

## Complex Adaptive Landscapes

Principles, Processes, Practices, and Philosophies

All things are  
interconnected  
interdependent in  
time and space.



Landscapes are relationships among organisms continually engaging ever-changing biophysical environments, all evolving from birth to death.

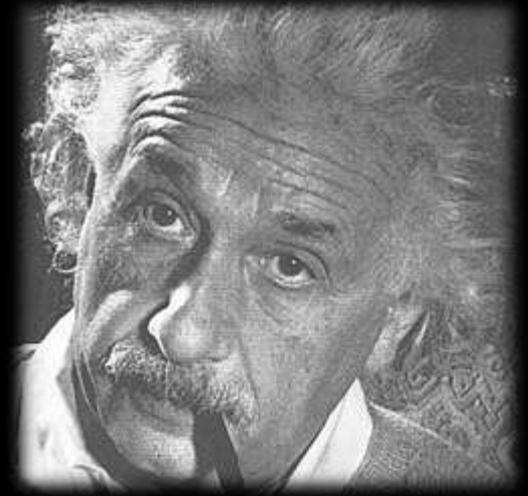


The only  
constant in life  
is change



# Einstein's Blunder

Even at largest scales of time and space, nothing is static: galaxies and solar systems rotate and the universe is expanding.



Locally  
floods,  
droughts,  
hurricanes,  
earthquakes

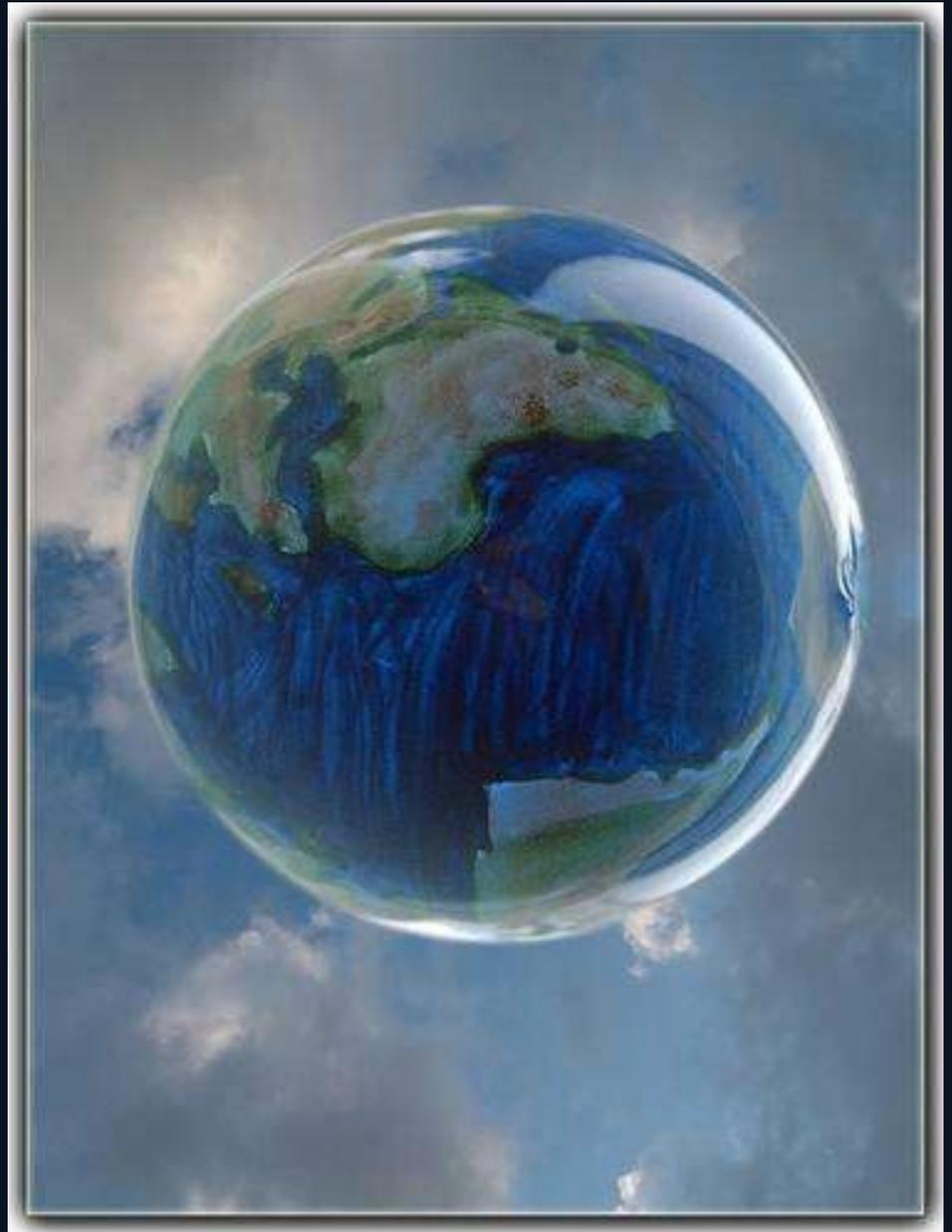


Nature  
Behaving  
Badly



## Our time on Earth is too short to see...

- ✓ Continents drift
- ✓ Mountains rise and fall
- ✓ Oceans become desert
- ✓ Climates warm and cool
- ✓ Plants and herbivores  
coming and going



Change isn't  
the exception to  
the rule, it's the  
only rule...

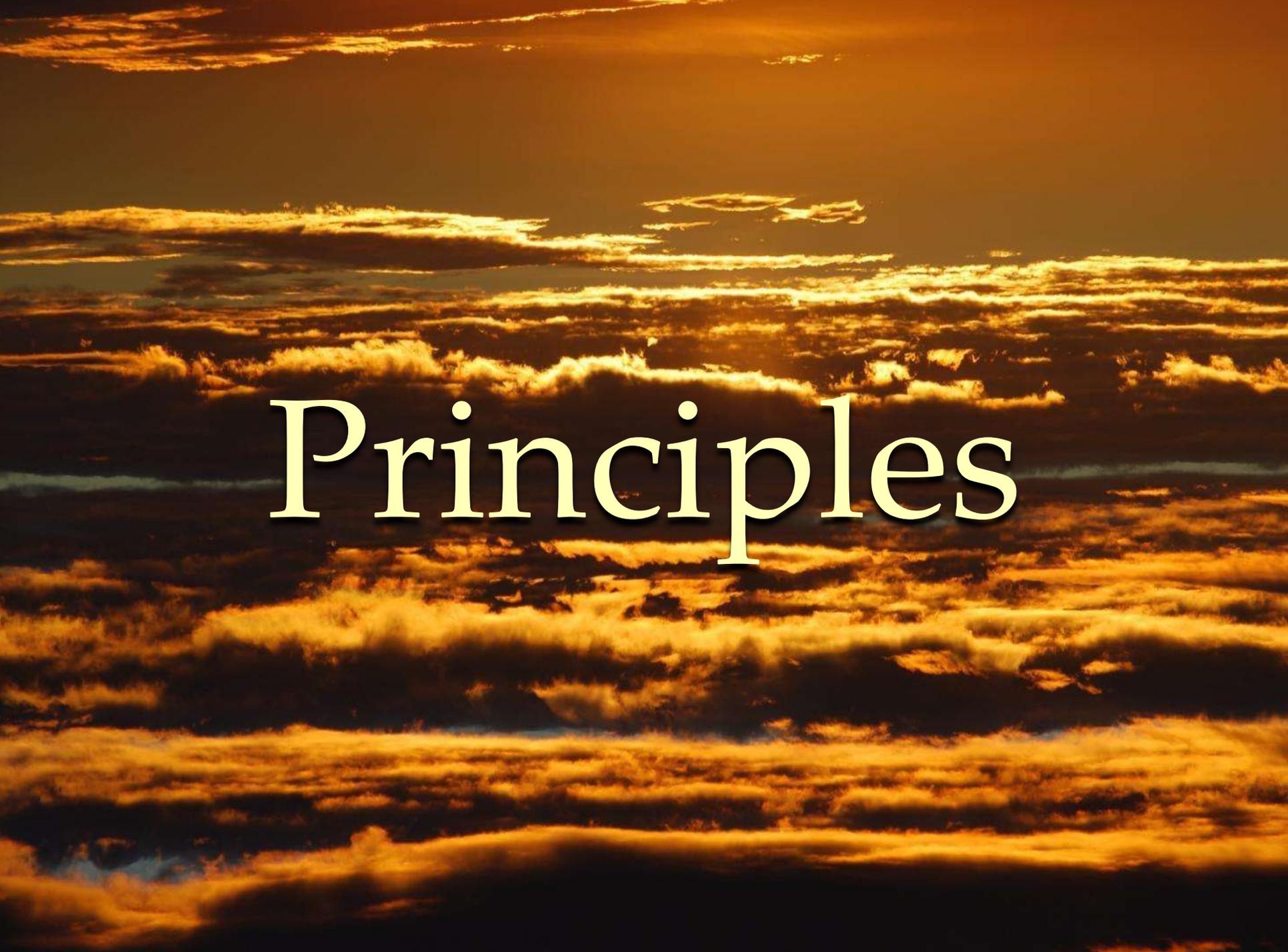


Species

Societies

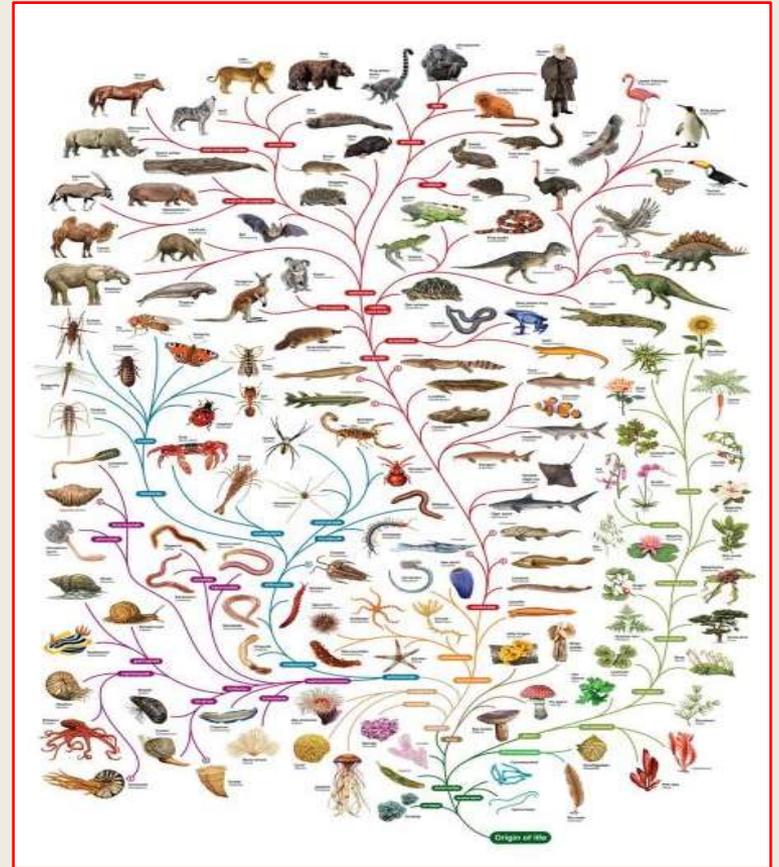
Corporations

Nothing Lasts



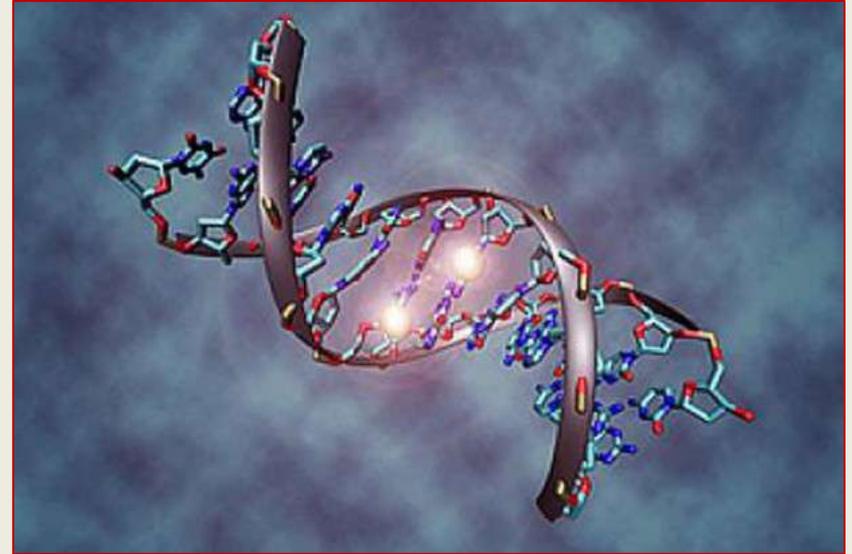
# Principles

According to traditional Darwinian Theory, species evolve when genetic mutations with value for survival are passed on to the next generation.



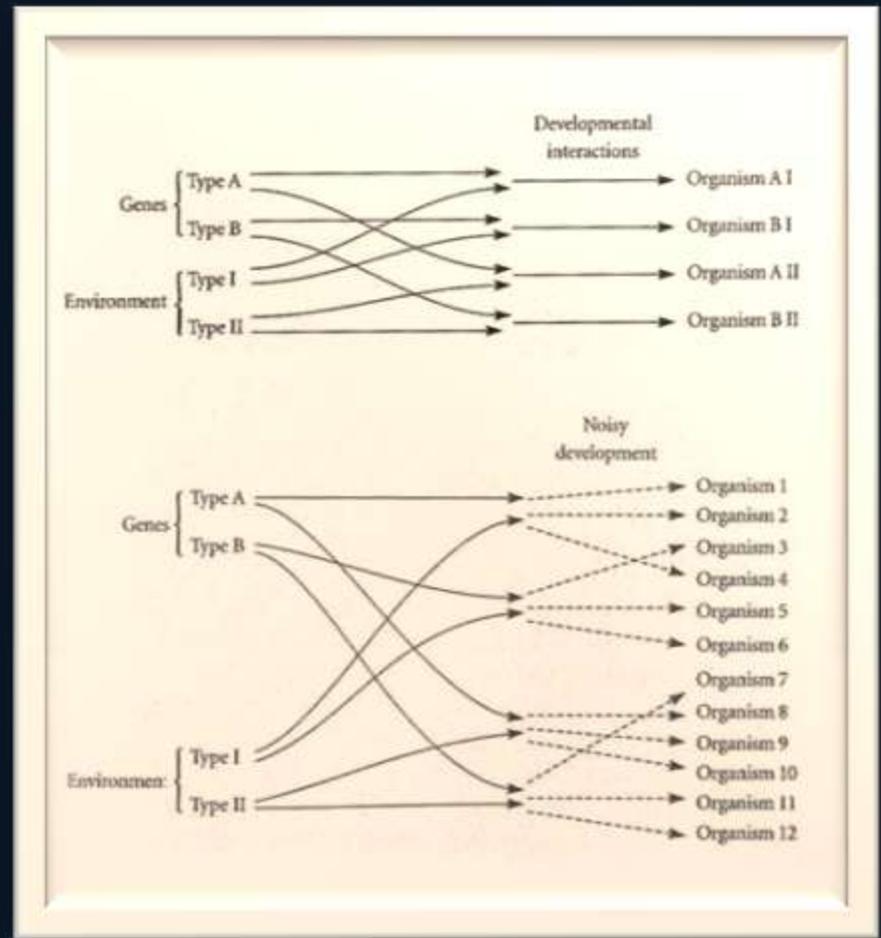
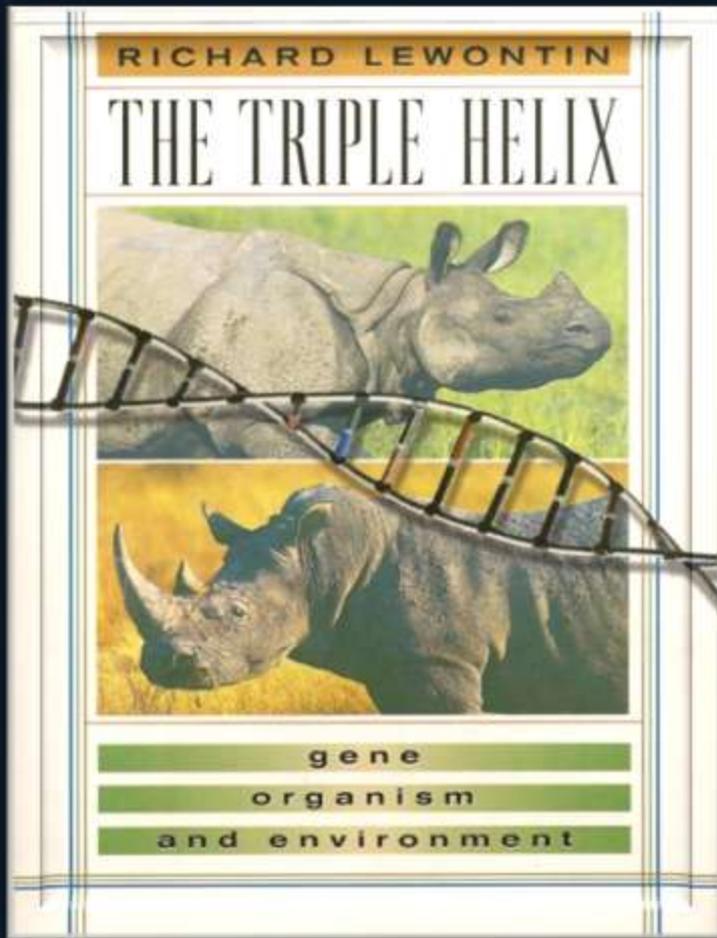
Environments pose problems, organisms throw up random solutions: organisms propose, environments dispose:

Epigenetics is the study of heritable changes in gene expression caused by mechanisms other than changes in the underlying DNA sequence.



Organisms are involved in the world, which allows them to evolve in the world.

# Genes + Environments + Chance = Individuals



Nature Abhors  
Sameness!



Nature fills vacuums  
with Individuals and  
no two are alike!

Organisms decide what's relevant to them in the landscapes they inhabit.



By actively participating, organisms create relationships among what they ascertain are the relevant facets of the social and biophysical worlds they inhabit.

Fatefully, they alter environments in ways that make the situation less hospitable for them and more hospitable for others.



The irony is that the environments they inhabit are changing because of their behavior and their running in the same direction only makes matters worse.

As organisms  
“run” they initiate  
downstream effects...



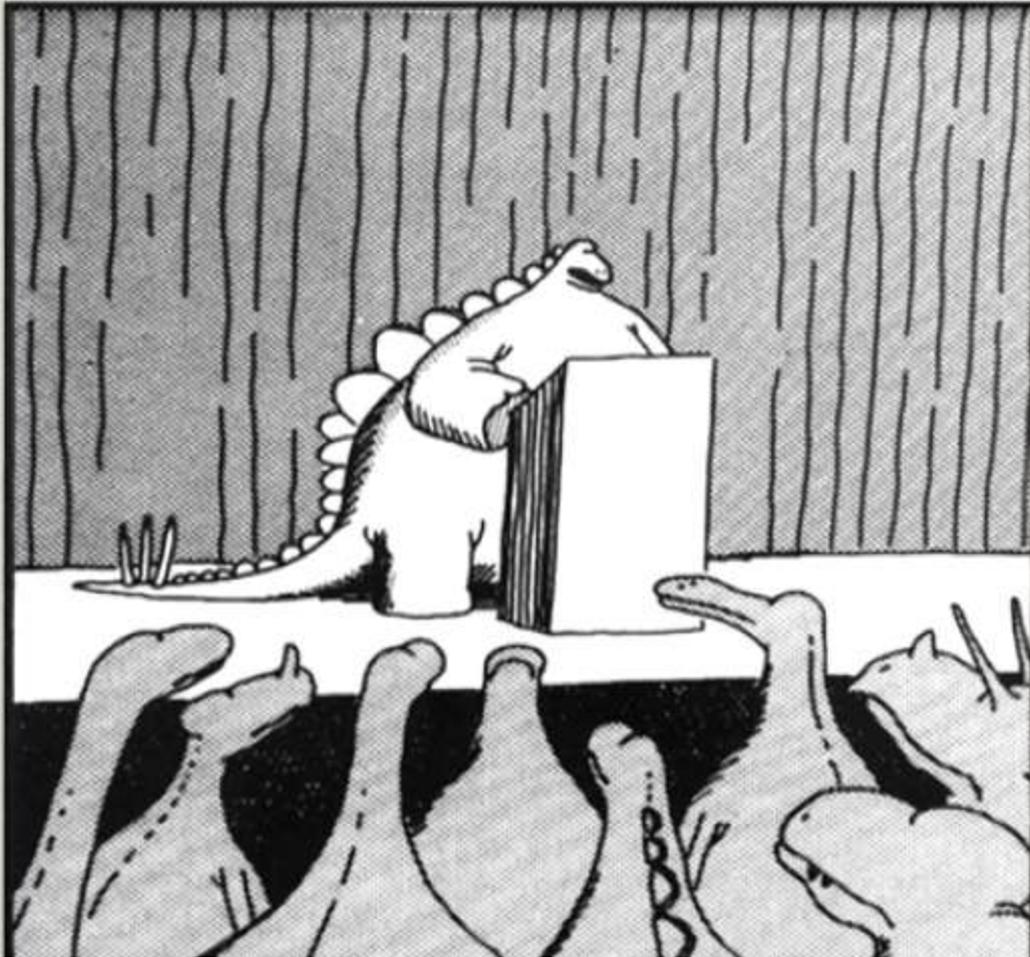
...that emerge  
days, weeks and  
even years later.

Life is an ongoing series of bifurcations in the face of varying degrees of uncertainty.





“Whoa! Another bad one! ... I see your severed head lying quietly in the red-stained dirt, a surprised expression still frozen in your lifeless eyes, ... Next.”



“The picture’s pretty bleak, gentlemen ... The world’s climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut.”

Every species, not only humans, is in the process of destroying its own environments by using resources that are in short supply and transforming them into a form that cannot be used again by individuals of the species...



...from death comes life and endless transformation.

Every act of  
consumption is also  
an act of creation.



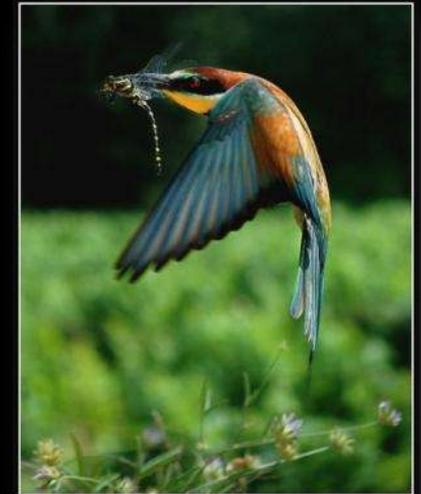
- ✓ Plants and animals create soil which creates plants and animals
- ✓ Plants are the givers of life
- ✓ Animal impacts create life in soil and nurture plants

Endless creativity  
in the universe is real,  
but it comes at a cost:  
the price of admission is  
endless transformation.  
The most interesting  
aspect is this universe  
lives by consuming itself.

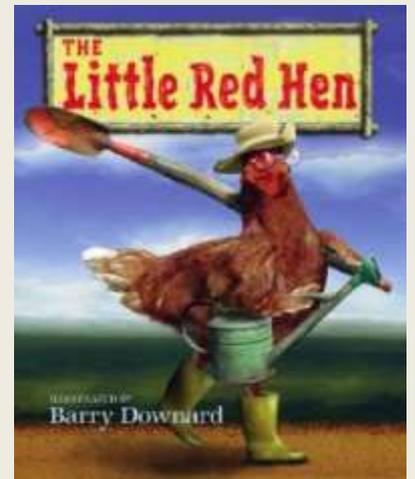
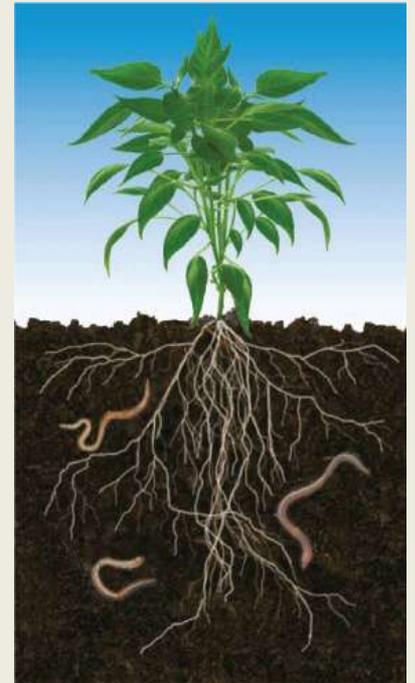




Life lives on life,  
from stars and galaxies  
to herbivores, omnivores  
and carnivores...



In environments where resources are not always available, organisms even out the effects of temporal variations by creating “buffers for rainy days.”



To be considerate members of communities, we must manage the present with a view to the future so that buffers are not prematurely exhausted.



- ✓ Setting stocking rates for lean as opposed to the good years
- ✓ Rotating livestock so only part of the landscape is used in any one year
  - ✓ Not grazing in the same ways repeatedly from year to year

From a production perspective, this approach will not always yield the short-term maximum productivity of any one component of the system, for instance the growth rate of forage or livestock.



Less-than-maximal production is a desirable trade-off if in return we increase longer-term profitability by reducing our reliance on external inputs whose price and availability are usually beyond our control.

All of this highlights  
the importance of  
managing functioning wholes  
rather than focusing on any  
one particular facet  
of the system.



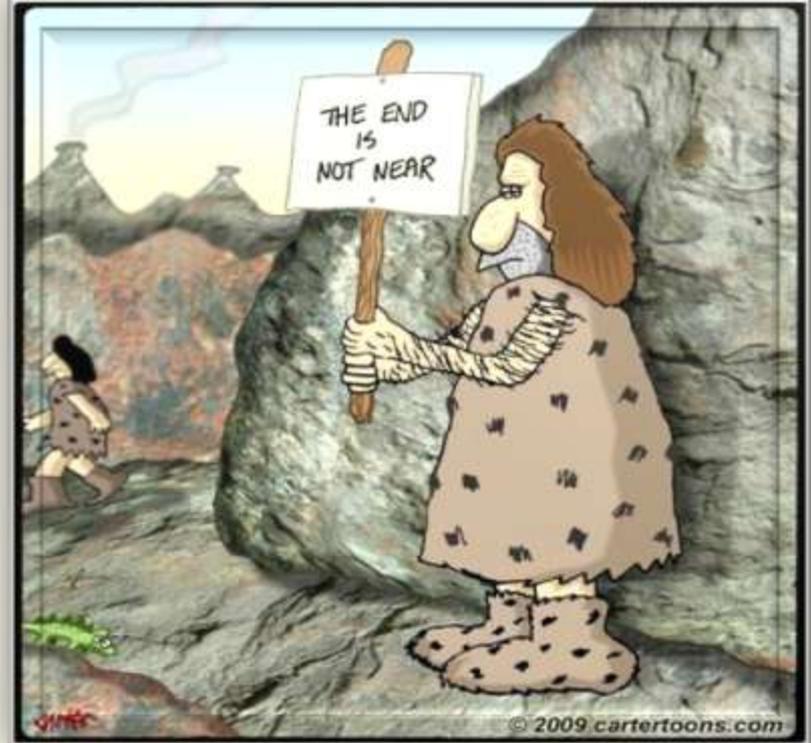
If we consider multiple  
components of systems, we are more  
likely to have a situation where energy and  
nutrients are transformed and cycled in  
ways that each organism is replenished  
by the end-products of another.

We don't understand complex adaptive systems except in a general way. Whenever we think we understand them, we learn we don't.



We simply interact with them, and adjust our behavior accordingly, based on whatever feedback we can gain.

Even our most enlightened efforts have unintended outcomes, because we did not know enough, or because the world responded to our actions in ways no one expected, or because we were unable to adapt to the changes we helped to create.



Ironically, we never admit that we were wrong in the past, and that we are quite likely to be wrong again in the future.

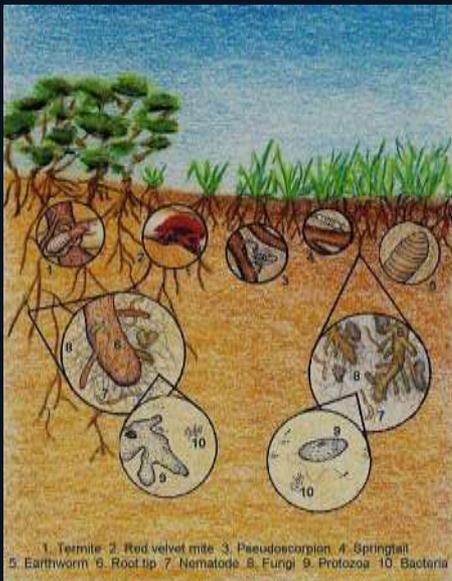
We dismiss earlier errors  
as bad thinking by people less  
knowledgable and then confidently  
embark on new blunders of our own.

You are here

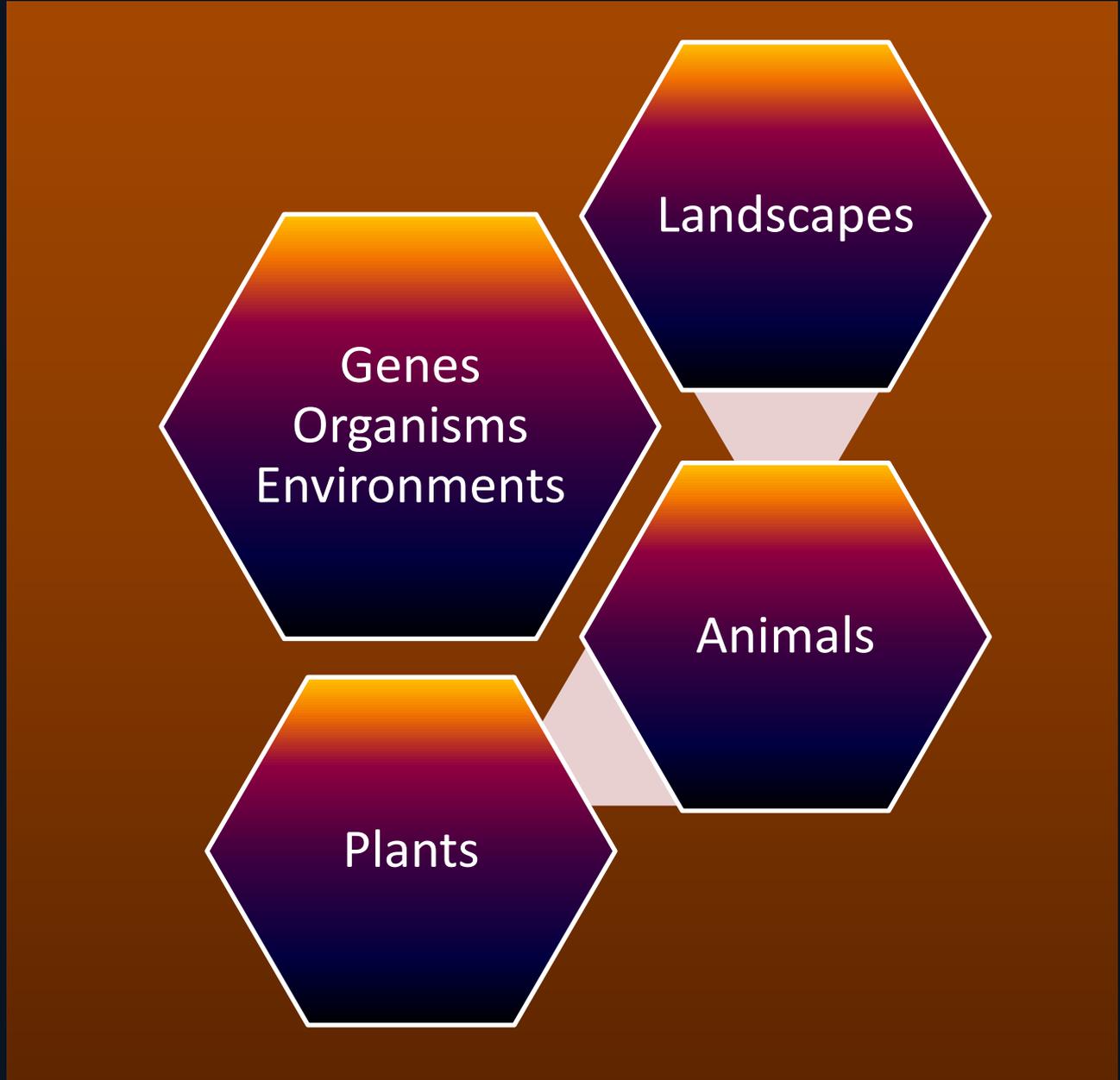




# Processes



1. Termite 2. Red velvet mite 3. Pseudoscorpion 4. Springtail  
5. Earthworm 6. Root tip 7. Nematode 8. Fungi 9. Protozoa 10. Bacteria



# Landscape Behavior

**E.C. Pielou**

**AFTER  
THE ICE  
AGE**  
*The  
Return of  
Life to  
Glaciated  
North  
America*



Pleistocene North America

Paleogeography based on  
The Evolution of North America by Philip B. King  
and the PaleoMap Project, [www.scotese.com](http://www.scotese.com)

# What is native?

Things never were  
the way they were,  
and they never will be again...



We interpret snapshots of times past as “the way things always were and always should be” without appreciating we are photographing moving targets.



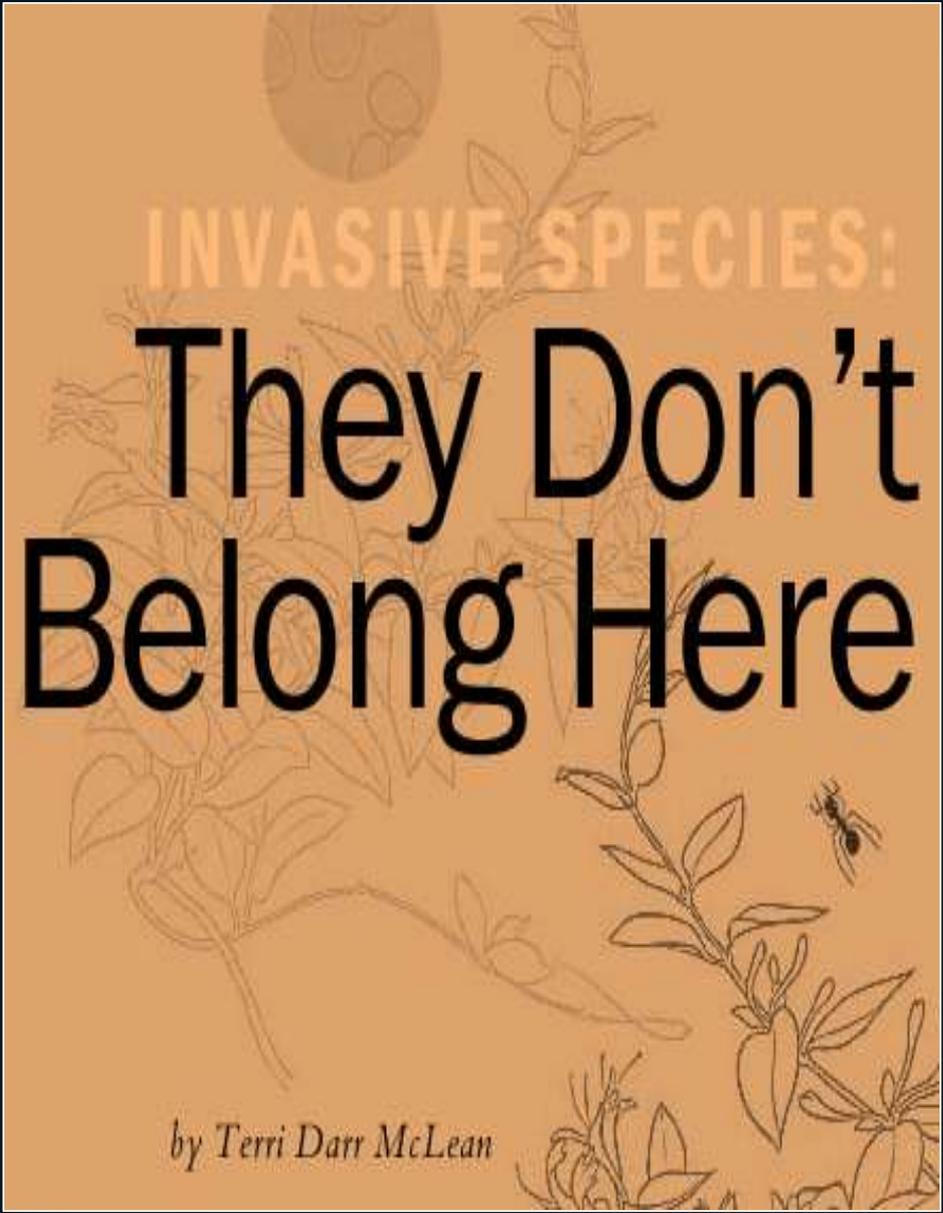
If we'd been here  
when plant species now  
“native” were invading,  
what would we  
have done?



...yesterday's invasives  
are today's new natives  
and tomorrow's relicts...

## Invasive Species

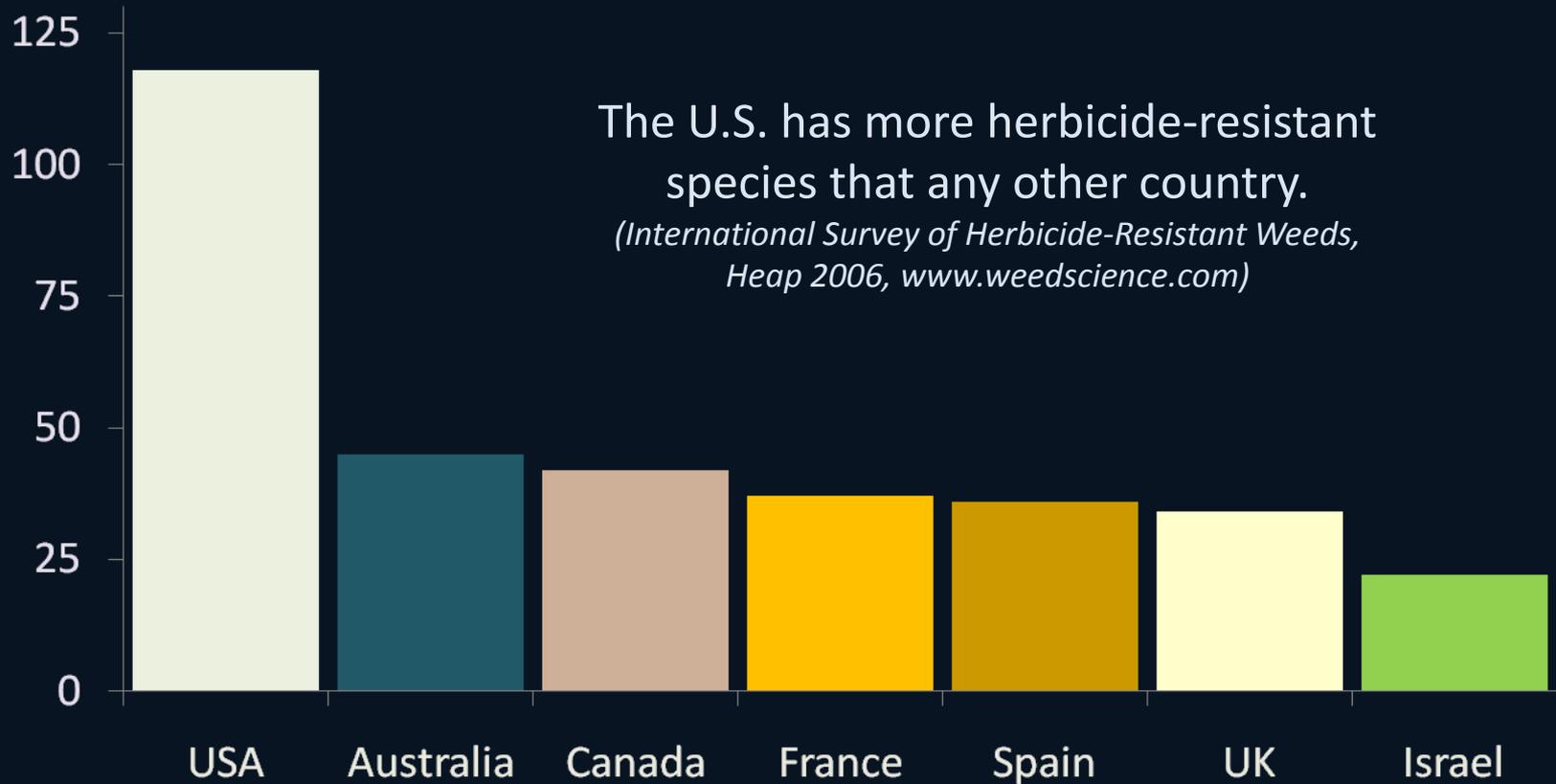
- 50,000 species
- Rising in the U.S.
- \$120 billion/yr in control/damages
- Few results



# INVASIVE SPECIES: They Don't Belong Here

by Terri Darr McLean

# Herbicide-Resistant Species



We must learn  
to love them to  
death with  
herbivores



Resource availability  
(soil water, nutrients, sunlight)  
influences the kinds and chemical  
characteristics of plants

Resource-poor areas select  
for low inherent growth rates  
and higher levels of defense.

Resource-rich areas select  
for high inherent growth rates  
and lower levels of defense.



# Herbivores Influence Resource Availability

Herbivore  
Impacts



Resource  
Availability



Plant Diversity  
and Chemistry



# Plant Behavior

# Primary Roles for Secondary Compounds in Plants



Sun Screen  
Antioxidants  
Adaptive Coloration  
Attract Pollinators  
Fruit Eaters

Allelopathy  
Drought Resistance  
Persistence



Recovery Injury  
Regrowth Grazing  
Defense Grazing

The environment where a plant is growing affects concentrations of primary and secondary compounds in real time.



- ✓ Wet vs. Dry Sites/Years
- ✓ Fertile vs. Infertile Sites
- ✓ Carbon- vs. Nitrogen-based Compounds
  - ✓ Associated Plant Species
  - ✓ Previous Herbivory

# Plant Responses to Grazing

## Influenced by Environmental Conditions at the Time of Grazing

How Much  
(Intensity)

Phytomass

Meristem  
Potential

When  
(Time)

Resources  
to Regrow

Stage of  
Growth

How Often  
(Frequency)

Phytomass

Acquire  
Resources

# Spatially Heterogeneous Influences of Grazing

Selective  
Grazing



Plants and  
Communities



Plant Diversity  
and Chemistry



# Animal Behavior



Behavior

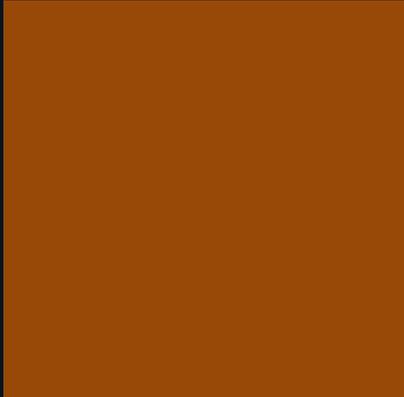
Consequences

Genes

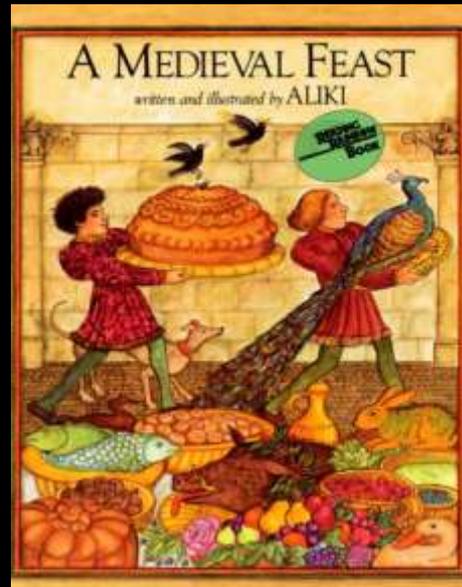
Organisms

Environments

Individuals



# What is Palatability?





OPEN →

A/R

# Picante Sauce



2ND  
FOODS

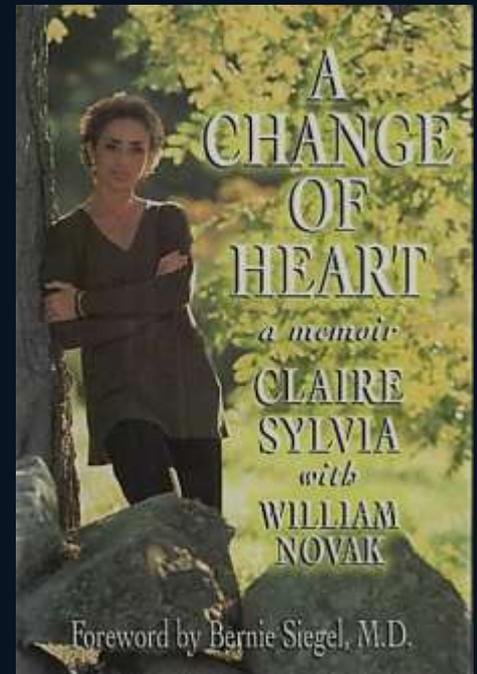
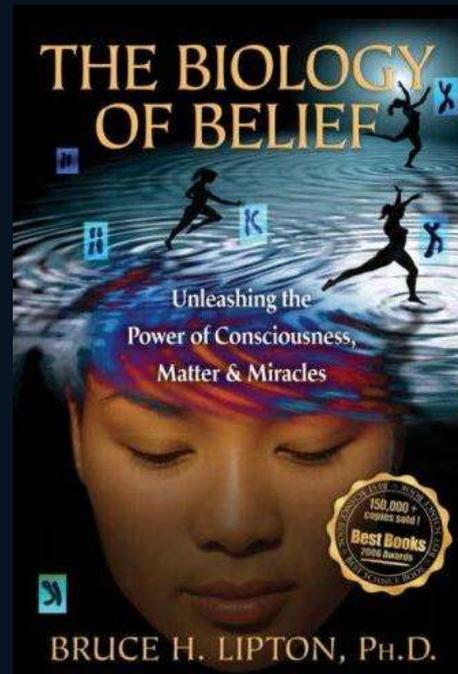
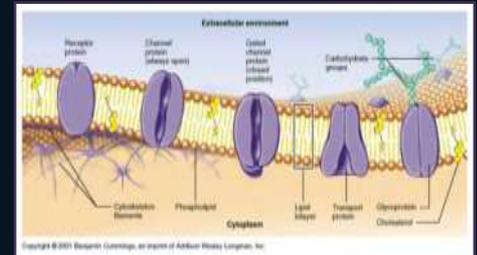
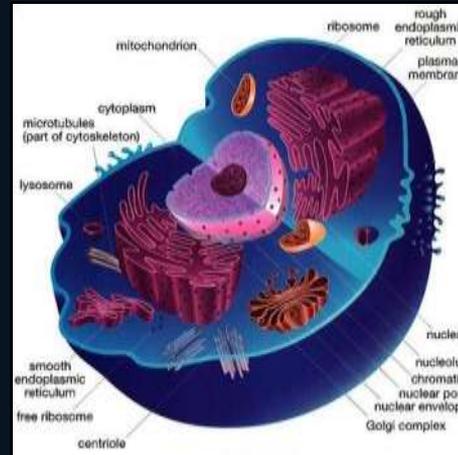
Gerber

NET WT. 4 OZ (113g)

Palatability is more than a matter of taste.



Flavor-feedback interactions involve phytochemicals interacting with cells and organ systems in a dynamic network that links digestive, excretory, cardiovascular, respiratory, nervous, endocrine, immune, skin, muscular, skeletal, and reproductive systems in the body.

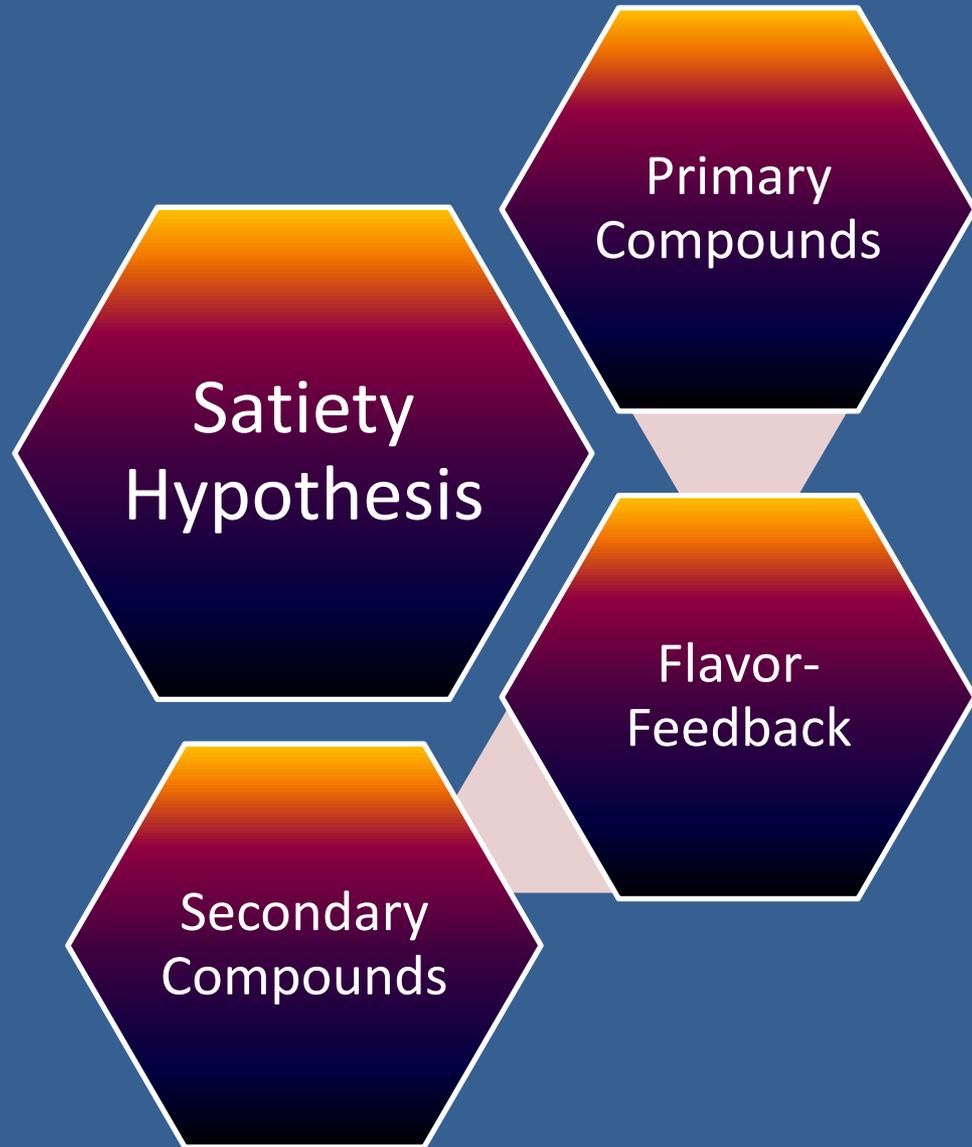


These relationships, mediated by nerves, neurotransmitters, peptides, and hormones, are the basis for the nutritional wisdom of the body manifest through the ability to meet needs for energy, protein, amino acids, various minerals, and to self-medicate.

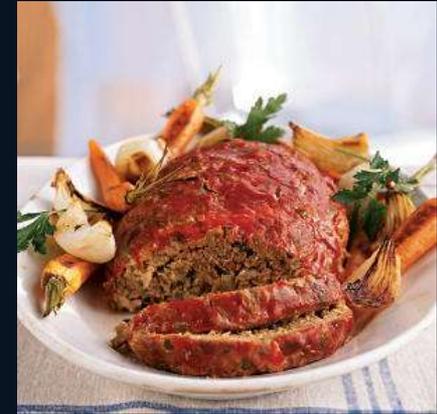




Why do animals eat a variety of foods?



Eating any food to satiety causes a transient food aversion based on interactions among flavor, primary, and secondary compounds.





Soil, plants, and herbivores benefit when herbivores roam, behaviors they do naturally when they are not confined.



- ✓ Stimulates appetite
- ✓ Enables individuality
- ✓ Enhances nutrition and health
- ✓ Decreases disease and parasites
- ✓ Minimizes overgrazing

Landscapes with diverse arrays of plants are nutrition centers and pharmacies with vast arrays of primary and secondary compounds.



Nothing is more important for health through nutrition than...

...eating a variety  
of foods and foraging  
in a variety of places  
for herbivores...



...exposing your body  
to a variety of whole foods  
and trusting the wisdom  
of your body to select  
what it needs.

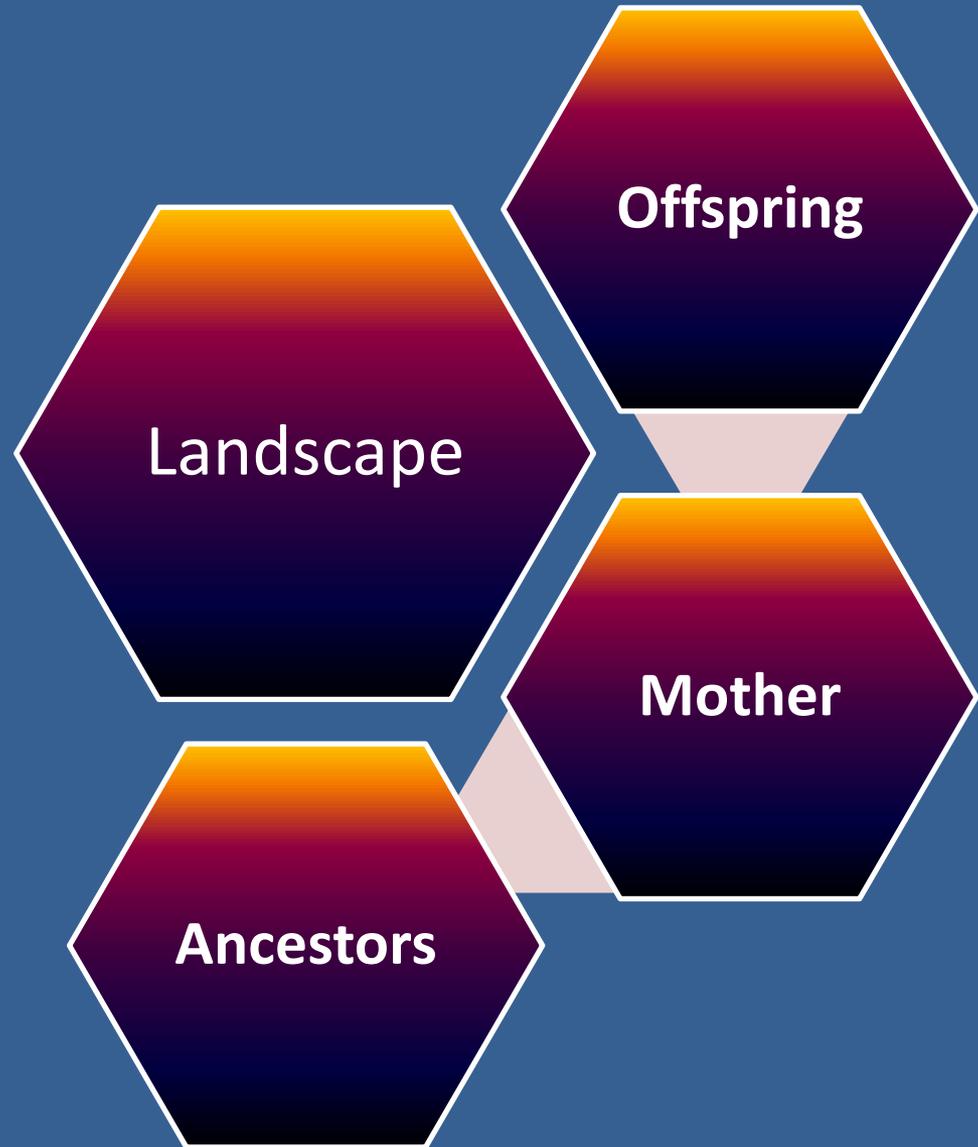


Assuming the foods on offer meet needs for energy, protein, minerals, and other phytochemicals, satiety leads to contentment and a lack of the cravings that cause animals to over-ingest foods.



Food systems based on *quantity* rather than *quality* have a destructive feedback loop built into them: the more low-quality food one eats, the more one wants to eat, in a highly profitable quest to obtain nutrients in low concentrations.

What does it mean for creatures to be locally adapted to a landscape?

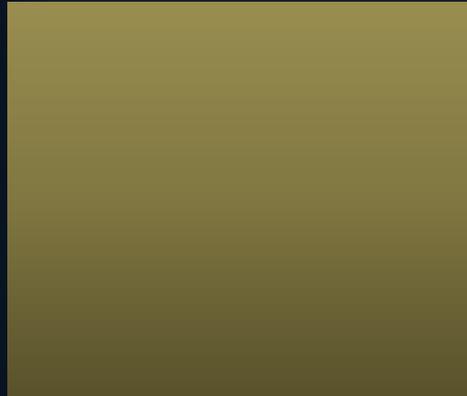


Natal experiences affect food and habitat preferences in a broad range of animal taxa including insects, fish, birds, and mammals (Davis and Stamps, 2004).



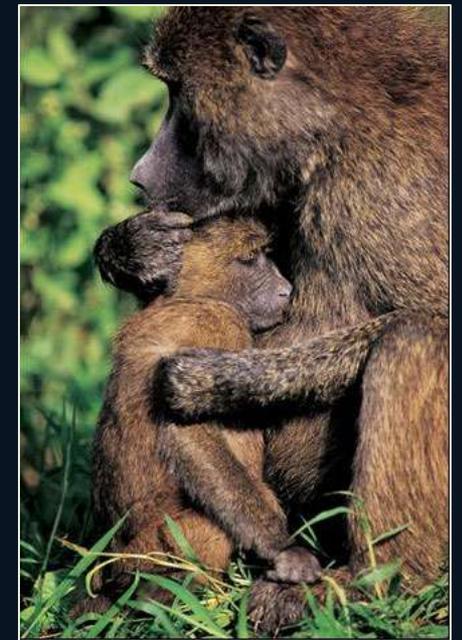
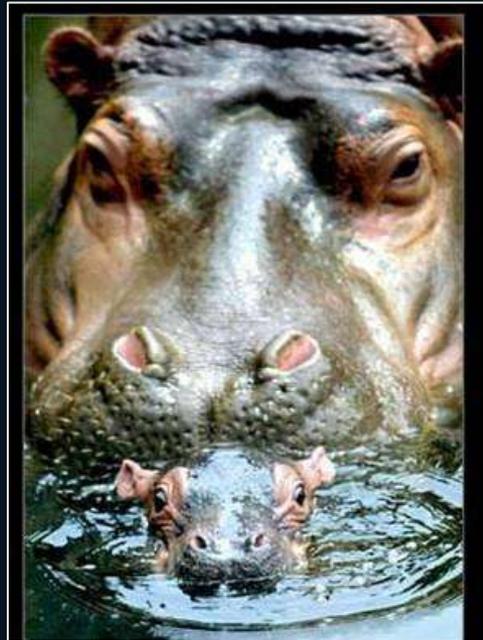
## A Mother's Lifelong Diet Influence

- *in utero*
- mother's milk
- mother as a model



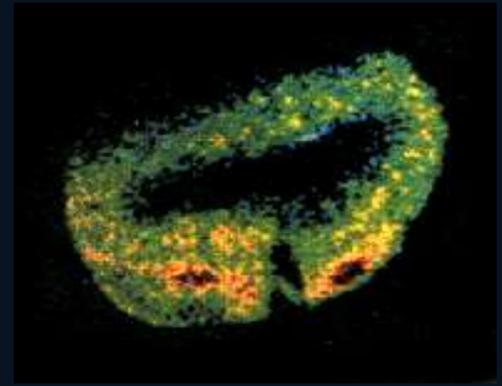
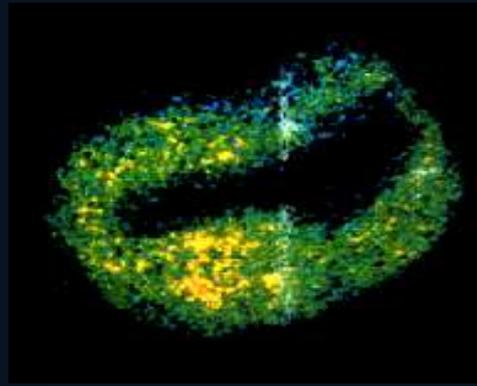
## Cultural Inflection

Expressed behaviors occur within the context of ongoing adaptation in environments where creatures are conceived, born, and live over many generations.



Genes influence form, function, and behavior, which in turn influences gene expression.

- ✓ Neurological
- ✓ Morphological
- ✓ Physiological
- ✓ Behavioral



As environments change in space and time, so do bodies within and among generations.

"A thrilling survey of how the science of fetal origins is changing the way we think about the nine months before birth."

—Dr. Mehmet Oz, coauthor of *YOU: Having a Baby*

HOW THE NINE MONTHS  
BEFORE BIRTH SHAPE THE  
REST OF OUR LIVES



# ORIGINS

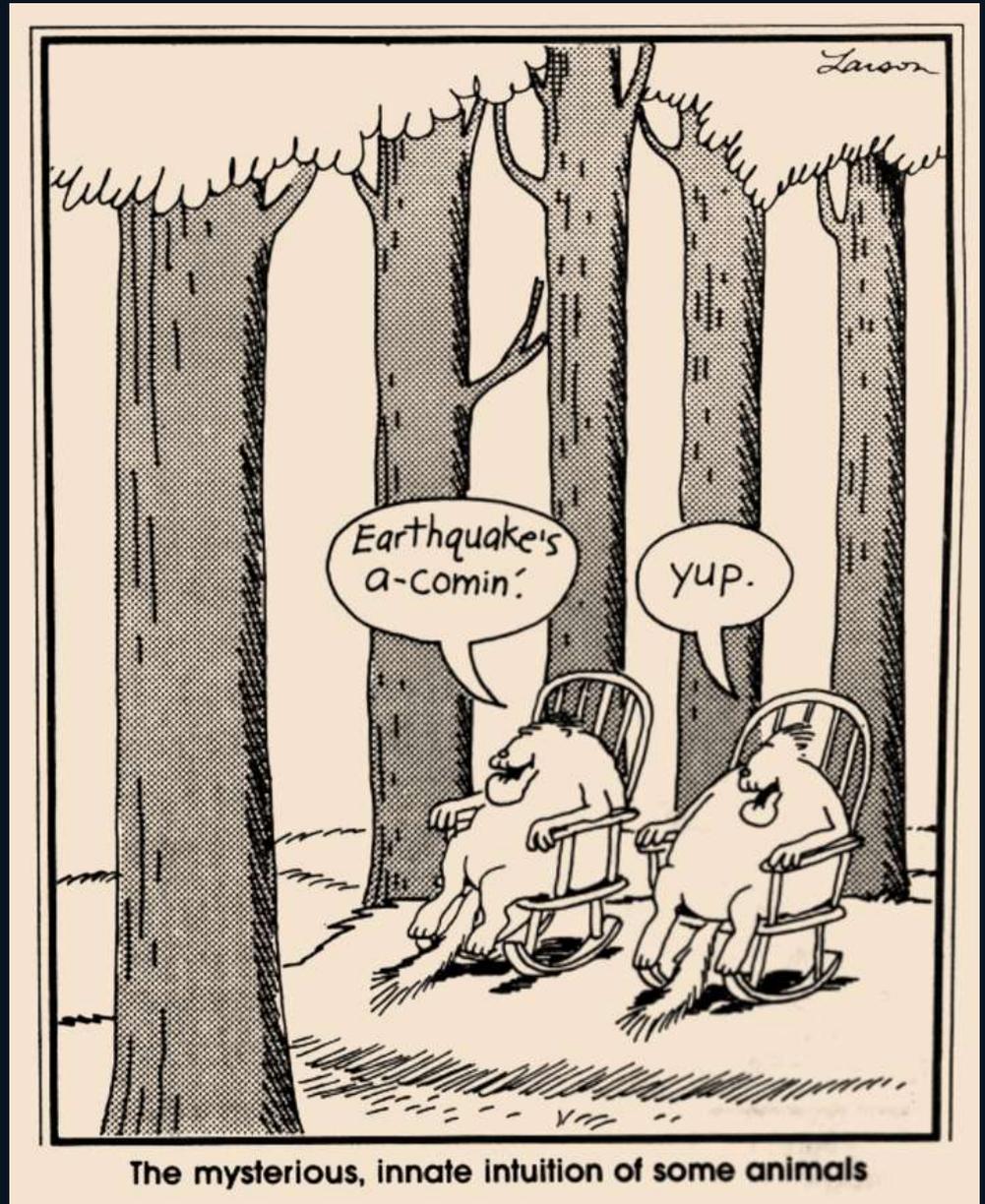
**ANNIE MURPHY PAUL**

*Author of *The Cult of Personality**

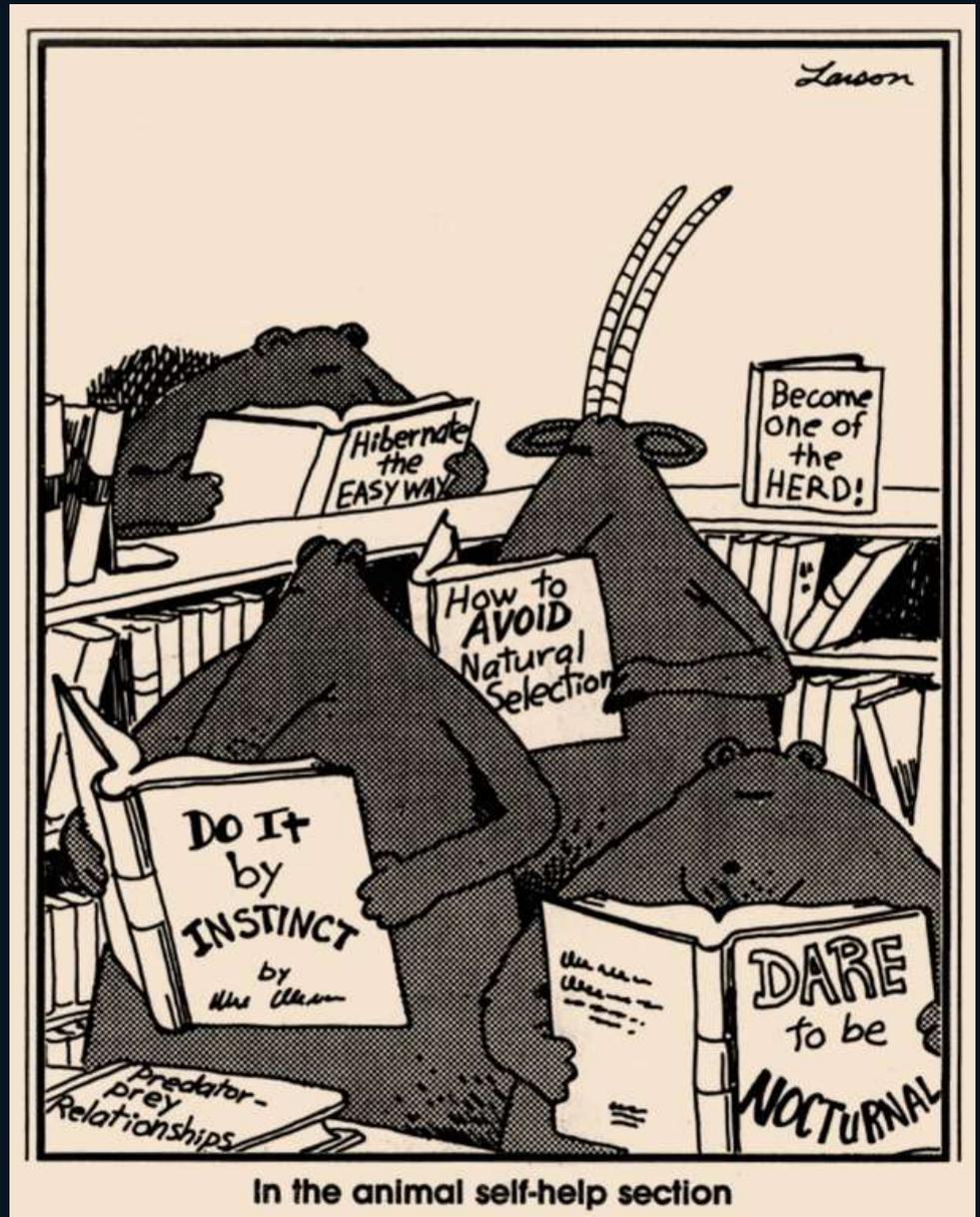
# GHOST IN YOUR GENES

Experts investigate how a mysterious "second genome" helps determine our biological fates.

We stress  
genetics as the  
mechanism of  
evolution...



...not appreciating that genes dialog continually with environments.



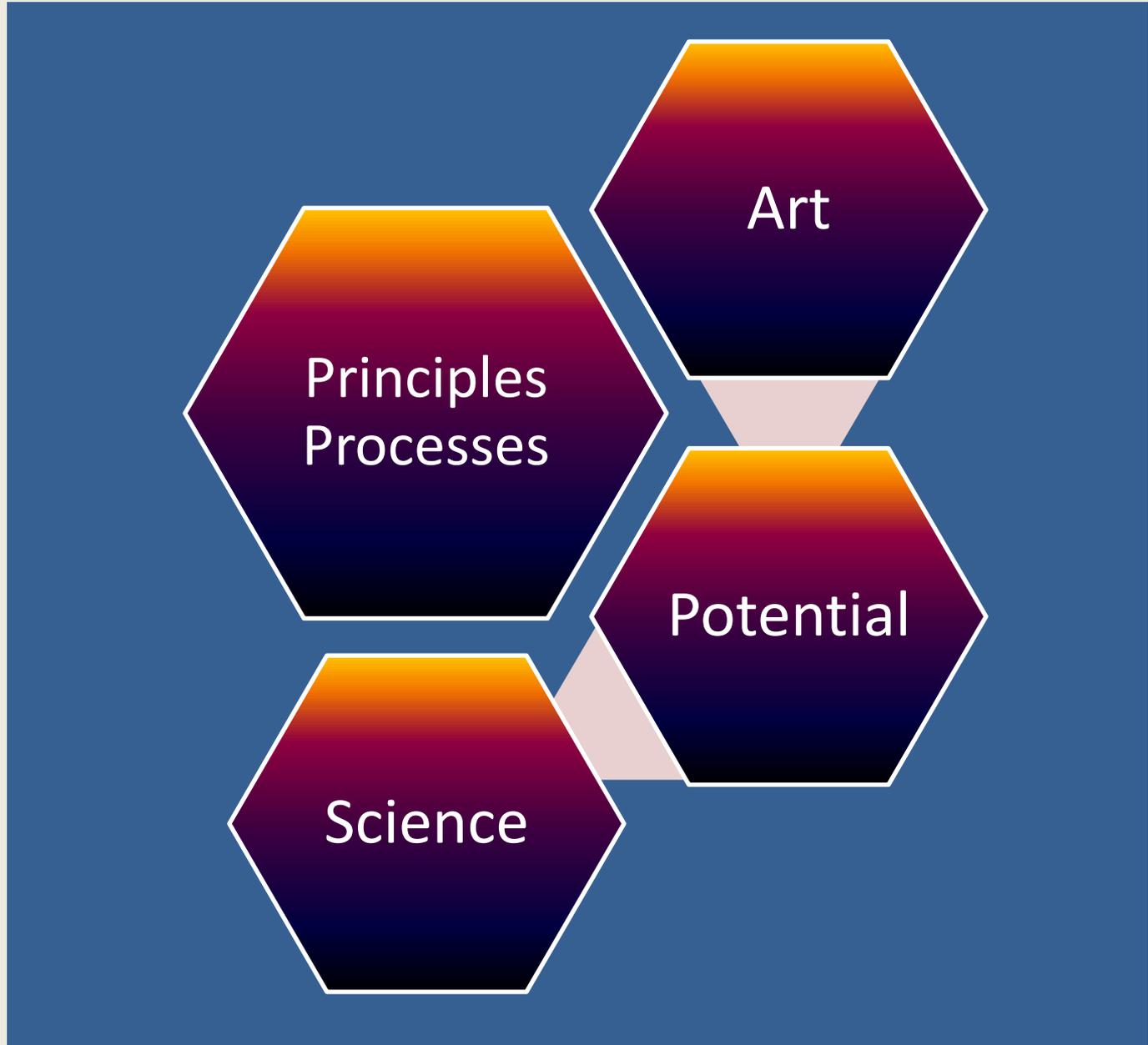
# Behavior-Based Adaptation

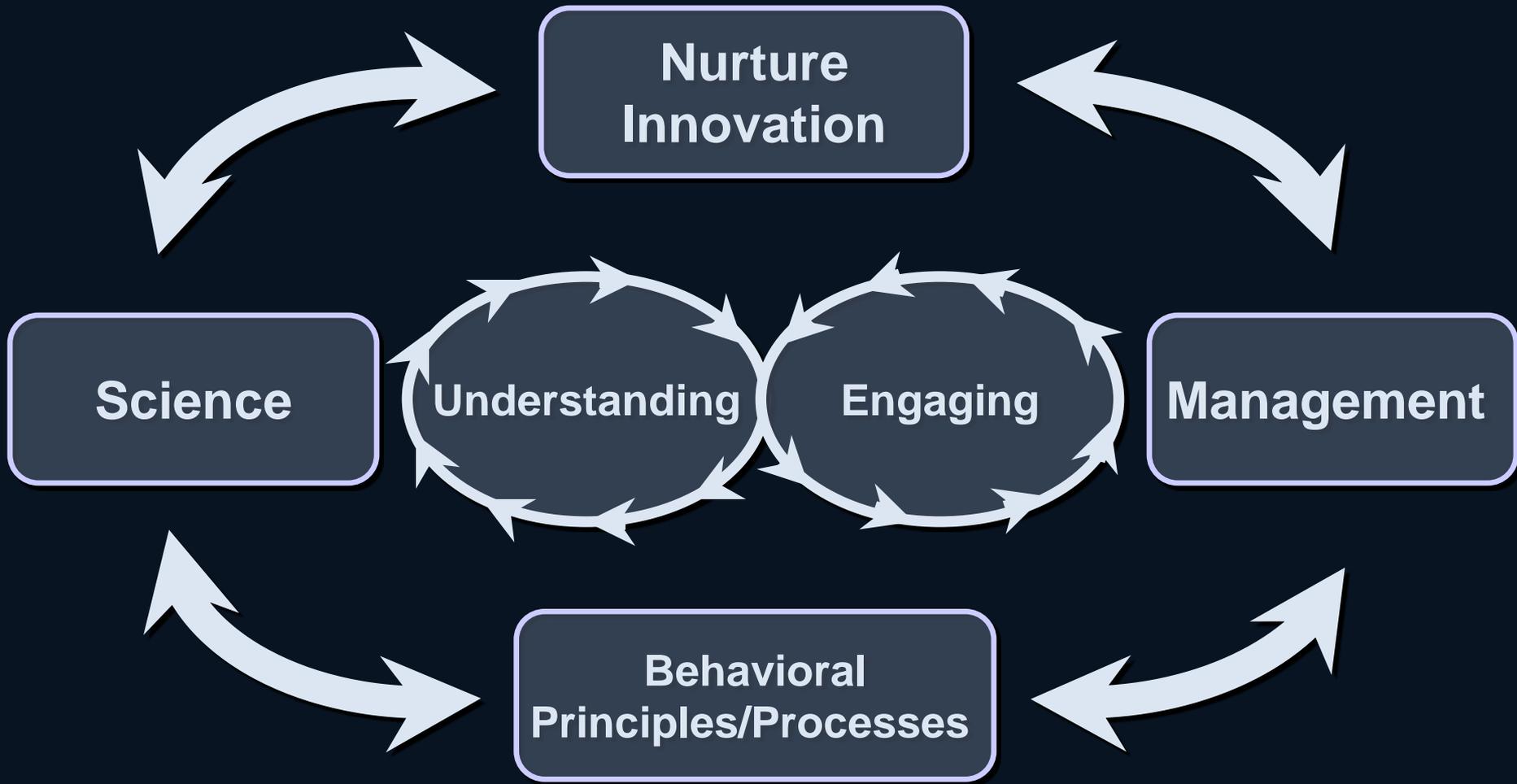
- Creatures aren't machines
  - Genes aren't destiny
  - Animals continually adapt



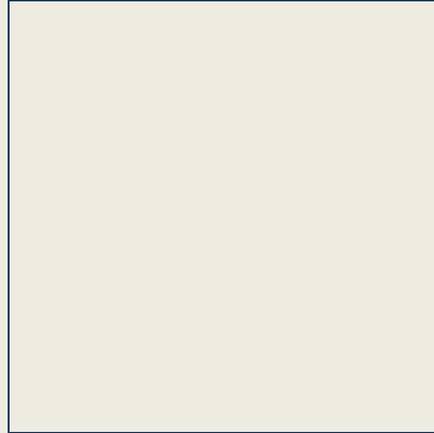
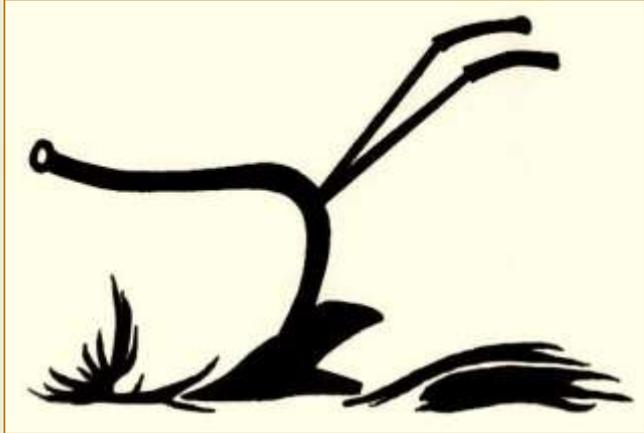
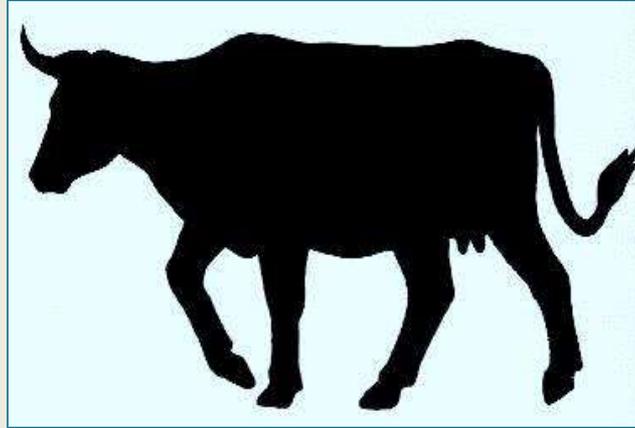


# Practices





BEHAVE is dedicated to integrating understanding of behavioral principles and processes with local knowledge to enhance social, economic and environmental values of communities and landscapes.



The Ax, the Cow, the Plow, and the People  
Managing Livestock Grazing for Biodiversity

Rekindling our relationship with landscapes and livestock: from fences as livestock-sitters to shepherds as ecological doctors.



We've come to  
rely on fences and  
grazing systems  
to influence  
distribution



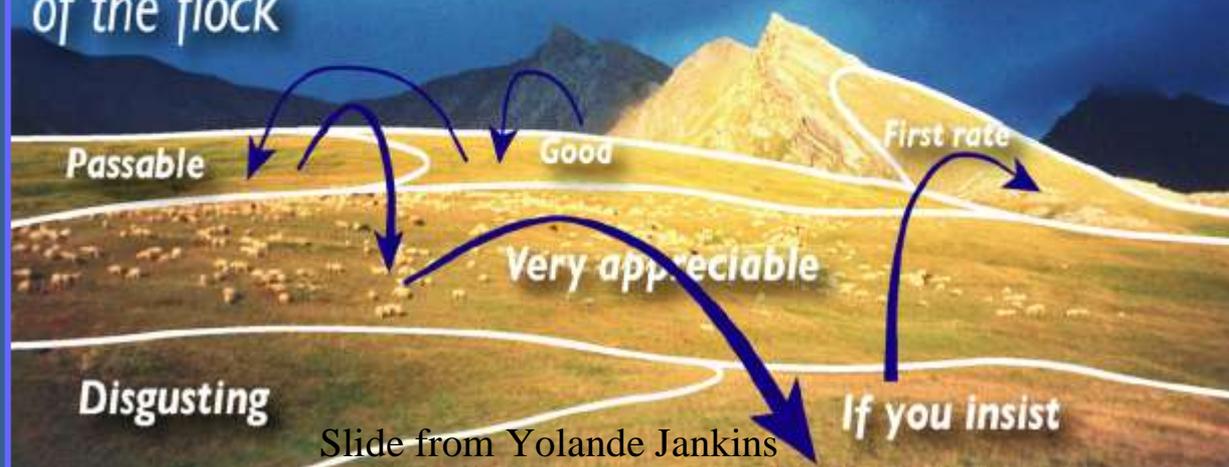
- ✓ Continuous to rotational grazing
- ✓ Low to high stock densities
- ✓ Infrequent to frequent moves
- ✓ Stockmanship to move and place

A Shepherd's  
Know-How  
Michel Meuret  
Fred Provenza  
Editors

Un Savoir-Faire  
de Bergers  
Michel Meuret  
Editor

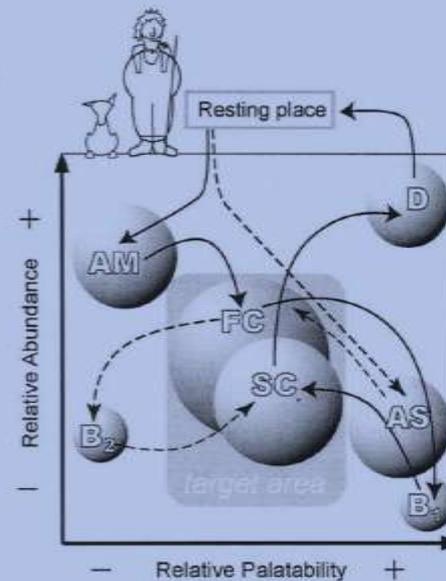
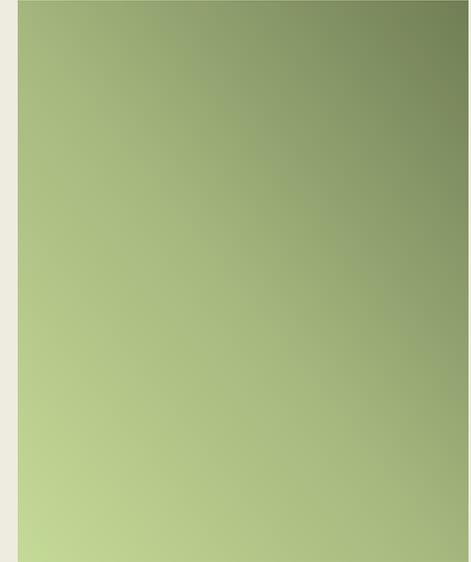
## 7. A few tricks to improve the flock's appetite

*Alternation is a key concept in maximizing the appetite of the flock*



# Grazing Circuits

- Stimulate appetite/intake
  - Enables individuals to regulate intake of primary and secondary compounds
  - Maintain biodiversity

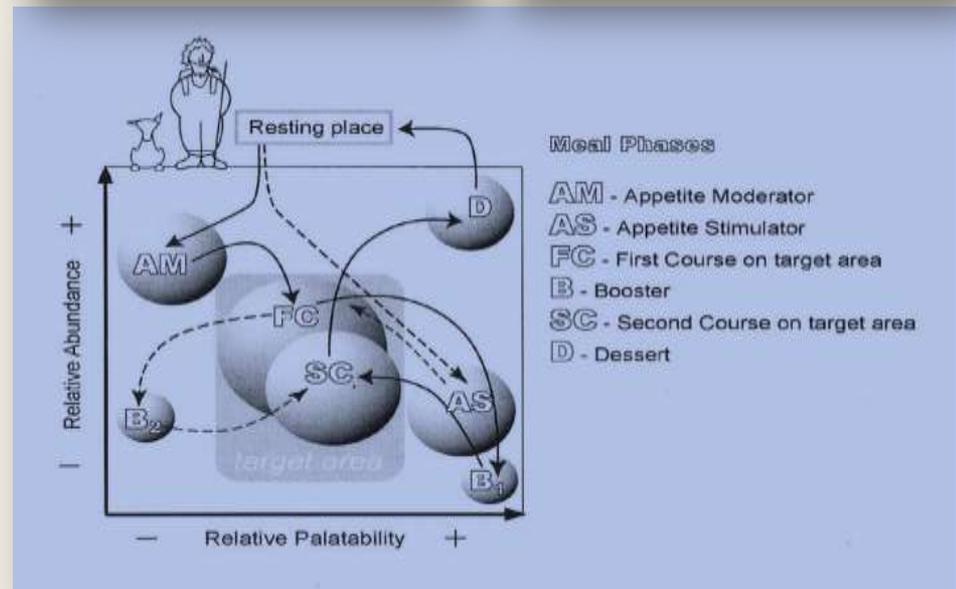


## Meal Phases

- AM** - Appetite Moderator
- AS** - Appetite Stimulator
- FC** - First Course on target area
- B** - Booster
- SC** - Second Course on target area
- D** - Dessert

Sheep eat  
spotted knapweed  
best after an appetizer  
of native plants.

Bitterbrush as an  
appetizer helps the  
sagebrush go down.



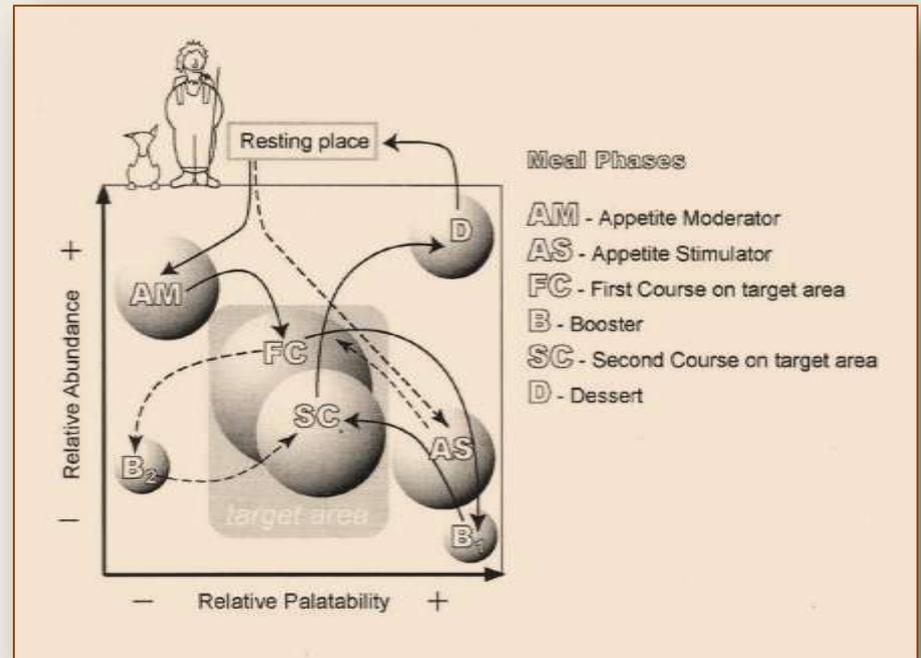
bitterbrush (tannins)



sagebrush (terpenes)

# Stockmanship Management- Intensive Grazing

Weeds - Australia  
Watersheds - Namibia



Stockmanship to  
move and place cattle  
to improve habitat for  
mule deer and elk at  
Hardware Ranch



Winter use by mule deer

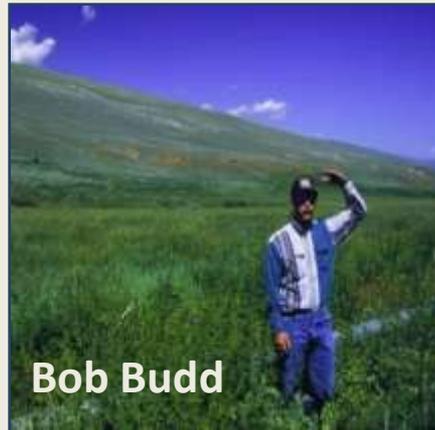


Spring use by cattle

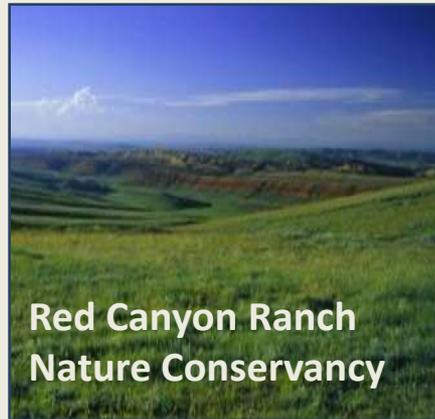


John and Jocelyn Haskell

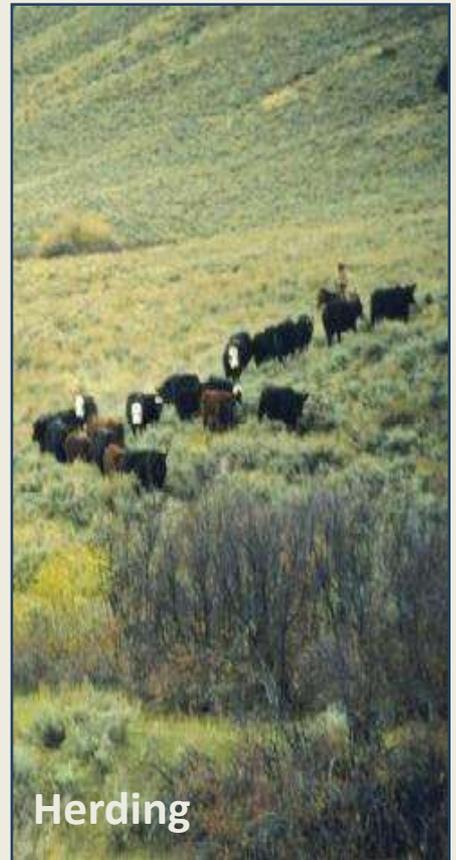
Stockmanship  
to change bottom  
dwellers into upland  
aficionados



Bob Budd



Red Canyon Ranch  
Nature Conservancy



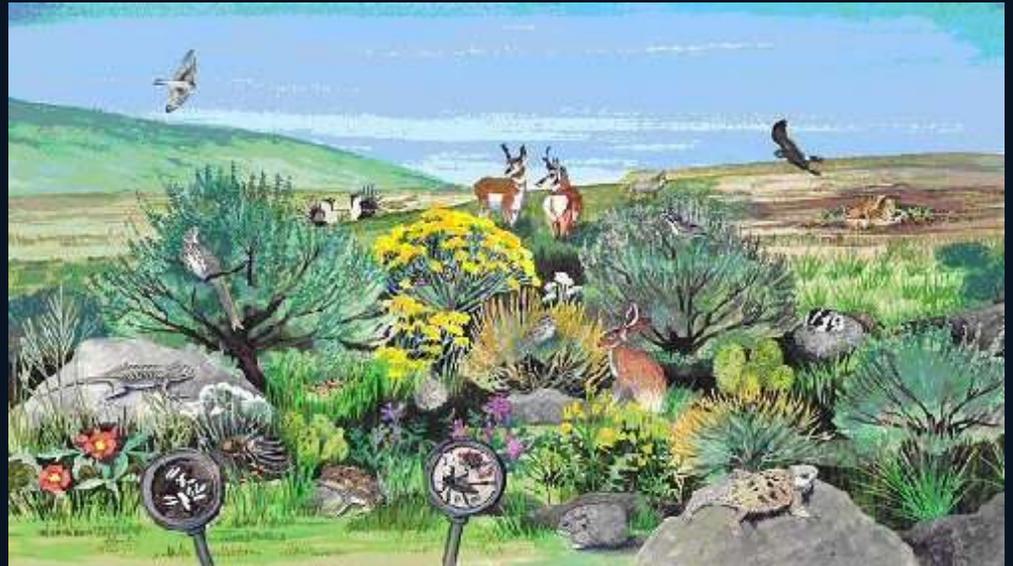
Herding



# Livestock as Land Rejuvenators

Sagebrush-Steppe

Lack of fire and spring grazing  
by livestock have caused  
vegetation changes



Increase sage, Decrease herbs



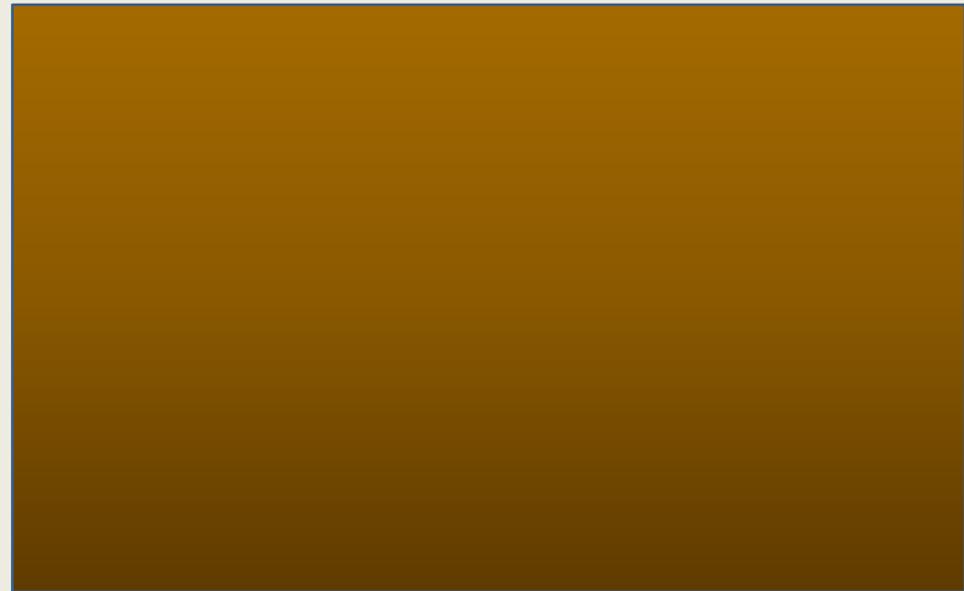
Less plant and animal diversity



Decrease in nitrogen  
Increase lignin and terpenoids



Decrease rates of plant  
decomposition and nutrient cycling



Turning cattle and  
sheep into low-cost  
rejuvenators of  
sagebrush-steppe

Utah, Oregon, Montana,  
Nevada, and Wyoming



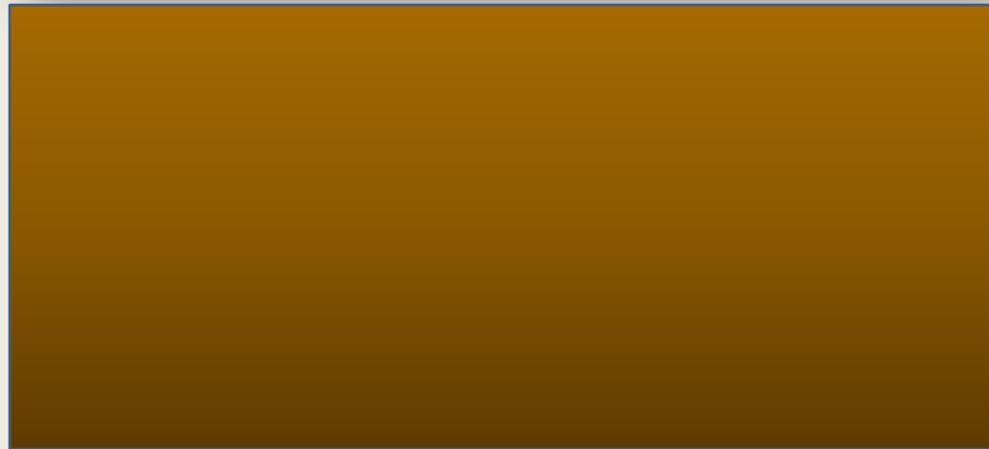
## Timing of Grazing

Fall and winter best  
for herbs, sagebrush,  
herbivores and  
ranchers.

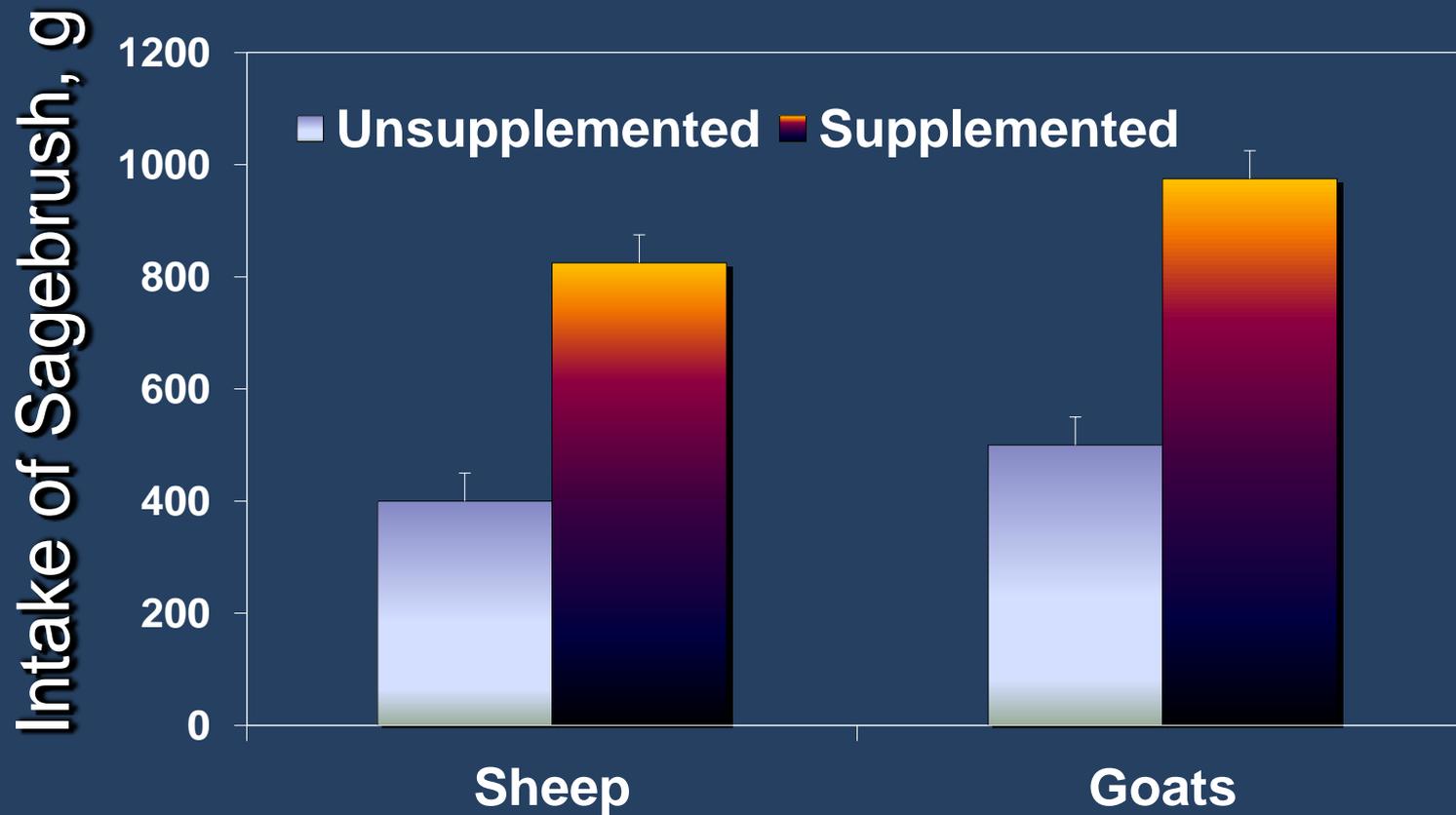


Terpene concentrations  
in sagebrush lowest in  
late fall and winter.

Supplemental  
energy and protein  
enhance intake of foods  
containing secondary  
compounds



# Supplemental protein and energy increase intake of sagebrush



In 2001

Low Stock Densities  
Inadequate Supplement



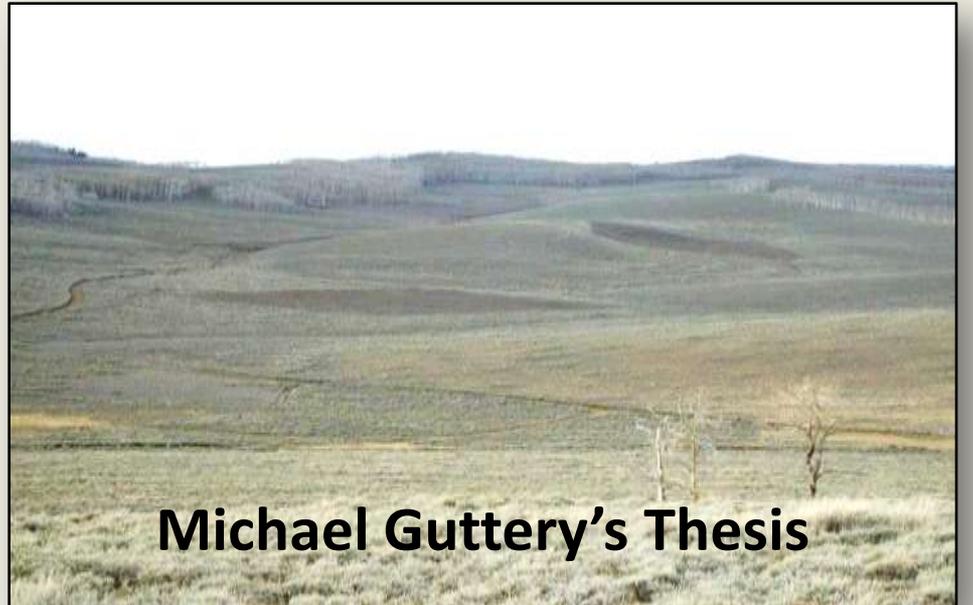
In 2003

High Stock Densities  
Adequate Supplement





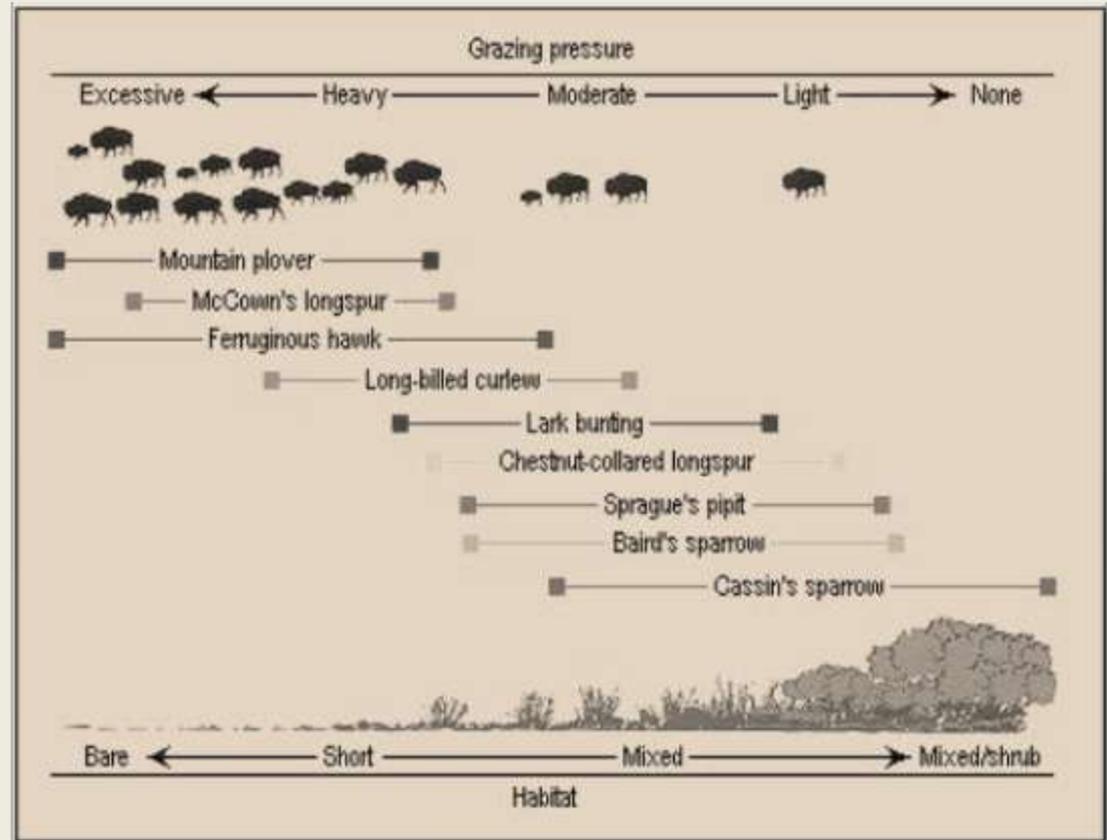
Sheep  
rejuvenate  
sage grouse  
habitat



**Michael Guttery's Thesis**

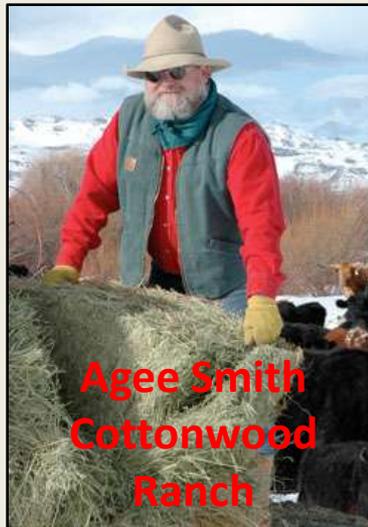
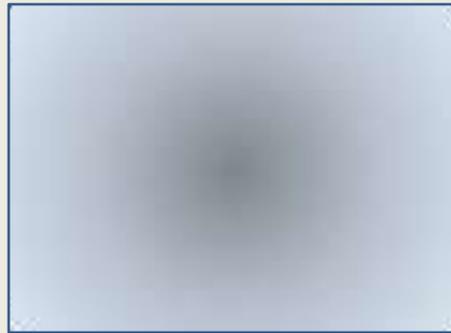
## Our Goals

- ✓ Integrate livestock into the system
- ✓ Create locally adapted cattle



Create mosaics of habitat to meet different needs within and among species

# Develop Locally Adapted Cattle



**Agee Smith  
Cottonwood  
Ranch**



**Chuck Petersen's Thesis**

Mat Carter  
Crown Cattle  
Company  
Oregon

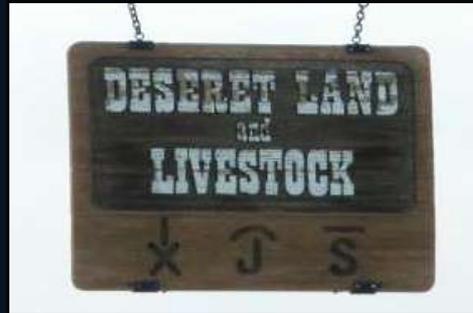


From sagebrush as a costly  
nuisance to sagebrush as a  
forage resource in winter

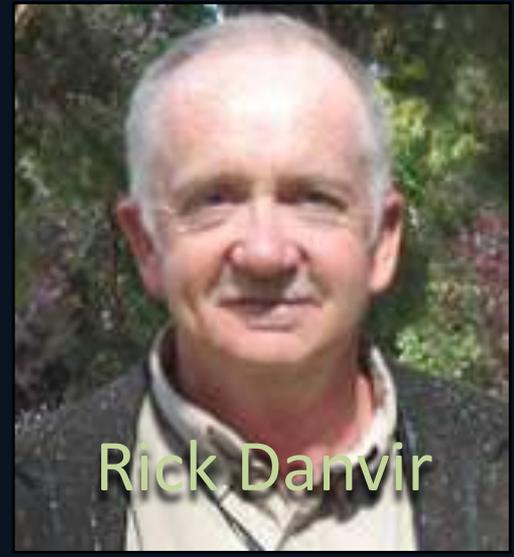


# Changing the Culture of Welfare Elk

Concerns:  
costs of feeding  
1,000 elk all winter,  
spread of brucellosis,  
chronic wasting disease,  
wolves...



DL & L began  
feeding elk in 1984



Rick Danvir

Strategic use of  
“carrots and sticks”  
(cattle grazing,  
supplementation,  
herding, hunting)  
changed food and  
habitat selection  
behaviors of elk



Areas grazed by cattle early in summer are attractive to elk in fall and winter due to the combination of re-growth and mature forage.



Stopped feeding to encourage  
elk not to use former feed grounds



Used stockmanship to  
move and place elk in desired locations



Provided  
supplemental  
energy and protein  
enable elk to eat  
more sagebrush



Used hunting to decrease elk use  
of areas where they were formerly fed



Since the project was initiated in 2004, elk have been fed only in 2005 and 2010

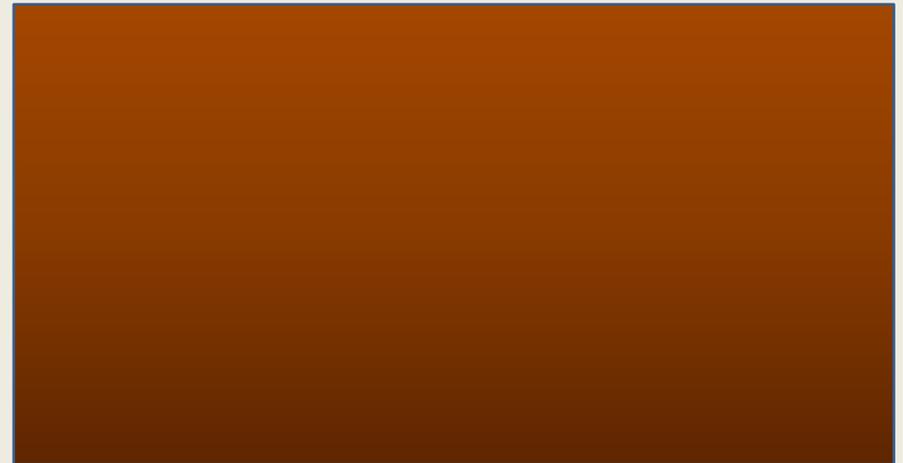
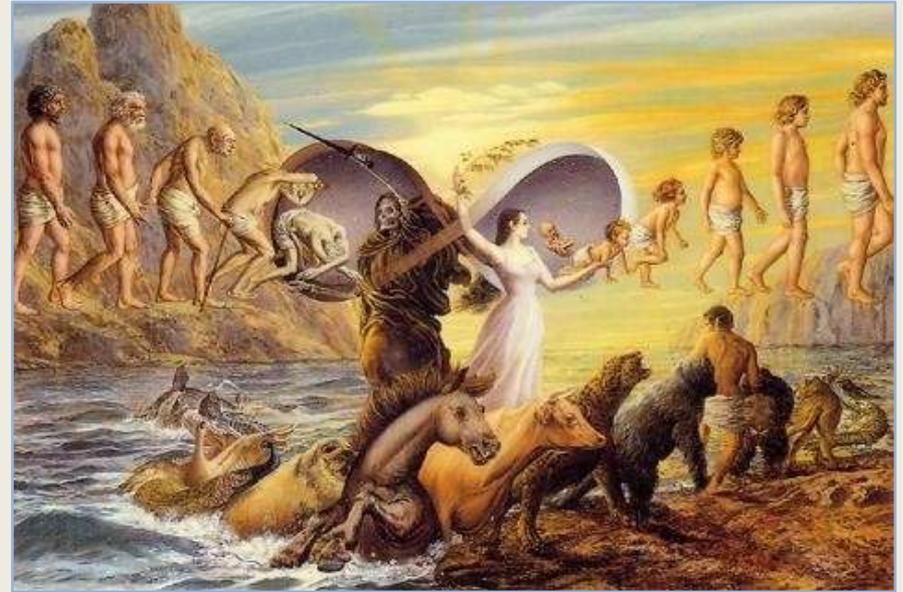


We fed hay only in areas we wanted elk and only on occasion



# Philosophies

In complex adaptive systems, components change, they cope and then capitalize, they emerge and then disappear...



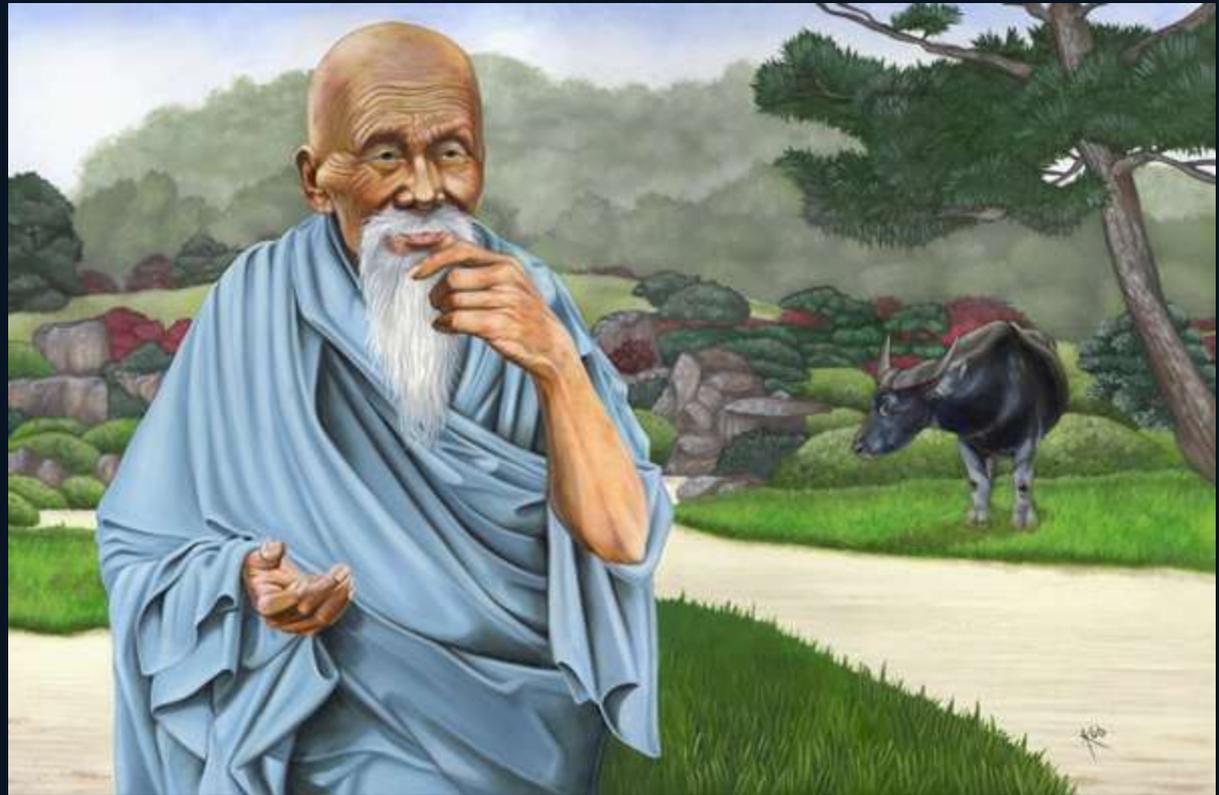
In attempting to “manage” complex adaptive systems, we typically long for a standard recipe to ensure we sustain the status quo, despite knowing that we are awash with variability in physical and biological environments largely out of our control.



Managing complex adaptive systems requires flexibility, and less effort attempting to control than to understand and respond cautiously but continuously to changes as they arise.

If you realize that  
all things change,  
there is nothing you  
will try to hold on to.  
If you aren't afraid of  
dying, there is nothing  
you can't achieve.

*Lao-tzu, Tao Te Ching*



Trying to control the future is like  
trying to take the master carpenter's place.  
When you handle the master carpenter's tools,  
chances are that you'll cut yourself.

*Lao Tzu, Tao Te Ching*

The greatest challenge in addressing any issue is crossing the divides that polarize and isolate us to address global challenges we all face as the world changes relentlessly.



The strange and wonderful irony is that we must work together to transcend the boundaries we create to address global issues.

## **“Love Your Enemies”**

**By opening up to other peoples,  
we vastly increase the diversity of  
options upon which to act.**

Love is the source of creativity.

When people lose the capacity to love one another, they lose hope. When they lose hope, they lose the ability to imagine the future, and in so doing they lose faith in their power to participate in creating it. In the end, there are but three things that matter, and the greatest of these is love.

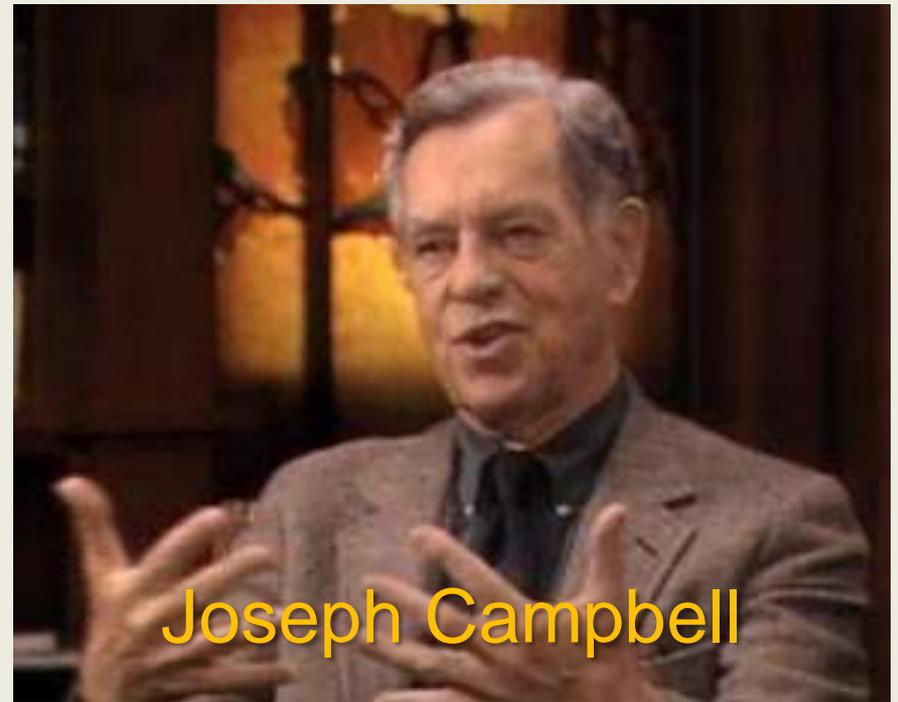
Life is the stage upon  
which the challenge to learn  
to love one another plays out,  
no matter one's vocation.

**The courage  
to love is the  
courage to transcend  
tradition and it is the  
source of creativity.**



**For as paradoxical as it may seem,  
creativity comes from the unions of pairs  
of opposites, from ceaselessly dying to  
one's self only to be born anew.**

We have not even to risk the adventure alone, for the heroes of all time have gone before us. The labyrinth is thoroughly known.



We have only to follow the thread of the hero path, and where we had thought to find an abomination, we shall find a god. And where we had thought to slay another, we shall slay ourselves. Where we had thought to travel outward, we will come to the center of our own existence. And where we had thought to be alone, we will be with all the world.

