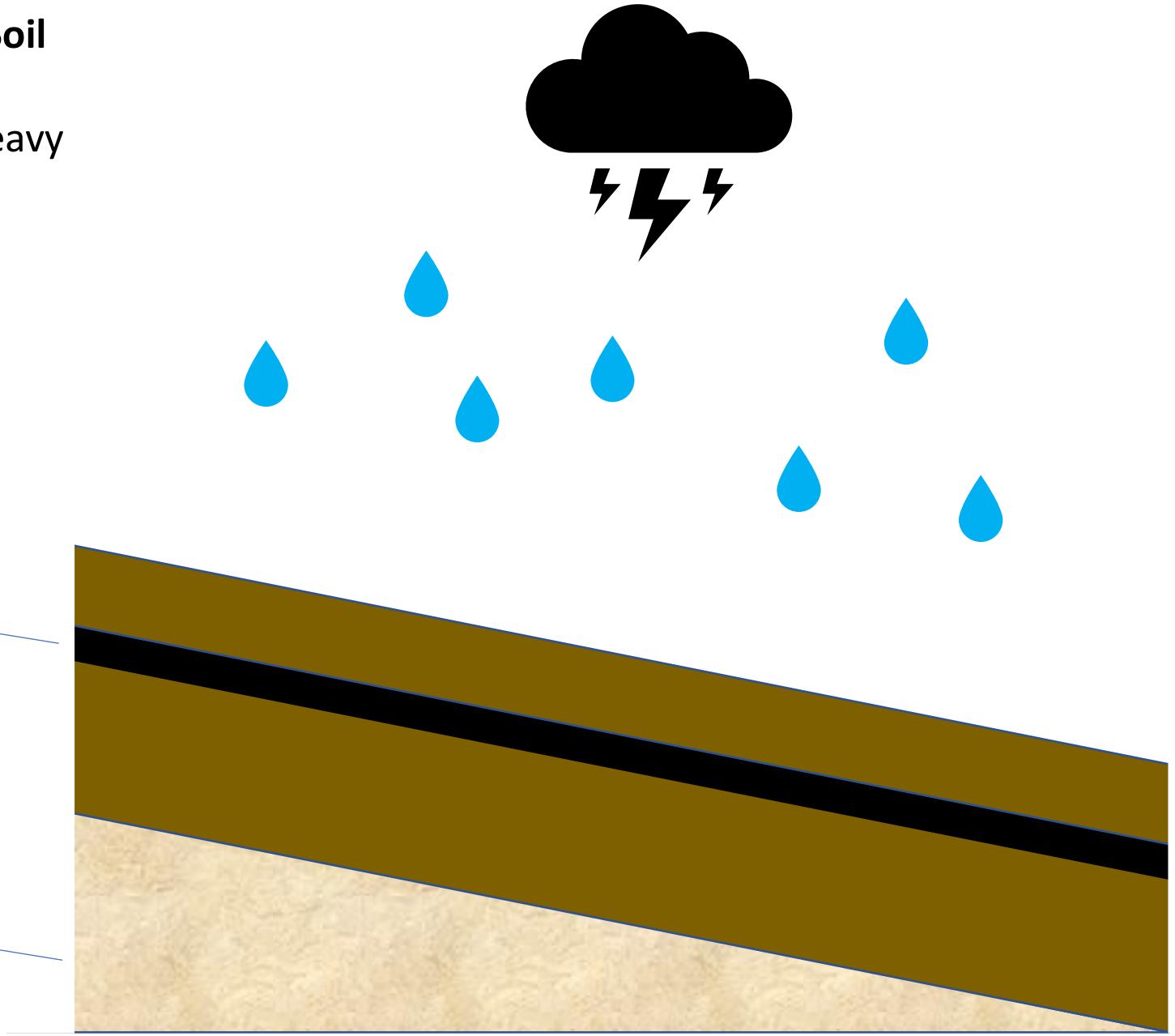
Healthy Structured Soil

…rain water flows through the structured soil, down into the bedrock.



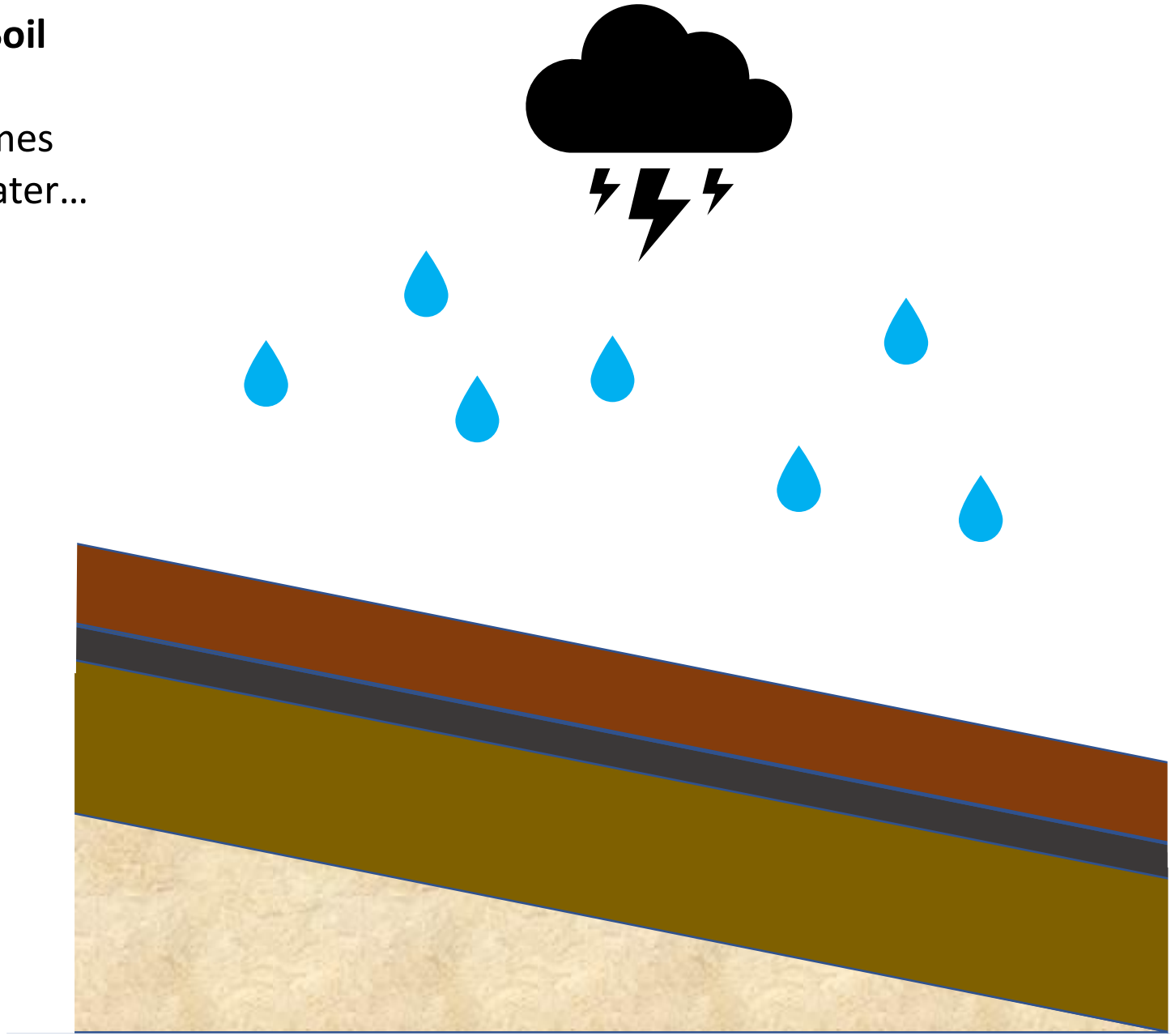
In a Compacted Soil

With the same heavy rain-storm.



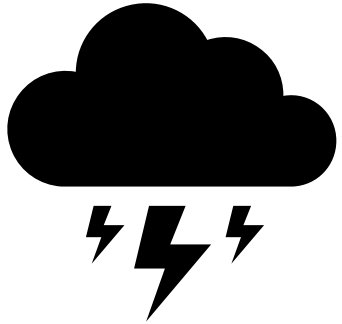
In a Compacted Soil

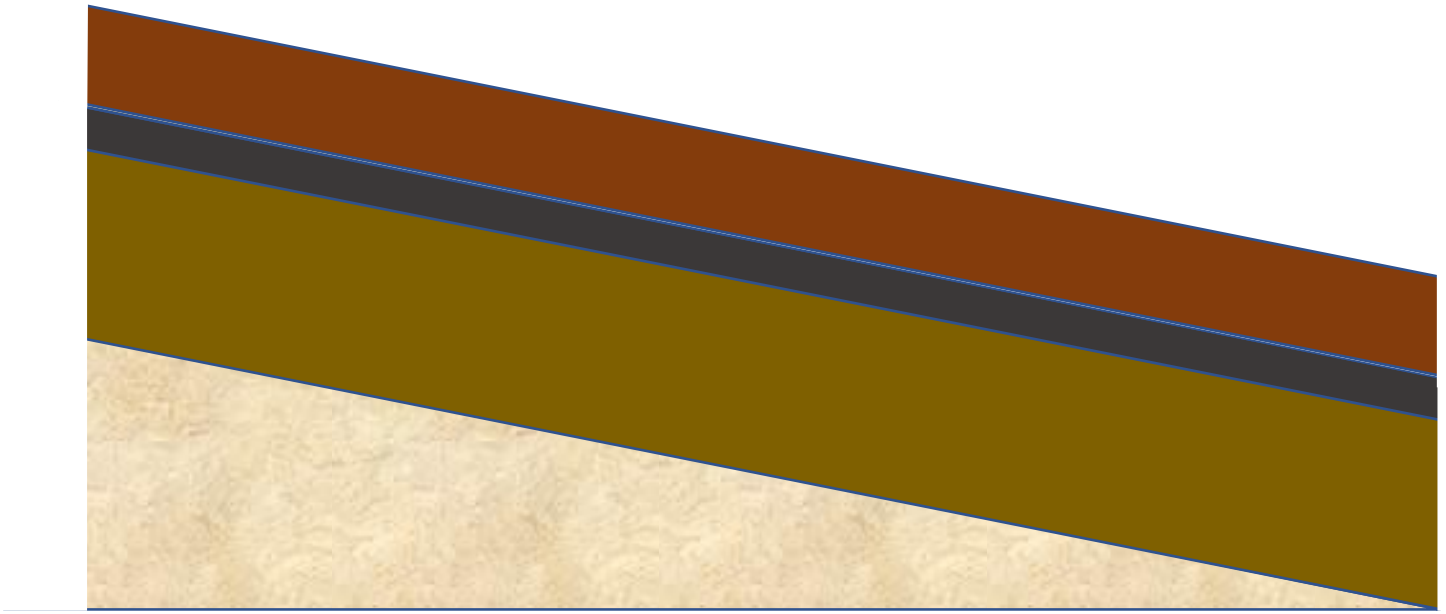
The topsoil becomes saturated with water…



In a Compacted Soil

….and eventually slides away down the hill.





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