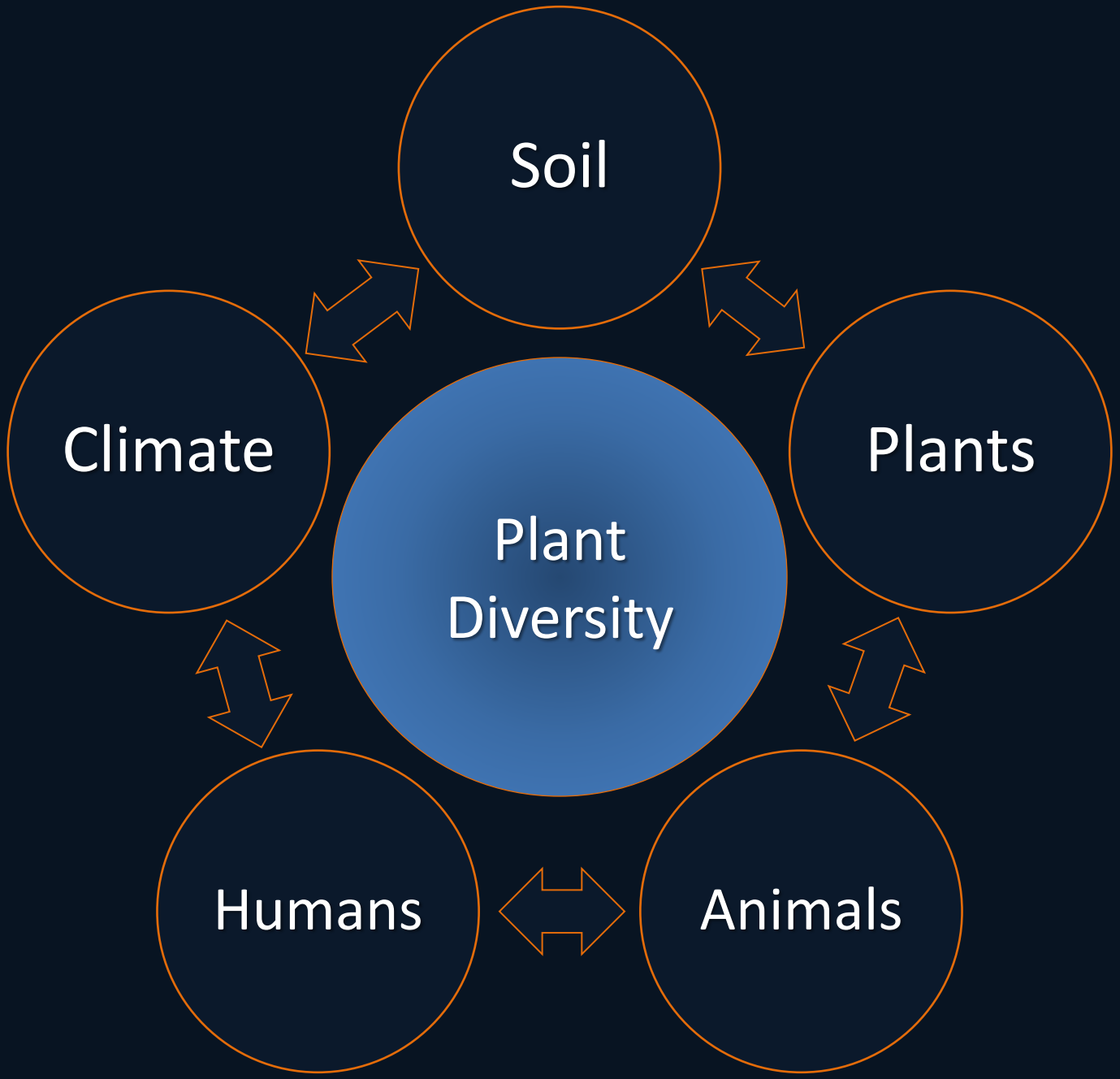
Palates Link Animals with Landscapes

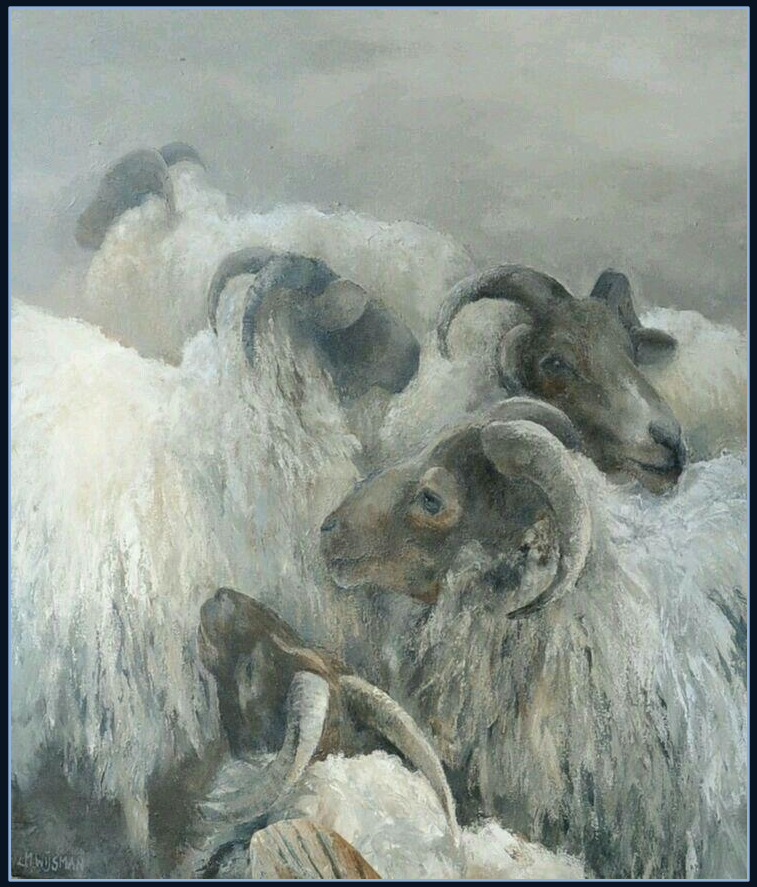
Plant Diversity, Livestock Health


Soil
Climate
Plants
Plant Diversity
Humans
Animals


Food for Thought

Why do goats avoid eating the more nutritious new growth of blackbrush?

Why do goats eat woodrat houses?



"I guess that just goes to show domestic animals lack nutritional wisdom."

Nobody must tell bacteria, or wild insects, fish, birds, or mammals how to eat, develop, and replicate.

Herbivores are challenged to select diets from hundreds of species of grasses, forbs, shrubs, and trees, each unique biochemically.

Some species and plant parts are nutritious, others are toxic.

Individual plants can be nutritious or toxic depending on the time of the day, week, and season…

…and on the resources available in the environment where the plant is growing.

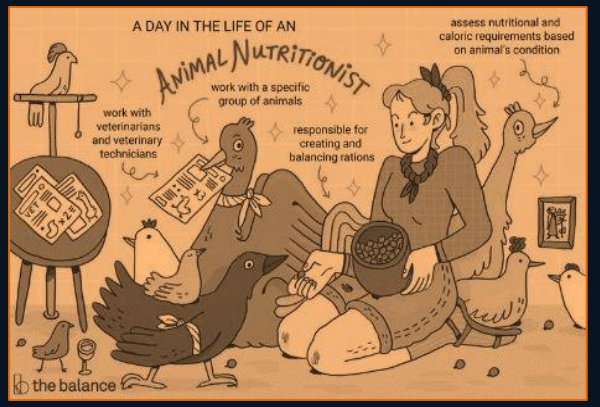
Plants respond biochemically to sunlight, moisture, nutrients, other plants, herbivory.

Herbivores respond to the chemical characteristics of plants.

amygdalin

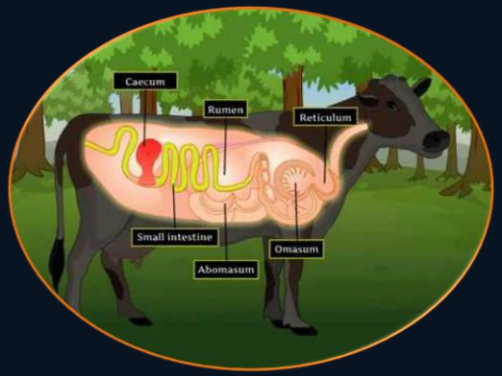
How do animals know how to meet needs for nutrients and medicines?

Nutritionists



Pharmacists

Veterinarians



Wholesome Foods

Wisdom of the Body

Flavor Feedback

Social Cultural

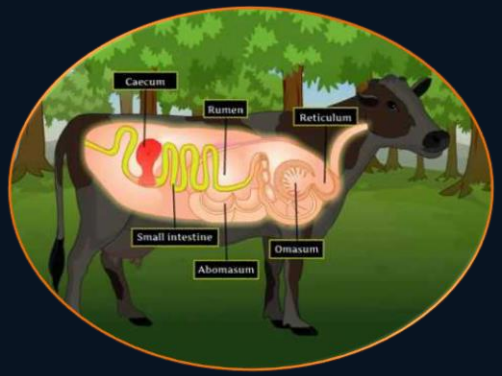
More Than a Matter of Taste

Flavor
Feedback

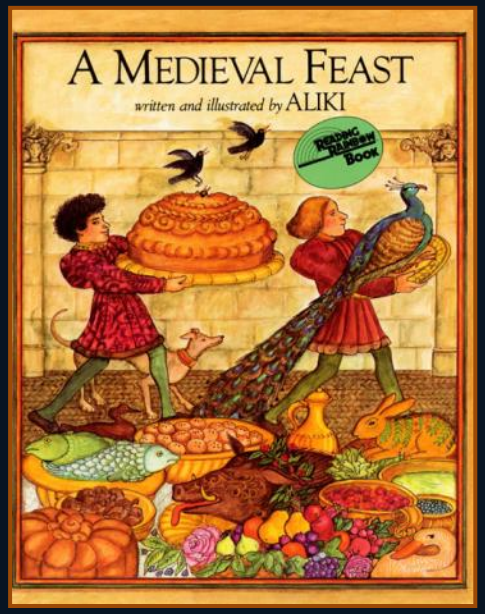
Wisdom
of the Body

Wholesome
Foods

Social
Cultural



What is Palatability?




OPEN
Picante Sauce
Gerber
2ND FOODS

Food Preference

Palatability is more…

…than a matter of taste

Feedback Cells/Organ Systems

Primary Compounds

Secondary Compounds

Nutrients Increase Palatability

Conditioning	Group 1	Group 2
• Odd days • Even days	apple → water maple → nutrient	maple → water apple → nutrient

Testing	Choice between apple and maple

What are calories?

Calories are little units that measure how good a particular food tastes. Fudge, for example, has a great many calories, whereas celery, which is not really a food at all but a member of the plywood family, provided by mother nature so that we would have a way to get onion dip into our mouths at parties, has none.

Dave Barry

Metabolically Mediated Flavor-Feedback Associations alter Liking for Food as a Function of Need

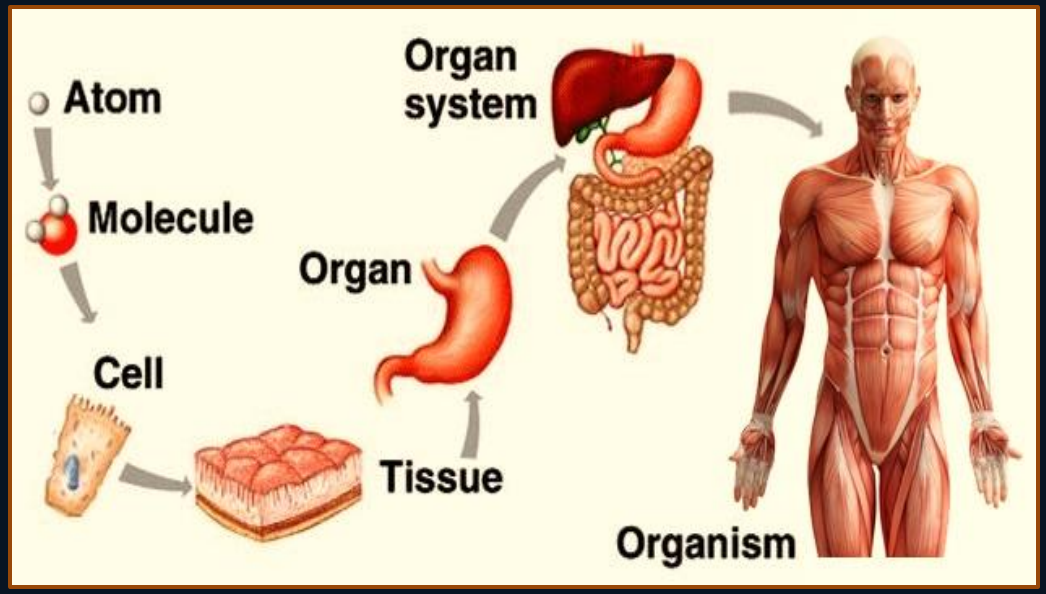
Primary Compounds

- Energy (cellulose, starch, glucose, VFAs)
- Protein (NPN, rumen degradable, bypass)
- Minerals (Na, P, Ca, Se, S)
- Vitamins (E)

Secondary Compounds

- Phenolics
- Alkaloids
- Terpenes
- Nutrients
- Medicines

Flavor-feedback associations involve phytochemicals interacting with cells and organ systems, including the microbiome, in a dynamic network of communication.



These relationships -- mediated by nerves, neurotransmitters, peptides, and hormones -- are the basis for the nutritional wisdom of the body to meet needs for energy, protein, amino acids, minerals, vitamins, and to self-medicate.

Why do goats avoid eating the more nutritious new growth of blackbrush?

Goats learn to avoid current season's twigs high in tannins.

Why do goats eat woodrat houses?

Woodrat houses have many rooms…

…including a bathroom soaked in urine...

Of 18 groups
of goats during
3 winters,
only 1 group
learned to eat
woodrat houses.

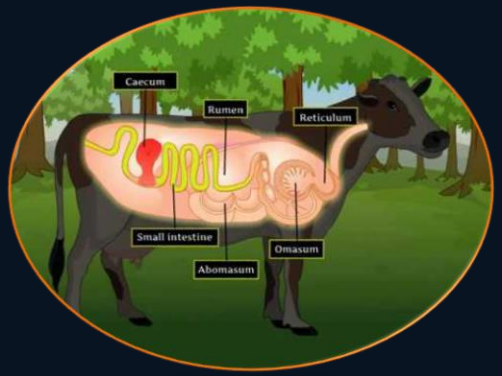
Transgenerational Linkages to Landscapes

Social
Cultural

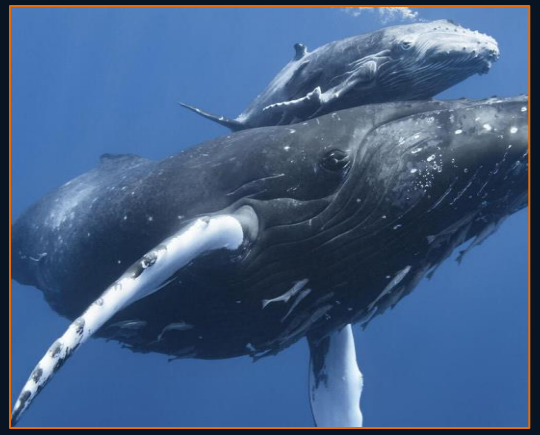
Wisdom
of the Body

Wholesome
Foods

Flavor
Feedback



Natal experiences affect food and habitat preferences in a broad range of animal taxa including insects, fish, birds, and mammals (Davis and Stamps, 2004).



Mother's Lifelong Influence on Diet and Habitat Selection

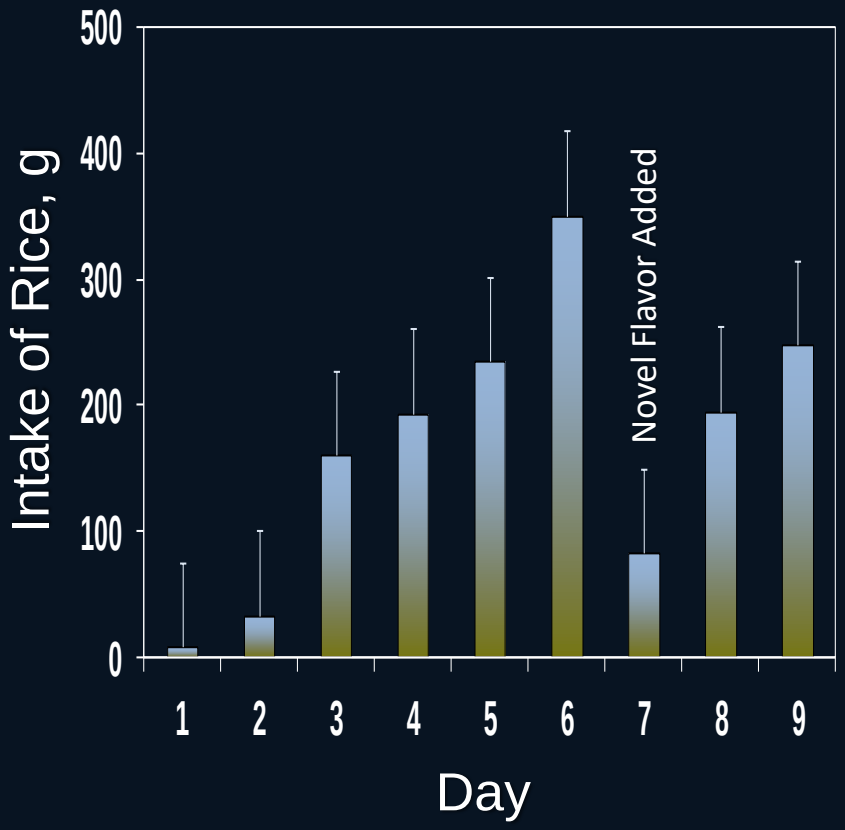
In Utero
Mother's Milk

Mother as a Model

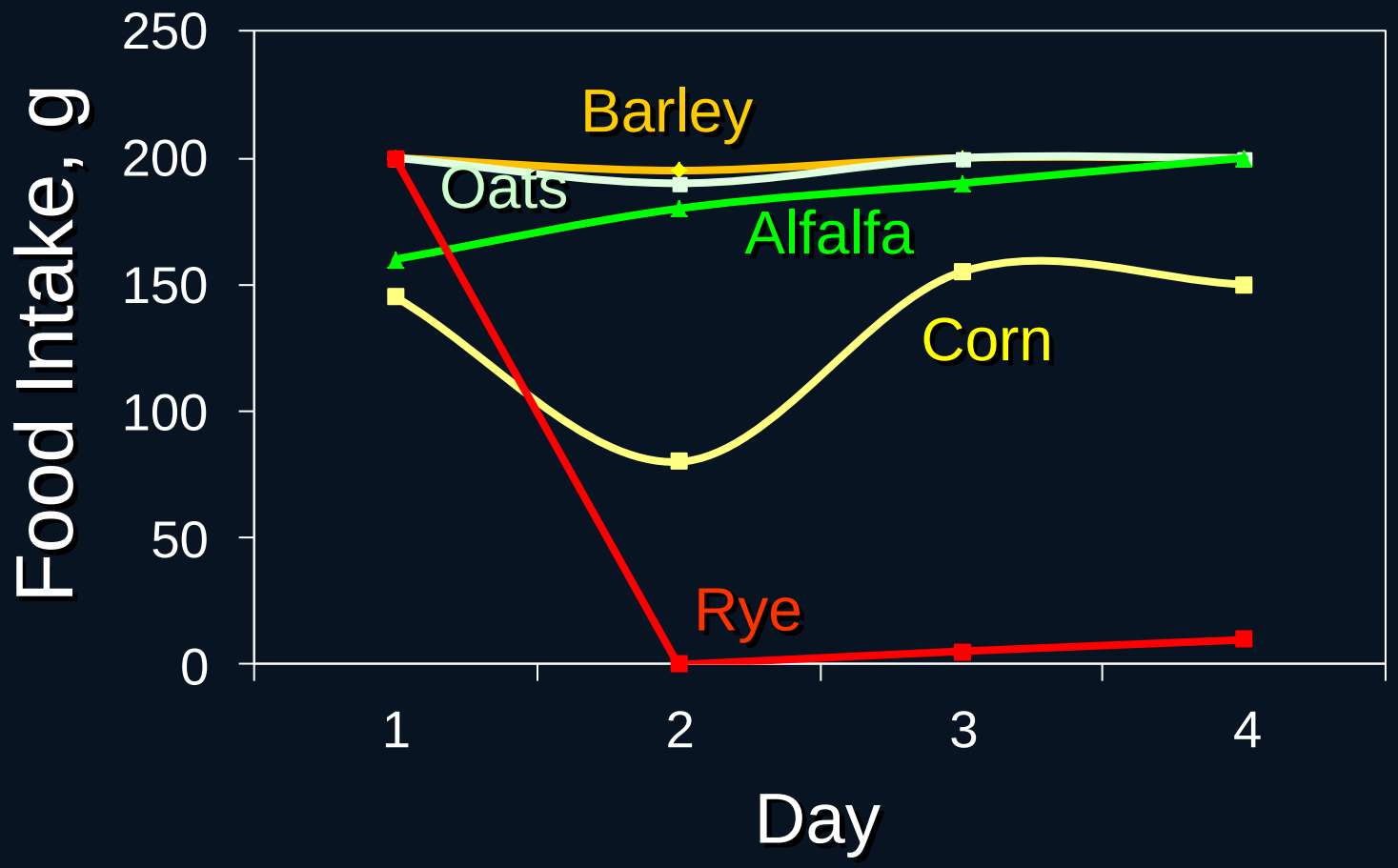
Familiar-Novel Dichotomy

What plant is this and is it poisonous?

If nutritional state is adequate, familiarity breeds content, novelty breeds contempt, animals are neophobic.



Familiar-Novel Dichotomy



Ruminant nutritionists, have been studying the links between microbes and herbivores for over 75 years.

Oxalates

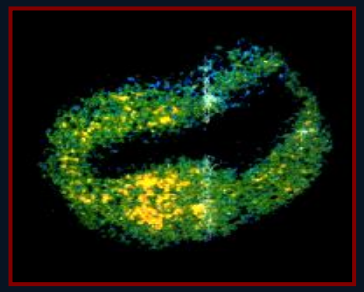
Mimosine

A diet rich in secondary compounds stimulates diverse microbial populations that can degrade secondary compounds, thus enabling herbivores to eat plants they otherwise could not eat.

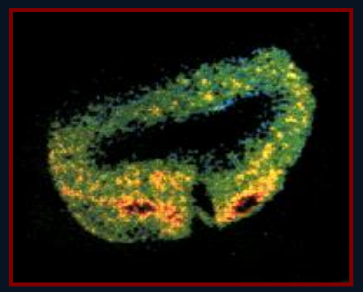
Learned patterns of behavior enable experienced animals to better use forages in a landscape.

Bitterbrush as an appetizer helps the sagebrush go down.

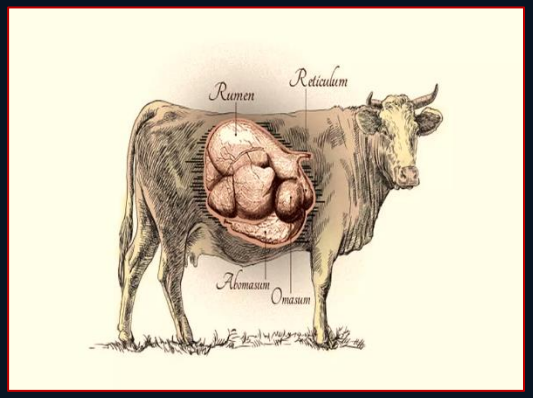
Experiences influence gene expression, which influences form, function, and behavior and in ever-changing environments ensure no two individuals are ever alike.



Altered Neural Responses



Enhanced Kidney Function



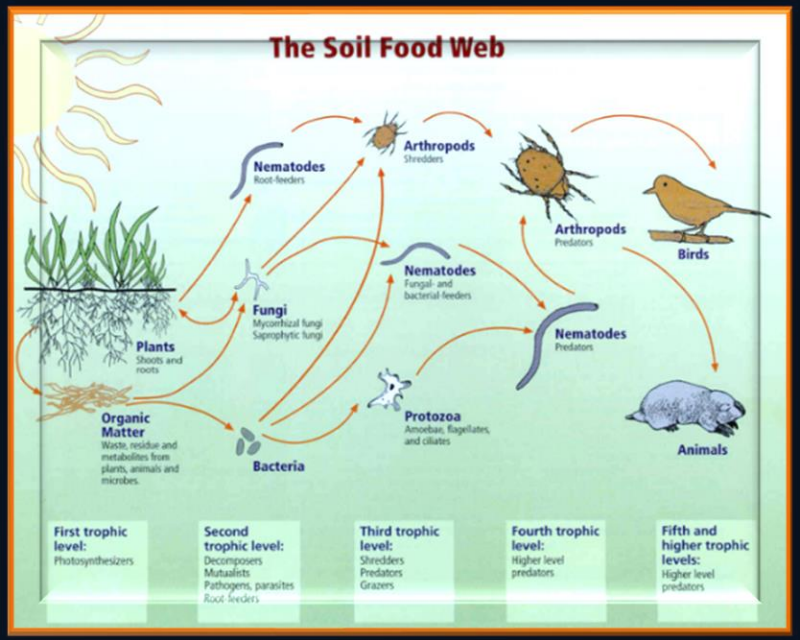
Altered Rumen Development

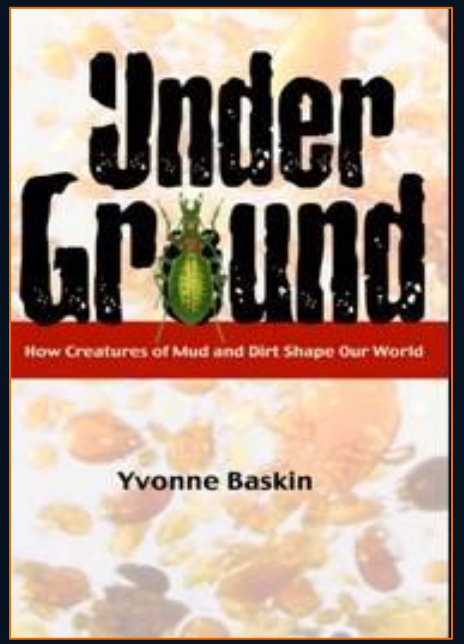
Plant Diversity
Livestock Health

We're all connected...

Resource Availability ⇔ Soil Attributes ⇔ Plant Diversity and Chemistry

Nourishing health from the ground up.





Primary Roles for Secondary Compounds

Sun Screen
Antioxidants
Adaptive Coloration
Attract Pollinators
Fruit Eaters

Allelopathy
Drought Resistance
Persistence

Recovery Injury
Regrowth Grazing
Defense Grazing

Plant mixtures can influence concentrations of secondary compounds

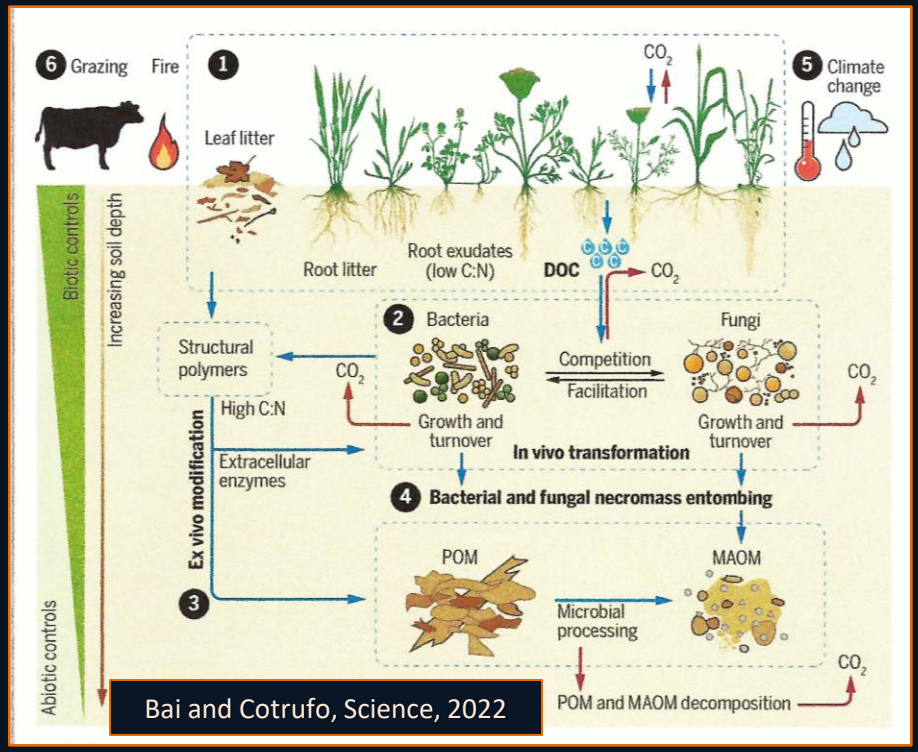
Growing fescue with alfalfa increases alkaloids in fescue

Growing trefoil with alfalfa decreases tannins in trefoil

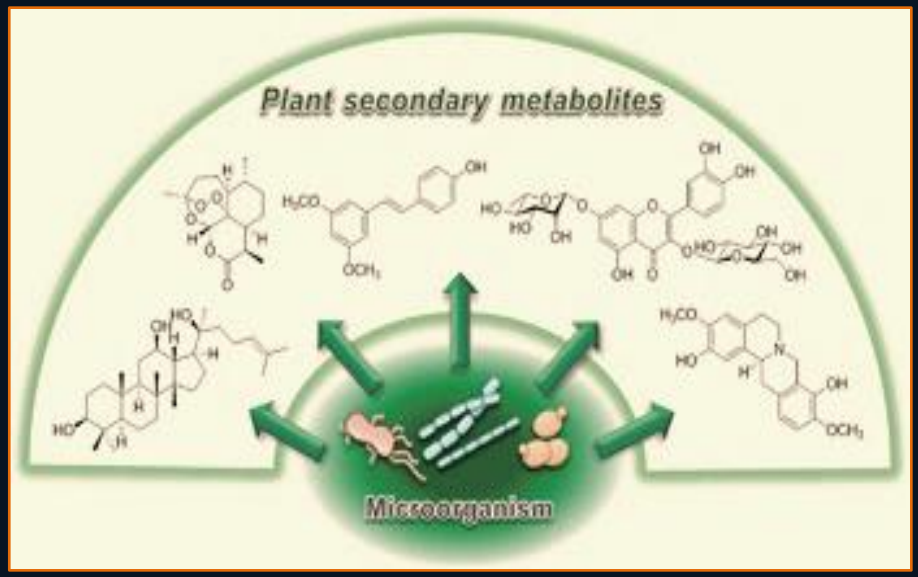
After 23 years, plots with 16 perennial plant species have ~150 to 370% more N, K, Ca, and Mg in plant tissues relative to monocultures of the same species.
(Furey and Tilman PNAS 2021)

They also have ~30 to 90% more water- and nutrient-holding carbon in soil.

Each plant species harbors a unique rhizosphere community. Diverse mixes of species interact in ways that enhance the soil microbiome, nutrient availability, and plant chemistry.



Bai and Cotrufo, Science, 2022



Nutrient inputs from ***living roots*** are 2-13 times more efficient than ***litter*** inputs at forming both slow-cycling, mineral associated soil organic carbon (SOC) and fast-cycling particulate organic carbon.

Nutrients from roots stimulate growth of microbial populations. Dead microbes can make up over 50% of all SOC, adhering to mineral surfaces and forming soil aggregates.

Plants turn dirt into soil and diverse mixtures of plants turn soil into homes for herbivores, carnivores, and omnivores below and above ground.

Nothing is more important for health through nutrition than landscapes with a variety of plants for herbivores, omnivores, and carnivores above and below ground.

Landscapes with diverse arrays of plants are nutrition centers and pharmacies…

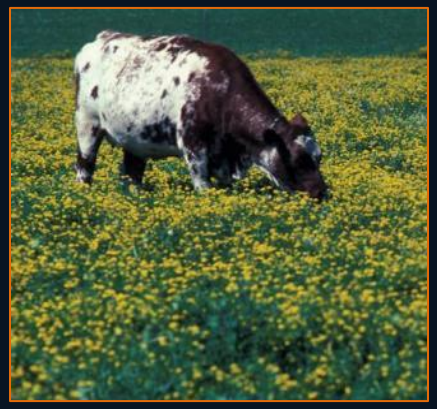
…with vast arrays of phytochemicals…

We've come to rely on antibiotics and anthelmintics to treat diseases and parasites.

Wild animals use phytochemicals to self-medicate.

Two Ways to Self-Medicate Therapeutically

Tannins for Bloat (distention)



Bentonite for Acidosis (nausea)

Polyethylene glycol for tannins

Animals Learn to Self-medicate

Di-Cal for oxalates

Azadirachtin for external parasites

Tannins, terpenes, alkaloids for internal parasites

Two Ways to Self-Medicate

Therapeutically

Prophylactically

While 3 to 5 plants make up the bulk of the diet, herbivores often eat 50 to 75 plants in a meal.

Health is enhanced when livestock graze phytochemically rich mixes of grasses, forbs, shrubs, and trees.

Health improves when livestock graze diverse mixes of plants compared with monocultures. They gain weight more efficiently (with less emissions of CH_4 and NO_3) and they can reach slaughter weight as quickly as animals in feedlots.

Compared with lambs whose mothers ate only ryegrass during pregnancy, lambs whose mothers ate ryegrass, chicory, plantain, red clover, and alfalfa…

…had less oxidative and metabolic stress at lambing and they birthed heavier lambs with lower levels of cortisol in wool.

A diverse diet increases lamb growth and carcass yield.

Pasture Design

Mixtures versus Patches


19 kg DM

Increases in Production on Grass-Clover Pastures

Sheep

Increase of 25% in intake (265 g/day)

Dairy Cattle

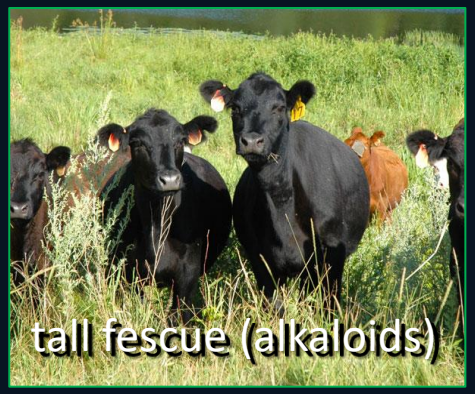
Increase of 11% in milk production (2.4 kg/cow/day)

Livestock producers are finding morbidity and mortality decrease…

Phytochemicals have antioxidant, anti-inflammatory, immunomodulatory, and prebiotic properties that result in robust animals tolerant of disease.

Why do cattle perform so well on the mix of plants from hell?

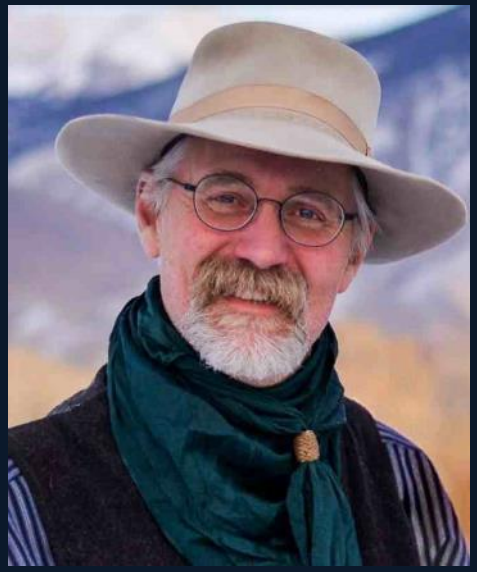
Biochemically diverse diets enable sequences that compliment one another.



An appetizer of trefoil (sainfoin) helps the fescue go down.

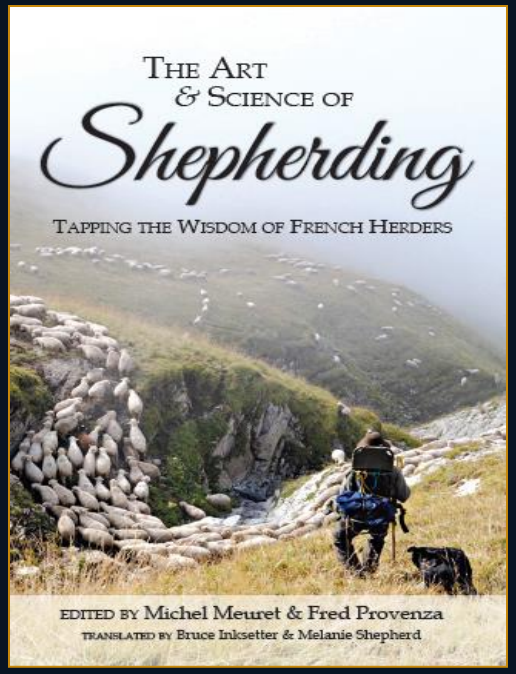
An appetizer of bitterbrush helps the sagebrush go down.

Glenn Elzinga



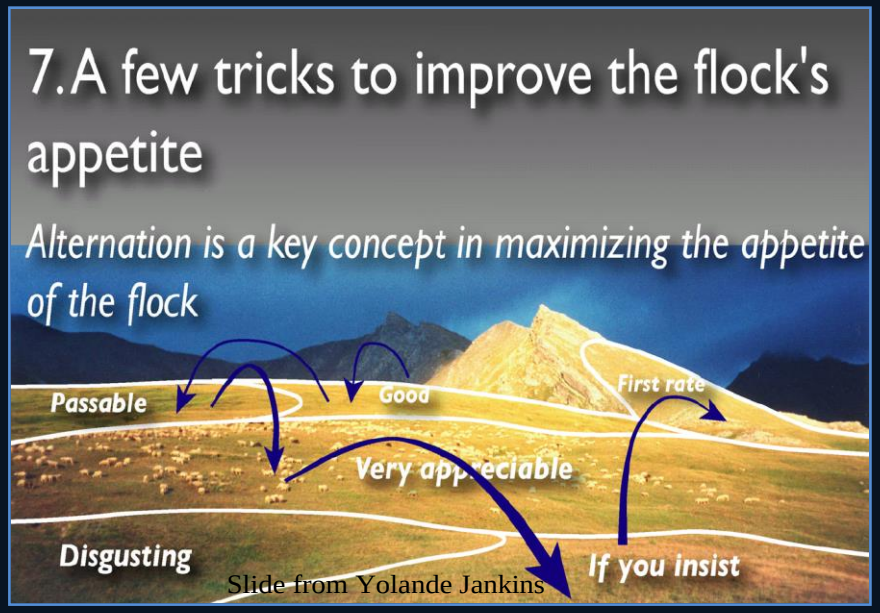
Alderspring Ranch

Nurturing health from soil and plants to herbivores and humans.



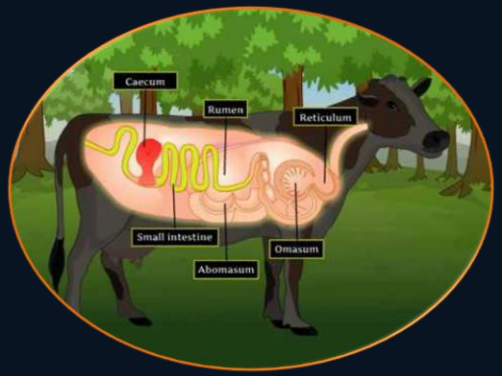
Grazing Circuits

- ✓ Enables individuals to regulate intake of primary and secondary compounds
- ✓ Stimulate appetite/intake
- ✓ Target grazing to enhance/ maintain biodiversity



Slide from Yolande Jankins

Plant Diversity Human Health



Wholesome Foods

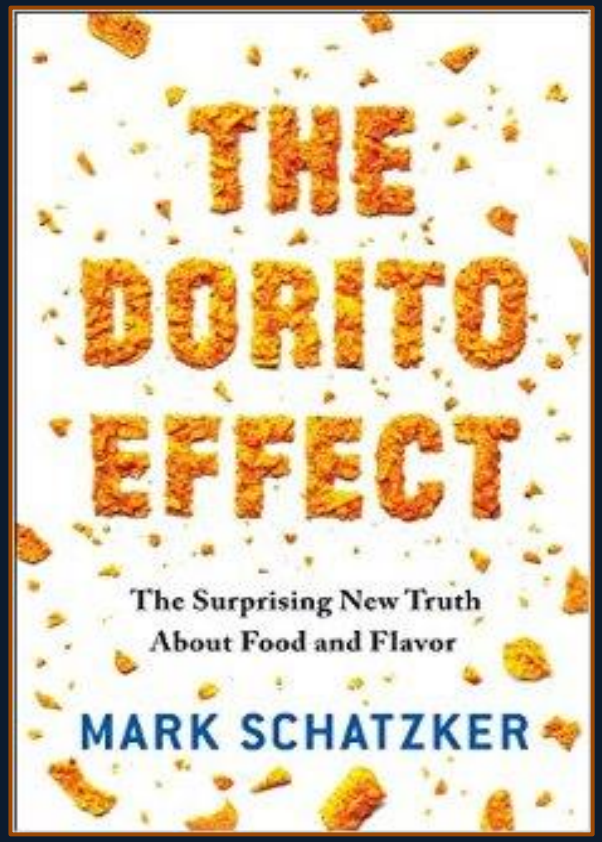
Wisdom of the Body

Flavor Feedback

Social Cultural

We're all connected...

Plant Diversity and Chemistry → Biochemical Richness Diet → Quality Milk, Cheese, Meat

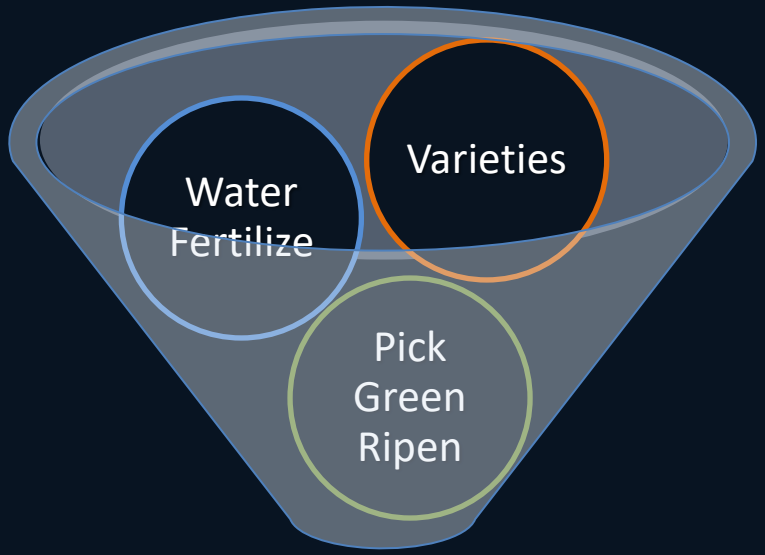


The flavors of meat and produce have become blander...

...at the same time processed foods have become irresistible.

We've disincentivized 'real' foods, because they don't taste good, and we've made junk food more desirable.

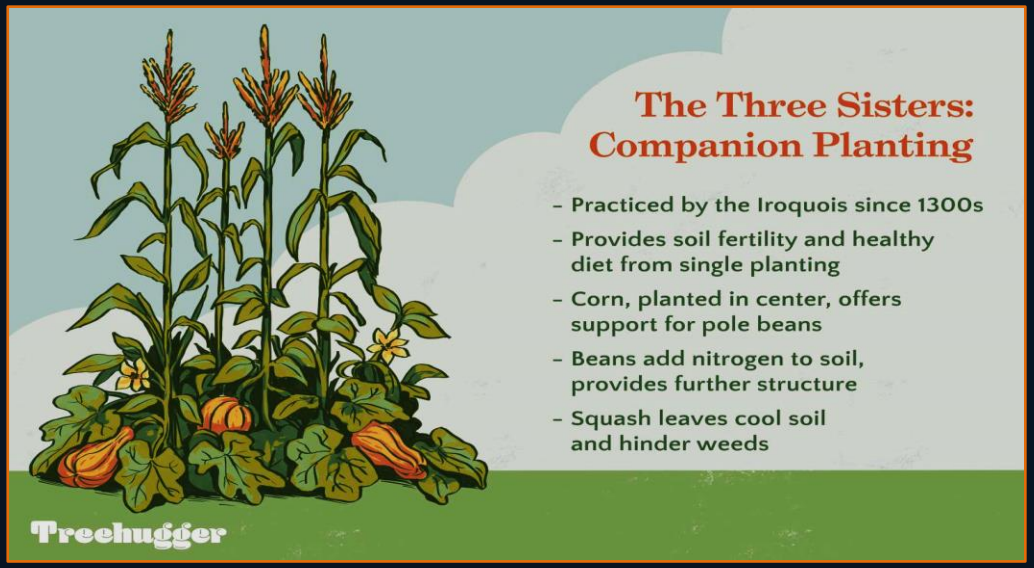
Phytochemical richness declined from 10% to 50% in 43 fruits, vegetables, and grains from 1950 to 1999.



Enhance growth at the expense of phytochemical richness

Phytochemical richness/flavor depend on plant variety and the site where the plant is growing.

Bodacious



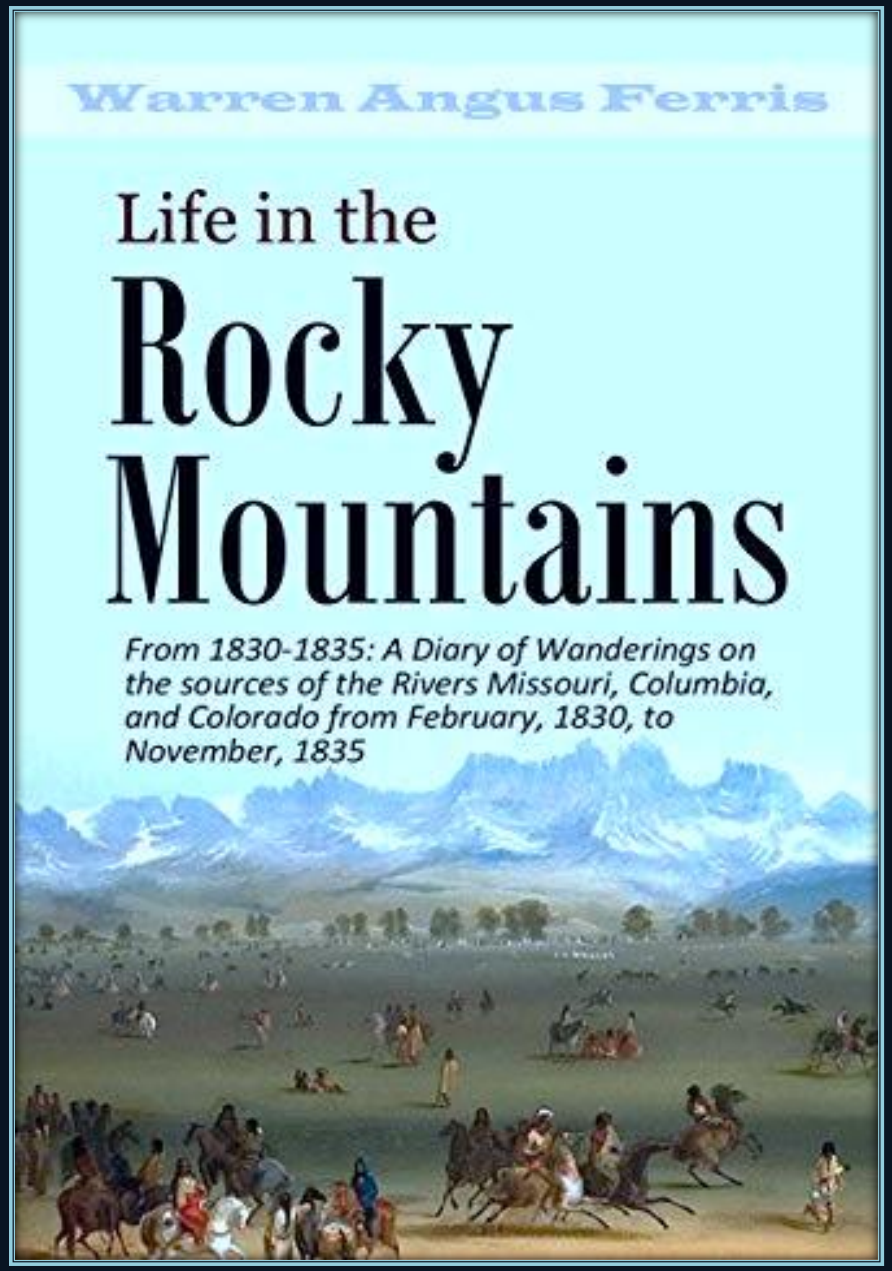
Mexico

When dairy cows graze botanically diverse swards, as opposed to eating a total-mixed ration of cultivated forages and grains…

…the flavor and biochemical richness of their milk and cheese are enhanced. Local peoples prefer the flavors of milk and cheese from dairy cows grazing on the botanically diverse swards.

The flavor of meat is influenced by phytochemical richness of the diet.

Yet, we know little about how phytochemical richness of the diet affects meat flavor, quality, satiety, and human health.

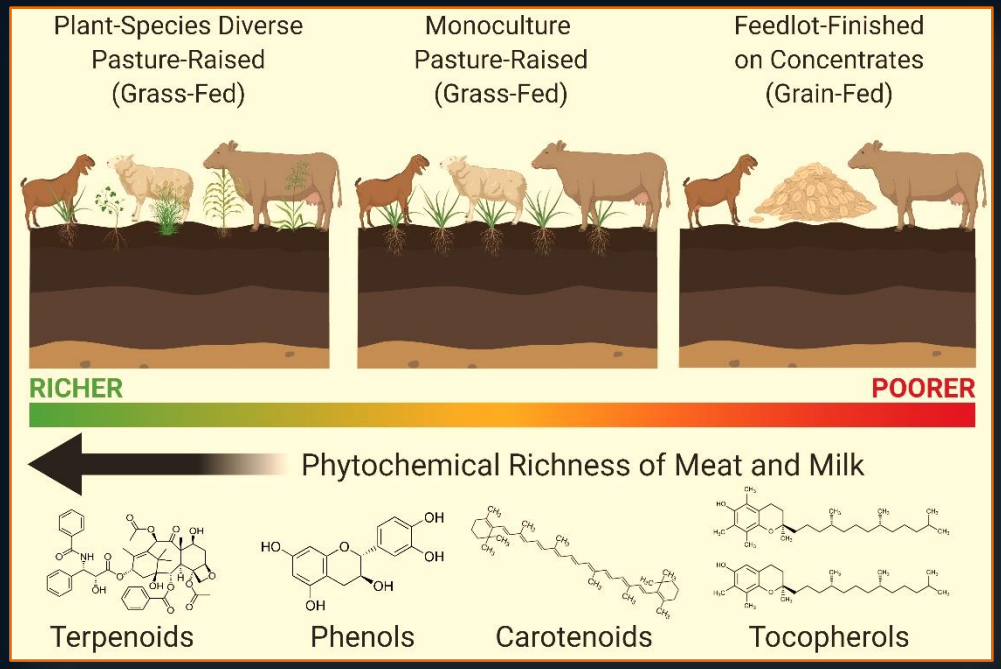


Bison in poor flesh were the worst diet imaginable, but as they became fat, “we grew strong and hearty, and now not one of us but is ready to insist that no other kind of meat can compare with that of the female bison, in good condition.”

"With it we require no seasoning; we boil, roast, or fry it, as we please, and live upon it solely, without bread or vegetables of any kind…

…and what seems most singular, we never tire of or disrelish it, which would be the case with almost any other meat, after living upon it exclusively for a few days."

We are comparing meat from feedlots with meat from animals eating phytochemically rich diets.



Stephan van Vliet, Utah State University

- Metabolomic analyses: phytochemical richness of meat
- Feeding trials: inflammation
- Clinical trials: satiety, inflammation, and health

≠

≠

Ground Beef

Nutrition Facts	
Serving size	**(113g)**
Amount Per Serving	
Calories	**220**
	% Daily Value*
Total Fat 14g	**18%**
Saturated Fat 5g	**25%**
Trans Fat 0g	
Cholesterol 60mg	**20%**
Sodium 70mg	**3%**
Total Carbohydrate 0g	**0%**
Dietary Fiber 0g	**0%**
Total Sugars 0g	
Includes 0g Added Sugars	**0%**
Protein 23g	**46%**
Vitamin D 0.1mcg	0%
Calcium 12mg	0%
Iron 2mg	10%
Potassium 289mg	6%
Thiamin 0.05mg	4%
Riboflavin 0.2mg	15%
Niacin 4.8mg	30%
Vitamin B6 0.4mg	25%
Folate 6mcg	2%
Vitamin B12 2mcg	80%
Phosphorus 175mg	15%
Zinc 4.6mg	40%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Soy-Based Alternative

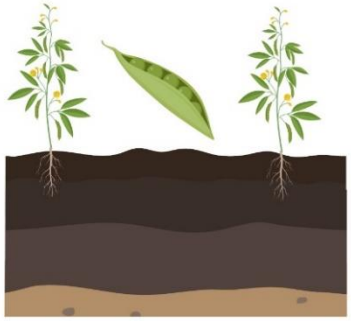
Nutrition Facts	
Serving size	**(113g)**
Amount Per Serving	
Calories	**250**
	% Daily Value*
Total Fat 14g	**18%**
Saturated Fat 8g	**40%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 370mg	**16%**
Total Carbohydrate 9g	**3%**
Dietary Fiber 3g	**11%**
Total Sugars 0g	
Includes 0g Added Sugars	**0%**
Protein 19g	**38%**
Vitamin D 0mcg	0%
Calcium 180mg	15%
Iron 4.2mg	25%
Potassium 610mg	15%
Thiamin 28.2mg	2350%
Riboflavin 0.4mg	30%
Niacin 4.8mg	30%
Vitamin B6 0.4mg	25%
Folate 115mcg	30%
Vitamin B12 3mcg	120%
Phosphorus 180mg	15%
Zinc 5.5mg	50%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Pea-Based Alternative

Nutrition Facts	
Serving size	**(113g)**
Amount Per Serving	
Calories	**260**
	% Daily Value*
Total Fat 18g	**23%**
Saturated Fat 5g	**25%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 350mg	**15%**
Total Carbohydrate 5g	**2%**
Dietary Fiber 2g	**7%**
Total Sugars 0g	
Includes 0g Added Sugars	**0%**
Protein 20g	**40%**
Vitamin D 0mcg	0%
Calcium 100mg	8%
Iron 4mg	20%
Potassium 280mg	6%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.



Metabolomics

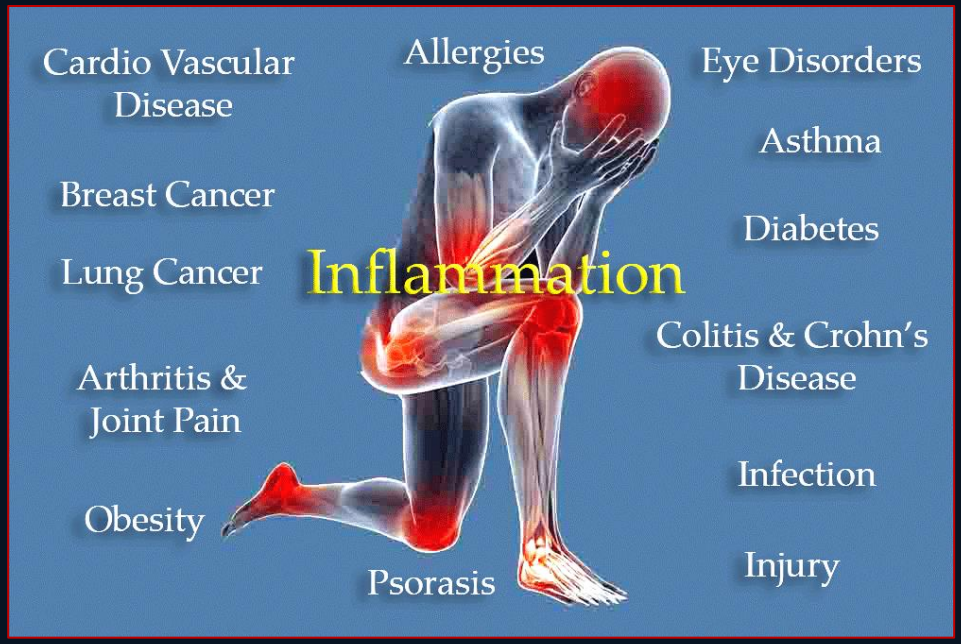
Meat from Bison

Rangelands vs Pens

- Phytochemicals
- Antioxidants
- Anti-inflammatory
- Less Oxidative Stress

Bison finished in pens show early signs of metabolic syndrome due to diet and lifestyle.

Inflammation occurs after each meal…



…with increasing odds of developing diseases when meals that elevate inflammation become dietary habits.

Pro-inflammatory

Trans Fats

Red Meat/Fat

Processed Meats

Omega 6 Fatty Acids

Refined Carbohydrates

Ultra-processed Foods

Anti-Inflammatory

Herbs and Spices

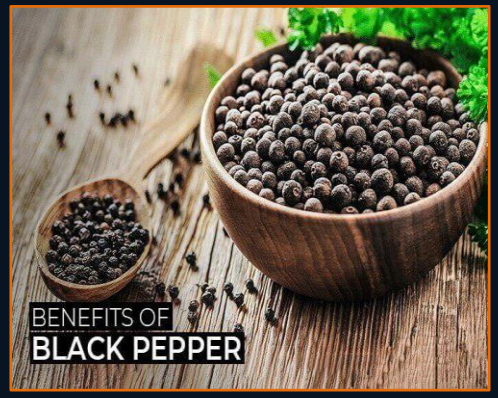
Vegetables and Fruits

Wholesome Foods

Phytochemically rich herbs and spices are anti-oxidant and anti-inflammatory.

Turmeric
Garlic
Cinnamon

Rosemarie
Ginger
Willow Bark



Cardamon
Cloves
Black Pepper

Herbs and spices added to foods enhance palatability, satiation, and satiety and they reduce alleged adverse effects of eating red meat.

Native Americans made pemmican from meat and wild berries that reduce alleged adverse effects of eating red meat.

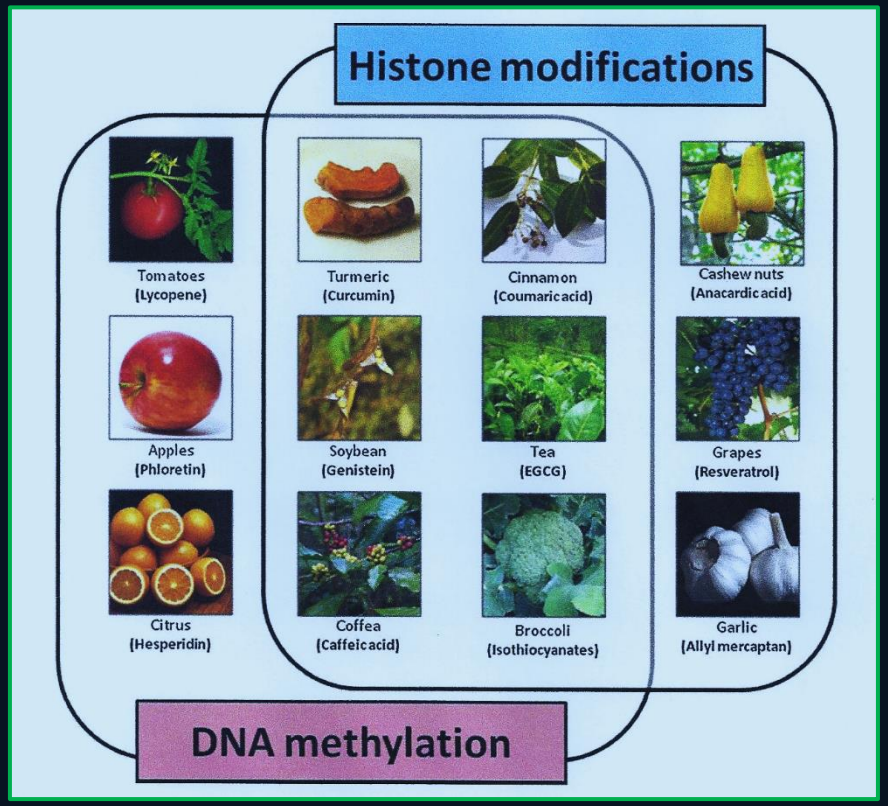
Inflammatory responses are much greater after eating meat from cattle (wagyu) fed a *high-grain diet* than for meat from a wild herbivore (kangaroo) eating a *phytochemically rich diet*…

…and that's true for meat from angus cattle grazing ryegrass versus a 24-species plant mix.

Eating traditionally processed meats is not associated with increased risks of cancer in Morocco.

Kaddid is ribs of beef, lamb, or camel cut into thin slices mixed with olive oil, herbs and spices such as cumin, garlic, coriander, salt, vinegar.

Phytochemicals can reverse epimutations and prevent diseases which is promising because epigenetic changes are more easily reversible than genetic changes.



Link et al., Biochemical Pharmacology, 80, 1771-1792.

Diet-induced changes in DNA-methylation (epimutations) can counter all the hallmarks of a cancer cell.

Meat isn’t meat isn’t meat,
and diary isn’t dairy isn’t dairy…

Our understanding of how diet affects health is limited to 150 nutritional components, including energy, protein, minerals, and vitamins.

These compounds are a small fraction of the tens of thousands of biochemicals in the human foodome.

Chemicals in oregano (numbers are ppm)

trans-anethole
apigenin
allo-aromadendrene (18-120)
bicyclogermacrene (51-340)
β-bisabolene (3-800)
borneol (32-315)
β-bourbonene (24-430)
δ-cadinene (2-4)
τ-cadinene (38-250)
10-α-cadinol (15-100)
caffeic acid
calamenene (18-120)
calcium (15,760-16,983)
camphene (1-64)
camphor (0-40)
carbohydrate (694,000)
δ-3-carene (2-120)
carotene (45)
carvacrol (68-8,300)
carvacryl methyl ether (12-80)
carvone (1)
caryophyllene (12-1,750)
caryophyllene oxide (84-420)
1,8-cineole (3-120)
α-copaene (14-90)
cuminal (2-10)
p-cymene (34-1,264)
dipentene
β-elemene (4-30)
τ-elemene
diosmetin
essential oil (1,500-10,000)
trans-α-farnesene (36-260)
β-farnesene
fat (110,000)
diber (162,000)
geraniol
geranyl-acetate (1-120)
germacrene D (142-1,490)
α-humulene (4-470)
iron (440-474)
kaempferol
ladene
leptosidin
limonene (1-600)
linalool (28-2,000)
linalyl-acetate (6-230)
luteolin
magnesium (2,700)
α-muurolene (2-30)
γ-muurolene (16-88)
muurolene (12-110)
naringenin
neryl-acetate
niacin (62-67)
ocimene (18-120)
cis-ocimene (202-1,740)
trans-ocimene (57-1,030)
3-octanol (2-150)
1-octen-3-ol (80-530)
oleanolic acid
pentyl alcohol
α-phellandrene (2-20)
β-phellandrene (9-60)
phosphorus (2,000-2,155)
phytosterols (2,030)
α-pinene (10-160)
β-pinene (1-312)
cis-piperitol (7-50)
potassium (16,690-17,985)
protein (119,000)
retusin
rosmaric acid (4,000)
rosmarinic acid (16,600)
sabinene (38-2,620)
cis-sabinene hydrate (1-58)
selinene
sodium (150-162)
spathulenol (8-50)
stachyose
tannin (80,000)
α-terpinene (7-222)
γ-terpinene (1-2,320)
terpinen-4-ol (17-390)
α-terpineol (100-670)
terpinoline (2-20)
terpinyl acetate (40-270)
thiamin (3-4)
α-thujene (4-40)
α-thujone
thymol (1-5,990)
thymyl methyl ether (9-60)
trans-2-hexanal (99-660)
2-undecanone (4-30)
ursolic acid (3,100)
zinc (44)

Biochemicals interact with one another and with cells and organ systems in extremely complex ways we will never fully understand.

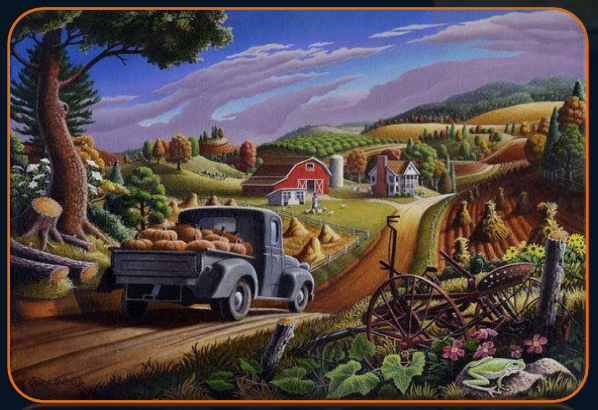
Consider the biochemical complexity of a meal of sautéed spinach with ginger, whole grain ravioli shells stuffed with butternut squash and spices, topped with a walnut tomato sauce or a meal of 10 to 50 species of grasses, forbs, and shrubs for herbivores.

We stopped listening to the wisdom body and yielded to advice from authorities.

Two Spiritual Dangers

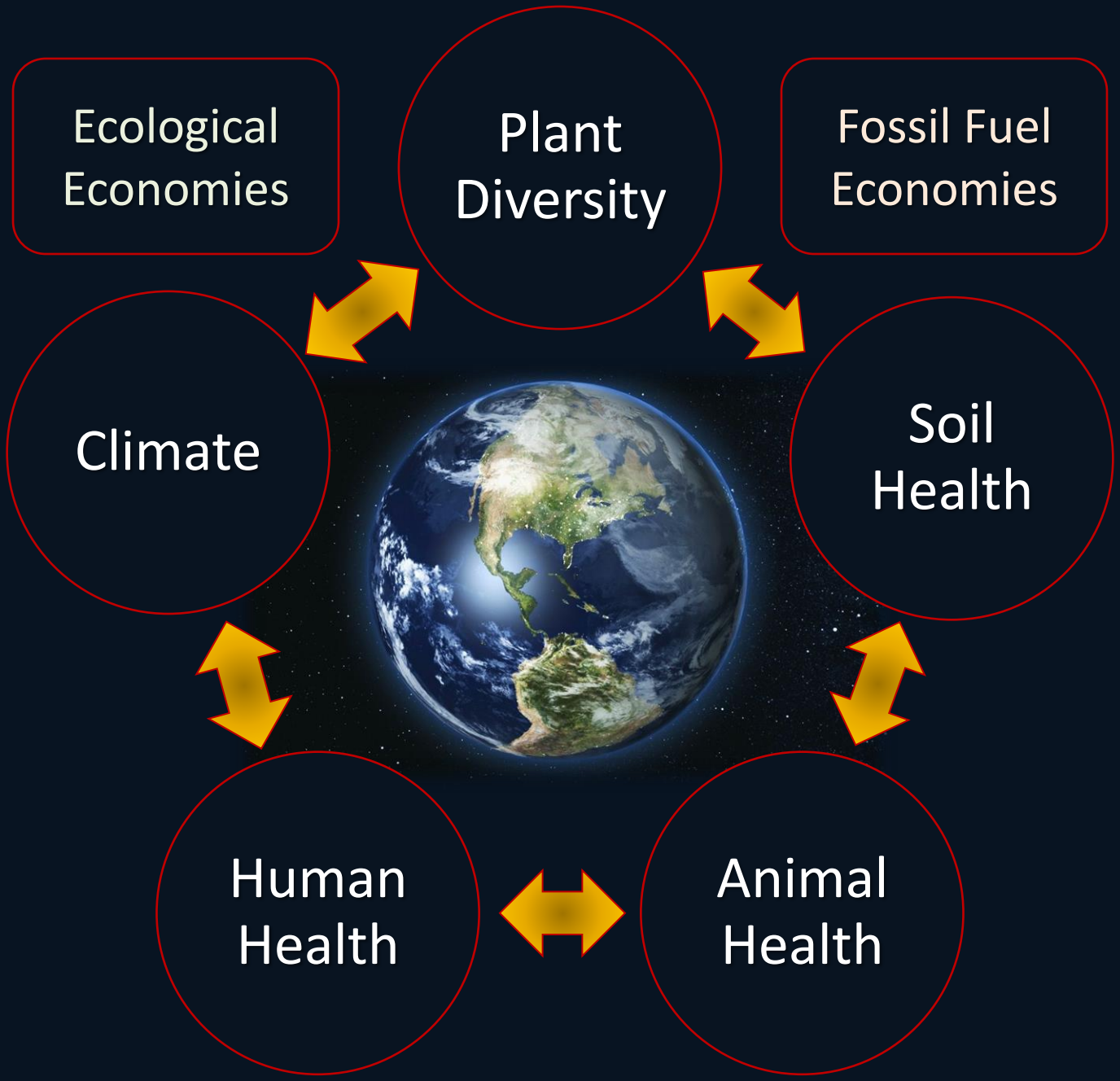
During the last 15,000 years, *Homo sapiens* transformed from hunters and gatherers to farmers to industrial agriculture.

Hunters Gatherers



Pastoralists Small Farms Ranches

Industrial Agriculture

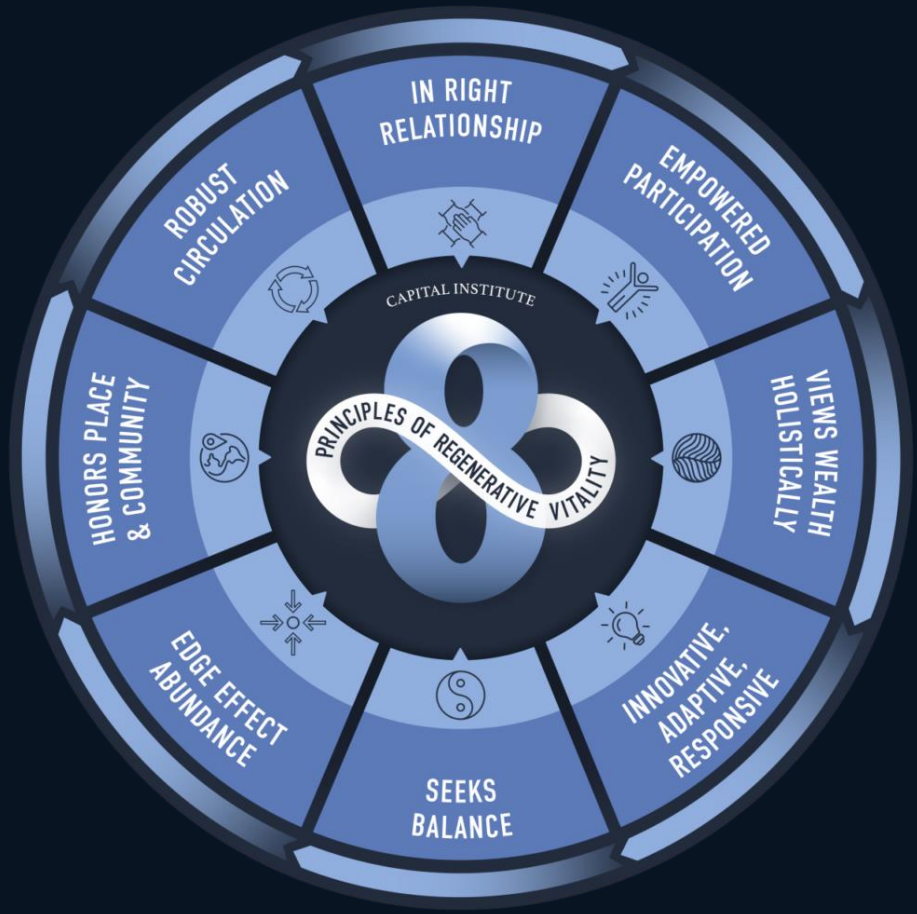

Ecological Economies
Plant Diversity
Fossil Fuel Economies
Climate
Soil Health
Human Health
Animal Health

To produce
1 calorie of food
requires 2 calories
of fossil fuels:

- machinery
- fertilizers, herbicides, and insecticides
- antibiotics and anthelmintics

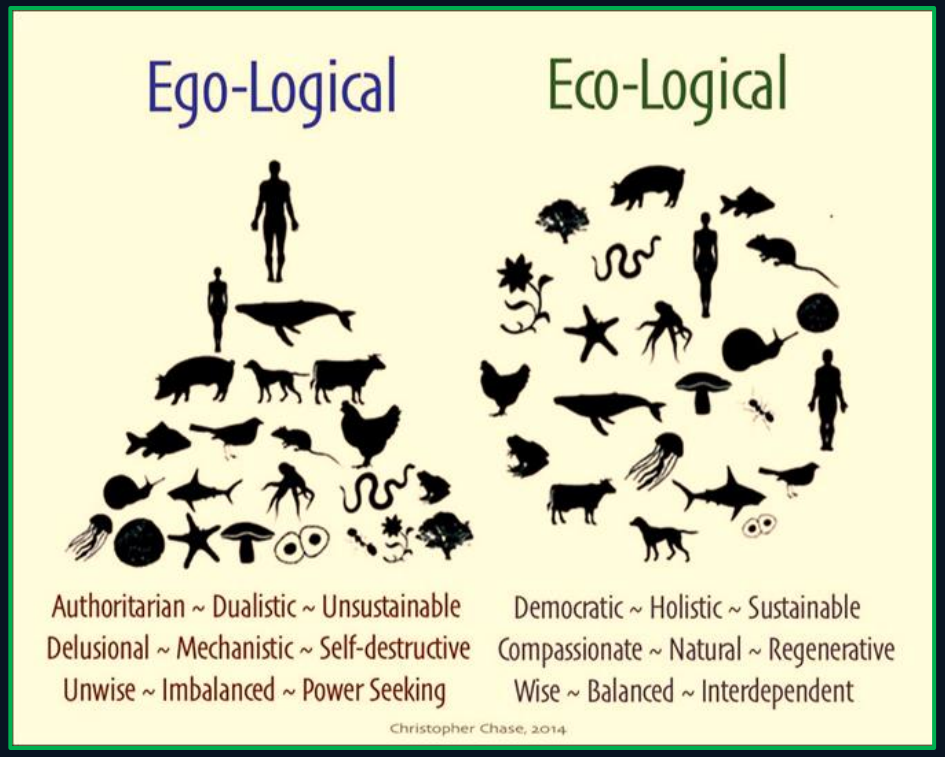
We use another 8-12
calories to process,
package, deliver, store,
and cook modern food.

Climate change
is a product of an
extractive economy
that is forcing us to
confront the outcome
of our consumptive
lifestyle: genuine
scarcity for which the
market has no remedy.



Regenerative economies
that cherish and reciprocate the
gift are the only path forward.

Farmers/ranchers can produce foods locally in ways that nurture relationships among soil, water, plants, herbivores, farmers, ranchers, and consumers.



Agriculture can once again be at the heart of communities, but from soils and plants to livestock and humans, we will need to learn what it means to be locally co-evolving with nature's communities.

"There are two spiritual dangers in not owning a farm."
Aldo Leopold
A Sand County Almanac

"One is the danger of supposing that breakfast comes from the grocery, and the other that heat comes from the furnace."

"To avoid
the first
danger,
one should
plant a garden,
preferably where
there is no grocer
to confuse
the issue."

"To avoid the second,
he should lay a split of
good oak on the andirons,
preferable where there is no
furnace, and let it warm his
shins while a February
blizzard tosses the
trees outside."







Most people don’t own farms or ranches,
but we have yards that can link us back with
wholesome foods and wild plants and animals.

Over 30 thousand tons of synthetic pesticides at a cost of well over $2 billion, not to mention all the herbicides and fertilizer to “weed and feed” our lawns.

Over 800 million gallons of gasoline.
The gas spilled refilling lawn mowers is 17 million gallons -- 1.57 times the amount spilled by the Exxon Valdez off the shores of Alaska.

Residential water use outside the home is 30% to 60% of total water use. Depending on the estimate, 7 billion to 9 billion gallons of water are used each day for suburban irrigation.

We've made an art form of dining…

…but tabled the larger questions…

Eating is participating in endless transformation as plants and animals give their lives to sustain our lives.

As I eat, energy and matter in *someone* becomes this entity I call “me”—which will, in the flicker of a cosmic eye, return to earth as plants and animals.

In pondering this mystery, we may come to realize that all life is sacred.

We are members of nature's communities: what we do to them, we do to ourselves. Only by nourishing them, can we nurture ourselves.

And we
do that by
declaring love
-- not war --
on one
another
and the
landscapes
we inhabit.