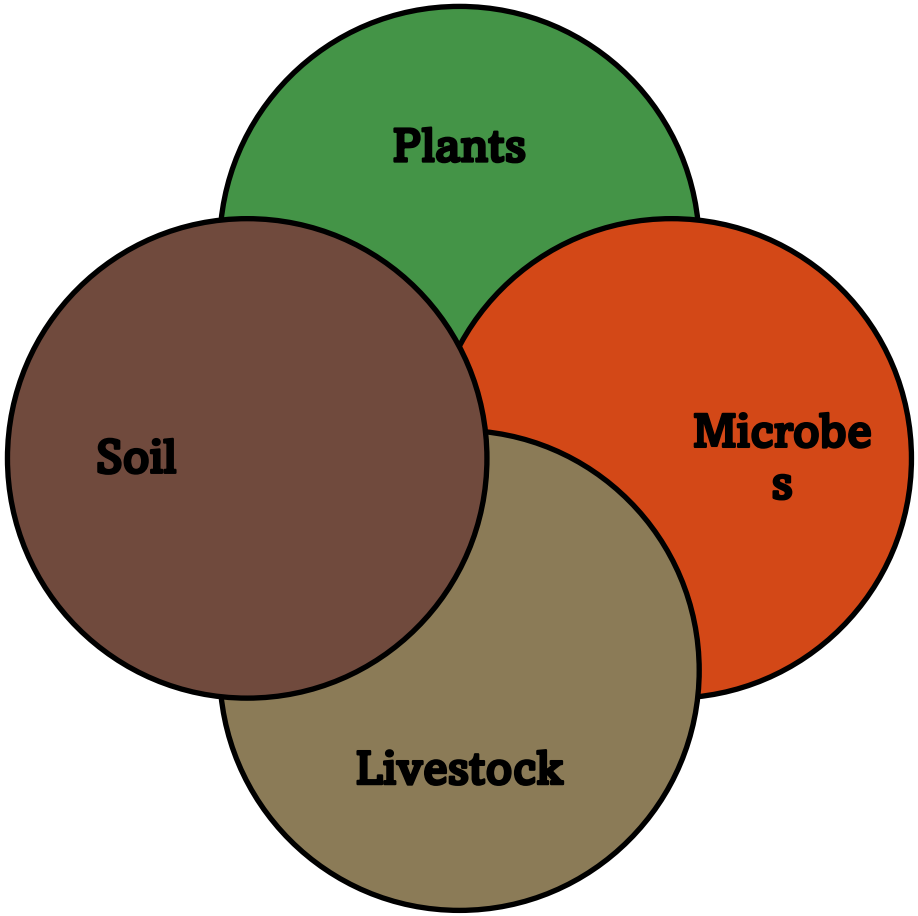
Developing Fertile, Functional Biological Systems

AS PRIMARY PRODUCERS, WE ARE IN THE BUSINESS OF GROWING LIVING THINGS !!!

The Chicken and the Egg

What came first:

healthy plants, active microbes, good soil or happy animals ?



We all know that good soils grow healthy plants, but without plants and their microbial and animal associates, soil would be little more than weathered rock particles

The Basics of Life

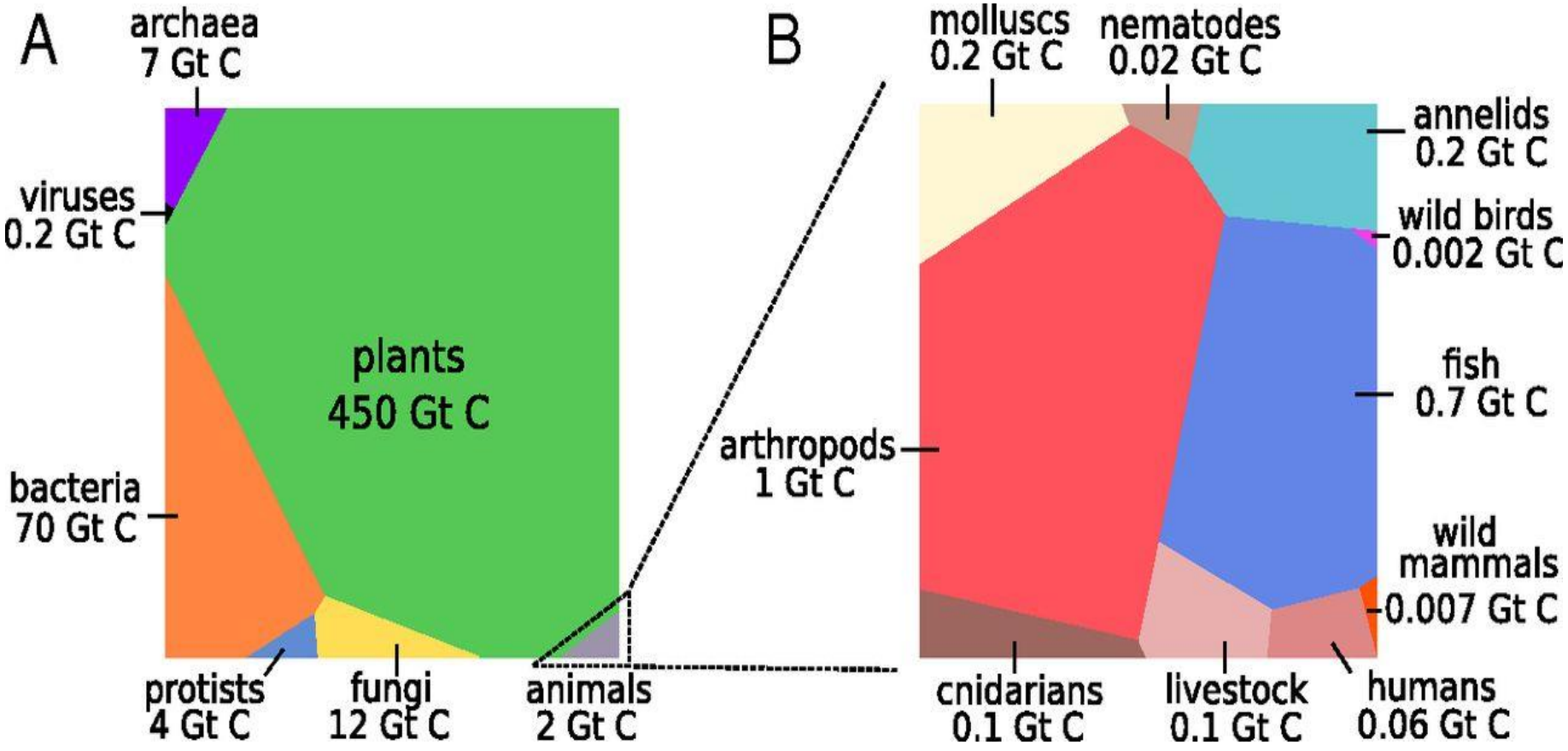
- Every cell in every living thing, from the smallest bacteria to the largest tree, requires the energy and materials needed to grow, function and reproduce

- The energy and materials needed by and for life must be acquired from the environment

- There are a range of mechanisms that different groups of organisms employ, to acquire energy and/or materials and make them biologically available

- Within living communities, the combined function of a diversity of species drives the generation of a collective energy and matter supply

Composition of Global Biomass



https://www.pnas.org/content/115/25/6506

It All Begins With Photosynthesis

Photoautotrophs

Photosynthetic organisms such as plants, algae, and certain bacteria produce more than 180 billion tonnes of organic matter each year from the fixation of carbon dioxide. Half of this biomass is made up of the biopolymer cellulose, which is the most abundant organic molecule on the planet.

Carbohydrates

- Plants are able to convert water, carbon dioxide and sunlight into simple sugar carbohydrates, releasing oxygen in the process

Carbon Dioxide + Water + Sunlight = Carbohydrates + Oxygen

- The energy captured from sunlight and held in carbohydrates is the predominant source of energy used for living.

- Carbohydrates are also the initial molecules of Carbon, Hydrogen and Oxygen from which, along with other elements, all organic materials are built.

Recommended viewing: How to Grow a Planet – Life from Light

Plant Matter

- Living Plants are made up of 80-90% water
- 97.5% of dried plant tissue is still made up of the atmospheric elements C, O, H and N
- The remaining 2.5% is made up of minerals that come from the soil

PLANT DRY MATTER WEIGHT

ELEMENT	% DRY MATTER WEIGHT	COMPOUND IT COMES IN
$^{6}C^{12}$	45%	CO_2
$^{8}O^{16}$	45%	CO_2, H_2O, NO_3
$^{1}H^{1}$	6%	H_2O, NH_4
$^{7}N^{14}$	1.5%	NO_3, NH_4 (Rhizobia $N_2 \rightarrow NH_4$)
4 elements/gases	97.5%	
Mg	0.2%	
K	1%	
Ca	0.5%	
P	0.2%	
S	0.1%	
5 elements	2%	

9 elements = 99.5%

MINERAL PERCENT OF DRY WEIGHT PLANT MATTER – COFACTOR ENZYME ACTIVATORS

Micro Elements	Symbol	Atomic Number	Period	Plant Dry Weight %
Boron	B	5	2	0.002
Chlorine	Cl	17	3	0.01
Manganese	Mn	25	4	0.005
Iron	Fe	26	4	0.01
Copper	Cu	29	4	0.006
Zinc	Zn	30	4	0.002
Molybdenum	Mo	42	5	0.00001
All Other Elements				0.46499
				TOTAL: 0.50%

The Carbon Economy

Carbohydrates are utilised by living organisms throughout the community food chain. In exchange, these organisms perform a range of services that promote plant growth as it is in their best interest to further the production of carbohydrates

- nitrogen fixation
- mineral acquisition
- assemble useful compounds
- deliver nutrition
- retain and cycle nutrient elements
- structure soil
- modify soil conditions
- induce immunity
- provide protection
- distribute products and resources
- etc…

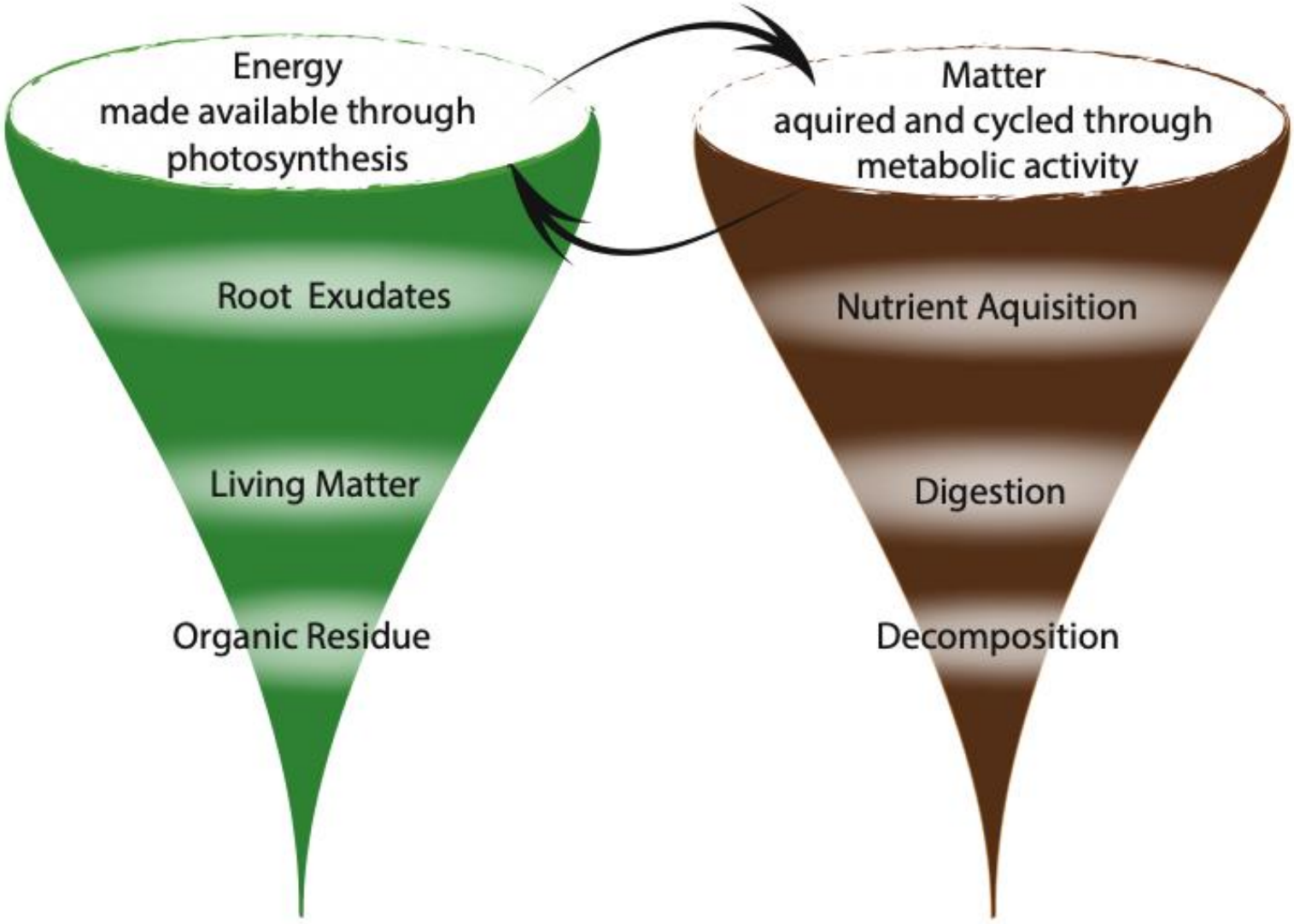
life.org

The capacity of life is determined by the efficiency with which living systems:

organise matter for the harvesting of energy, from sunlight, to fuel living activity

use available energy to acquire material elements, from the environment, and build living biomass

Biological Production Economy



It’s All Happening in the Rhizosphere

It is evident that plants actively cultivate microbes internally, on surfaces and in soils to acquire nutrients, modulate development and improve health

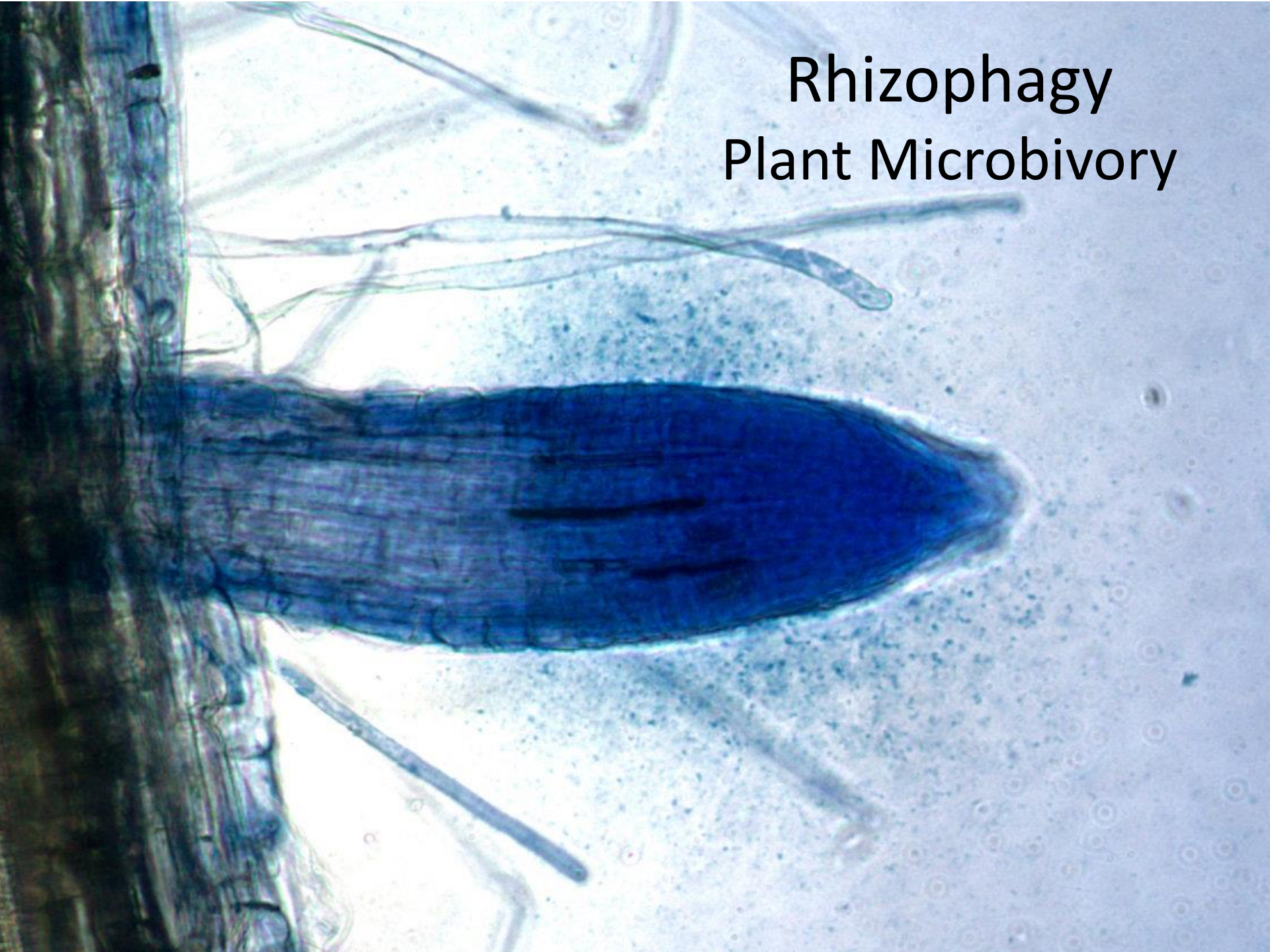
Residue	Weight (μg)	mole%[1]
Arabinose	113.7	13.7
Fucose	377.0	41.8
Xylose	27.1	3.3
Glucuronic acid	28.6	2.7
Galacturonic acid	0.0	0.0
Mannose	27.1	2.7
Galactose	354.3	35.8
Sum	927.8	100

[1]Values are expressed as mole % of total carbohydrate

Diazotrophs

Nitrogen Fixation

Mycorrhizal Fungi
Root Networks


Rhizophagy
Plant Microbivory

Animals

- Consume species that aren't performing well, making resources available for higher production
- Regulate vegetative growth
- Rapidly turnover organic materials
- Incorporate organic materials
- Structure soil
- Deposit fertility through the landscape
- Pollinate plants

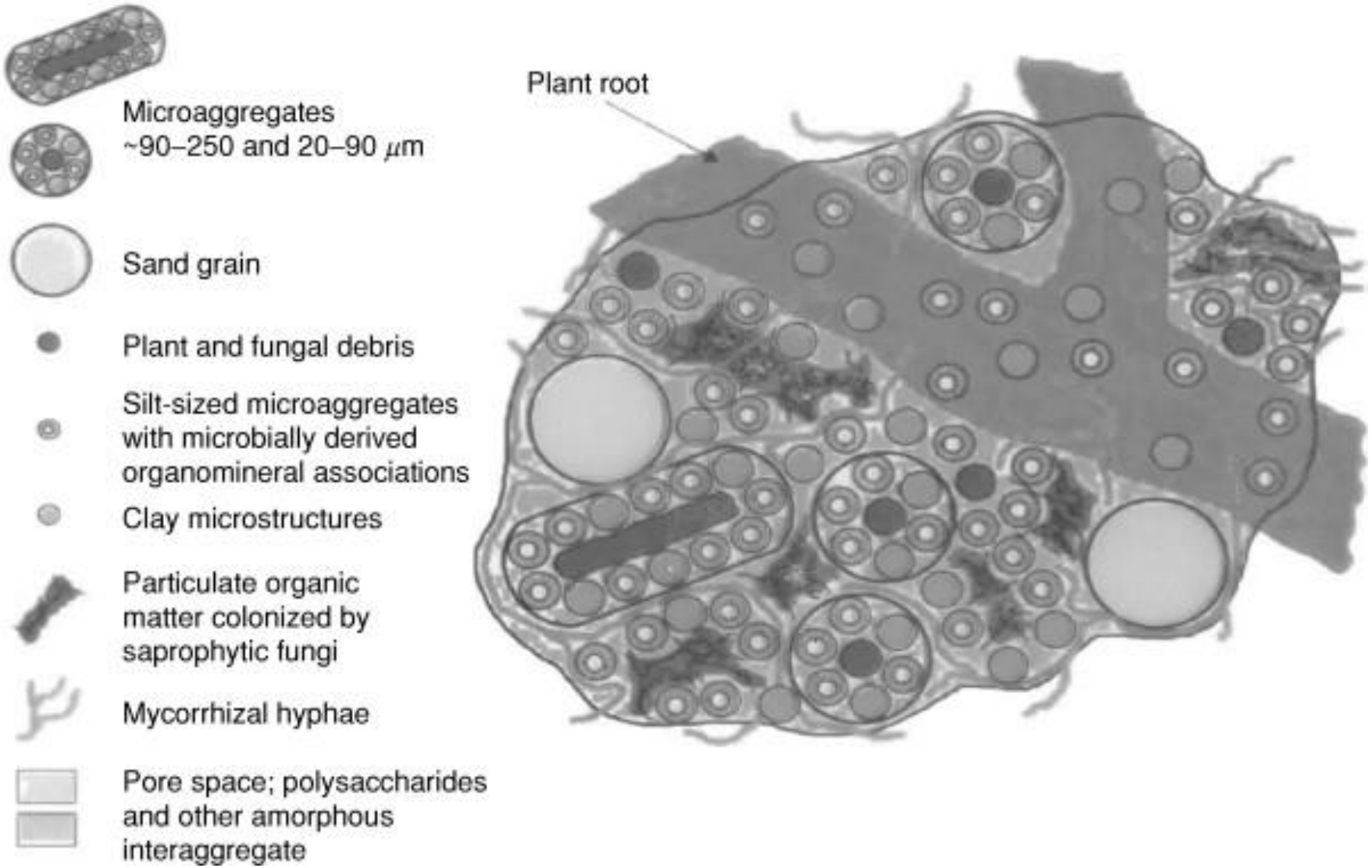
Decomposition

- Decomposers including saprophytic fungi, small invertebrates, worms, protozoa, bacteria, yeasts etc… break down residual materials.
- In the process, they liberate inherent nutrients, making them available once again for plant uptake.
- Other by-products of the decomposition process include humus and bio-chemicals (auto-inducers) that are known to stimulate soil microbial activity, promote growth and trigger root exudation.

A Sense of Humus

- Humus is minute fractions of organic matter that are resistant to further decomposition
- It is predominantly made up of microbial necro mass
- It adheres to the surface of mineral particles, forming stable organo-mineral complexes that persist in the soil for long periods of time
- Humus colloids have a much higher holding capacity than soil particles
- Has fractions that hold onto anions as well as cations
- In the soil, humus coats and bind clusters of fine soil particles together, forming micro aggregates

Aggregation , Aggregation, Aggregation !!!



Soil Structure

- Micro aggregates, along with larger soil particles and organic materials, are bound together by mycorrhizal fungi, plant roots and soil organisms like earthworms, into macro aggregates
- Moisture levels and the state of nutrients remain more stable within the contained environment of soil aggregates, through seasonal fluctuations
- The gaps between aggregates enable water and air, to move down into the soil, and carbon dioxide released through decomposition to escape up and out
- Decaying plant roots and larger soil microbes and animals create channels for air and water as they move up through the soil
- Unlike dirt, there is structure in living soils, making materials far less prone to being washed or blown away


Functional Diversity 101

Variety is the Spice of Life

It is well established that plant diversity is an important characteristic of robust and resilient living systems

- Different plant types host and associate with unique microbial and animal populations
- Plant diversity promotes microbial and animal diversity, above and below ground
- Diversity entails better access to and production of resources and a greater range of services
- Diverse living networks enable efficient and widespread exchange of goods and services
- Communities as a whole, benefit from the inherent traits various species bring to the table

Multi Species Cover Crops

Putting it to the Test

Peas in Mix

Peas Alone

No Fert ?

Fert ?

Planting Multi Species Cover Crops

- In our Mediterranean climate It's easier to sow cover crops in early autumn when there is reliable rainfall on the way
- After the dry summer, there isn't an active stand of existing pasture plants and weeds to deal with
- Weed management at establishment is just as important as it is when you sow other crops
- Weed management strategies include dry seeding before autumn weeds germinate (with the season rain break) or carrying out some sort of weed control once weeds have germinated i.e. shallow cultivation, herbicide application…
- Planting and growing conditions are better earlier in the season, before it gets too cold and wet

Cool Season Annual Cover Crop Species

Grasses

- Oats
- Rye corn
- Barley

Legumes

- Field Peas
- Vetch
- Fava Beans

Broadleaves

- Daikon Radish
- Linseed

Setting the Scene for Pasture Diversity

- It must be understood that there may initially be some production trade offs during the establishment of multispecies pastures.
- The successful implementation of a multispecies pasture program may take a number of seasons and can only be maintained with appropriate management

Annual Pasture Species

Grasses

- Ryegrass
- Forage Barley/Oats

Legume

- Balansa, Persian, Sub Clovers
- Medics
- Seradella

Broadleaves

- Forage Brassicas
- Beets

Establishing Perennials

- For the establishment of perennial species, the soil needs to be in a healthy enough state to foster strong growth over the wet season and hold onto enough moisture in the dry season for them to survive their first summer
- Perennials, especially perennial grasses, are notoriously slow to get going and don't fare well with competition so measures must be taken to manage faster growing annual weeds and pasture species
- We can use annual cover crops in proceeding seasons to improve the soil and create a more favourable species profile for the establishment of perennial species
- We need to allocate longer periods of time between graze events with perennial species, as they require more time for recovery, than annual pasture species

Perennial Pasture Species

Grasses

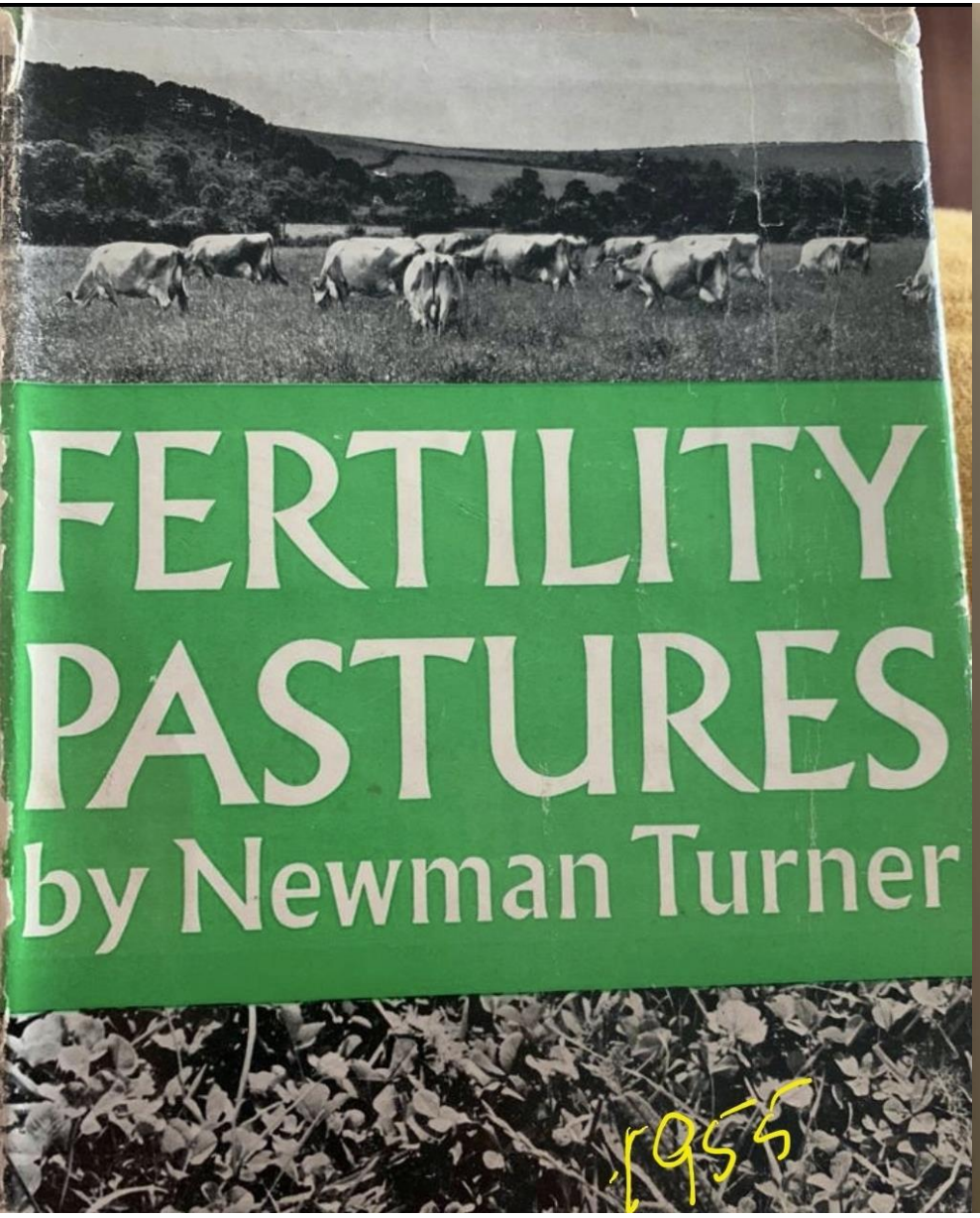
- Cocksfoot
- Phalaris
- Fescue
- Perennial Ryegrass

Legumes

- White, Red and Strawberry Clover
- Lucerne

Broadleaves

- Chicory
- Plantain



FERTILITY PASTURES

by Newman Turner

1955

Herbal Ley Mixture for very Thin, Dry Soils

(and to resist extreme drought conditions)

	lb. an acre
Cocksfoot, S.143	5
Crested Dogstail	4
Tall Fescue	4
Lucerne	4
Kidney Vetch	4
Chicory	4
Burnet	4
Ribgrass or Plantain	4
Late-flowering Red Clover	2
Alsike	2
Trefoil	2
S.100 White	1
Yarrow	½
American Sweet Clover	2
Broad-leaved Plantain	1
	43½

1955

The main essential of a mixture for thin soils, soils overlying and close to the rock, and in excessively dry countries, is that it should contain a predominance of the deepest-rooting varieties available, consistent with their production *above* the ground. This makes the most of such little moisture as is present in the deeper subsoil; and where the subsoil is largely rock some penetration of the rock can be achieved by the more powerful of the deeper rooters.

Every one of the ingredients of this mixture is an exceptionally deep rooter, except the clovers S.100, Trefoil, Alsike and Late-flowering Red—and even Alsike and Trefoil are reasonably drought-resistant. All prosper on the thinnest soils; but the

Fodder Trees

- Acacias
- Cape Leeuwin wattle
- Tagasaste
- Poplars
- Willows
- Casuarinas
- Carob
- Mulberry
- Oaks
- Ash
- etc…

Herbivores

Nature's Way

What is best for livestock health and production is also what's best for pasture composition and growth, and soil health

Mob Grazing

The number of animals, and space and time allocated to grazing events can be managed to:

- avoid selective grazing
- better utilize forage
- evenly distribute manure and urine
- minimize compaction
- avoid grazing fresh regrowth
- give grazed plants time for adequate plant recovery

Stockpiling Forage

Letting plants grow without grazing during the growing season:

- creates lots of lignified biomass which provides protective cover, habitat and food for a diversity of life, above and below ground over the hot, dry season
- gives desirable species adequate time to establish and set seed
- enables the development of extensive root systems and building of soil at depth
- Provides us with a cheap source of non growing season feed, especially legume species (may need to supplement protein to meet minimum requirements)
- gives us a source of fiber at the beginning of the growing season when new growth is low in fiber and high in sugar and protein
- Paddocks that were stockpiled the previous growing season get away to the best start the following growing season

DIY Microbial Cultures

Composting & Vermiculture

Bio Ferments

Plant Endophytes

- These microbe groups are active in living plants but can survive and spread in dormant states between growing seasons
- Reproductive material is found in root fragments, seeds and soil around plant roots
- Commercial inoculants can be used to introduce endophytes into new growing environments
- Different plant species are hosts to select populations of endophytes
- Legumes host certain rhizobia species i.e. peas, beans, clovers etc…
- Some annual plant species host a wide range of endomycorrhizae fungi species i.e. sorghum, millet, oats, sunflowers etc…
- Some tree families host a wide range of ectomycorrhizal fungi species i.e. Pinaceae, Betulaceae, Fagaceae, Myrtaceae etc…

Biological Planting Treatments

A Good Start in Life

Biostimulants

Any substance or microorganism applied that stimulates biology as a means to enhance plant nutrition, stress tolerance and crop quality traits, regardless of its nutrient content

- Humic substances
- Amino acid hydrolysates
- Seaweed extracts
- Microbial cultures
- Compost
- Manure
- Molasses
- Milk
- Chitosan and other biopolymers
- Wood vinegar
- Etc…

Bio-centric Practices

Benefit	Hinder
• Soil coverage with living plants and organic residue	• Bare fallow, burning stubble, overgrazing
• Diversity, stacked enterprises	• Monoculture production
• Bio-logical nutrition, P&D management and weed control	• Synthetic fertilizers, herbicides, pesticides and fungicides
• Traffic management	• Compaction
• Conservation, non inversion and no till practices	• Heavy tillage, especially in the warm dry season
• Mob grazing	• Set stocking

Thank You

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