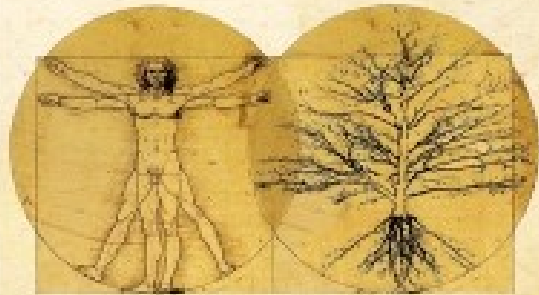


Foundations *for* Sustainability

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A Coherent Framework of Life–Environment Relations



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Chapter 4

Life: From origins to humans

Chapter 4

Life: From origins to ~~humans~~ destiny

Your reaction

1) It may be that we cannot know and achieve sustainability on Earth until we know and achieve colonization of Life beyond Earth.

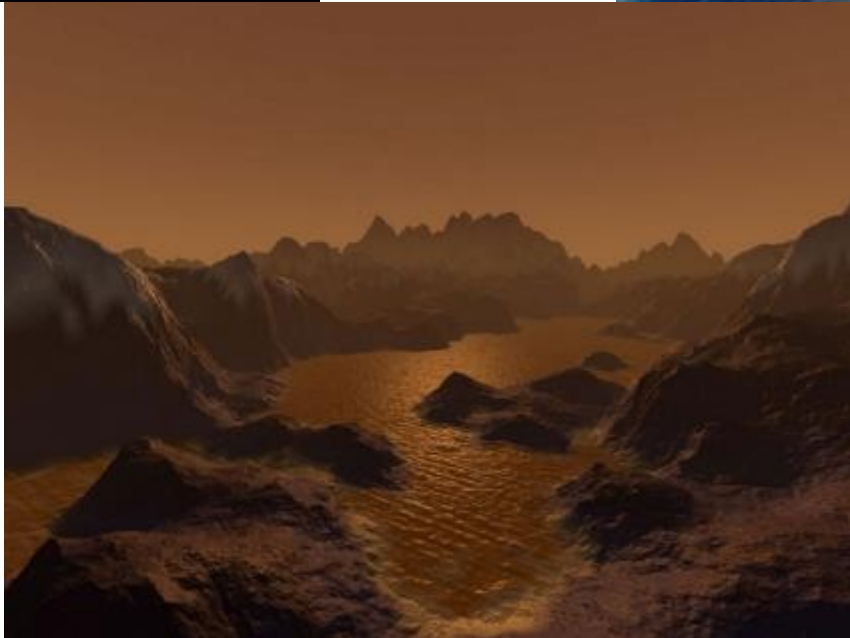
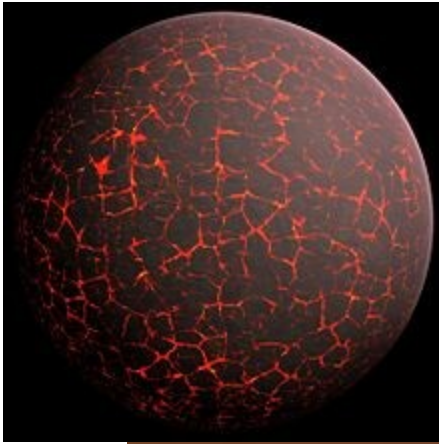
What does this mean and do you agree?

2) What part was most confusing or most difficult to understand?

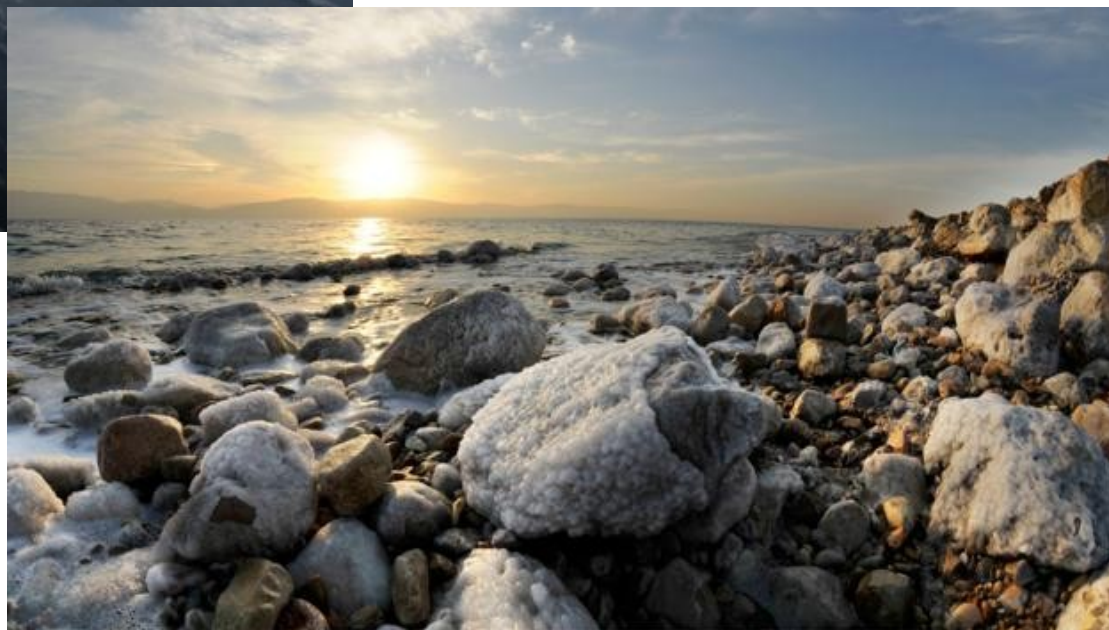
Ecosystemic Life hypothesis

- Which came first the organism or the ecosystem?

Earth before Life

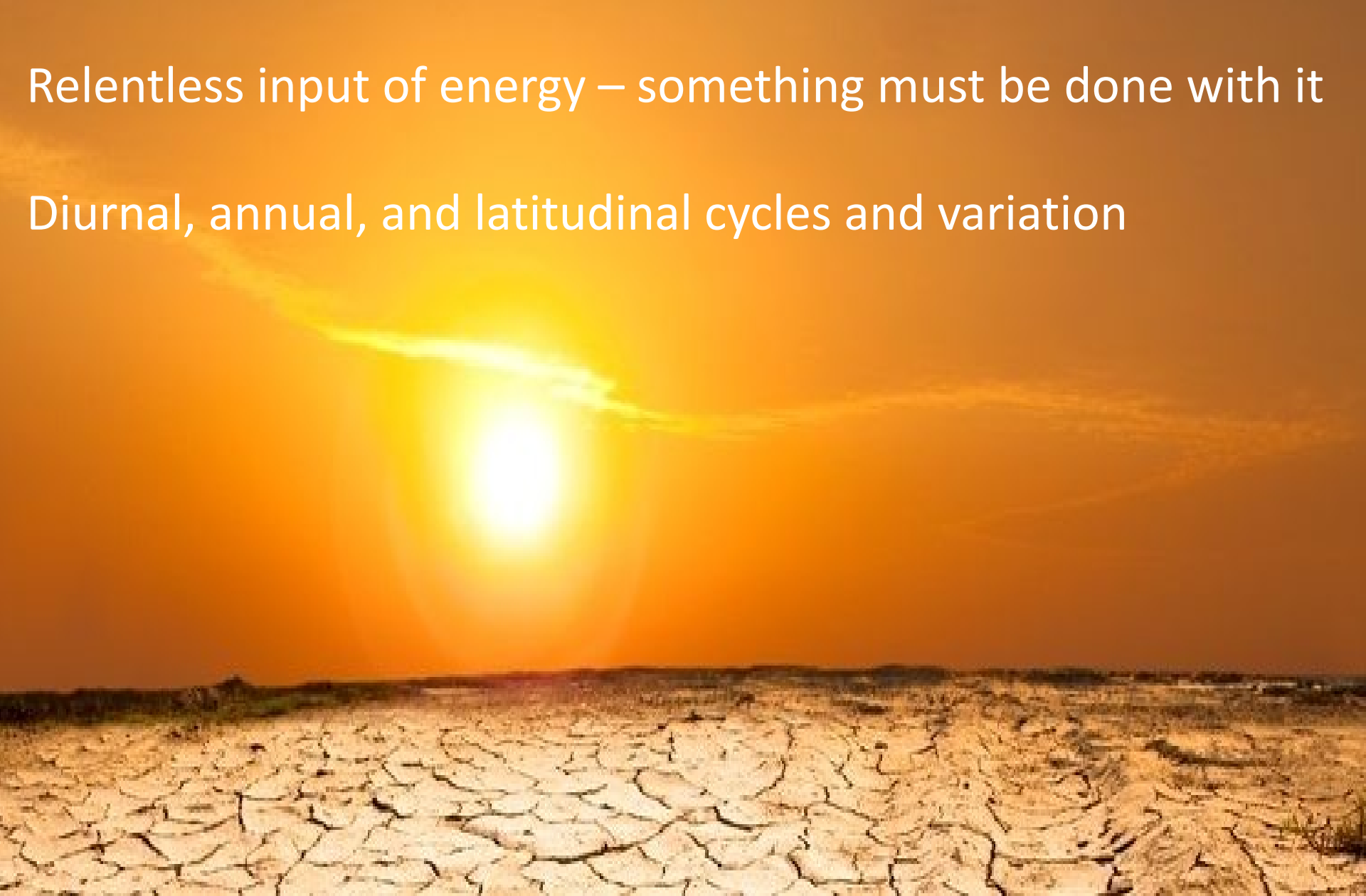


Solar energy

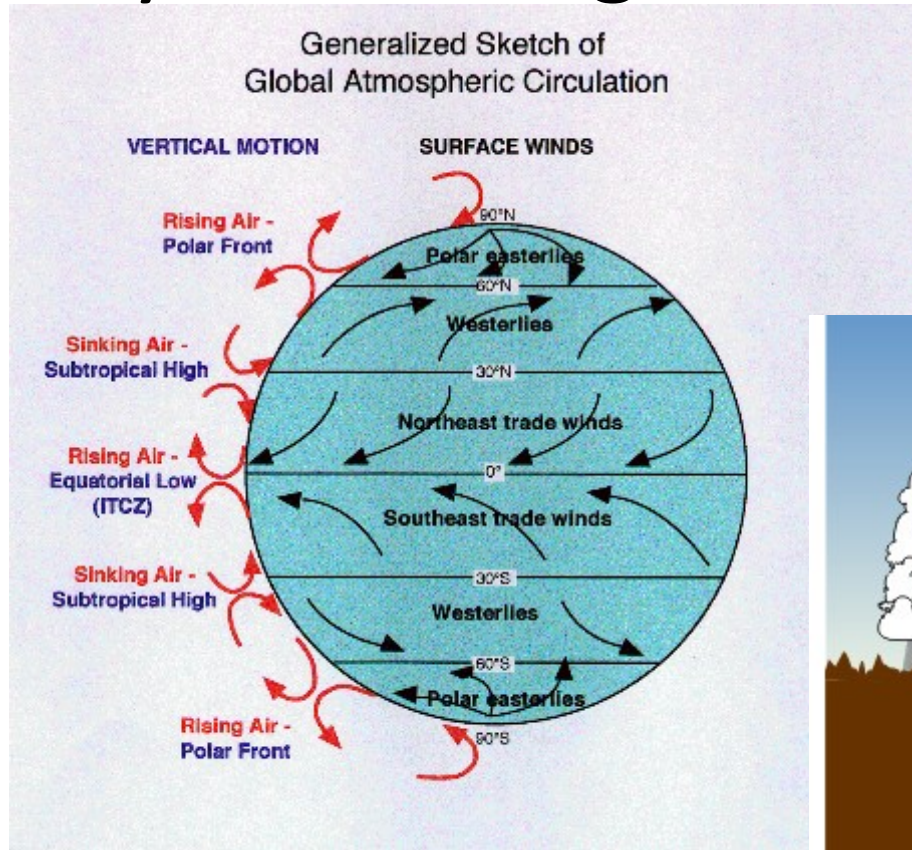


Relentless input of energy – something must be done with it

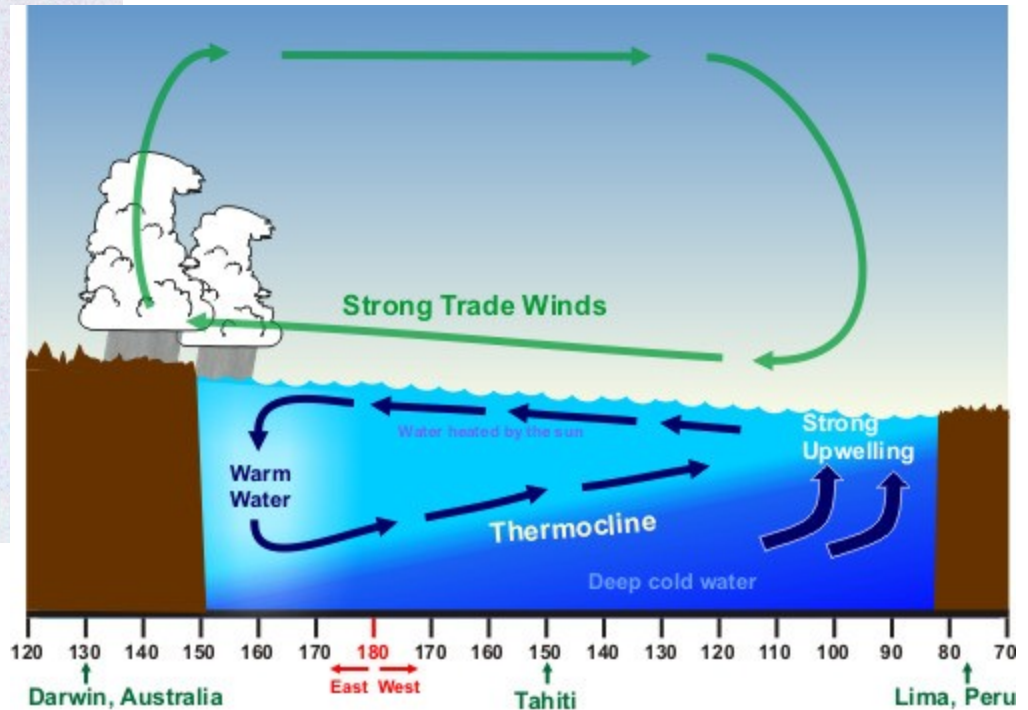
Diurnal, annual, and latitudinal cycles and variation



Energy gives rise to gradient formation: cycles emerge to dissipate the gradients



In air and sea together

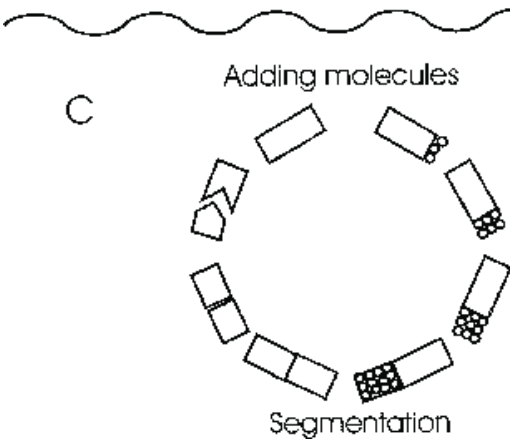
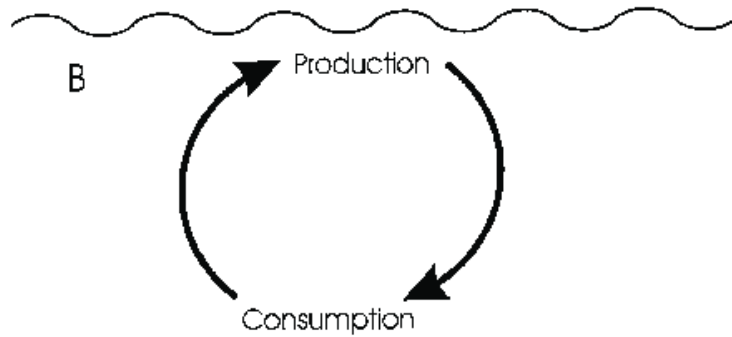
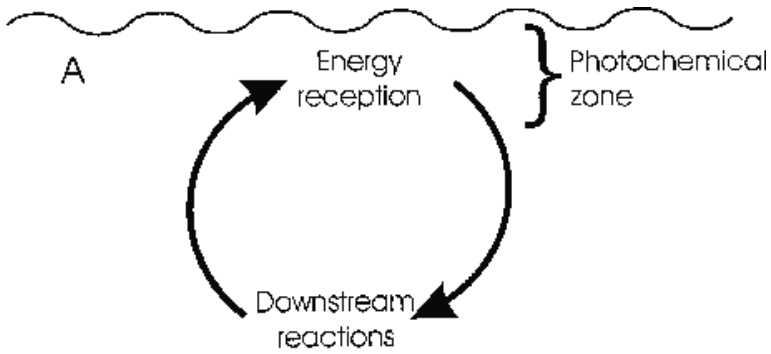


gradient is a differential (e.g., hot and cold) that has the ability to do work

Geothermal energy



Also gives rise to gradients and flow



Ecological Origin of Life

HT Odum

Prebiotic coupled complementary processes

- Production
- Consumption

The ecological cycle generated

- cells
- organisms

Encapsulation of the processes



In the seas and at the margins of land
Estuarine turbidity maximum



An alternative – the first organism



I'm here
What's for dinner?

LIFELESS
planet

An organism without an ecosystem?

Undifferentiated wholeness

- A time before a distinction of life and non-life
- Only one relation: environment-environment

- Two new relations were created inside the former undifferentiated system:
 - Life-Environment relations
 - Life-Life relations



Life-Environment relation is inherently good

- Survival of life (sustained life) is value basis
- Environment can be good toward Life, and
- Life can be good for the environment

- Relations can squeeze more value out of the energy gradients, i.e, by being more complex can do more work, persist longer

- Life must be working with, augmented by Environment, else would have perished long ago

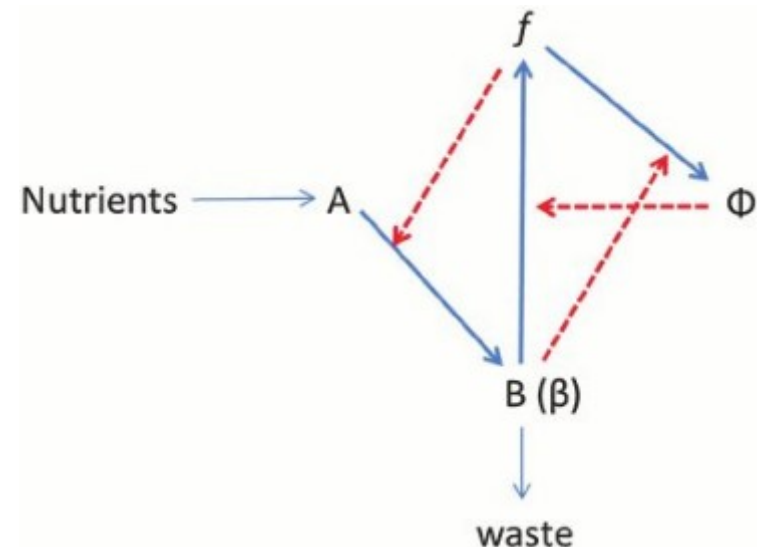
What is Life?



- 1) Life has a metabolism, where it harvests energy/resources from an external source for its own use.
- 2) Life can grow, adapt to its environment, or can otherwise evolve from its present form into a different one.
- 3) Life responds to external stimuli from its environment, and alters its behavior accordingly.
- 4) And life can reproduce, creating viable offspring that arise from its own internal processes.

Robert Rosen's (M,R)-system

- Metabolism and Repair
- Why is an organism different than a machine?
 - Organisms are self-making and self-causing
 - Closed to efficient cause



To understand how life persists on Earth, we have to understand ecosystems

“We tend to think about life in terms of individuals, because individuals are alive. But sustaining life on Earth requires more than individuals or even single populations or species...

Living things require 24 chemical elements, and these must cycle from the environment into organisms and back to the environment. Life also requires a flow of energy...

Although alive, an individual cannot by itself maintain all the necessary chemical cycling or energy flow. *Those processes are maintained by a group of individuals of various species and their non-living environment...*

Sustained life on Earth is a characteristic of ecosystems, not of individual organisms or populations.” (Keller and Botkin 2008, p. 66)

Sustained Life
Living Beyond Boundaries

Unit of selection

- Could an ecosystem provide a robust unit of selection?
 - Discrete construction of life
 - Sustained construction of life
- Life selects its environment as much as Environment selects Life



Eohippus
55–45 million years ago

Meshippus
40–30 million years ago

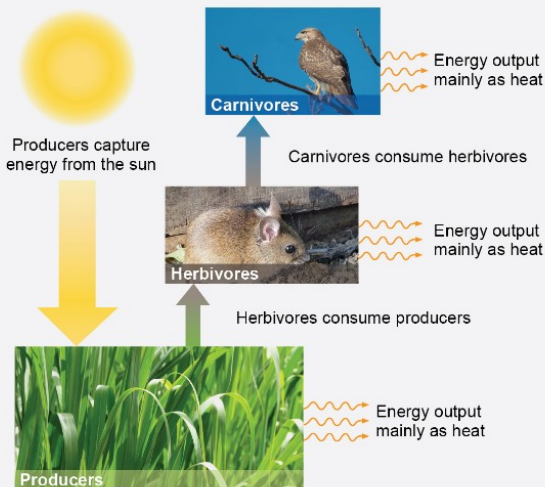
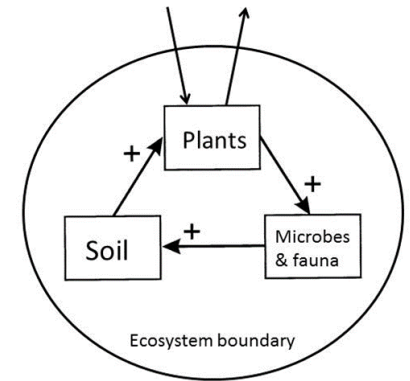
Hipparion
23–2 million years ago

Przewalski horse
recent

Grazing
Fertilizing
Aerating
Compacting

Gradients

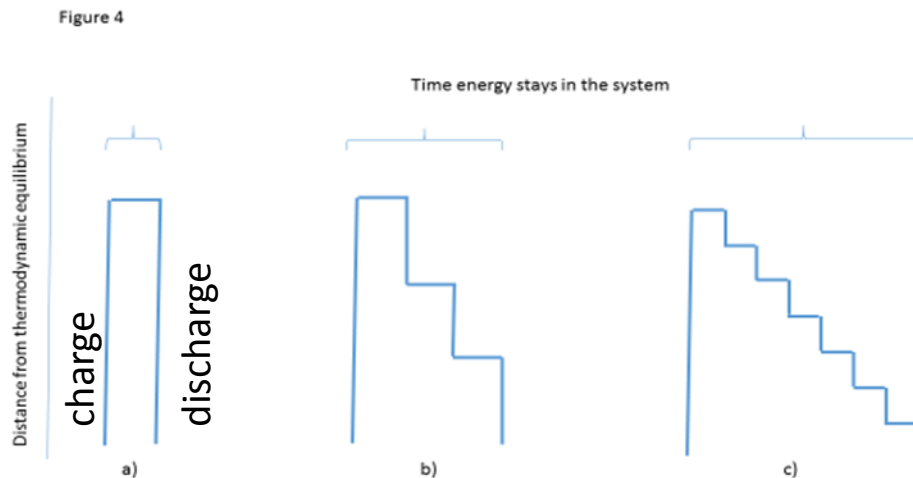
- The build up of gradients
 - Through autocatalytic processes
 - Non-random structures
 - Amounts or concentrations of energy and matter
- The pace of release, use, or dissipation of the gradients



an ecosystem can be thought of as a conduit through which energy passes, with *many or few transformations* of energy/matter during its trip through the conduit. The interesting question is what happens in the conduit.

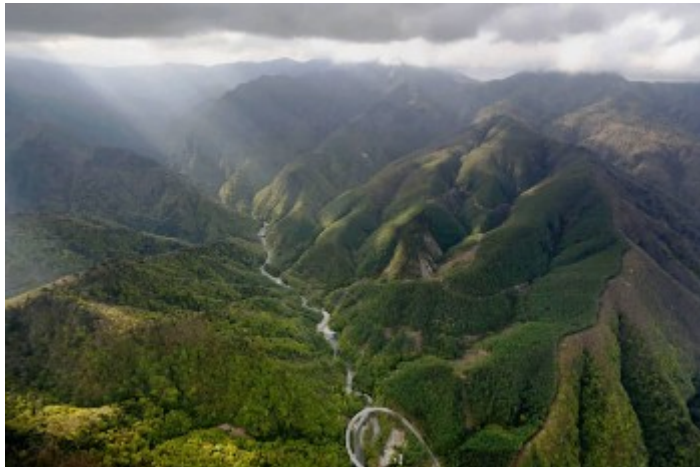
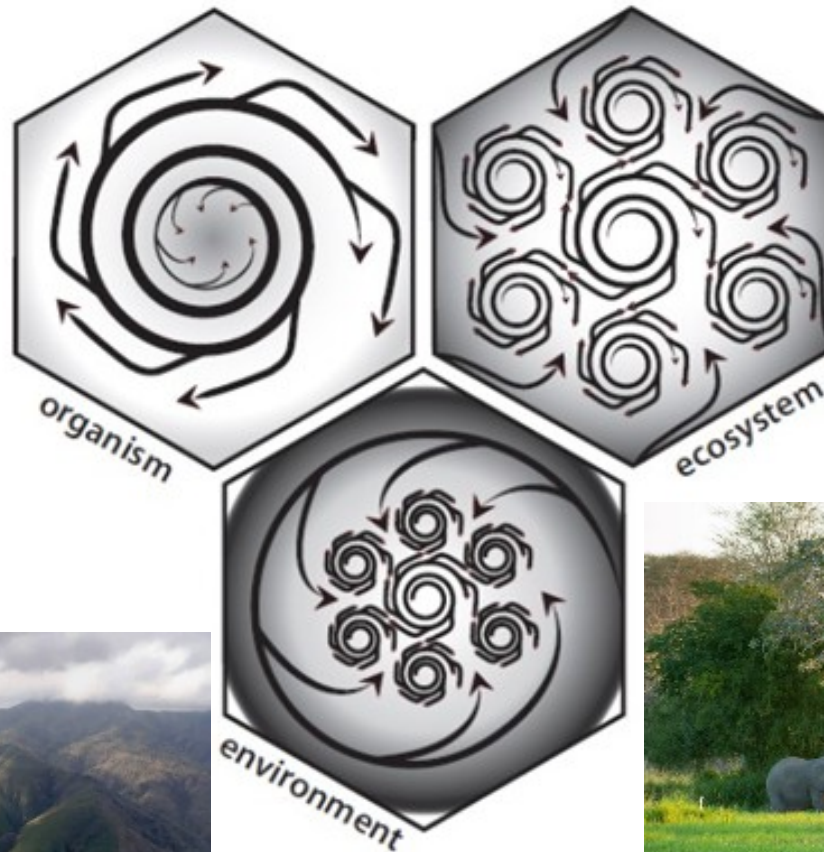
Organization matters

- Desert – energy passage is swift and simple leaving little traces of its passage
- In the forest, energy flow is anything but swift and simple, because of the diverse and roundabout way that the system's web of teeming, interdependent organisms uses energy.



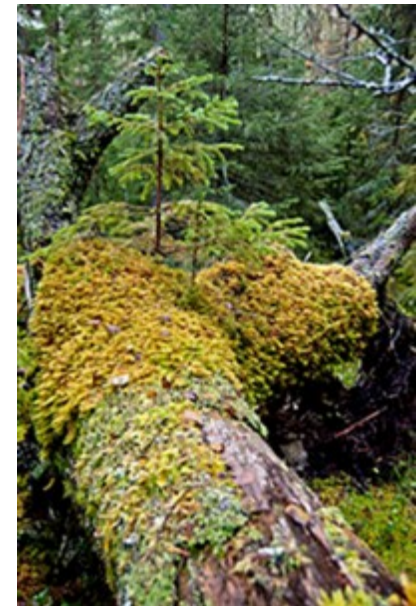
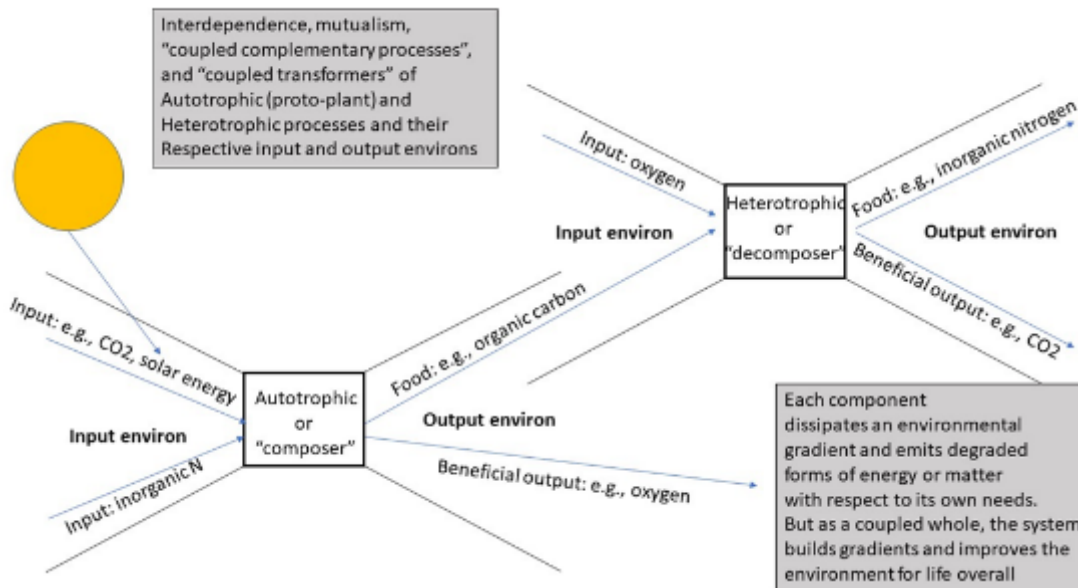
Is the driver: 1) the structure, 2) the dissipation, 3) the process, or something else?

Definition of Life requires at least three unit-models



Closure of efficient cause

- Life emerges and self-sustains through a type of self-organization such that each participant “thing” is “doing its own thing” and “doing its own thing to fit together”
- “The function of each task is its role in the reproduction of this Kantian whole.” Kaufman 2011



Ecological self

- Discrete self (bounded by skin)
- Extended self (including environmental context)



- Remain healthy in a holistic + context fashion, caring for the Life-support systems we depend on

Discussion questions

- What is the role of water in the origins of life?
- Which came first the organism or the ecosystem?
- What does it mean to say relations are not material and need not be conserved?
 - Life: a novel emergence of relations

Discussion questions

- What is the relevance of Hierarchy in the hexaflexagon?
- Is the whole idea of autocatalysis and closure making sense?
 - The result of systemic operations are once more systemic operations
 - Can there be circular hierarchies?