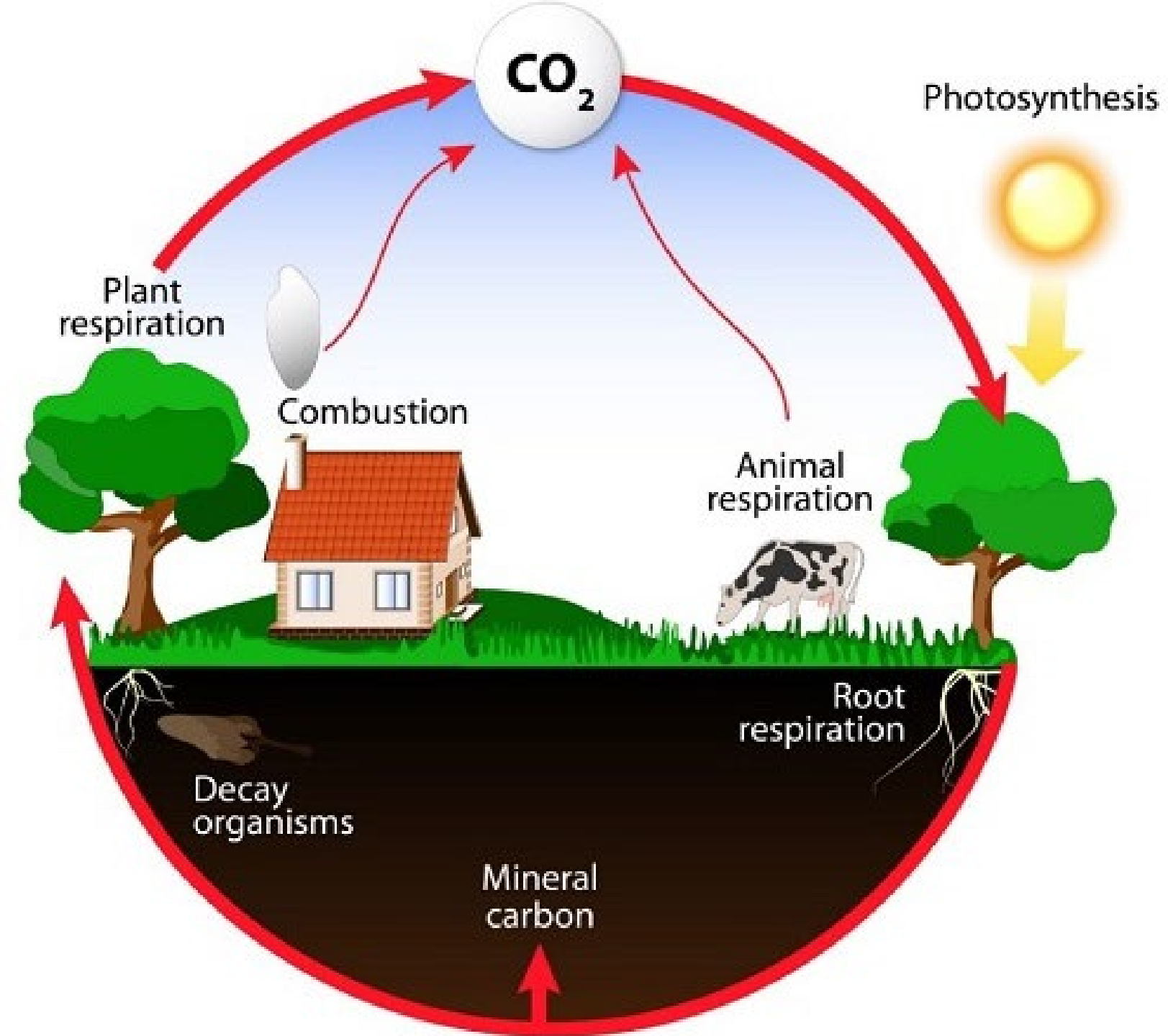
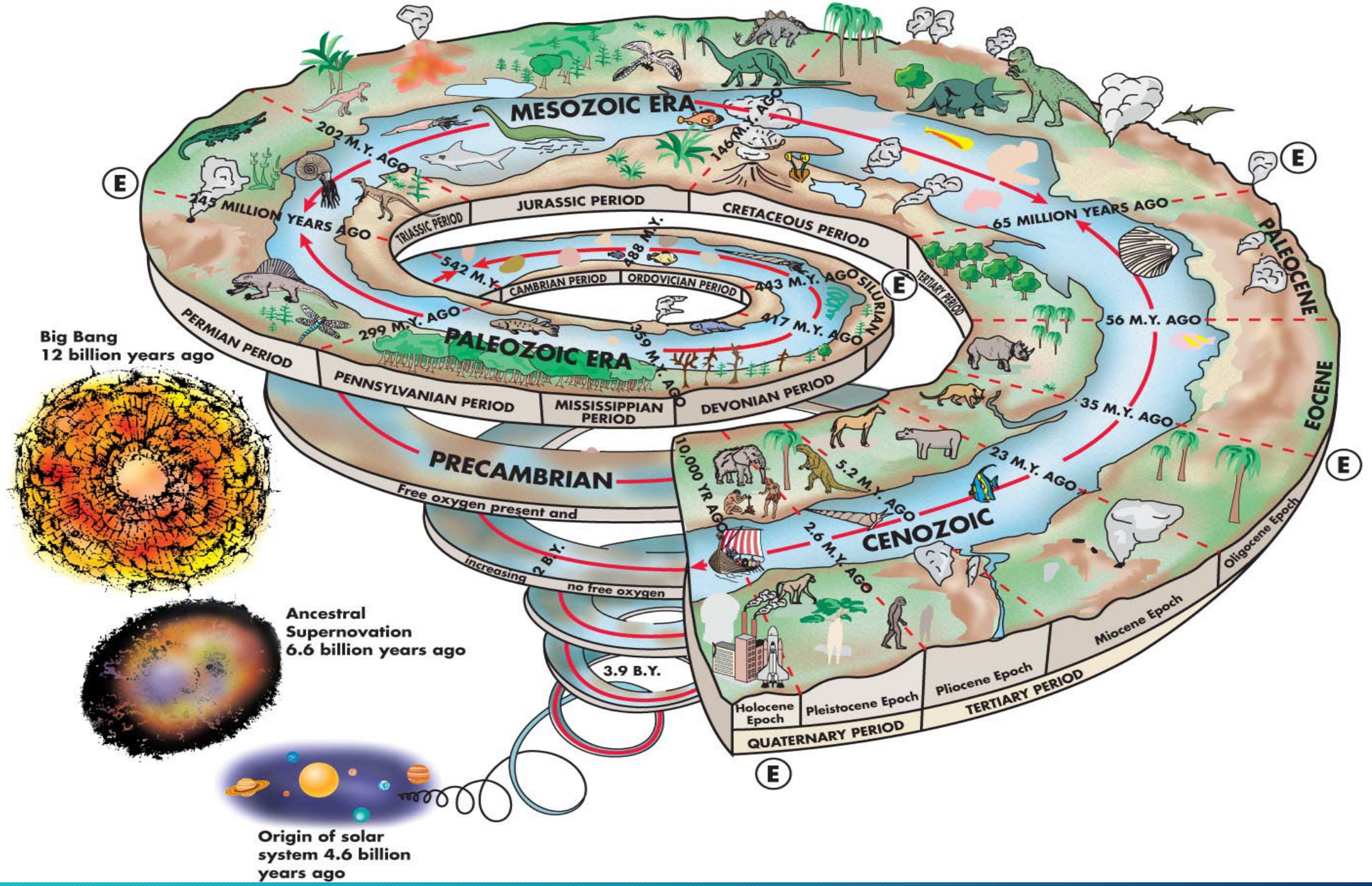

CO_2
Photosynthesis
Plant respiration
Combustion
Animal respiration
Root respiration
Decay organisms
Mineral carbon

Energy Flux through Ecosystems


MESOZOIC ERA
202 M.Y. AGO
146 M.Y. AGO
245 MILLION YEARS AGO
65 MILLION YEARS AGO
TRIASSIC PERIOD
JURASSIC PERIOD
CRETACEOUS PERIOD
TERTIARY PERIOD
PALEOZOIC ERA
542 M.Y.
488 M.Y.
443 M.Y. AGO
417 M.Y. AGO
359 M.Y. AGO
299 M.Y. AGO
CAMBRIAN PERIOD
ORDOVICIAN PERIOD
SILURIAN
PERMIAN PERIOD
PENNSYLVANIAN PERIOD
MISSISSIPPIAN PERIOD
DEVONIAN PERIOD
PRECAMBRIAN
Free oxygen present and increasing
2 B.Y.
no free oxygen
3.9 B.Y.
CENOZOIC
56 M.Y. AGO
35 M.Y. AGO
23 M.Y. AGO
10,000 YR AGO
5.2 M.Y. AGO
2.6 M.Y. AGO
PALEOCENE
EOCENE
Oligocene Epoch
Miocene Epoch
Pliocene Epoch
Pleistocene Epoch
Holocene Epoch
QUATERNARY PERIOD
TERTIARY PERIOD
E
Big Bang
12 billion years ago
Ancestral
Supernovation
6.6 billion years ago
Origin of solar
system 4.6 billion
years ago

4.6 Ga

TABLE 1.2 Geologic Time with Important Events

Era	Period	Epoch	Million Years before Present	Events: Life	Events: Earth	Million Years before Present	True Scale (Million Years before Present)
Cenozoic	Quaternary	Holocene	0.01	• Extinction event • Modern humans	Ice Age		
		Pleistocene		• Early humans	Formation of Transverse Ranges, CA		
	Tertiary	Pliocene	2.6			2.6	Cenozoic
		Miocene	5.2		Formation of Andes Mountains		
		Oligocene	23	• Grasses • Whales	Collision of India with Asia forming Himalayan Mountains and Tibetan Plateau		
		Eocene	34	• Extinction event • Mammals expand			
		Paleocene	56		Rocky Mountains form		
Mesozoic	Cretaceous		65	• Dinosaur extinction[1], extinction event		65	Mesozoic
	Jurassic		146	• Flowering plants	Emplacement of Sierra Nevada Granites (Yosemite National Park)		
	Triassic		202	• Birds • Mammals • Dinosaurs	• Supercontinent Pangaea begins to break up		
Paleozoic	Permian		251	• Extinction event • Reptiles	• Ice Age	251	Paleozoic
	Carboniferous		299	• Trees (coal swamps)			
	Devonian		359	• Extinction event	Appalachian Mountains form		
	Silurian		416	• Land plants			
	Ordovician		444	• Extinction event			
	Cambrian		488	• Fish			
			542	• Explosion of organisms with shells		542	Precambrian
Precambrian			2500	• Multicelled organisms • Free oxygen in atmosphere and ozone layer in stratosphere	• Ice Age		
			3500	• Primitive life (first fossils)	• Ice Age		
			4000		• Oldest rocks		
			4600		• Age of Earth	4600	4600

TABLE 1.3 How We Became 6 Billion heading to 8+ billion 2050 est. 9.7 billion

40,000–9,000 B.C.: Hunters and Gatherers
Population density about 1 person per 100 km^2 of habitable areas;[1] total population probably less than a few million; average annual growth rate less than 0.0001% (doubling time about 700,000 years)
9,000 B.C.–A.D. 1600: Preindustrial Agricultural
Population density about 1 person per 3 km^2 of habitable areas (about 300 times that of the hunter and gatherer period); total population about 500 million; average annual growth rate about 0.03% (doubling time about 2,300 years)
A.D. 1600–1800: Early Industrial
Population density about 7 persons per 1 km^2 of habitable areas; total population by 1800 about 1 billion; annual growth rate about 0.1% (doubling time about 700 years)
A.D. 1800–2000: Modern
Population density about 40 persons per 1 km^2; total population in 2000 about 6.1 billion; annual growth rate at 2000 about 1.4% (doubling time about 50 years)

Energy Flow

- Endogenic = Energy generated from within the Earth E.g.?
- Exogenic = Energy derived from outside the Earth E.g.?
- Anthropogenic = Human altered… concentrated… changed…

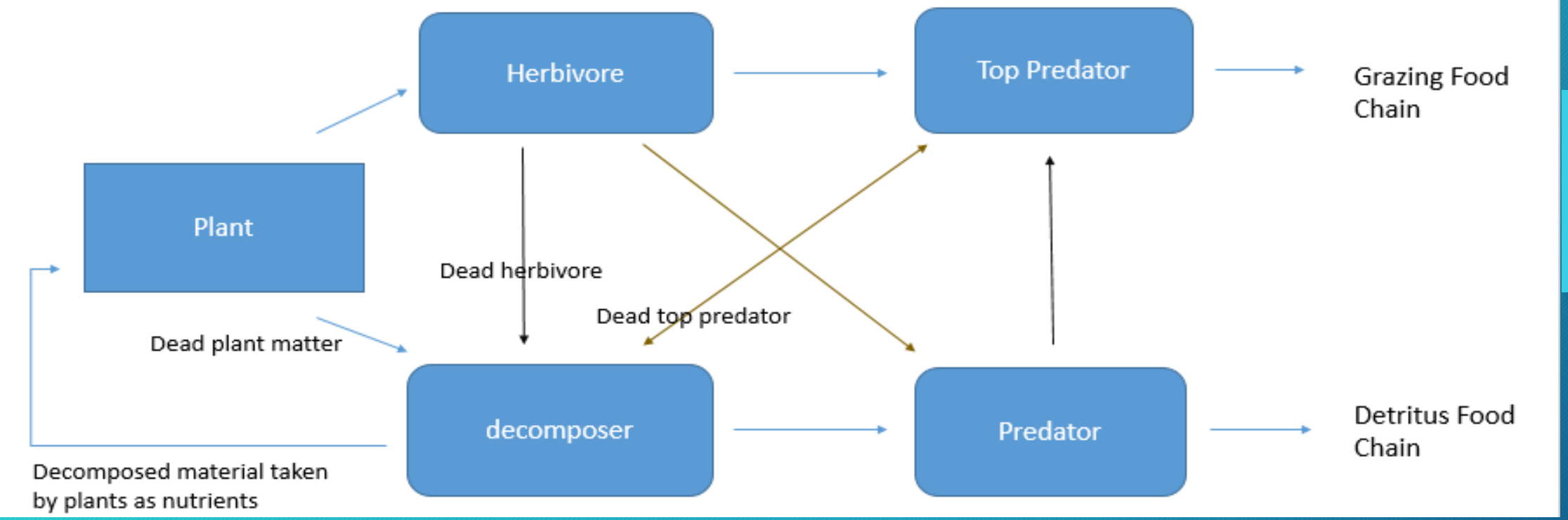
Comprehensive Systems

Ecosystems
Environments
Landscapes

Characterizing, modeling, interpreting Earth System requires…

1. Calculating energy and mass balance ‘budgets’

2. Quantifying changes in exo and endo energy sources
    a. Intensities
    b. Distributions



3. An understanding of the Earth's oceans! They are very important in understanding energy distribution, storage, and transfer throughout all systems.

4. Recognize and account for humanity's ability to concentrate energy and power (energy per unit of time)

Earth – A System

Components

- Atmosphere
- Hydrosphere
- Biosphere
- Lithosphere

Anthropogenic manipulation

Systems contain components that mutually adjust, so that changes in one part of the system bring about changes to other parts.

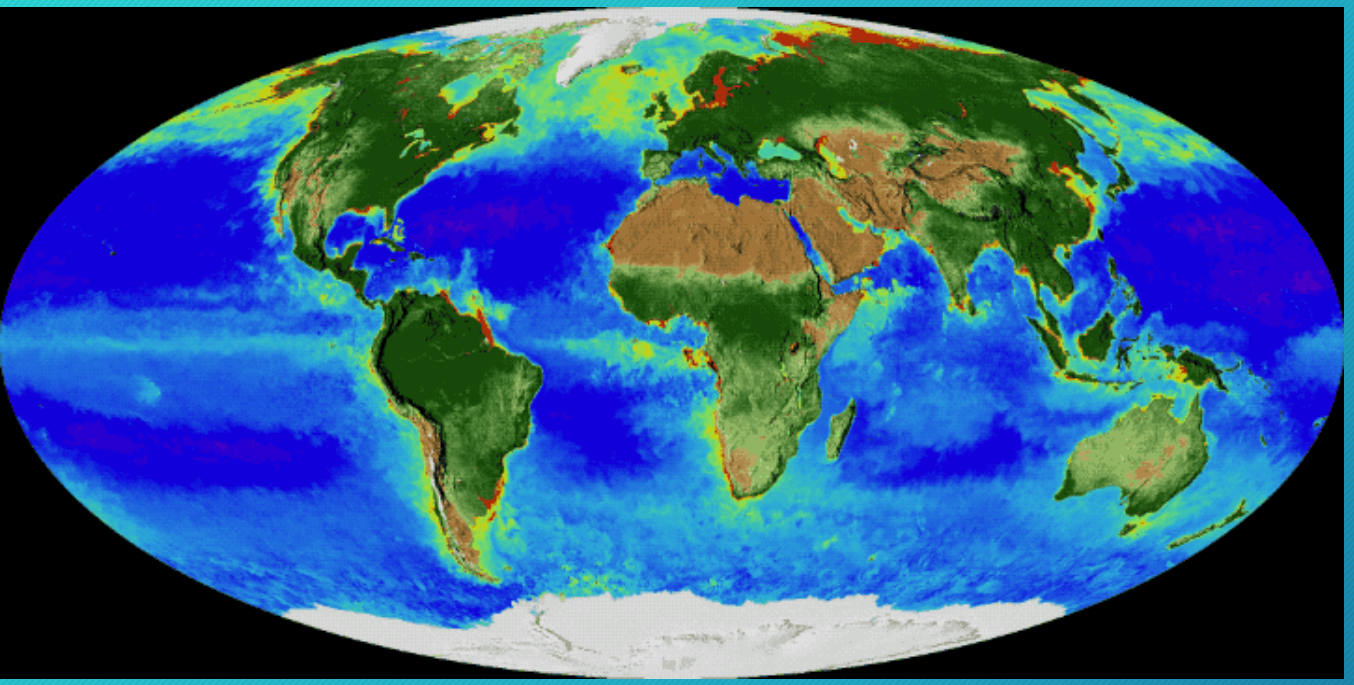
Principle of Environmental Unity

"Anything affects Everything else"

"Everything affects Everything else"

Gaia Hypothesis – Earth as an organism

James Lovelock



1. Life significantly affects planetary environments.
2. Life affects environments for the planets betterment.
3. Life deliberately OR consciously controls the global environment.

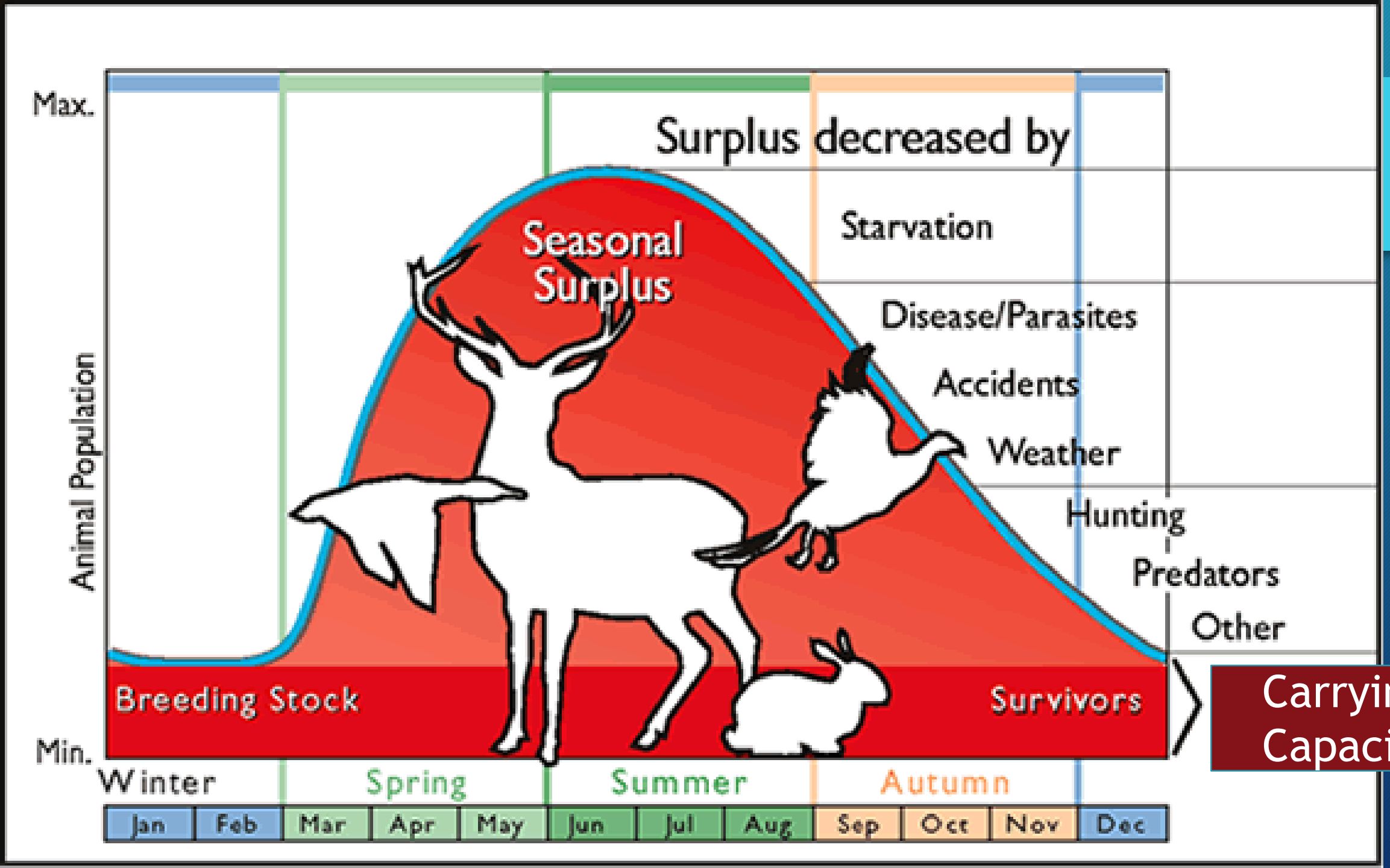
Major Earth System Types

- Open – A system that exchanges material and energy with its surroundings.
- Sun's Exogenic energy
  - Some is absorbed/received
  - Some is reflected

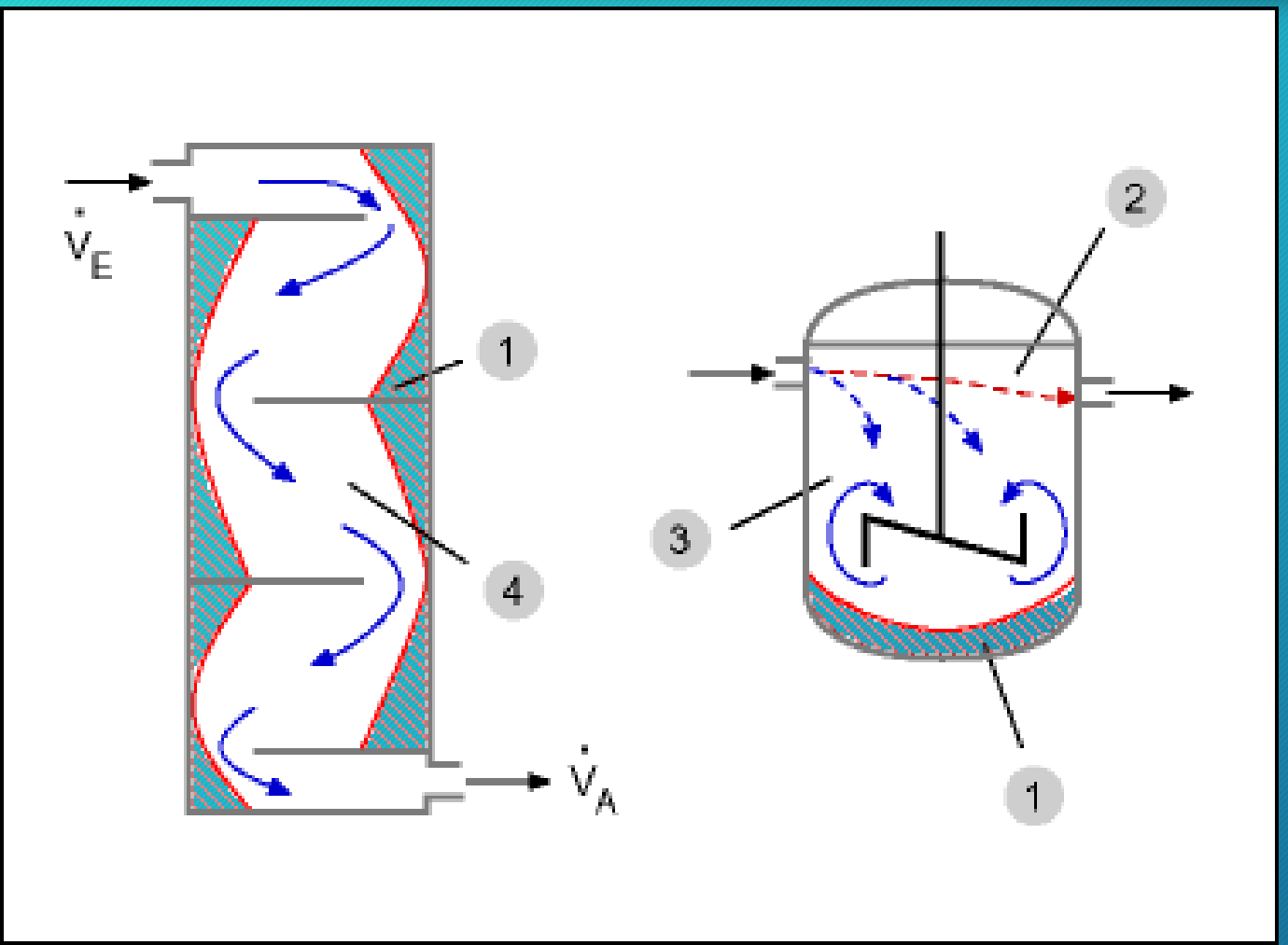
- Closed – Most of the Earth's material is continuously recycled.
- Mass/material is neither gained or lost just changed.
- Rock and Water cycles

System complexity

- Feedbacks
  - Positive
  - Negative


Max.
Min.
Animal Population
Surplus decreased by
Seasonal Surplus
Starvation
Disease/Parasites
Accidents
Weather
Hunting
Predators
Other
Breeding Stock
Survivors
Carrying Capacity
Winter
Spring
Summer
Autumn
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Residence time



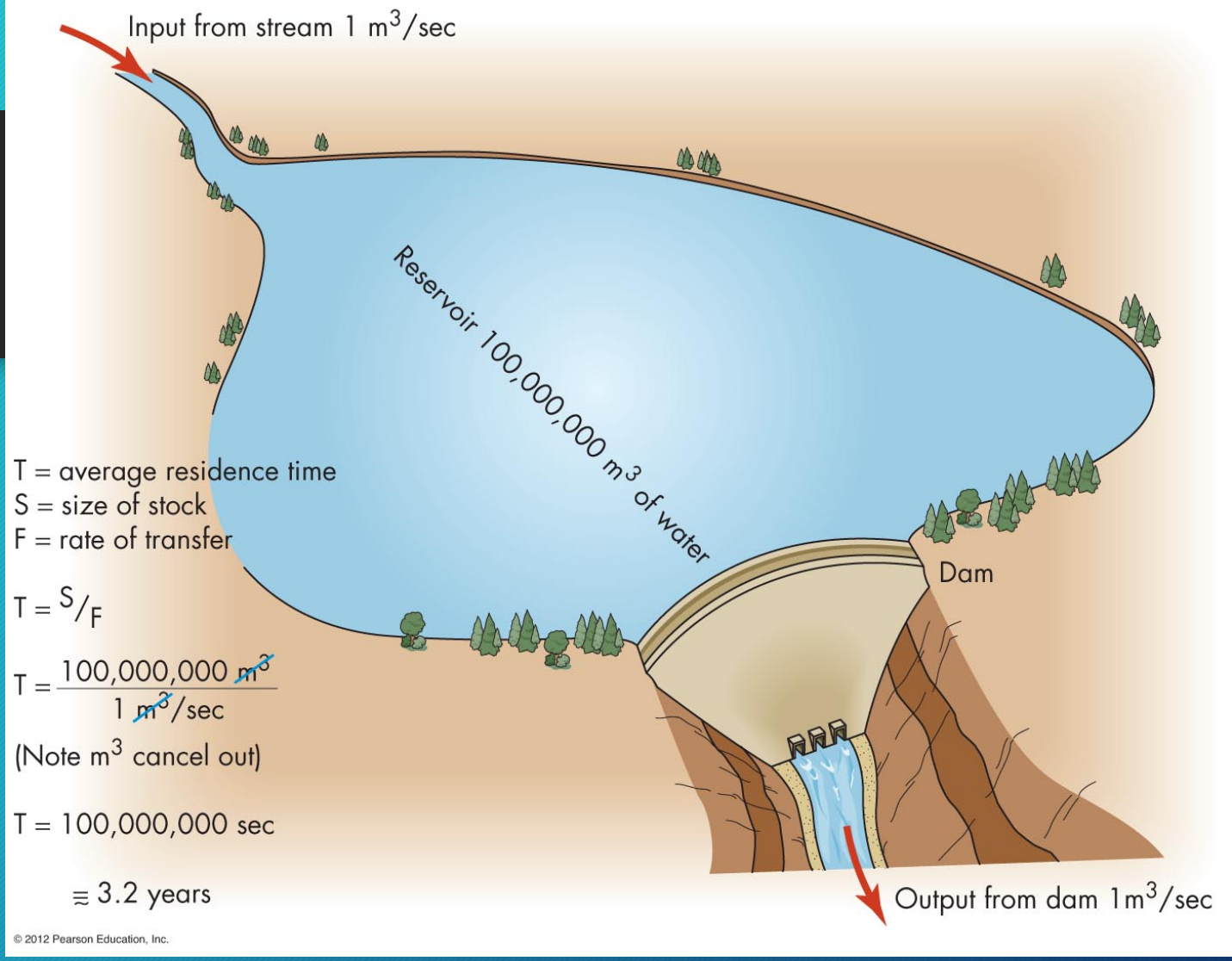
- A measure of the time it takes for the total stock/supply of a material to move through a system
- rT = S/F
  - S = size of stock
  - F = rate of transfer

Question

- How long (in years) does it take for a cubic meter of water to move through a reservoir (e.g. lake)?
- E.g.

S = 100,000,000 m^3

F = 1m^3/sec



Challenge question

How long does it take for a cubic meter of water to move through Lake Superior?

Its average depth is 80.5 fathoms (147 m) with a maximum depth of 222.17 fathoms (406 m). Lake Superior contains **12,100** km^3 of water. (approx. 10% of the Earth's fresh water!)

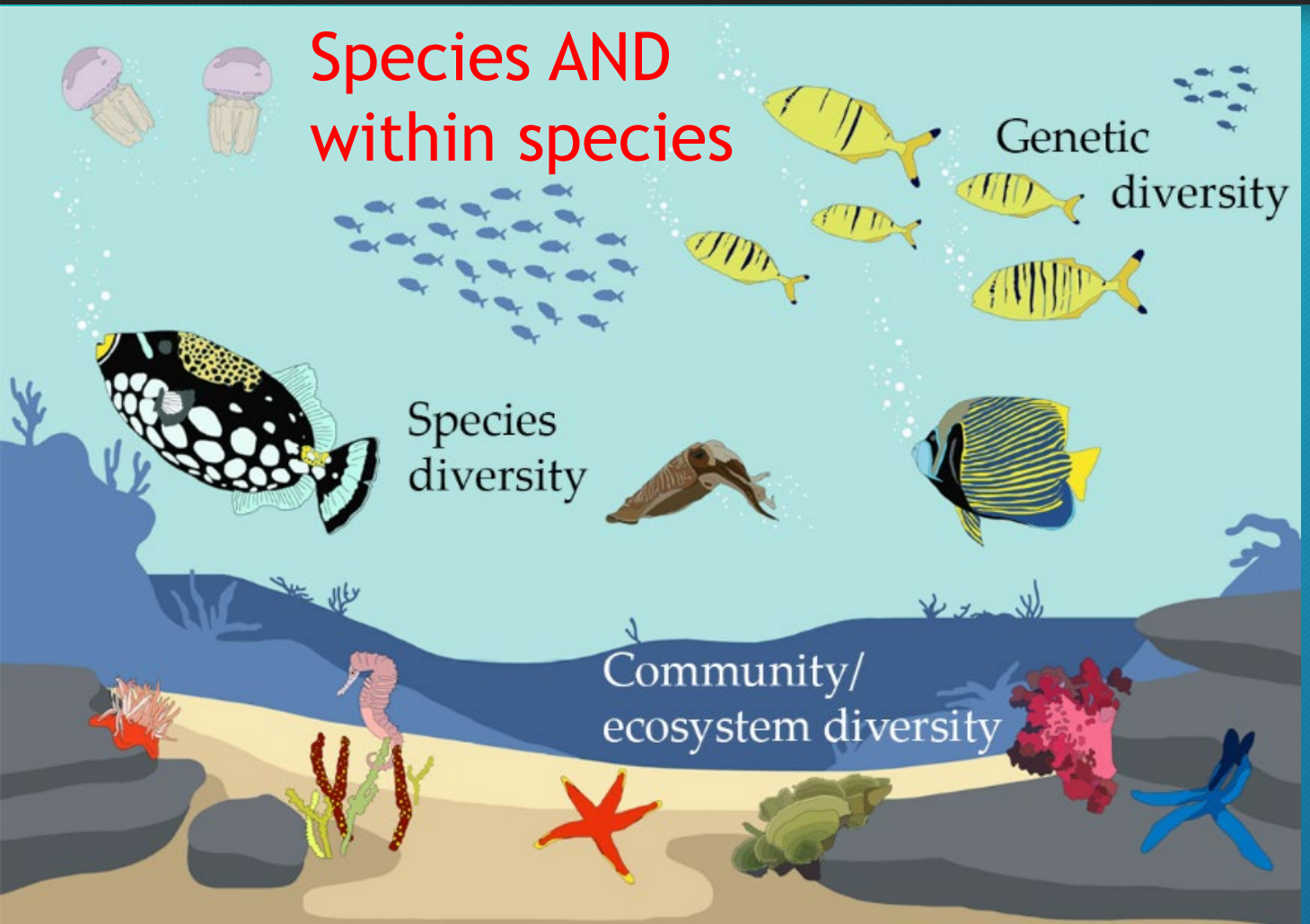
Transfer rate =2,124 cubic meters per sec.

Exponential Growth

- Human population
- On Sunday 2/7/21 at 10am
- 7,844,324,527

- Are we at or beyond the Earth's carrying capacity?
- What factors determine this?
- Humans vs All life?
- Importance?
- Specific links to Earth Science?

Biodiversity



Number or abundance of species in and environment or ecological community.

An indicator of environmental health

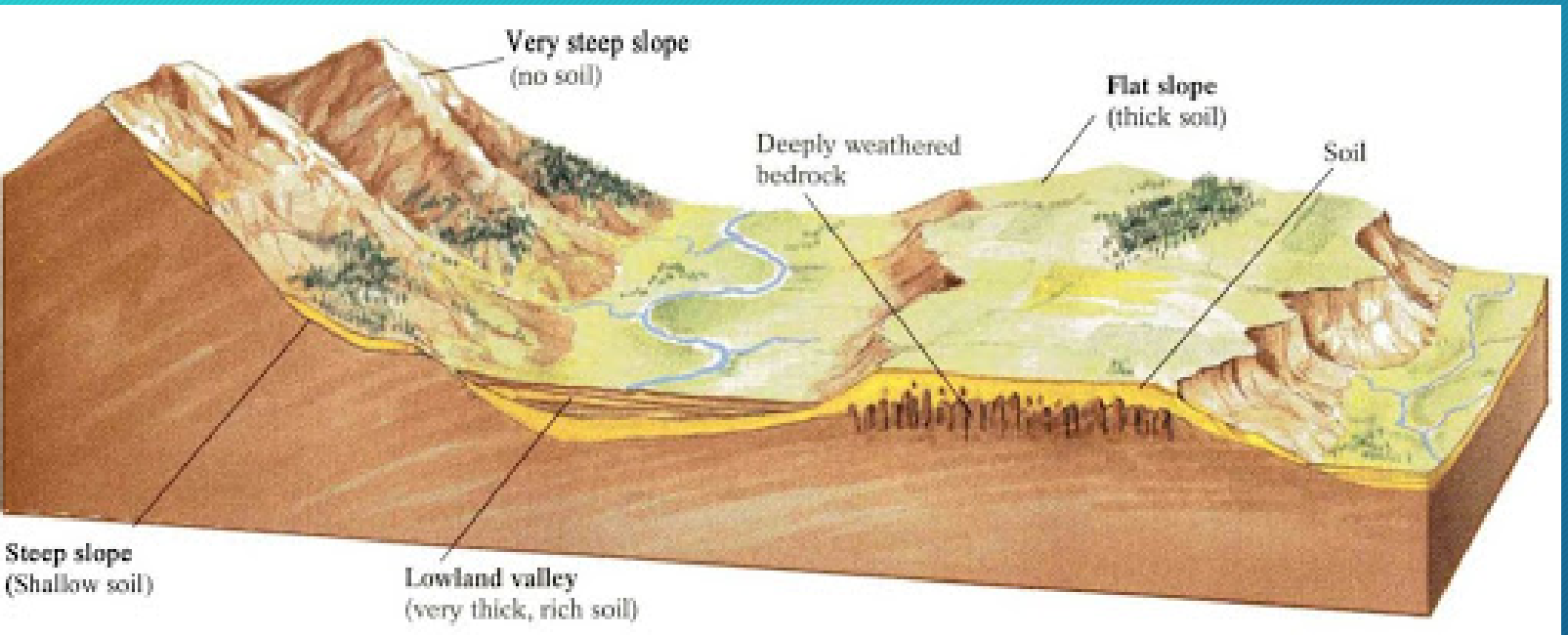
Geology's influence in Biodiversity

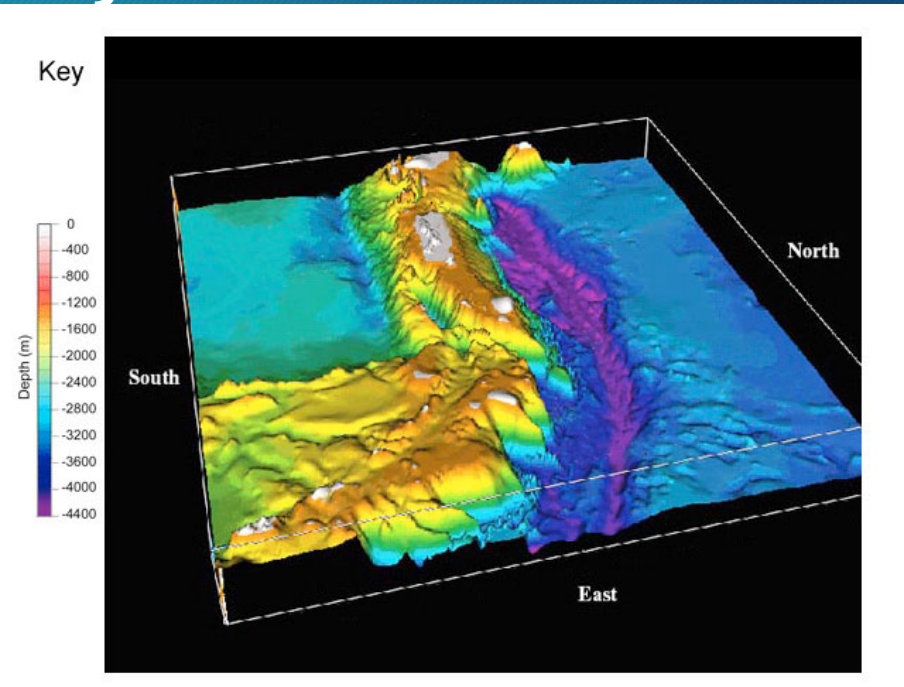
Small scale

Minerals available to soil development

Large scale

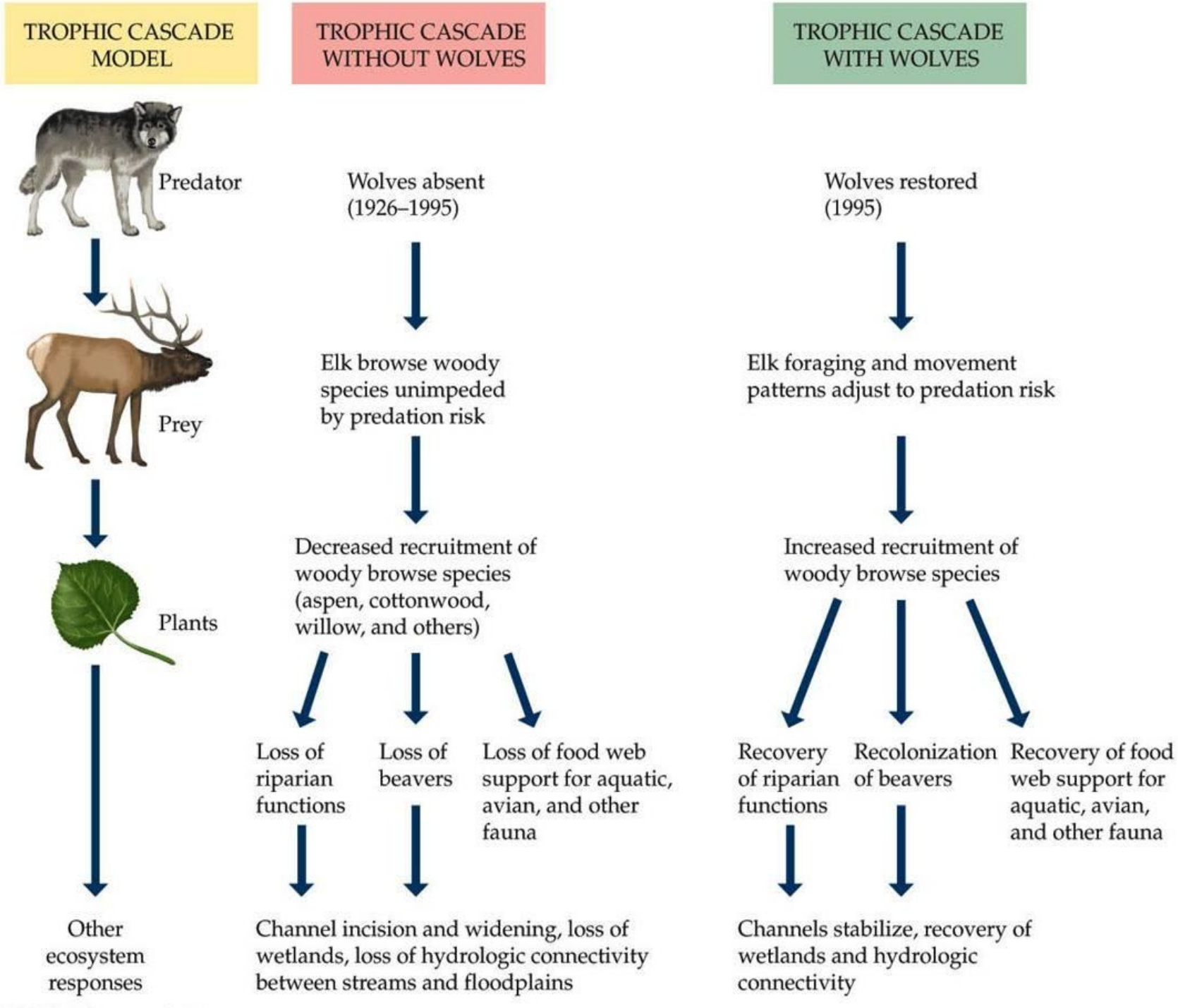
Plate tectonics to ocean bathometry and currents





Biodiversity's role in Geology

Keystone species – Two or more organisms interacting in complex ways that affect other organism and their environments.



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- http://www.northshoreinfo.com/lakesuperior/