
“Carbonomics”
The Wonderful Economy
of the Soil

Farming Background

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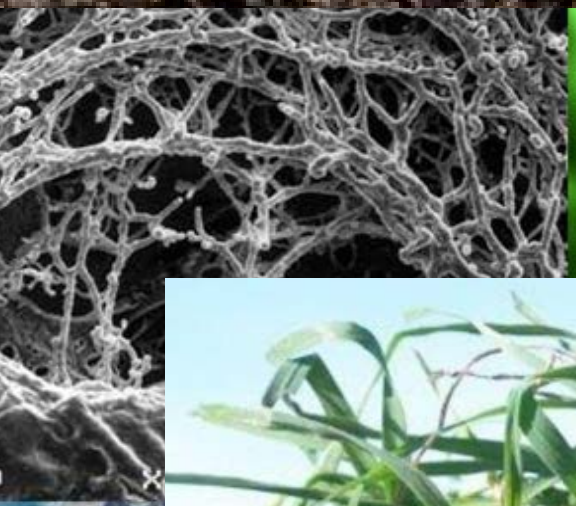
- No-tilling for 25+ years
- 2/3 dryland 1/3 irrigated
- Corn – Beans – Cereal rotation
- Added rye, triticale, oats, barley, vetch, sunflowers, buckwheat

Farming Background

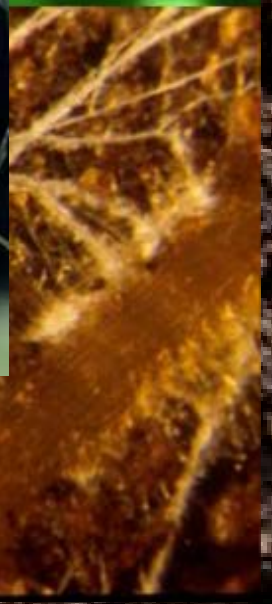
- Cover crops for 8 years
- Green Cover Seed started in 2009

SOIL HEALTH INSTITUTE


•Pride goeth before a *fail*...





Carbonomic$ – The Wonderful Economy of the Soil

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7 Keys To A Healthy Economy

- Supply (Producers/ Sellers)
- Demand (Consumers/ Buyers)
- Currency
- Capital
- Energy and Resources
- Infrastructure
- Defense and Protection

Supply (Producers/Sellers)

- Strong Economies are very productive
- High percentages of all entities involved in the economy are producing something
- Diversity is very important

Demand (Consumers/Buyers)

- Strong economies have a high demand for products
- Economies are strongest when majority are both Suppliers (producers) and Demanders (consumers)
- **Diversity is very important**

Currency

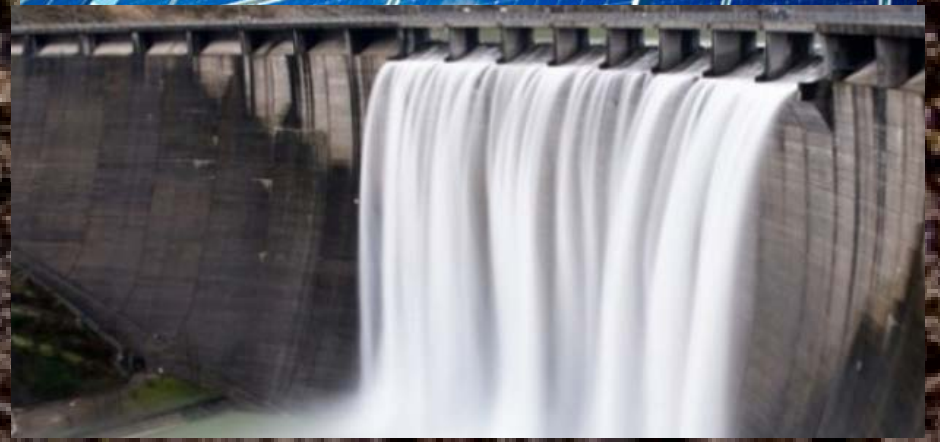
- Allows for quick, efficient and fair transactions or exchanges between Producers and Consumers
- Needs to be universally desired and accepted.
- Needs to have different forms and move (flow) easily

Capital

- Accumulated (stored or saved) currency
- Needed for Growth and Stability

Energy and Resources

- Energy drives the system but it is expensive
- Resources provide a base for growth and expansion



Infrastructure

- Allows economies to grow beyond subsistence
- Communication
- Transportation

Defense and Protection

- Strong Economies will always be under attack by those who want to Consume without Producing
- Requires investments of Capital

7 Keys To A Healthy Economy

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7 Keys To A Healthy ***SOIL!***

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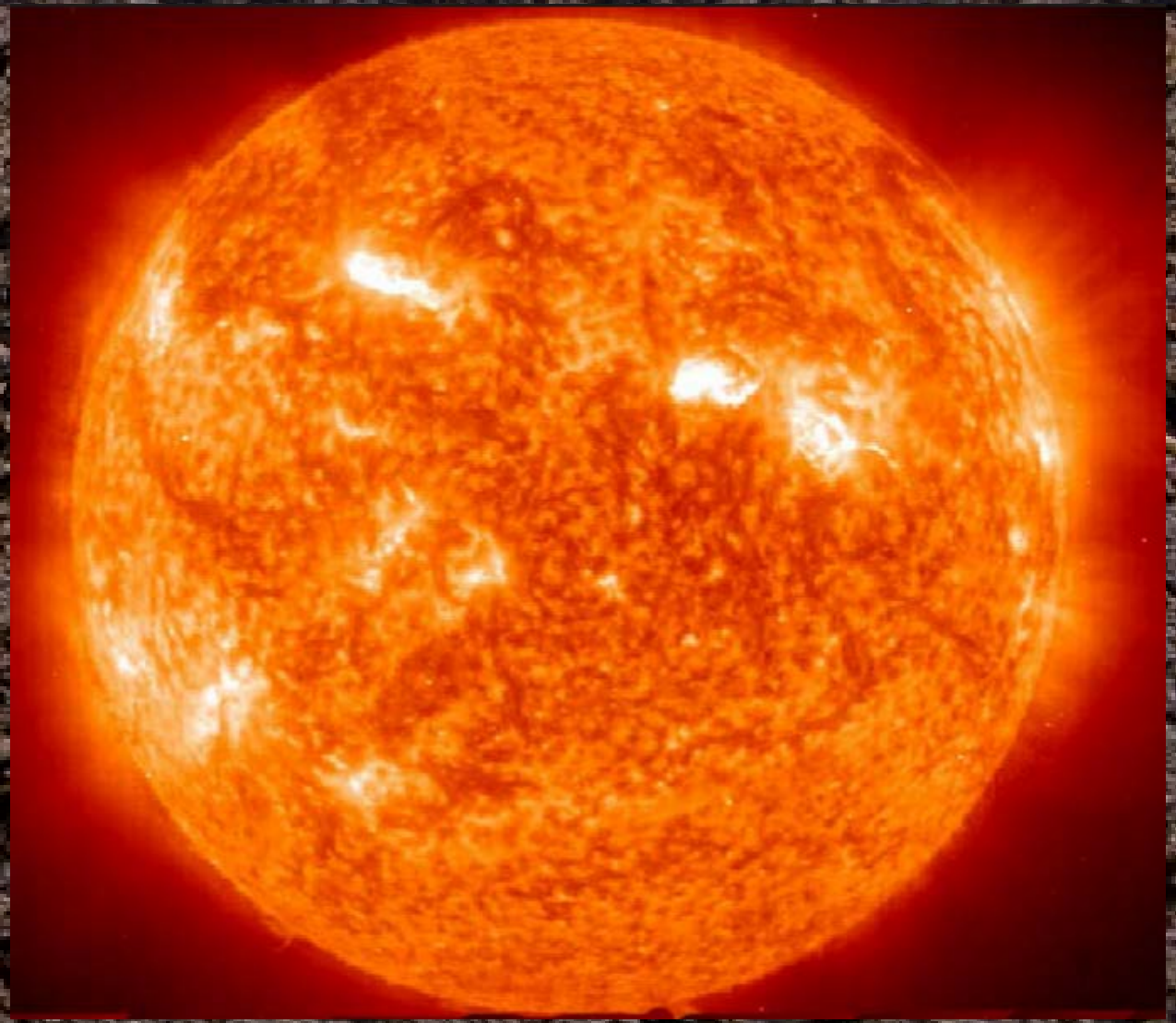
The Soil Economy



Carbonomic$ – The Wonderful Economy of the Soil

Keys To A Healthy ***SOIL!***

The Soil Economy

Soil

Plants

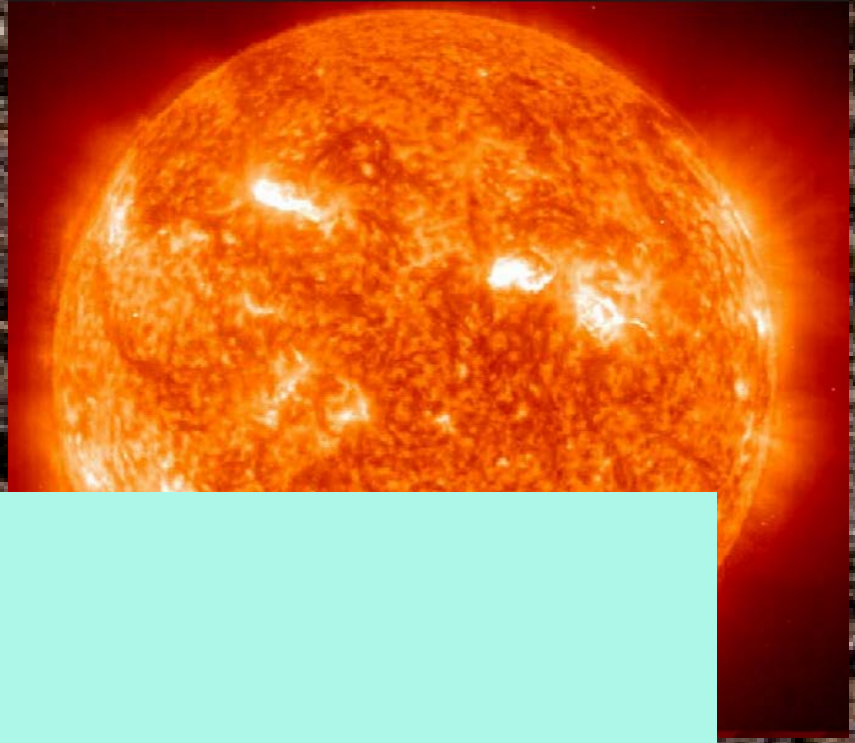
Animals

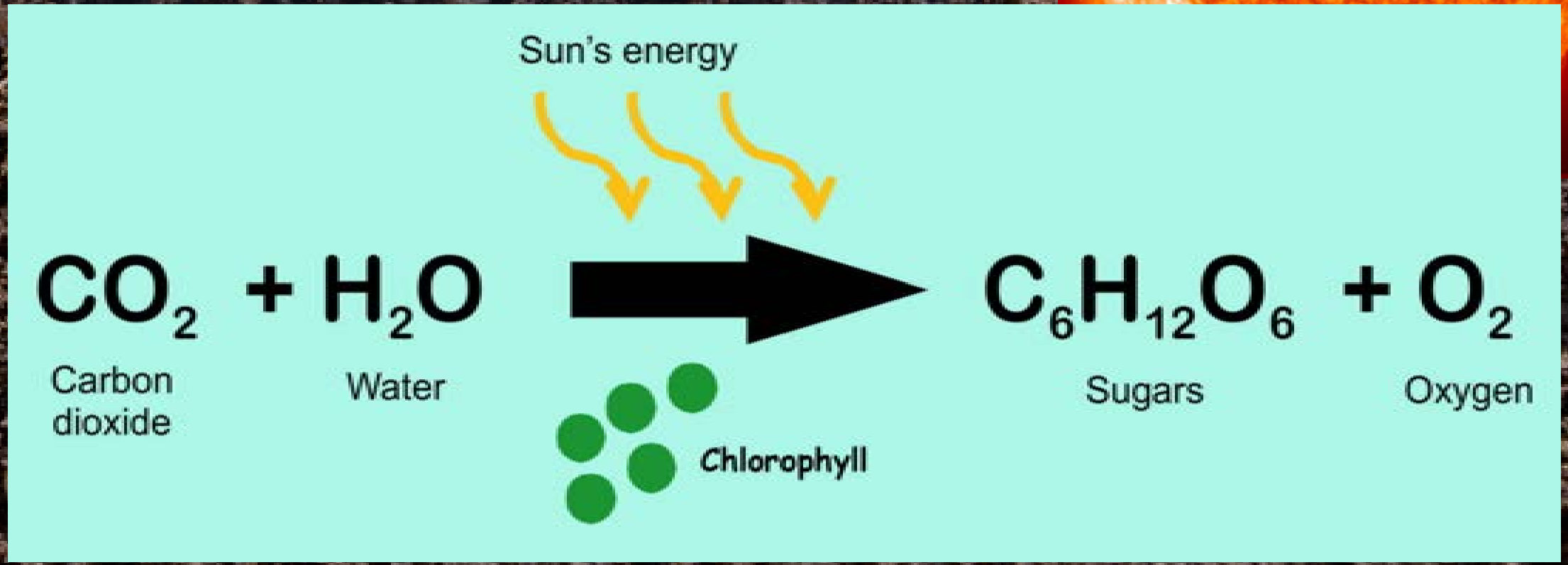
Carbonomic$ – The Wonderful Economy of the Soil

Keys To A Healthy ***SOIL!***

Supply (Producers/ Sellers)

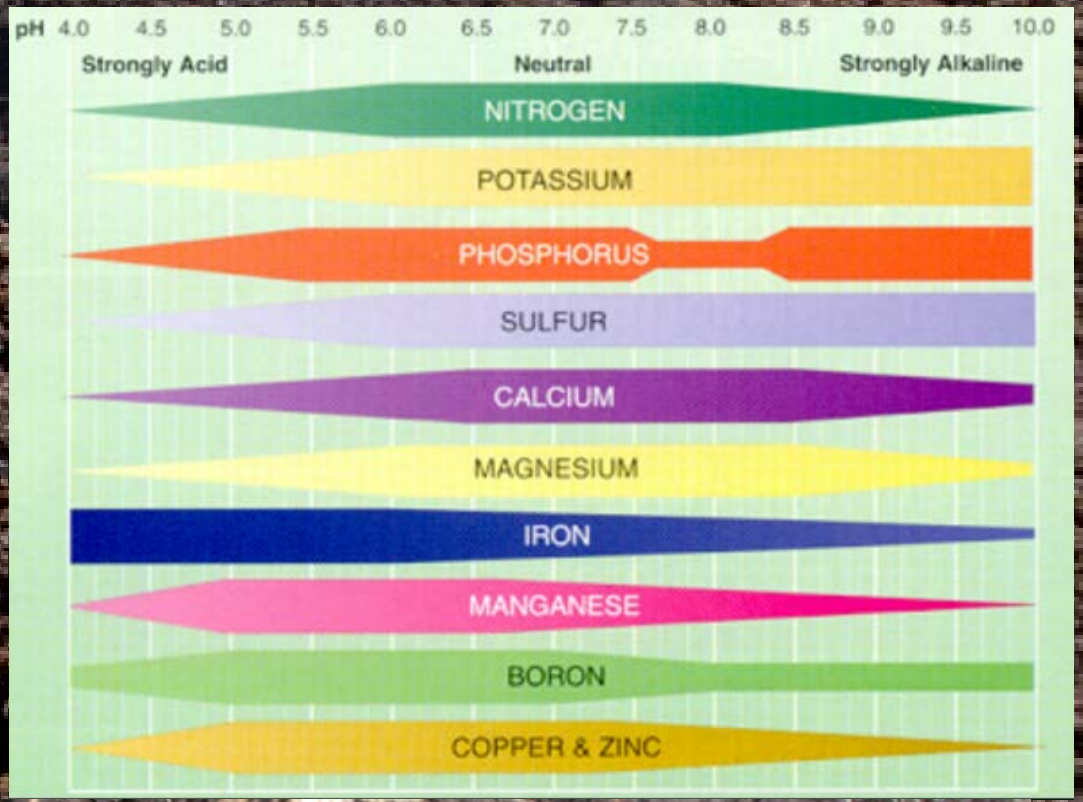
- Plants – Producing Carbon





Supply (Producers/ Sellers)

- Soil – Provides Nutrients (Minerals)
- Soil – Provides Habitat for Roots and Biology
- Soil – Provides Water storage



Supply (Producers/ Sellers)

- Soil Biota – Producing Nutrients (Fixation) (Cycling) (Availability)
- Soil Biota – Providing Defense and Protection

Demand (Consumers/ Buyers)

- Plants – Need Nutrients and Water
- Plants – Need Services (Protection, Support, etc..)

Demand (Consumers/ Buyers)

- Soil– Needs Carbon
- Soil– Needs Services (Protection, etc..)

Demand (Consumers/ Buyers)

- Soil Biota– Needs Food and Habitat

Producers –(Sellers) Consumers (Buyers)

- In a strong human economy, one of the leading indicators is low unemployment rate, where most people are both consumers AND producers and are actively engaged in making a contribution to the system.

Producers –(Sellers) Consumers (Buyers)

- The soil economy is strongest when plants, soil, and animals are ALL producing and consuming.
- Diversity is very important.

Agricultural Welfare

- When we externally provide the plant with everything that it needs from the outside, we weaken the economy.
  - Fertility inputs
  - Crop protection inputs

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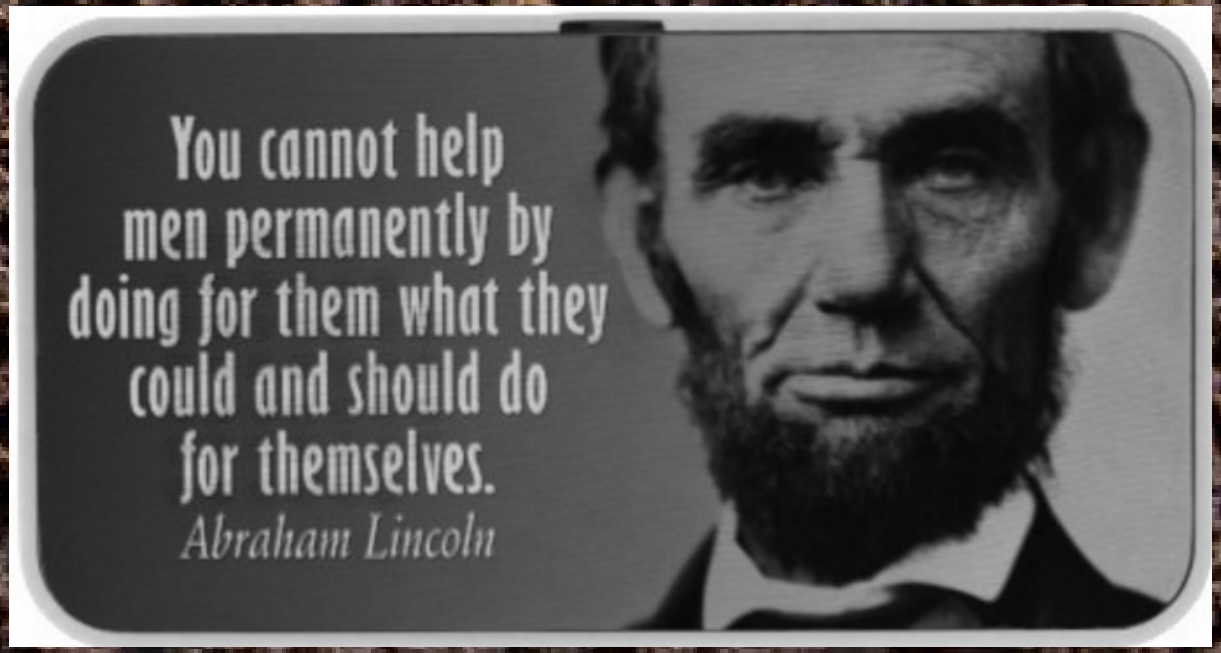


We need to allow the system to work the way it was created to work!

Plants

Soil

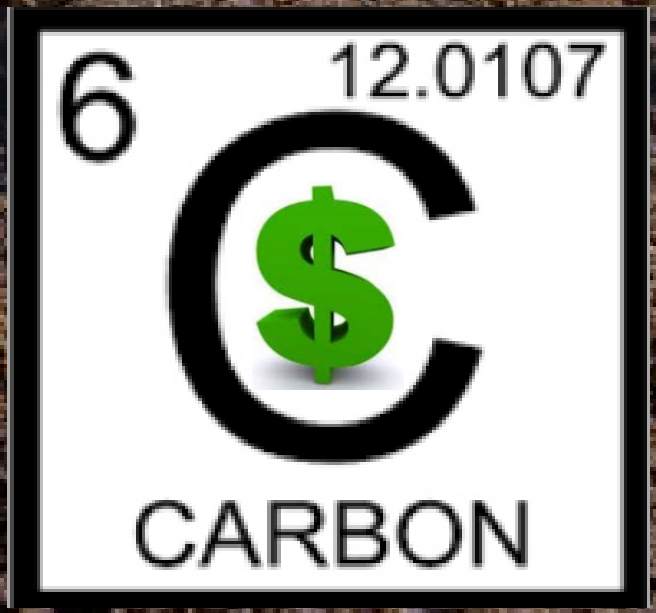
Soil Biota

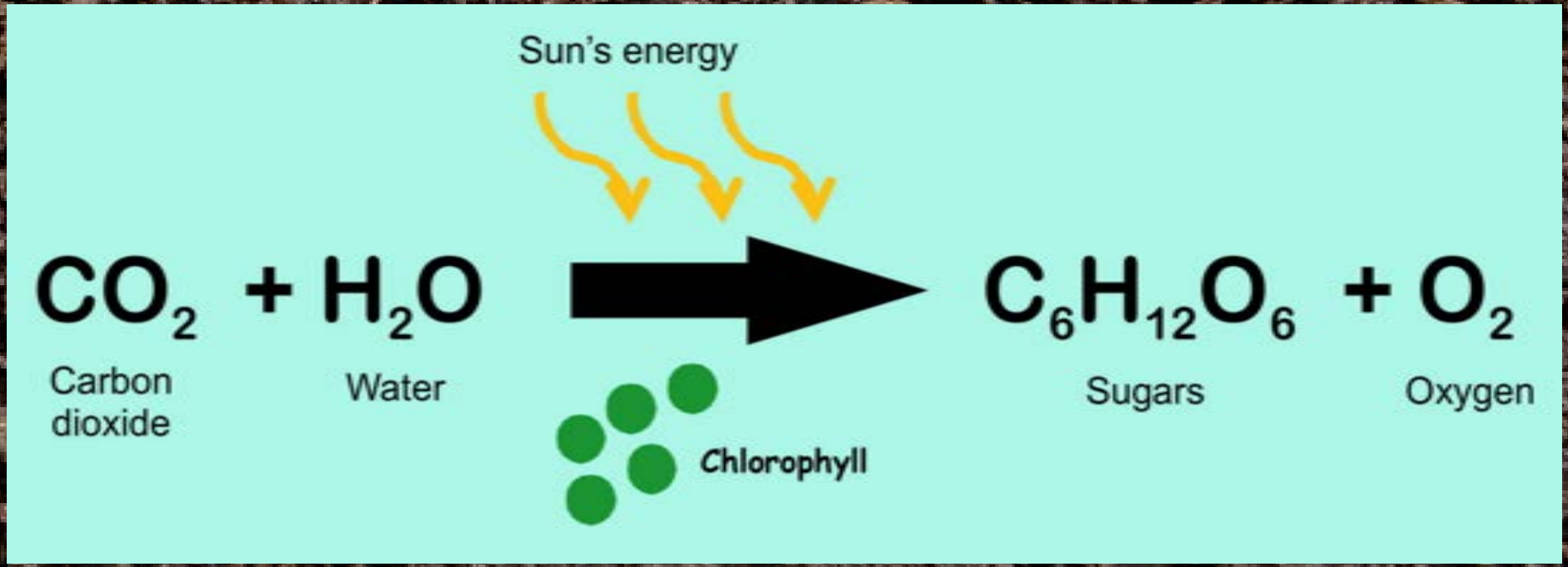
Currency

- Currency is important because it allows goods and services to be exchanged more efficiently

Currency

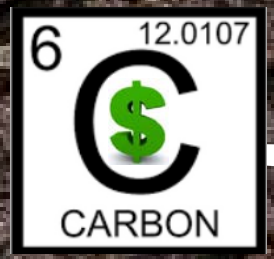
- In the plant economy, the currency is Carbon





Carbon Currency

- Currency (Carbon) is important because it allows goods and services to be exchanged more efficiently with the soil economy.



Carbon Payments

Root Exudates

Plant Services

Sourcing, Delivery, Protection

Carbonomic$ – The Wonderful Economy of the Soil

Keys To A Healthy ***SOIL!***

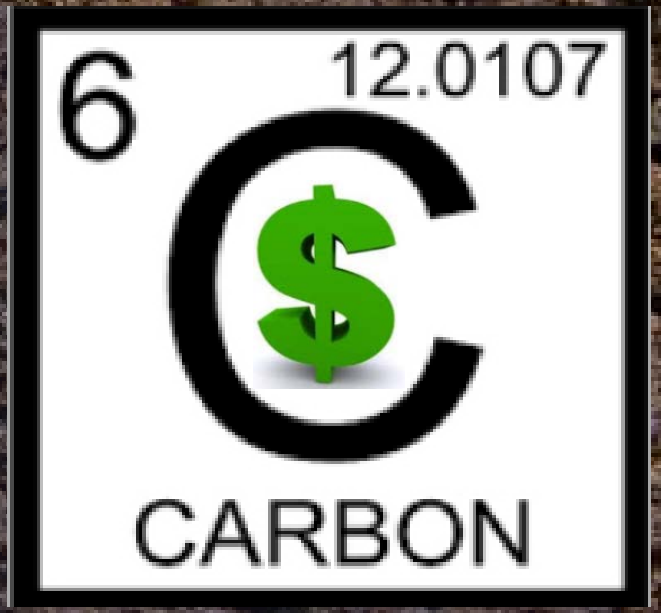
Importance of Carbon

- Carbon is essential to all life
- People are 19% carbon
- Carbon can form over 10 million compounds
- Carbon is the *most important* but *most overlooked* of all plant nutrients
- Carbon is the main food source for soil biology

Increased Soil Carbon Currency

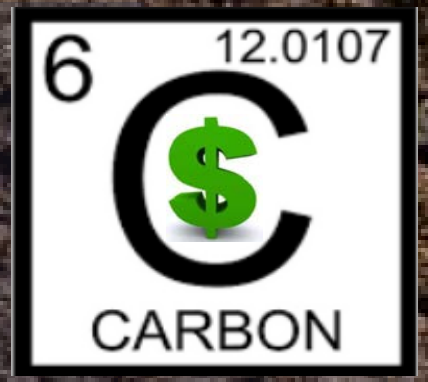
- Normalizes soil pH
- Increases CEC
- Increases availability of P, Ca, K, S, Zn, Fe, Mo, B
- Reduces availability of Na and Al

Carbon Currency



- Carbon can be:
  - collected (photosynthesis)
  - spent (traded to soil organisms)
  - saved (soil organic matter)
  - desired by all members of the economy

Carbon Currency

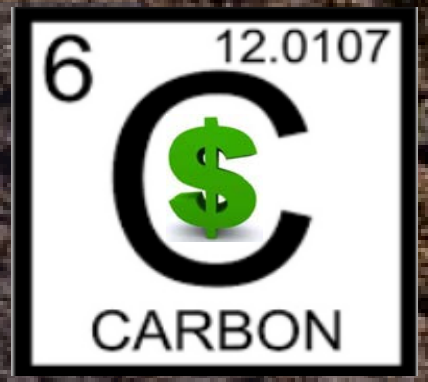


- Carbon has different states
  - Gas – CO_2

  - Liquid – in plants and soils

  - Solid – in living organisms and Organic Matter

Carbon Currency



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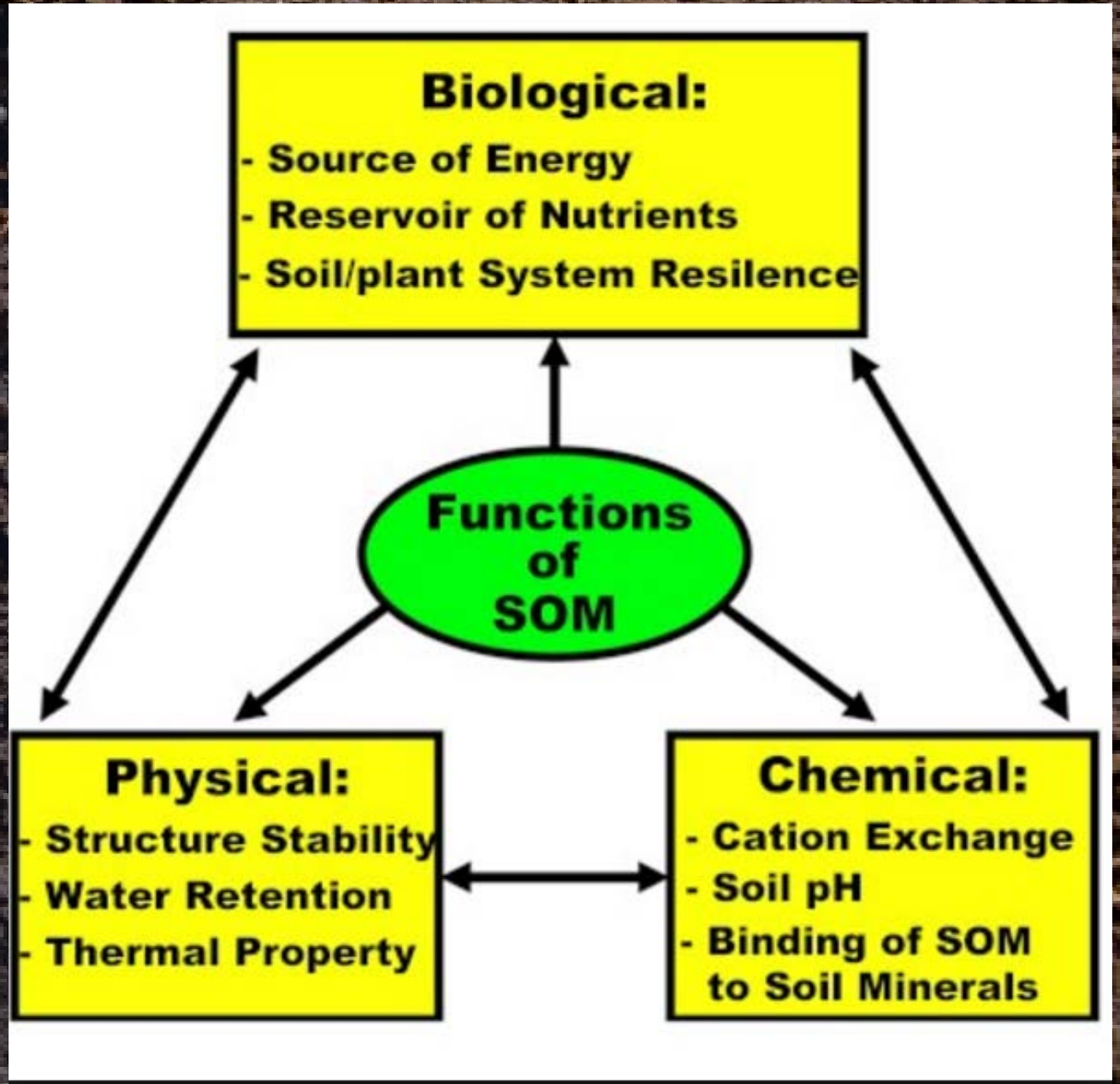
Capital

- Accumulated (stored or saved) currency
- Needed for Growth and Stability

Soil Carbon Capital

- Organic Matter and Humus
- Accumulated (stored or saved) carbon currency
- Needed for Growth and Stability



Capital Rich Economies

= High Organic Matter Soils

- Productive
- Stable
- Resilient
- Efficient

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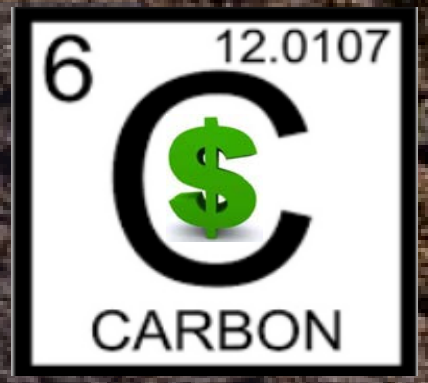
Soil organic matter generates and regulates every ecosystem service that sustains life on earth”– Rattan Lal

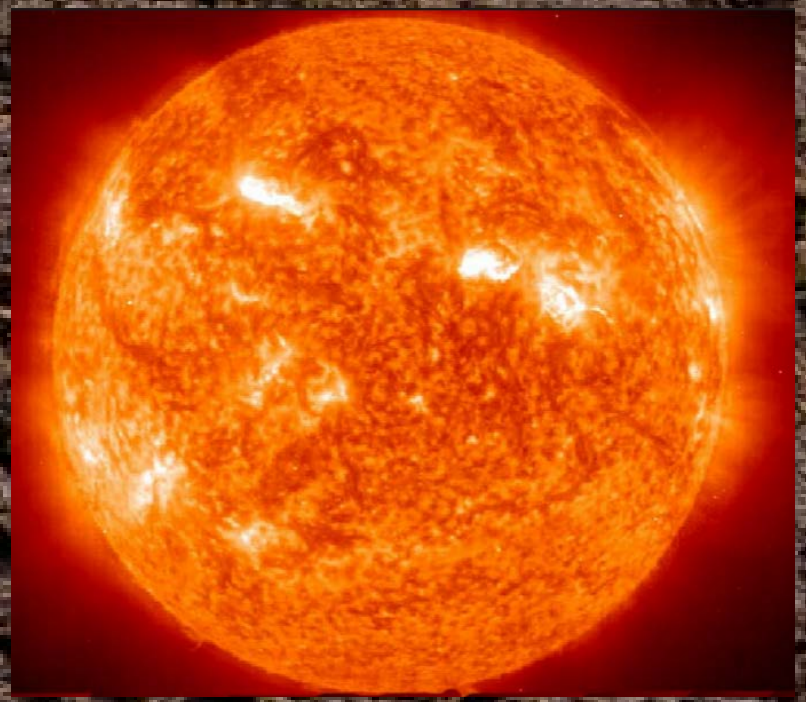
Carbon Capital

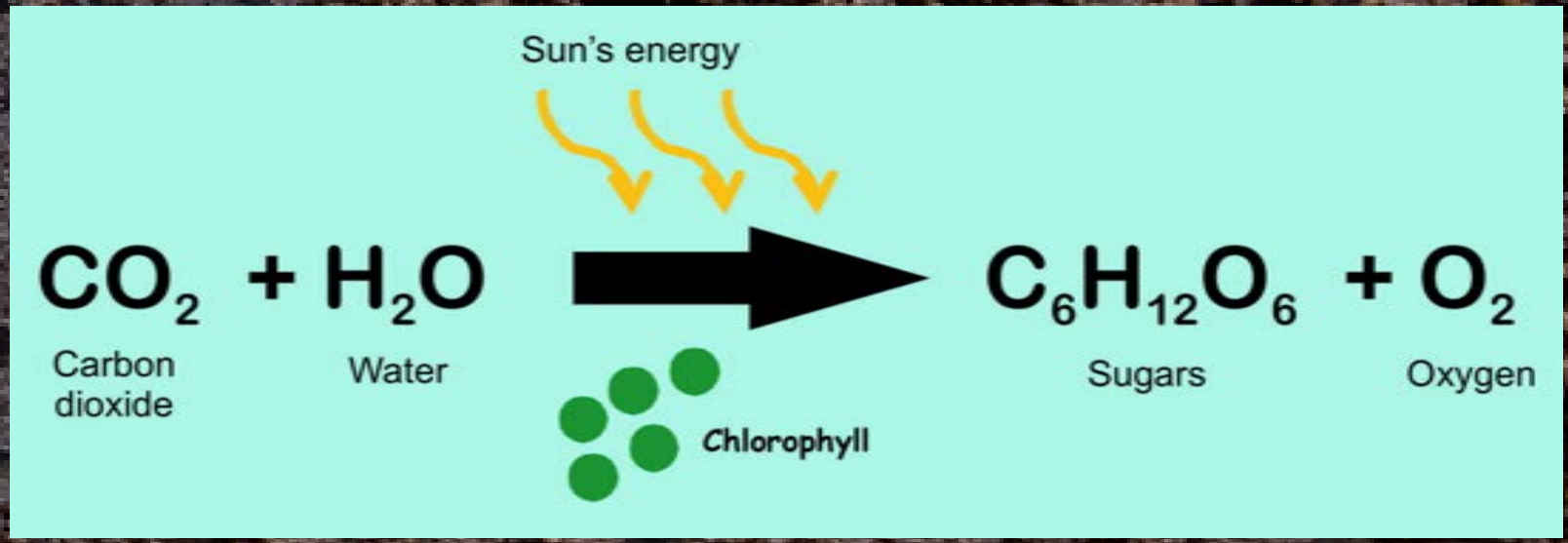


- Capital (Savings) can't be increased without an excess of cash income
- Soil Organic Matter can't be increased without an excess of soil carbon currency
- Soil Carbon can't be increased in most rotations without the use of cover crops

Energy and Resources

- Plant economy energy comes from the sun





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- Plant solar collectors (seeds) are MUCH cheaper and easier to install than man-made solar panels!

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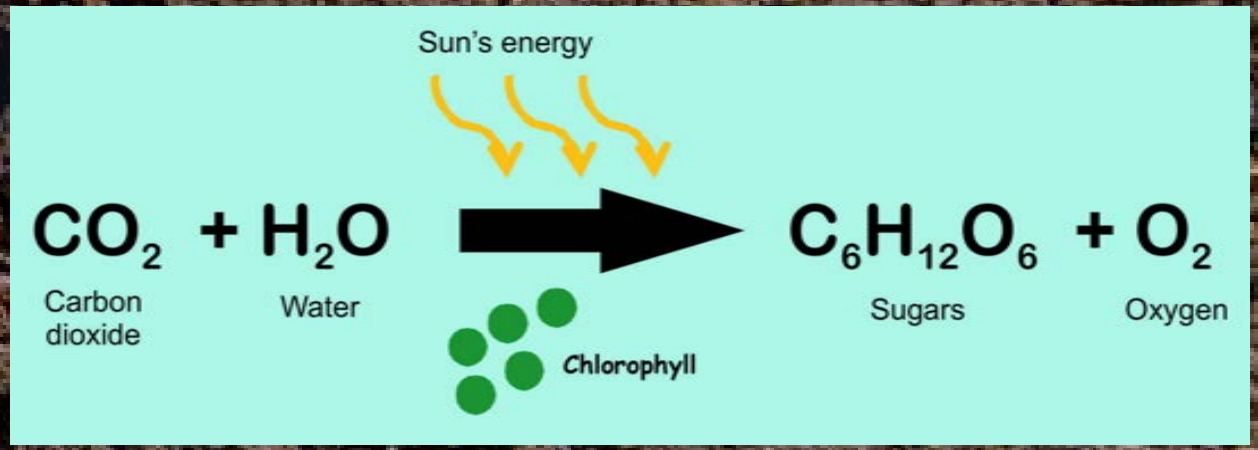
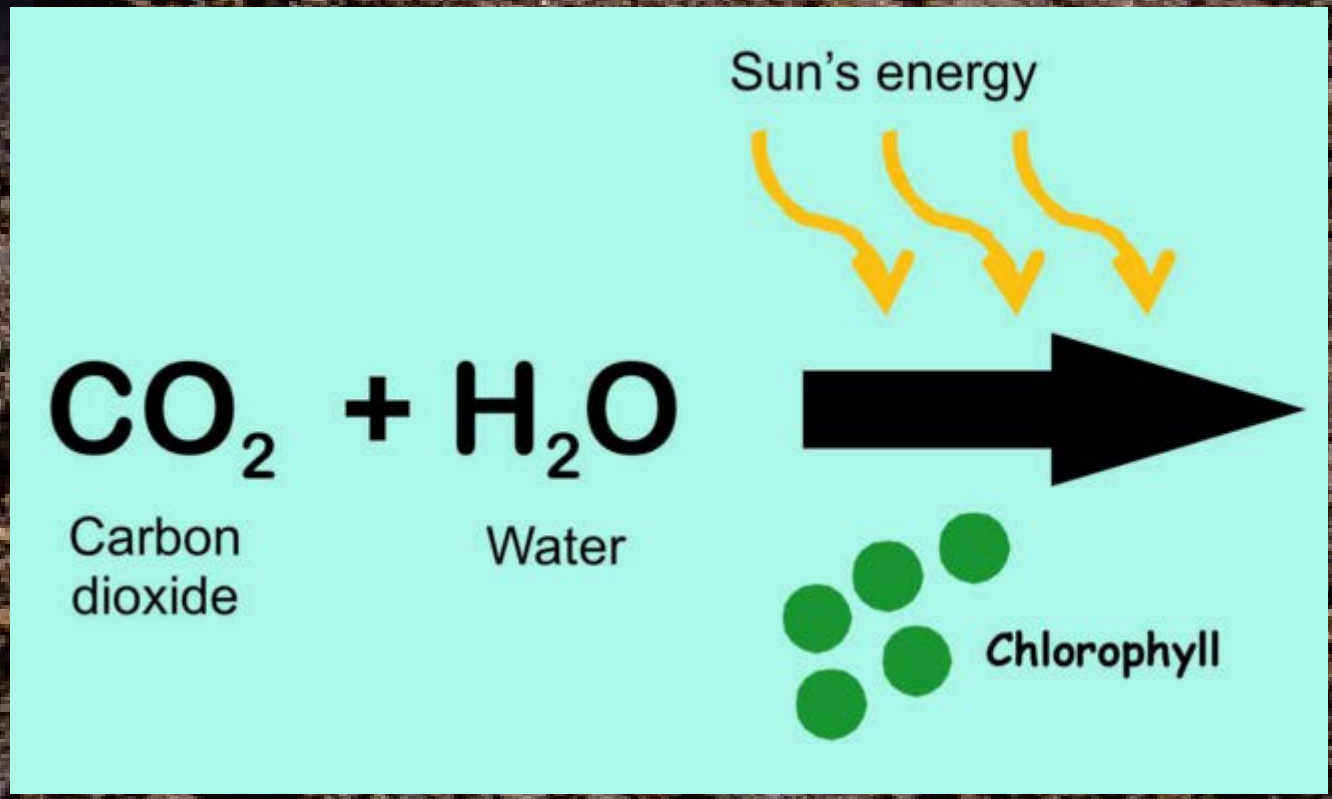
- Plant solar collectors (seeds) are MUCH cheaper than man-made solar panels!
- A healthy soil economy should not need significant purchased energy inputs



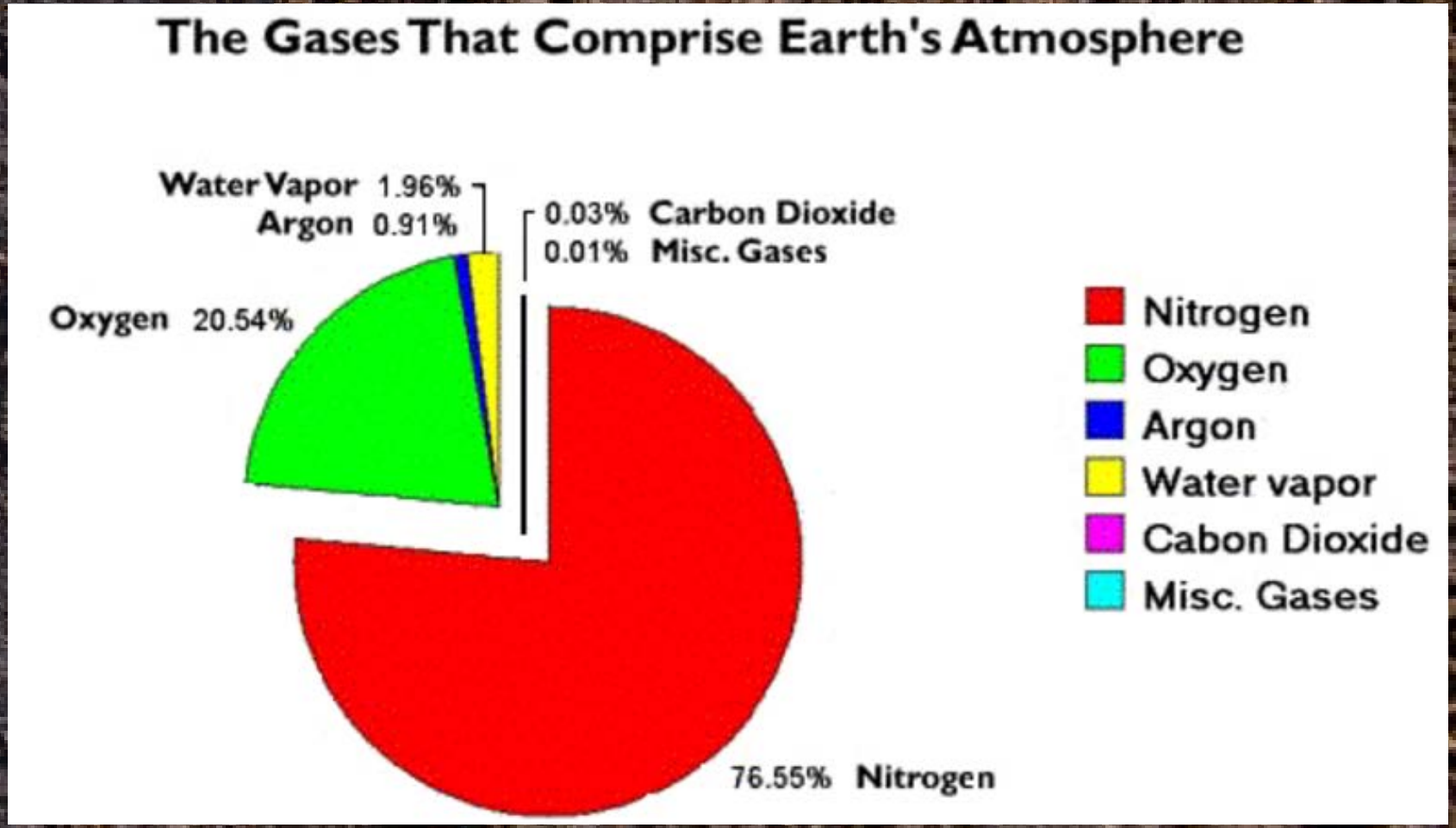
Energy and Resources

- Plant economy resources
- # 1 is CARBON



Energy and Resources

- Plant economy resources
- # 1 is CARBON
- # 2 is NITROGEN



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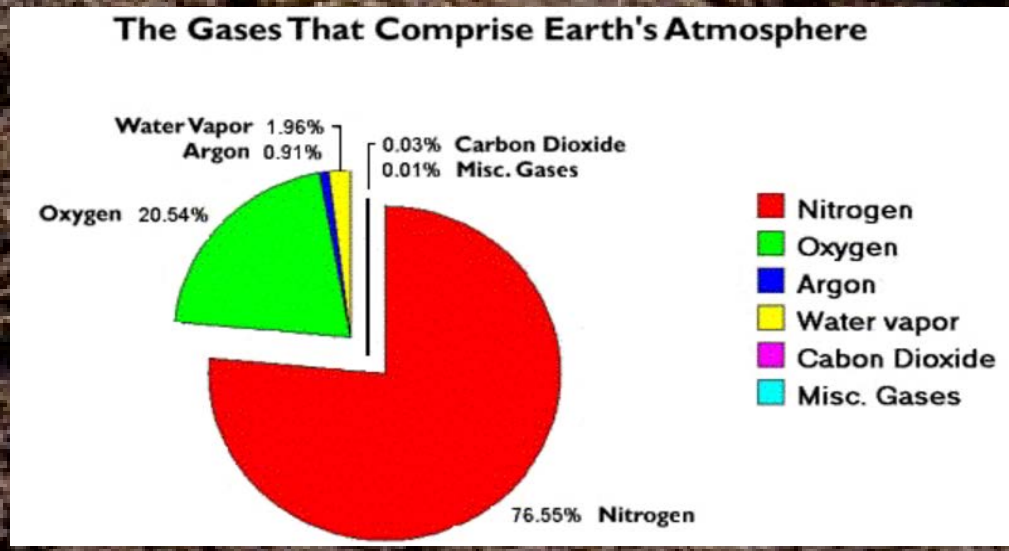
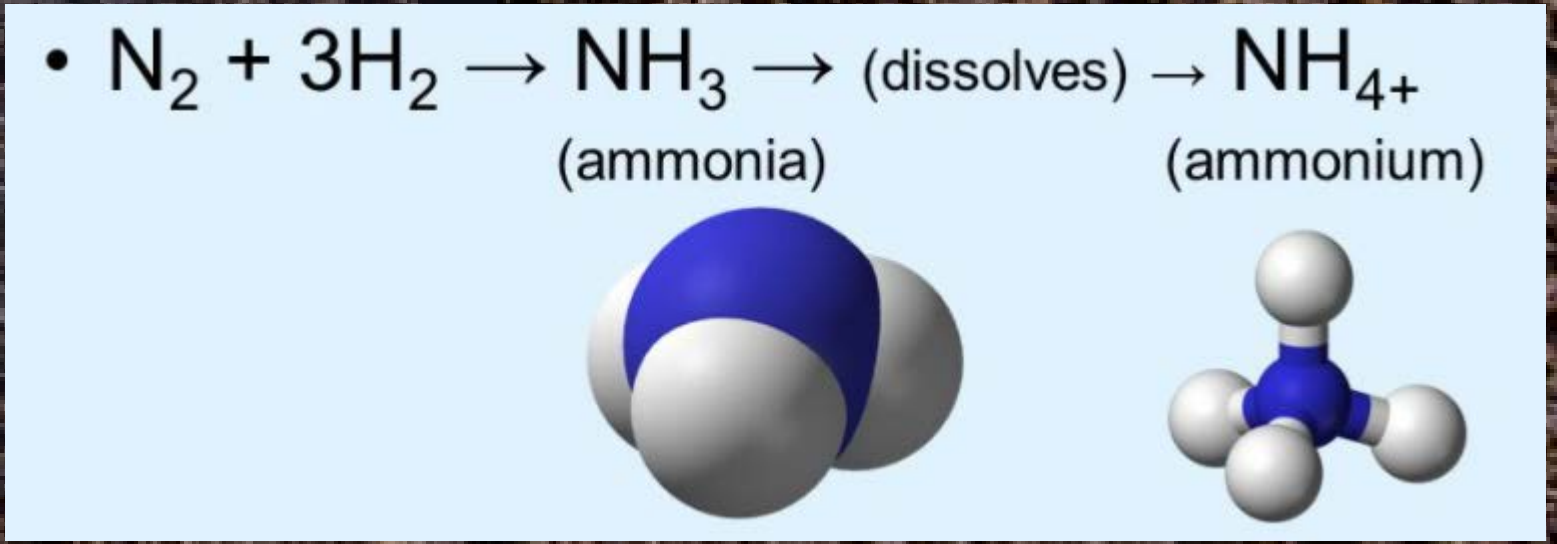


Energy and Resources

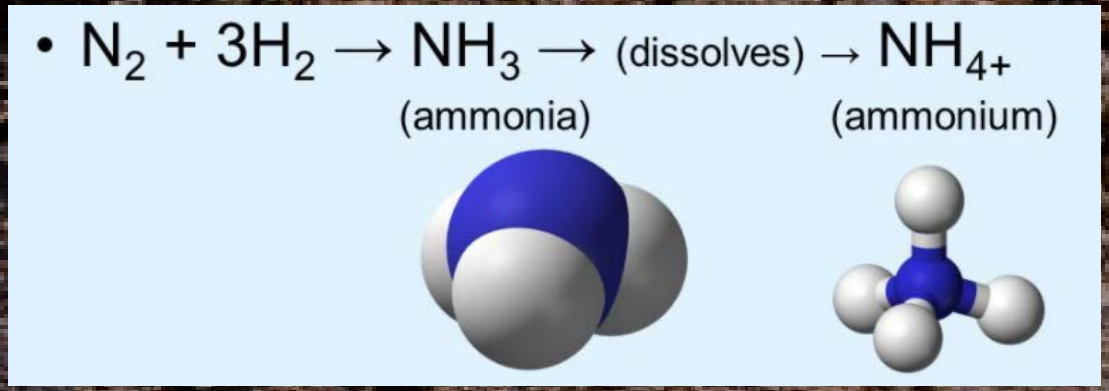
- Nitrogen gets "fixed" or made plant available when combined with hydrogen or oxygen



Energy and Resources

- Nitrogen gets "fixed" or made plant available when combined with hydrogen or oxygen

- Very energy intensive process

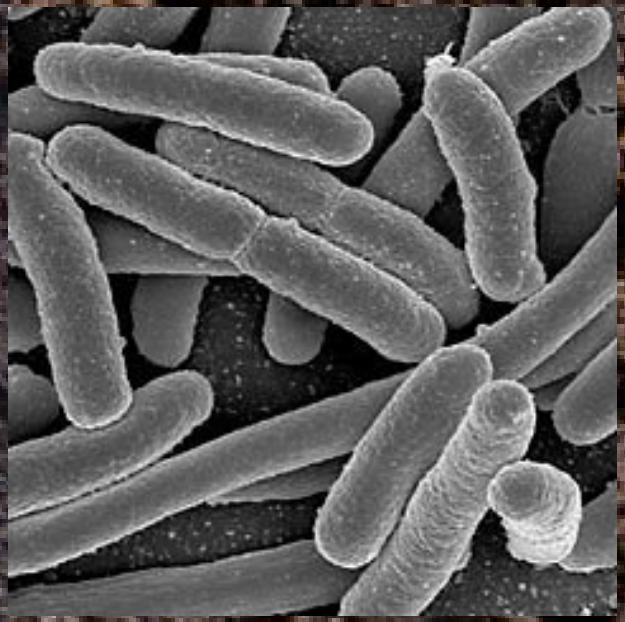


Energy and Resources

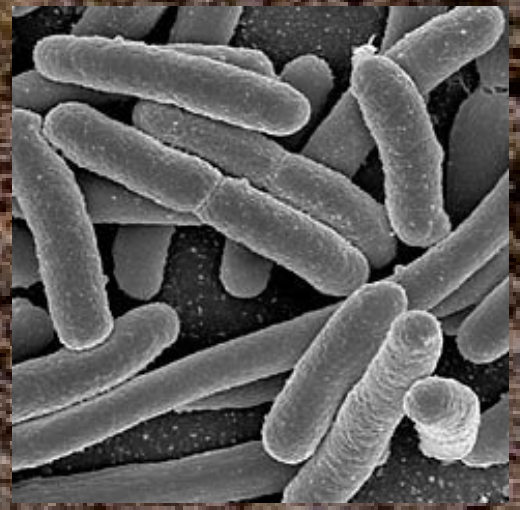
Rhizobia Bacteria

Nitrogen Factories

- Azosprillium
- Azotobacter
- Not limited to legumes



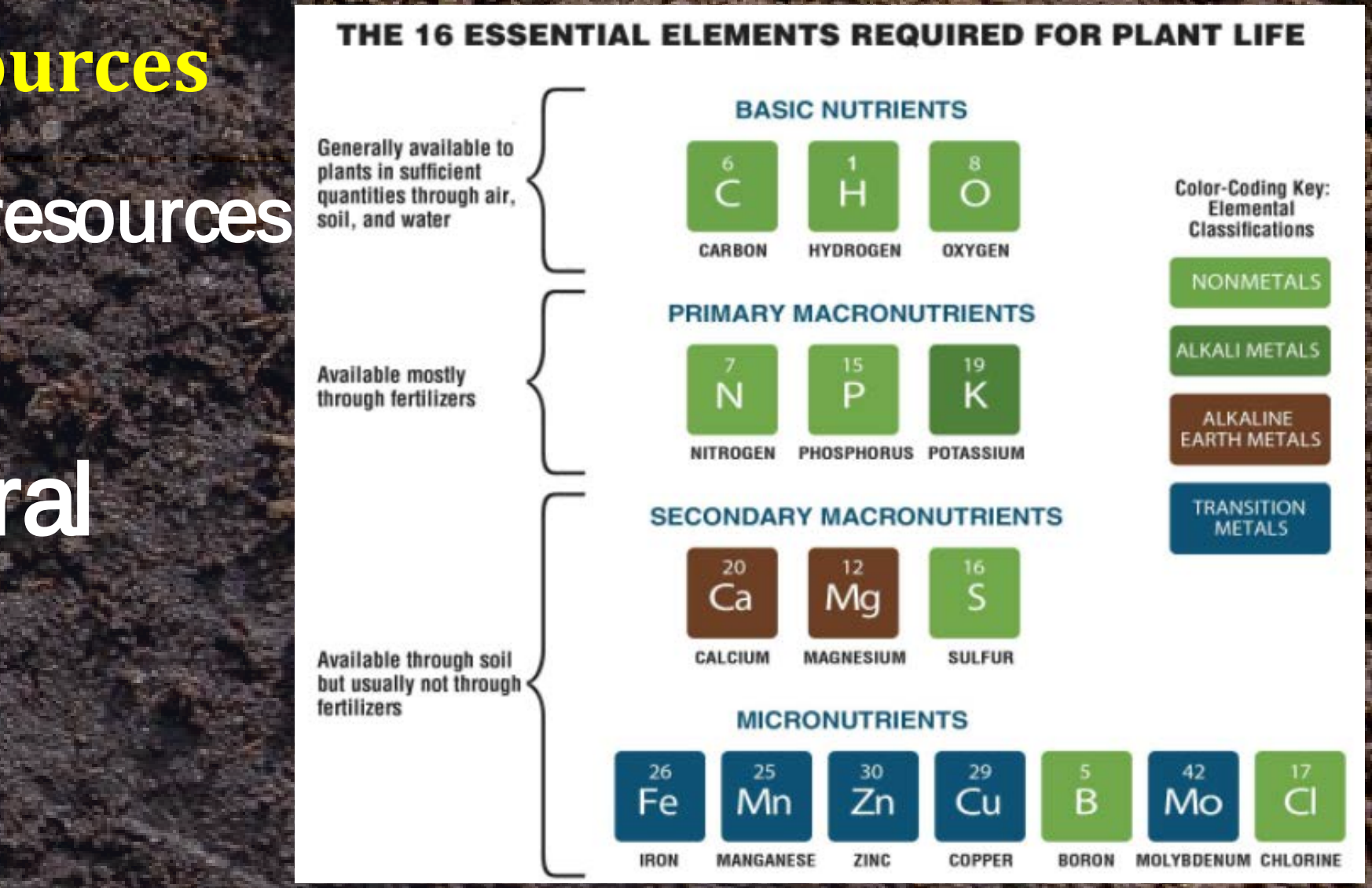
Nitrogen Factories



- Azosprillium
- Azotobacter
- Rhizobia
- Must associate with a plant
- "Trade" nitrogen to the plant for carbon
- Will not happen if excess N is in the soil

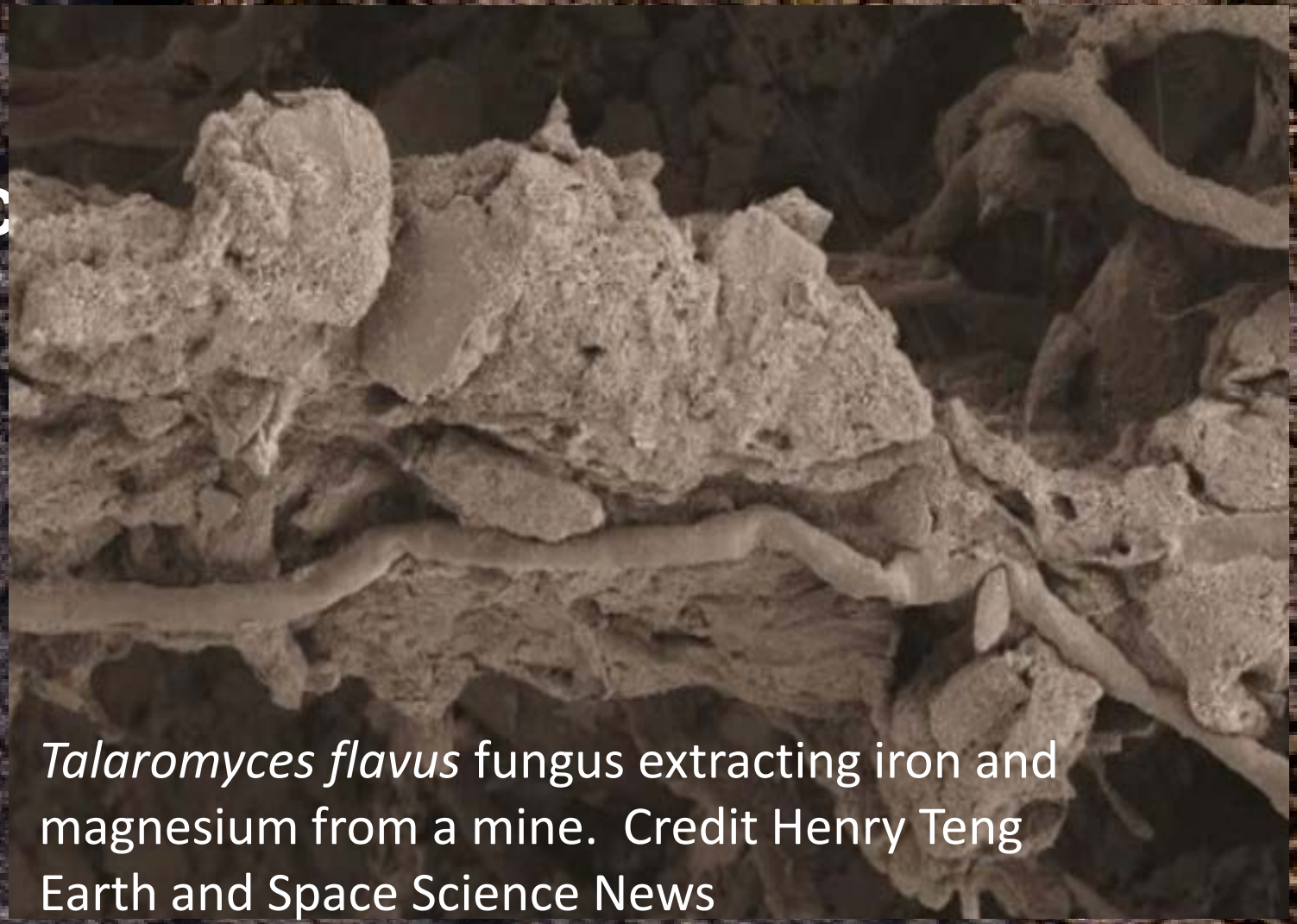
Energy and Resources

- Plant economy resources
  - #1 is CARBON
  - #2 is NITROGEN
- Other mineral resources



Energy and Resources

- Plant economy resourc
- # 1 is CARBON
- # 2 is NITROGEN
- Other mineral resources
- Employ tiny miners to extract the nutrients from the soil.



Talaromyces flavus fungus extracting iron and magnesium from a mine. Credit Henry Teng Earth and Space Science News

Mycorrhizal Fungi run the Largest Mining Operation in the World

Up to 85% of plants depend on fungi to survive. Plants and fungi depend on each other for nutrient cycling and water absorption

Photo: Amanita gemmata by Courtney Celley: US Fish & Wildlife Service

SCIENTIFIC AMERICAN

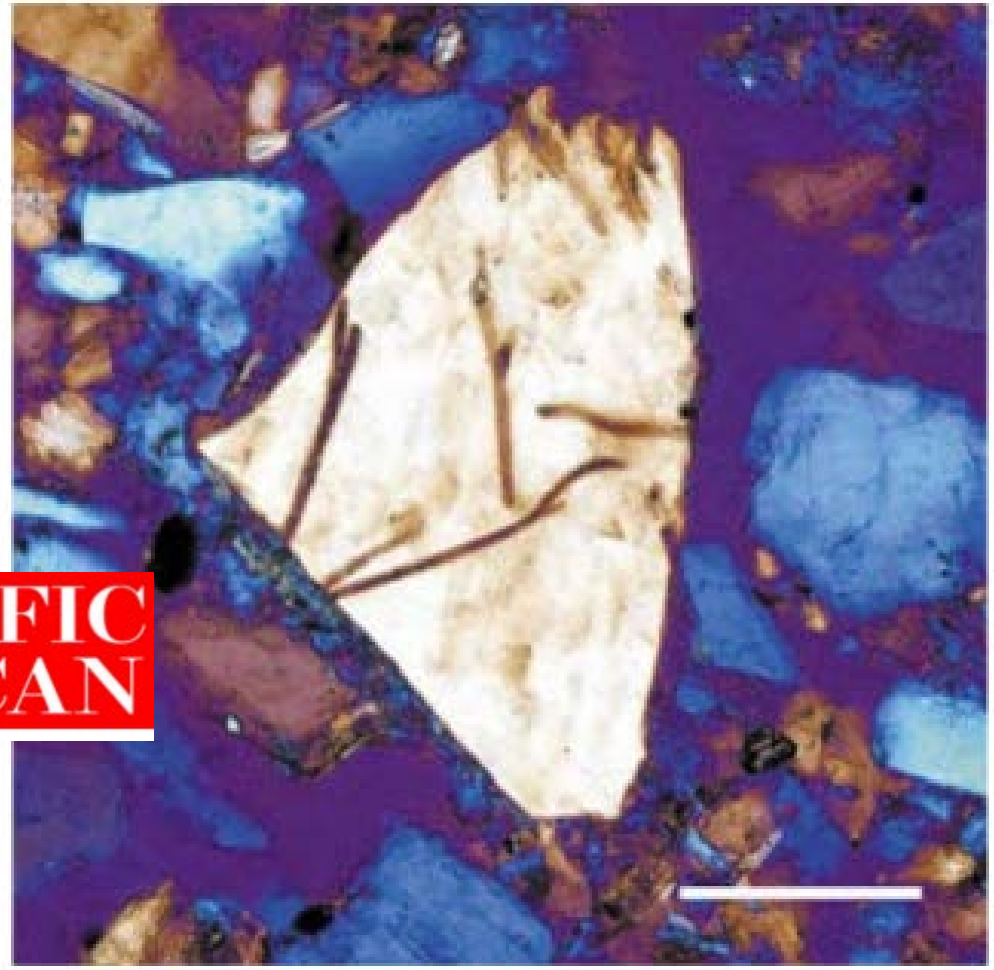


Image: Landeveert 2001

Thin-section micrograph of a tunneled feldspar
Scale bar = 100 micrometers

Arbuscular Mycorrhizal Fungi

Mineral Resources

- Mycorrhizal fungi mine the soils not only for the basic nutrients like nitrogen, phosphorus, etc, but also those hard to come by trace elements (Zinc, Copper, Manganese, etc) which plants need for strong immune system health and survival… Oddly enough many soils are rich in important nutrients, but they are often locked up in a physical form which makes them unavailable to most plants.

(Source: Scientific American - Jennifer Frazer)

infrastructure

noun | in·fra·struc·ture | \ˈin-frə-ˌstrək-chər, -(ˌ)frä-\

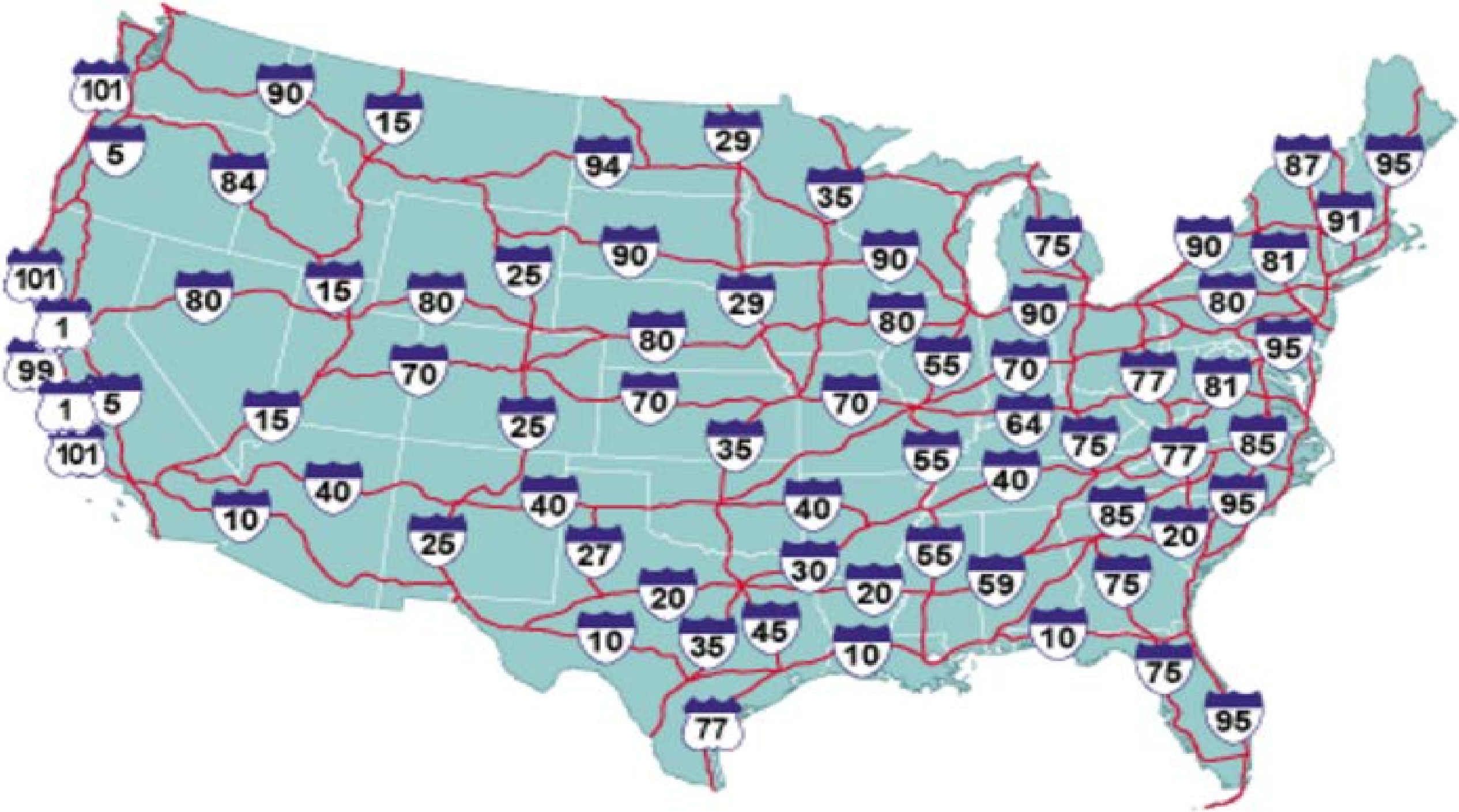
Simple Definition of INFRASTRUCTURE

Popularity: Top 20% of words

: the basic equipment and structures (such as roads and bridges) that are needed for a country, region, or organization to function properly

- Transportation
- Communication
- Economies will be severely crippled or limited when these are lacking or disrupted (war strategies)

infrastructure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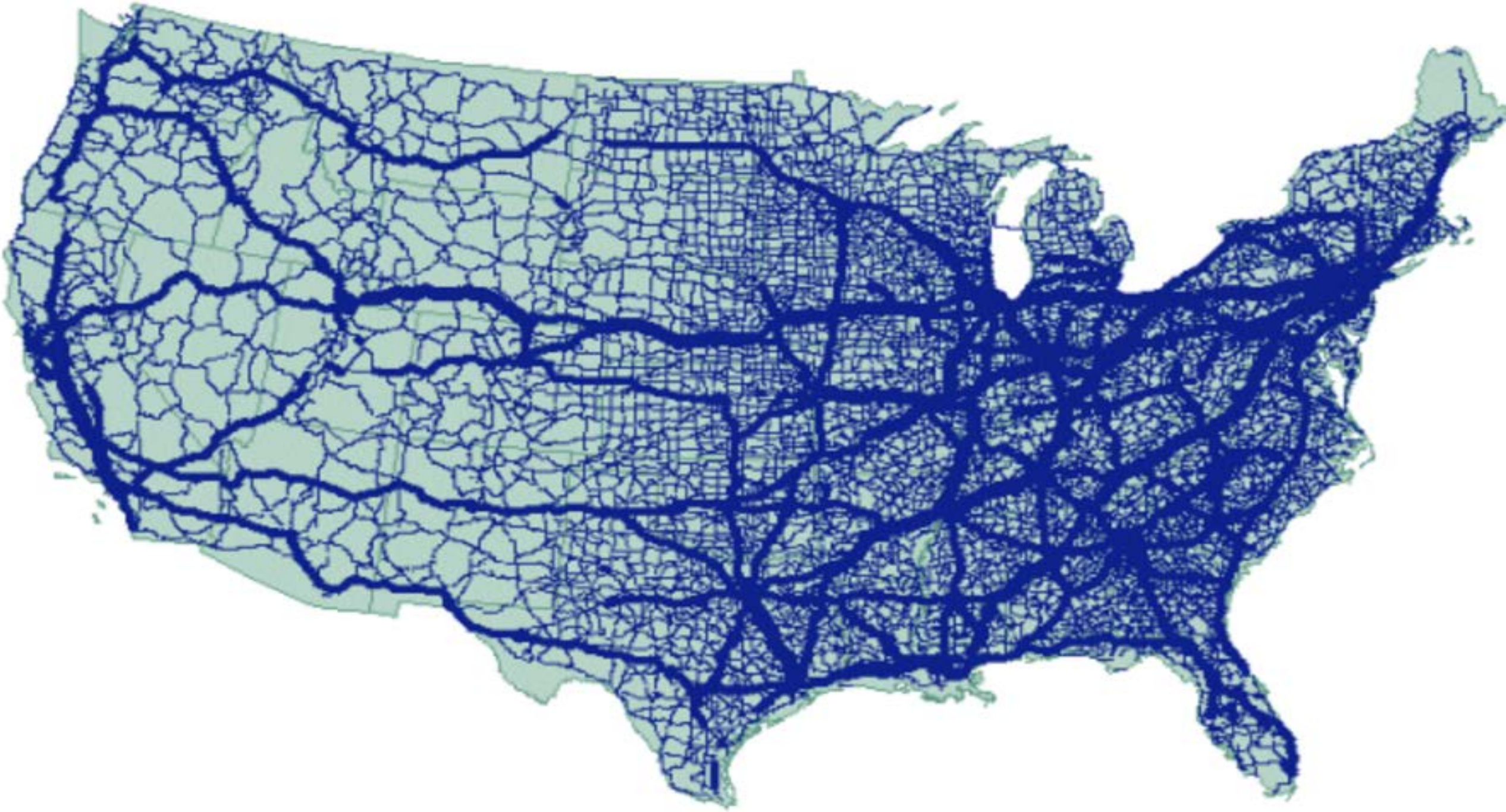


NON-MYCORRHIZAL
ROOTS


ROOTS WITH
MYCORRHIZAL FUNGI

Mycorrhizal fungi transports:

- Phosphorus – one of the hardest to access
- Nitrogen, Potassium, Calcium, Magnesium, Iron
- Zinc, Boron, Manganese and Copper.
- In dry times they help transport and supply water.

Transportation Infrastructure

- A soil system without Mycorrhizal fungi is like a farming system without roads, rail lines or ports – huge potential but severely limited.

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Transportation Infrastructure

Earth worms help transport:

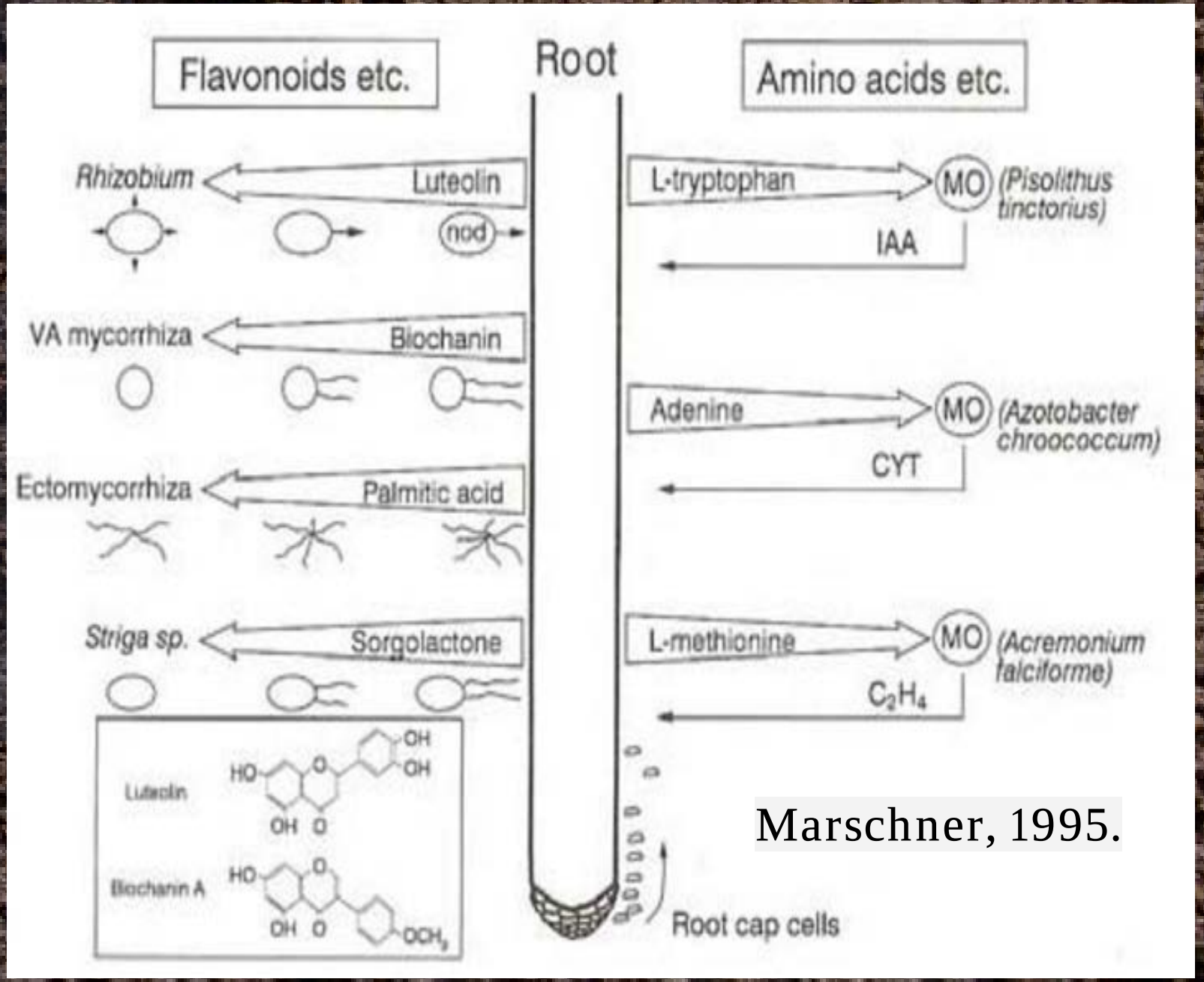
- Water
- Oxygen
- Surface carbon (residue)
- Other biota

Rhizophere Marketplace

The area right around the roots is where communication and commerce are occurring

Communication Infrastructure

Plants use liquid carbon root exudates to communicate to soil biota what they need



Marschner, 1995.

Communication Infrastructure

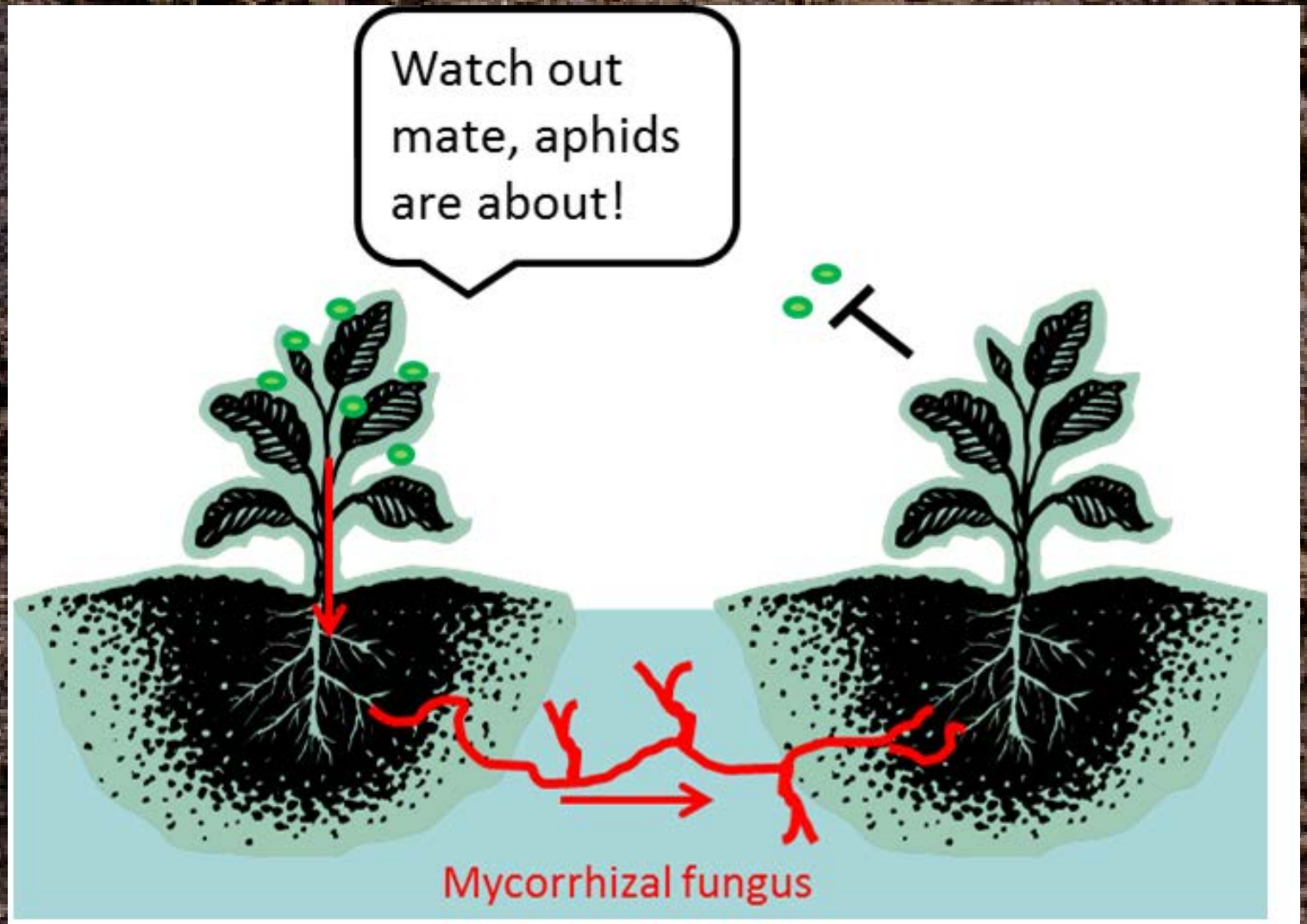
Plants use liquid carbon root exudates to communicate to soil biota what they need

Carbon Compounds

- Carbohydrates
- Sugars
- Proteins
- Fats
- Lipids
- Oils

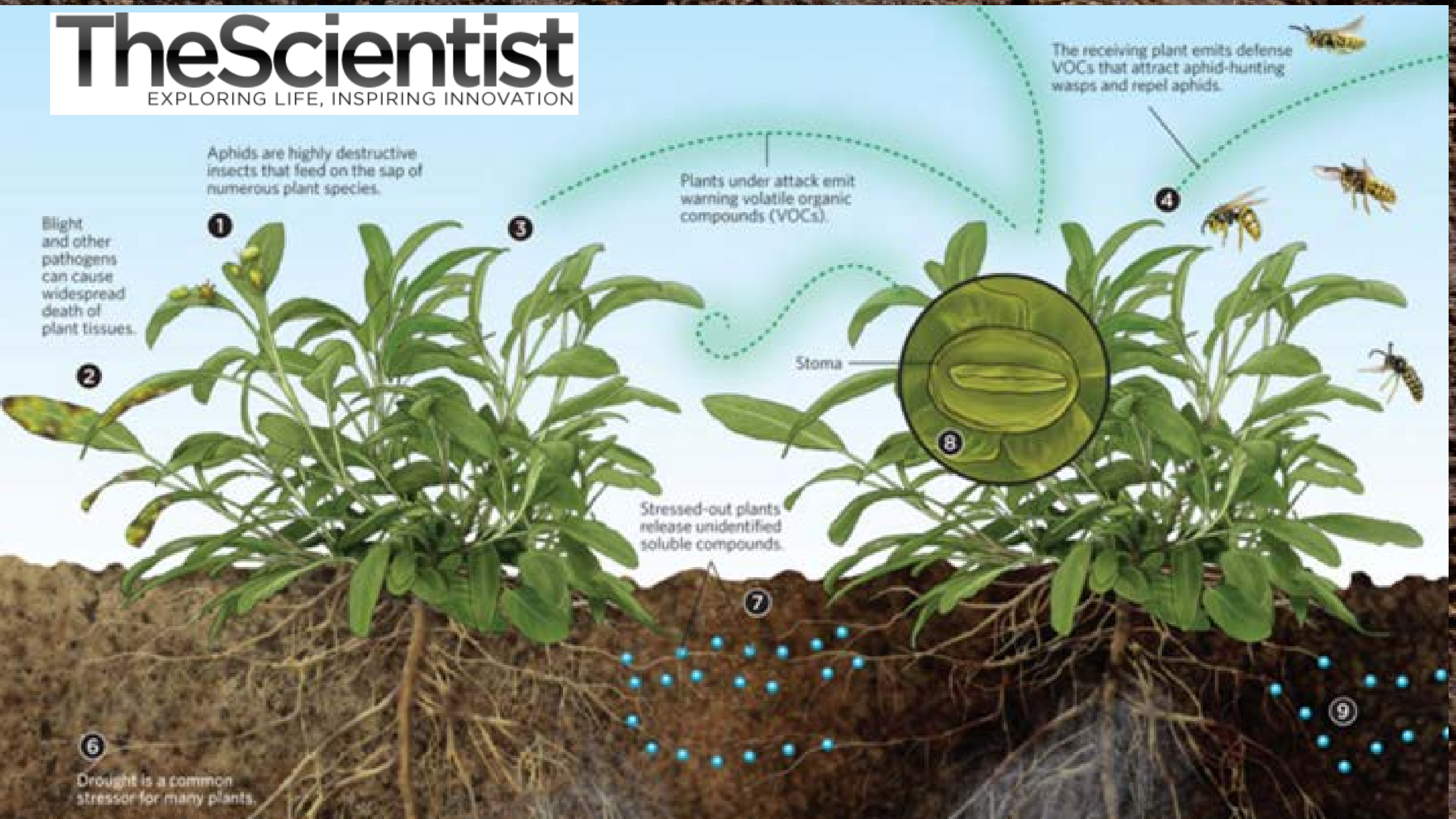
Communication Infrastructure

Mycorrhizal networks interconnect root systems and allow plants to communicate threats through chemical signaling



When aphids infect the plant on the left a signal travels to through the mycorrhizal network warning other (uninfected) plants that aphids are nearby. This induces defence responses that include the production of methyl salicylate, which repels the aphids and attracts the parasitoid wasp (an aphid predator).

TheScientist
EXPLORING LIFE, INSPIRING INNOVATION



Communication Infrastructure

TheScientist
EXPLORING LIFE, INSPIRING INNOVATION

Plant Talk

Plants communicate and interact with each other, both aboveground and below, in surprisingly subtle and sophisticated ways.

By Dan Cossins | January 1, 2014

Plants can communicate with insects as well, sending airborne messages that act as distress signals to predatory insects that kill herbivores.

Defense and Protection

The plant/soil economy needs protected from:

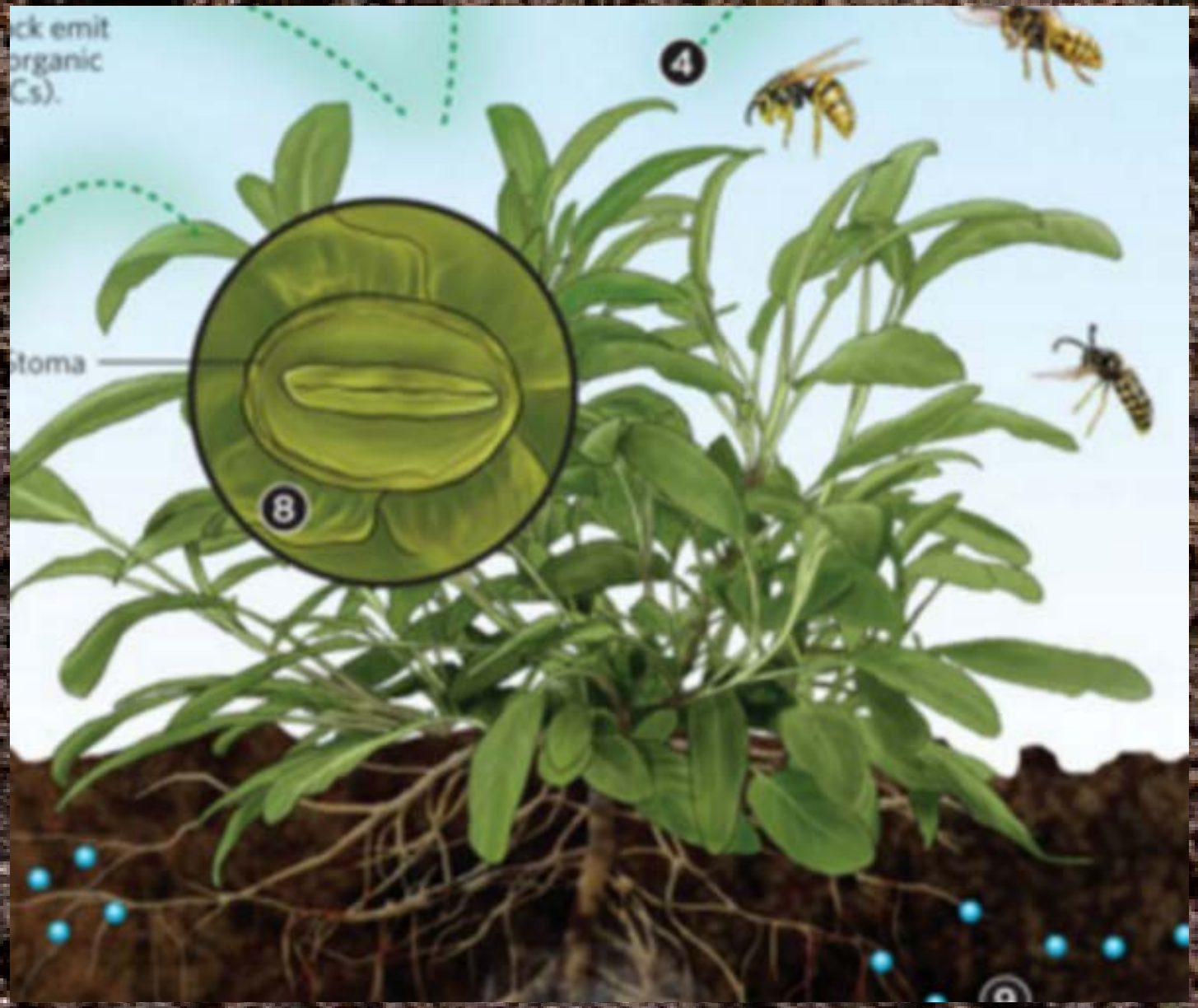
- Water (too much or too little)
- Wind
- Heat
- Cold
- Compaction
- Weeds
- Insects
- Diseases

Defense and Protection

The first line of defense is soil armor (cover)

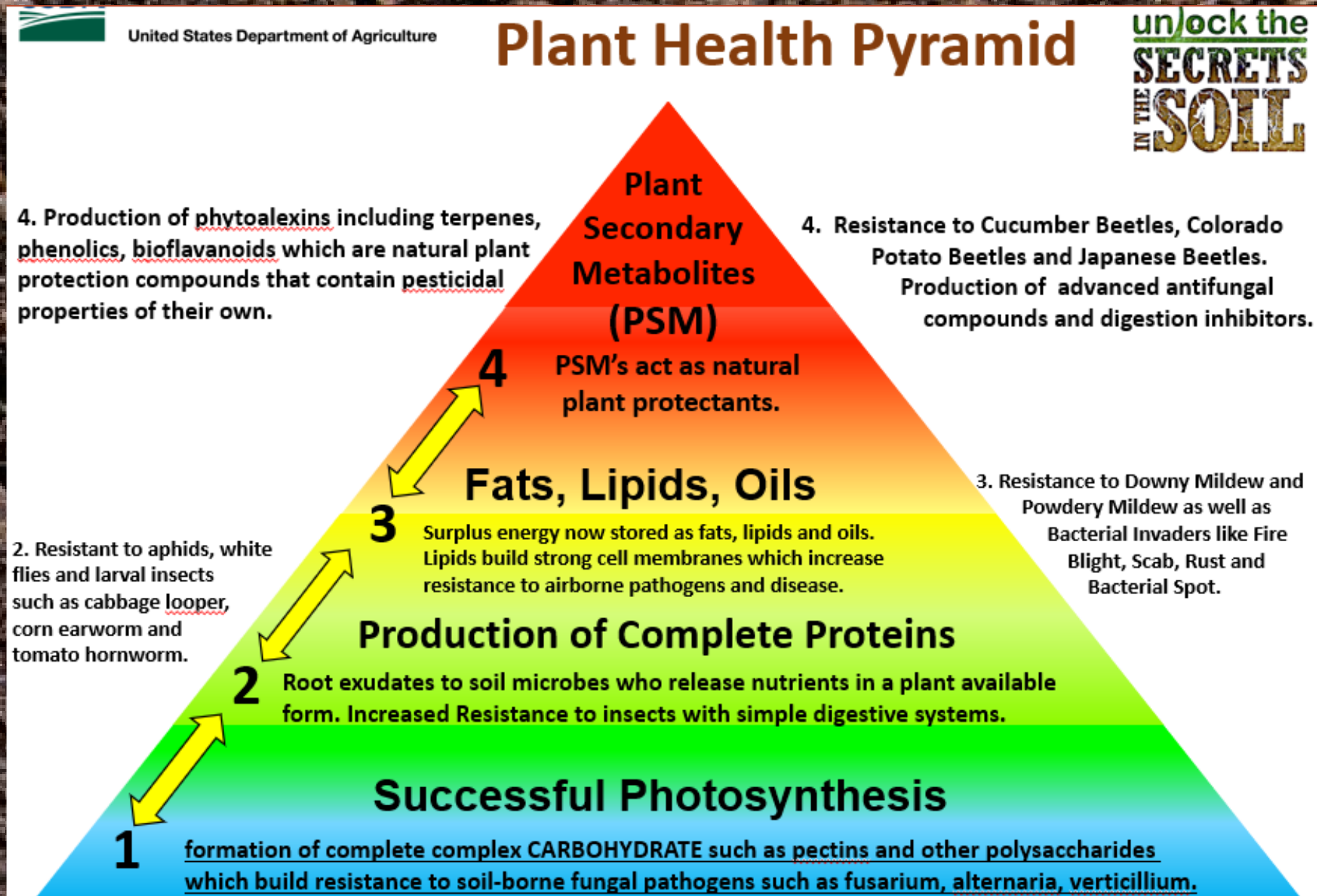
Defense and Protection

The second line of defense is plant signaling - plants signaling each other and signaling insects and soil organisms to assist in defense



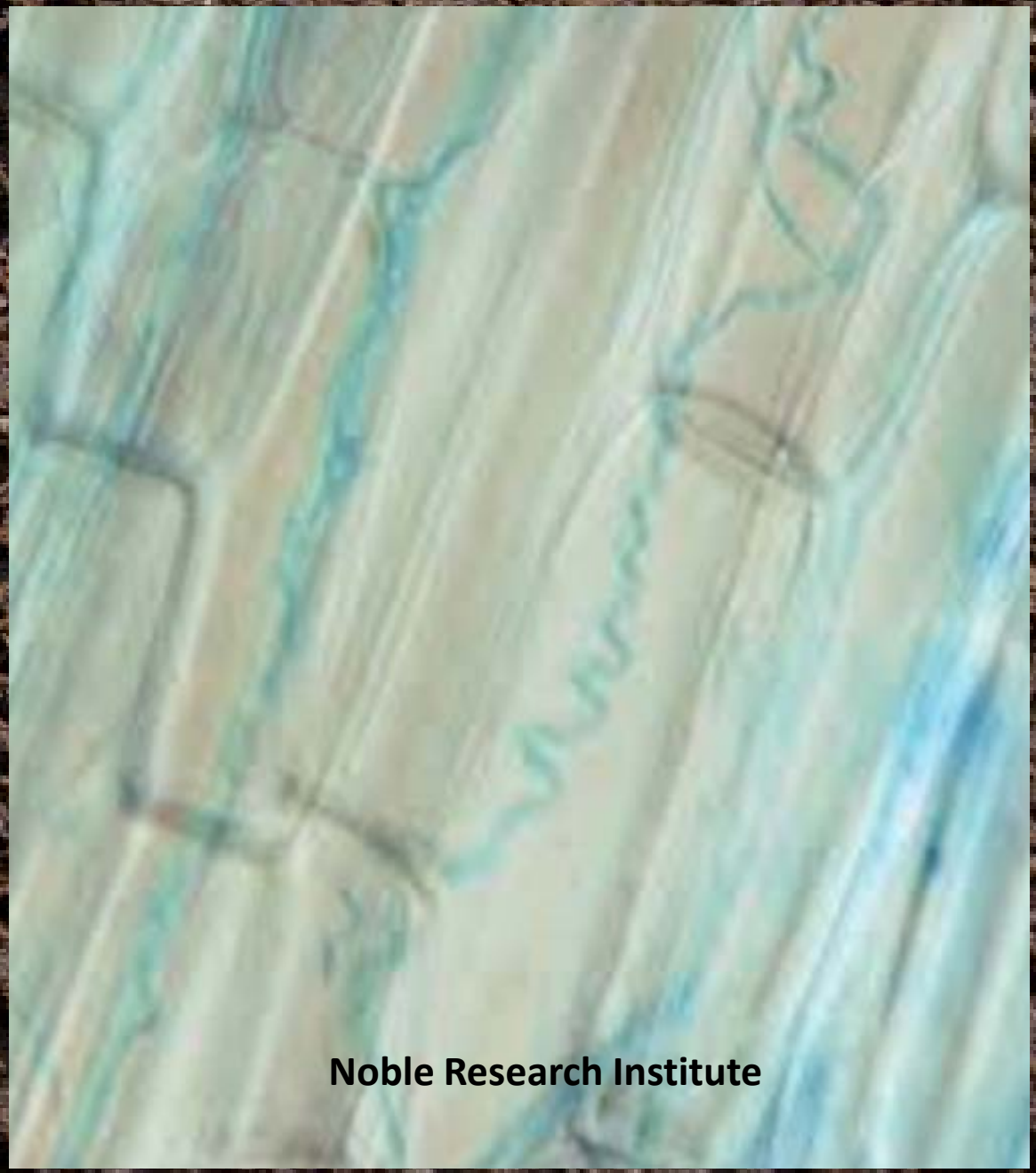
Defense and Protection

The third line of defense is healthy plants producing complex compounds which give natural resistance



Defense and Protection

The fourth line of defense is symbiotic relationships between plants and organisms such as endophyte fungus



Defense and Protection

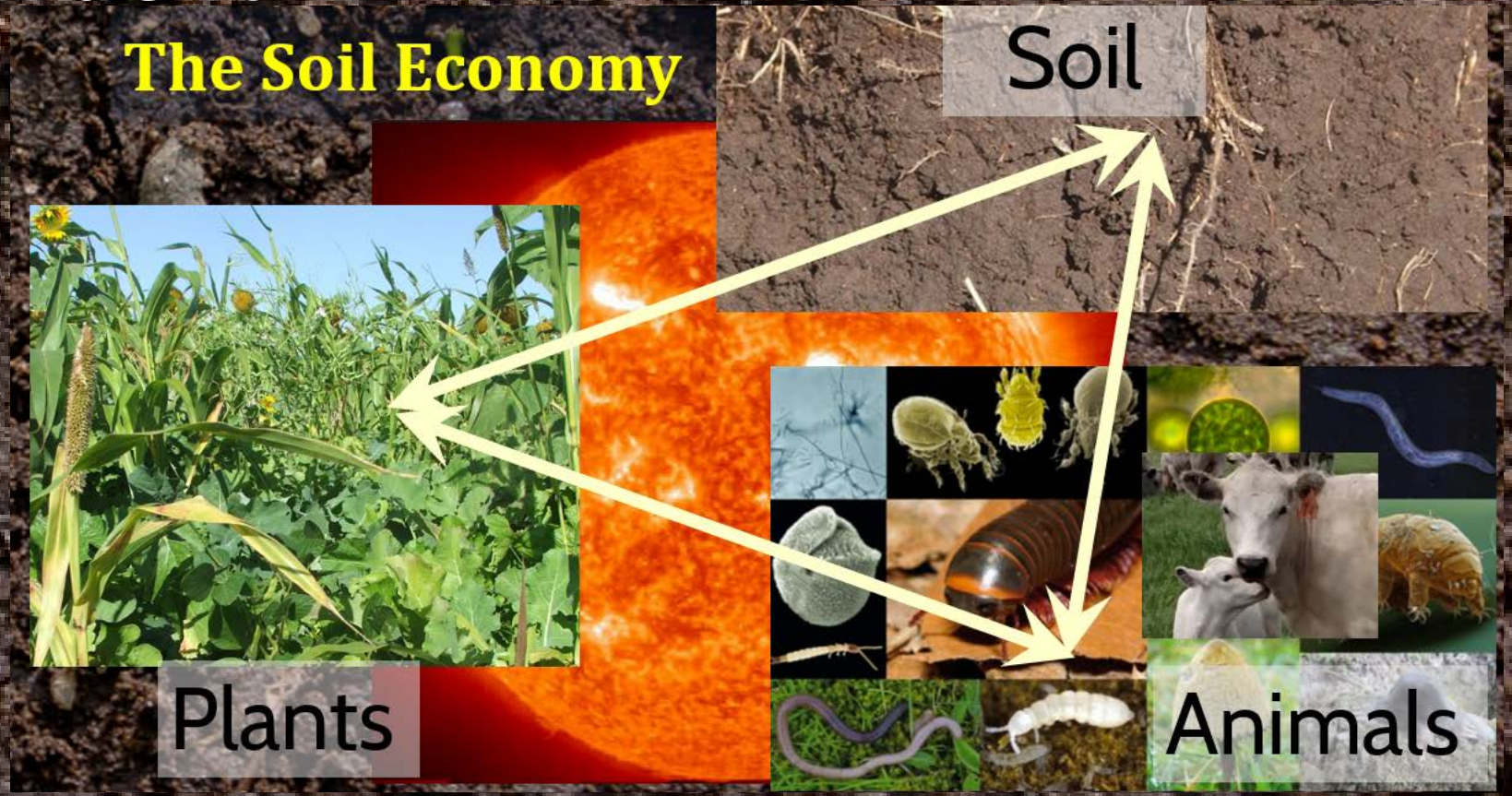
- The fifth line of defense is Diversity - of plants, roots, types, seasons, insects, biota
- Most attackers will focus on only one or two things

Keys To A Healthy ***SOIL!***

- Supply (Producers/ Sellers)
- Demand (Consumers/ Buyers)
- Currency
- Capital
- Energy and Resources
- Infrastructure
- Defense and Protection

Eight Take-Away Points

1. Economies are intricately interconnected and interdependent



Eight Take-Away Points

2. Reduce the amount of welfare you are giving your economy - get everyone working!

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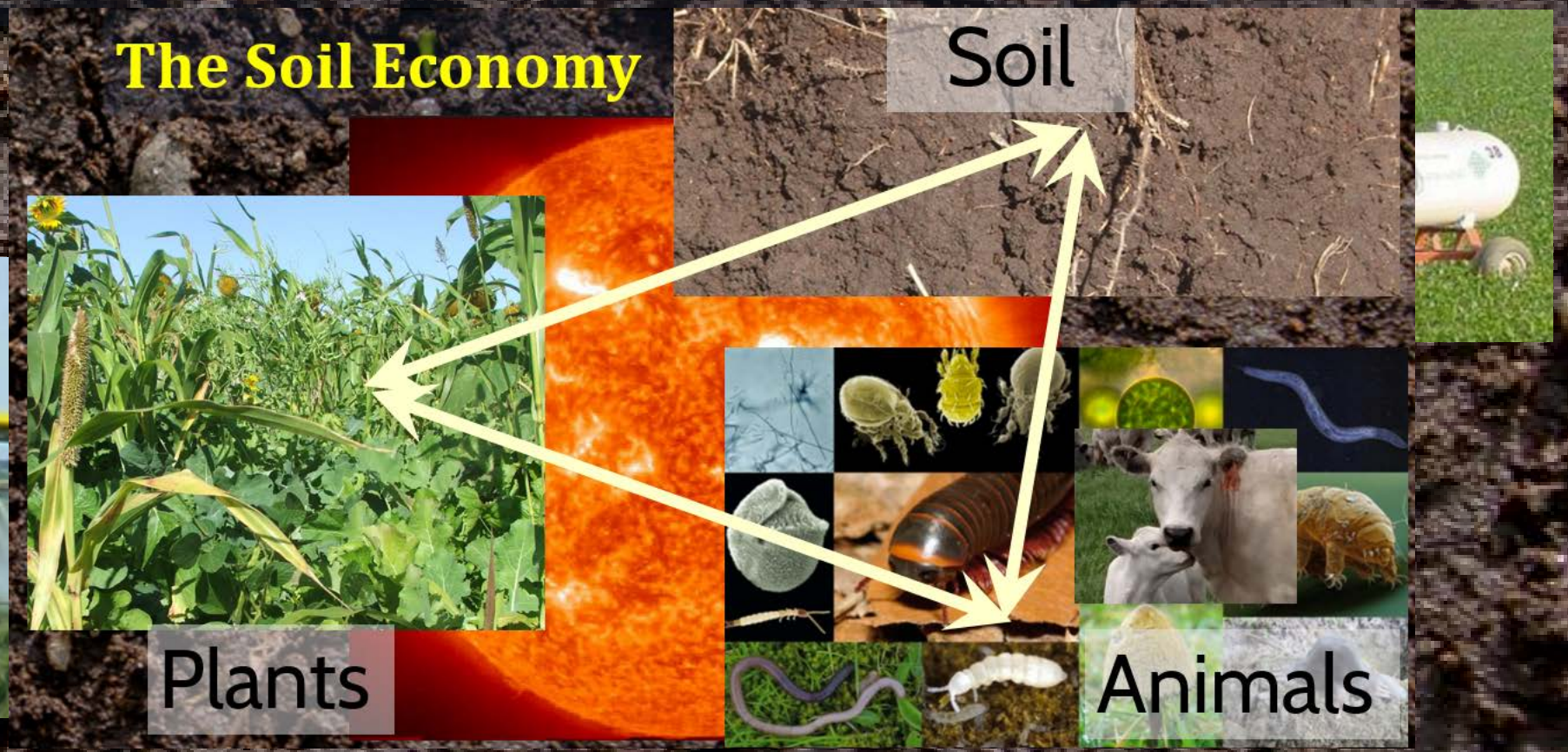
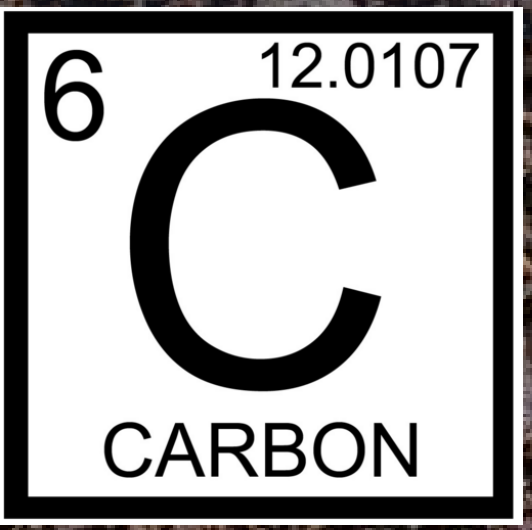
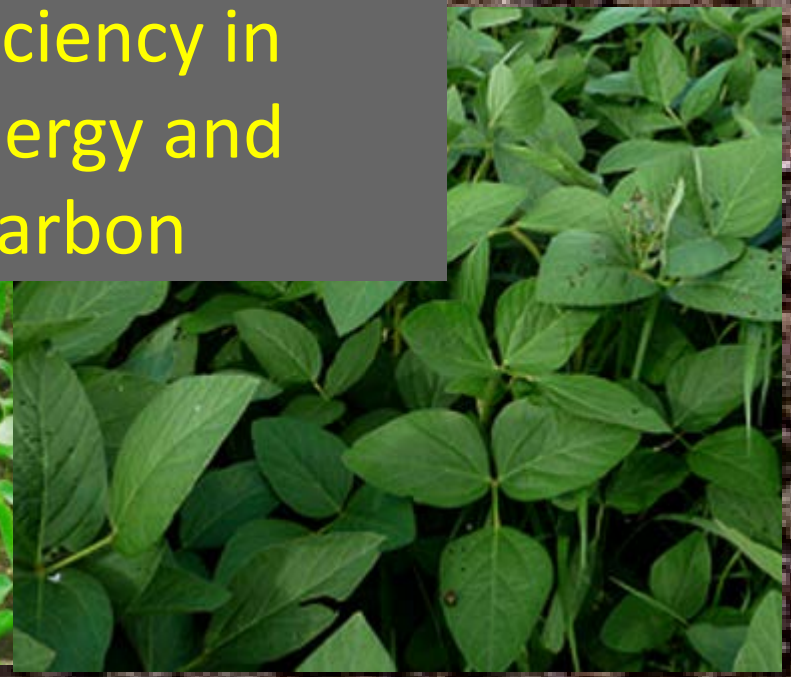


Eight Take-Away Points

3. Increase your “cash flow” of carbon currency



Less than 50% efficiency in collecting solar energy and producing liquid carbon



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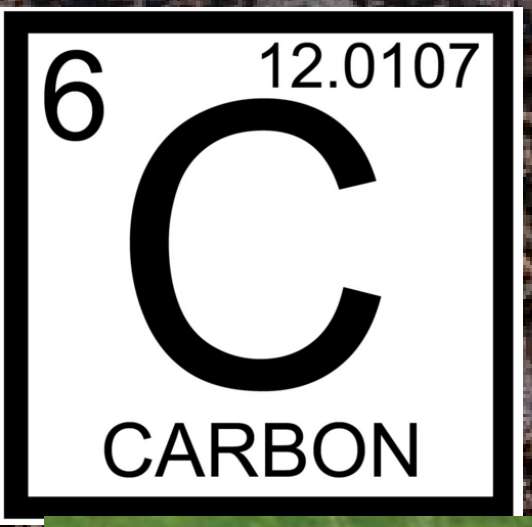

Less than 50% efficiency in collecting solar energy and producing liquid carbon

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4. Make capital investments of long term carbon (organic matter) and don't sell off investments

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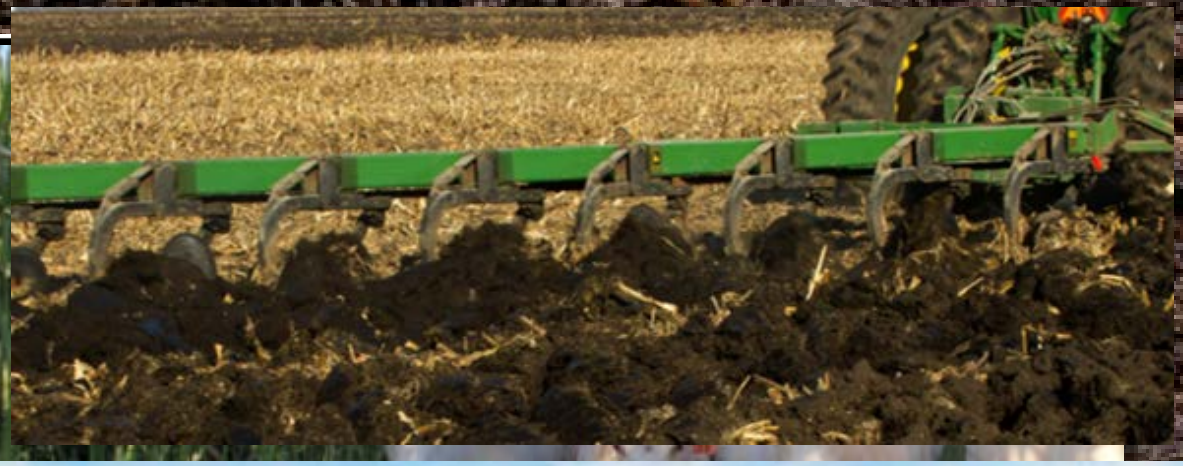

Eight Take-Away Points

5. Take advantage of free tiny workers
- Manufacturing
- Mining
- Transportation
- Communication
- Protection

Biological Diversity

Eight Take-Away Points

6. Build and do not destroy infrastructure - you will really see your economy grow!

Eight Take-Away Points

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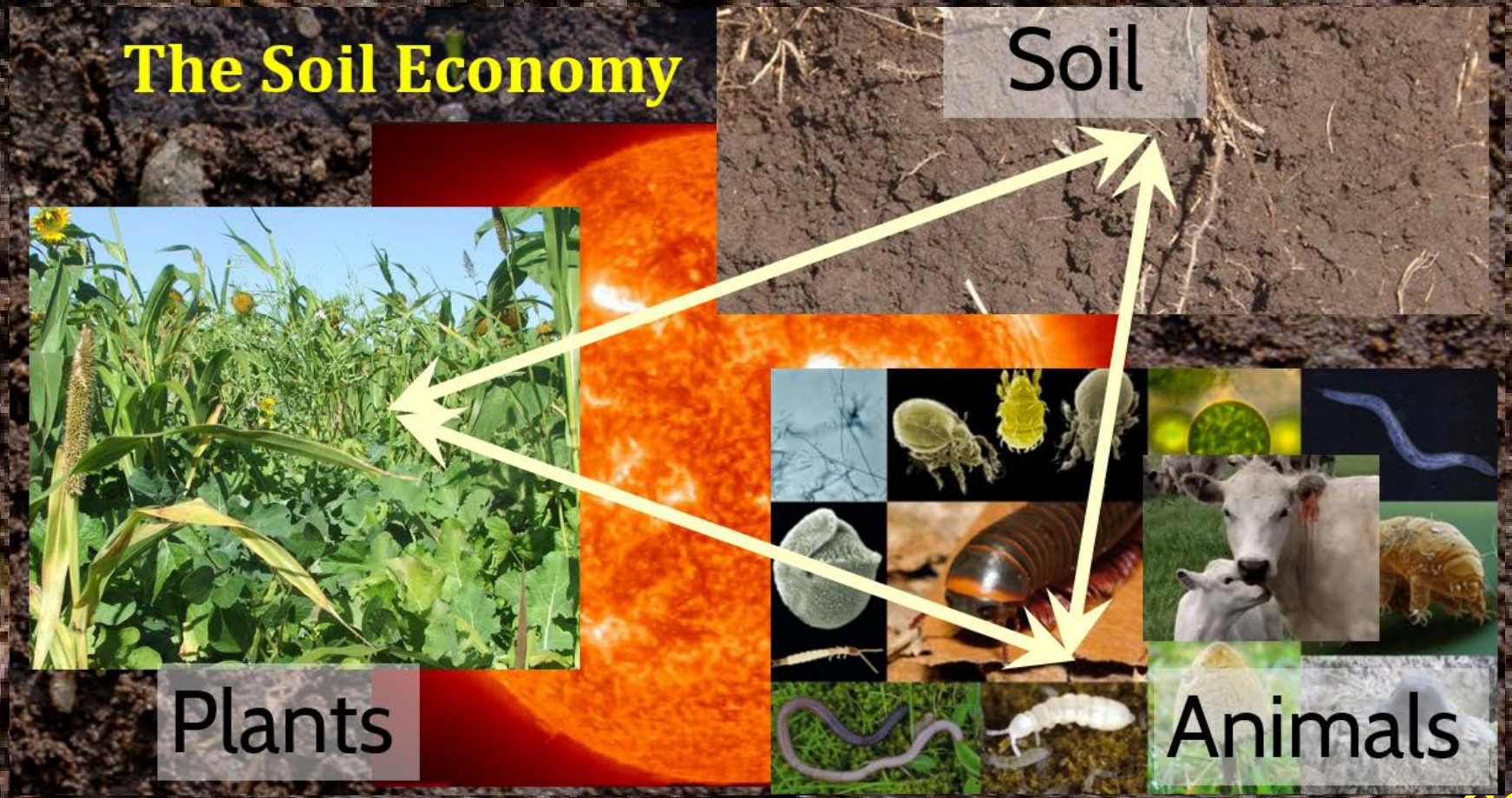
Eight Take-Away Points

7. Protect your economy with soil armor

Eight Take-Away Points

8. Diversity is so very important for a healthy economy - plants, roots, and soil animals



Carbonomic$ – The Wonderful Economy of the Soil