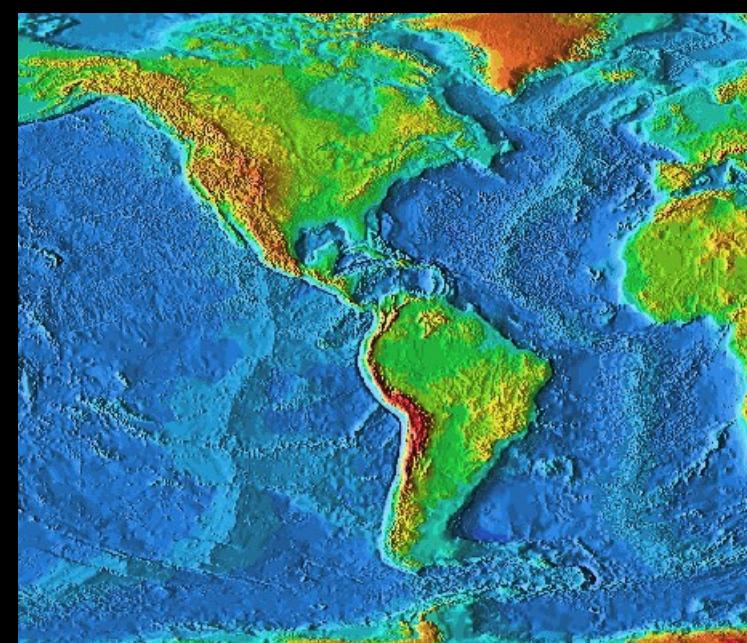
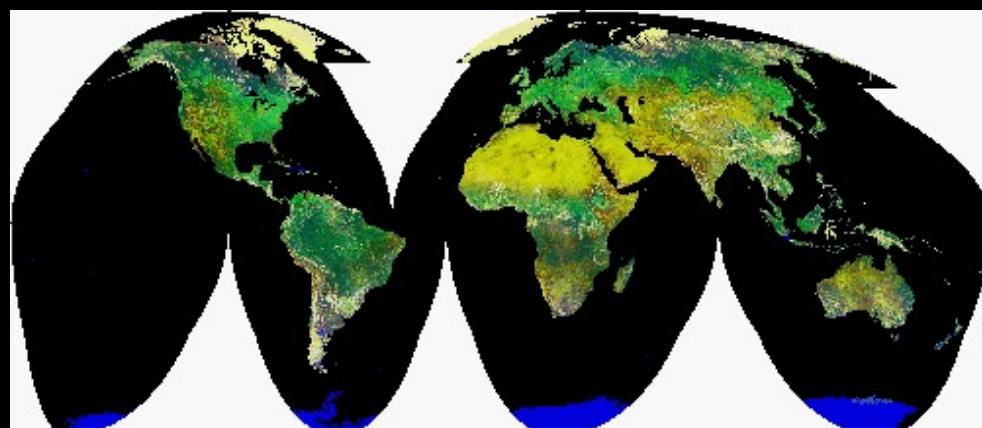
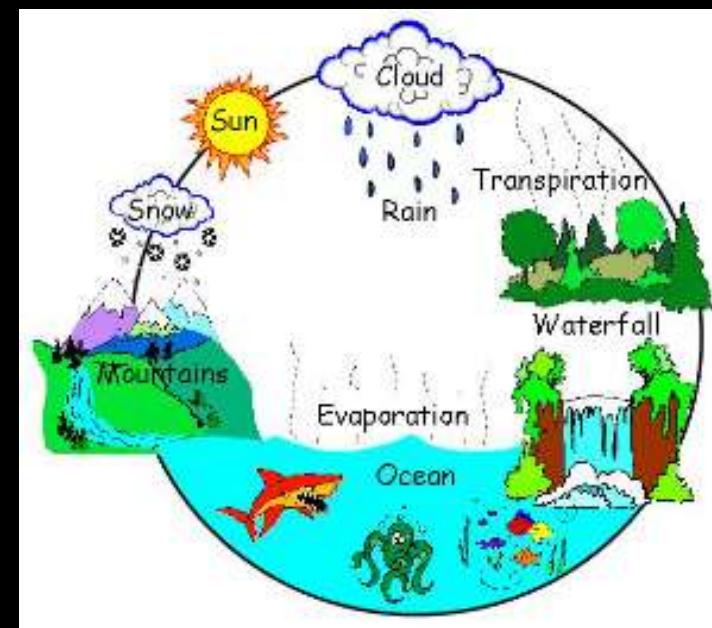
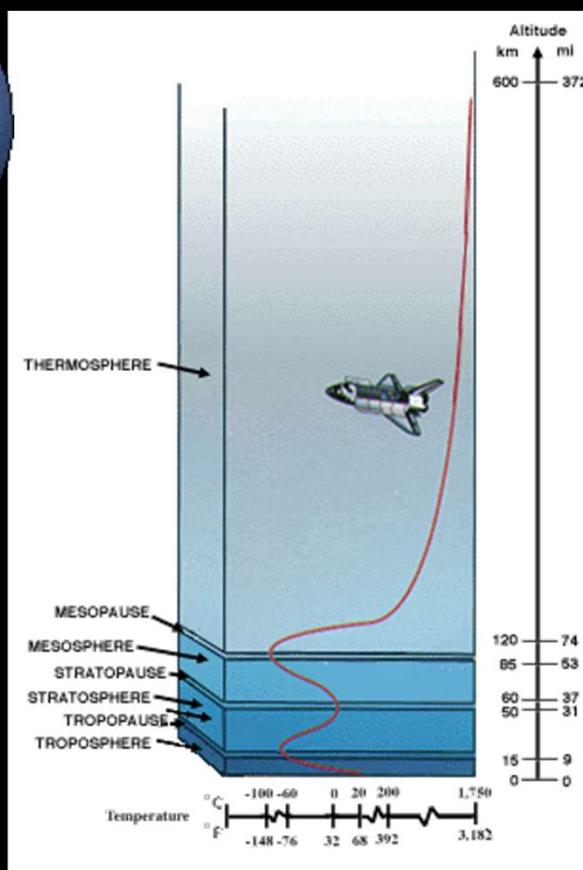
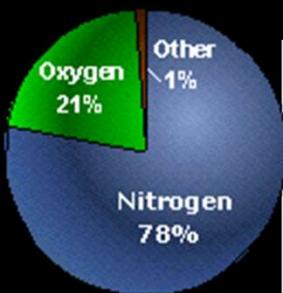


Class-6

# Earth System and its Components

30<sup>th</sup> August 2022

# Earth Systems Overview



# Layers of Earth

**Core**- center, mostly iron

Inner core- 1220 km thick, T & P cause iron to solidify

Outer core- 3480 km thick, liquid iron, creates magnetic field

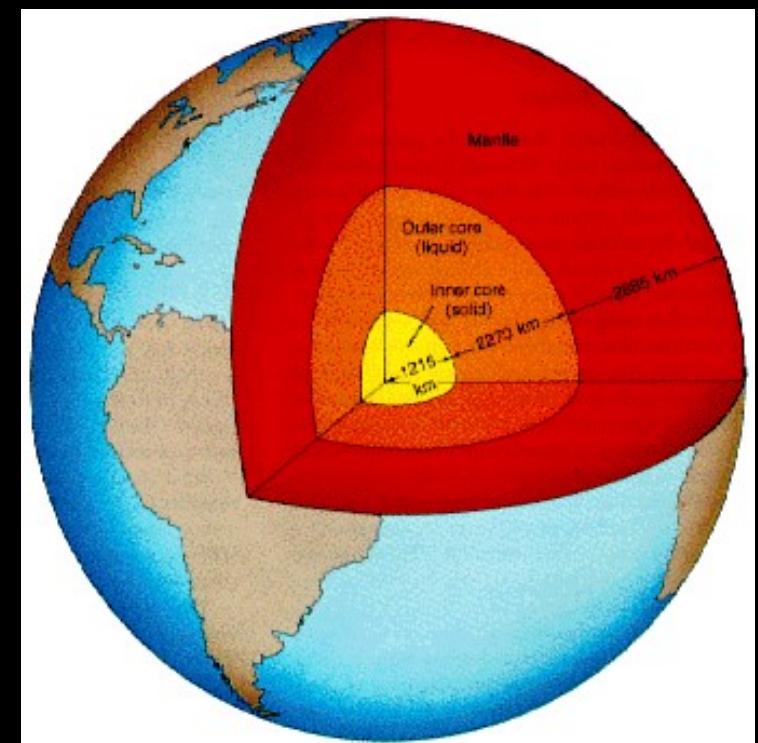
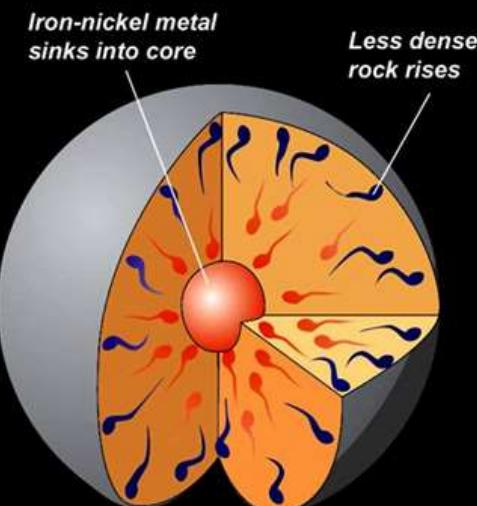
**Mantle**- 70% of earth's interior, made of O, Si, Mg

Asthenosphere- closest to core, gelatinous, where magma is formed

Upper mantle- cooler, more solid, brittle

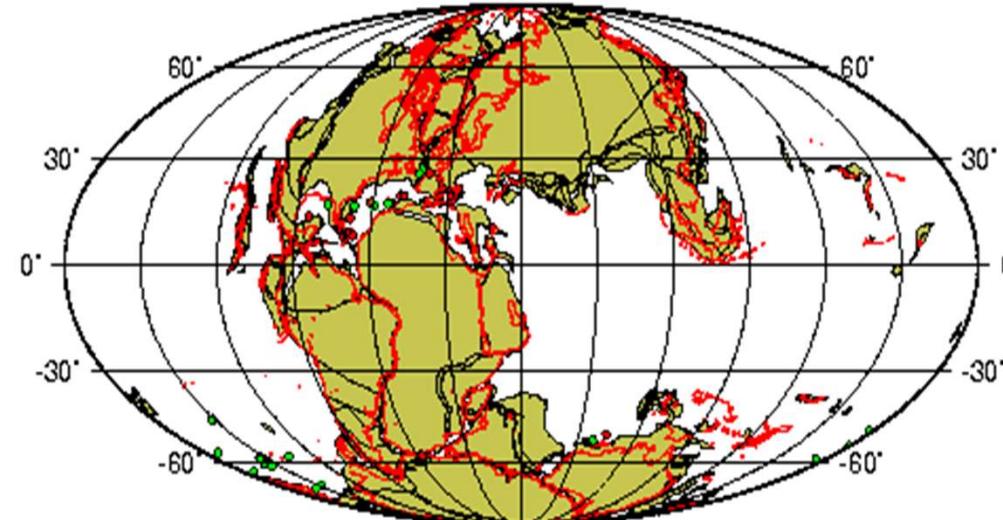
**Crust**- outermost layer

Crust + upper mantle make up lithosphere

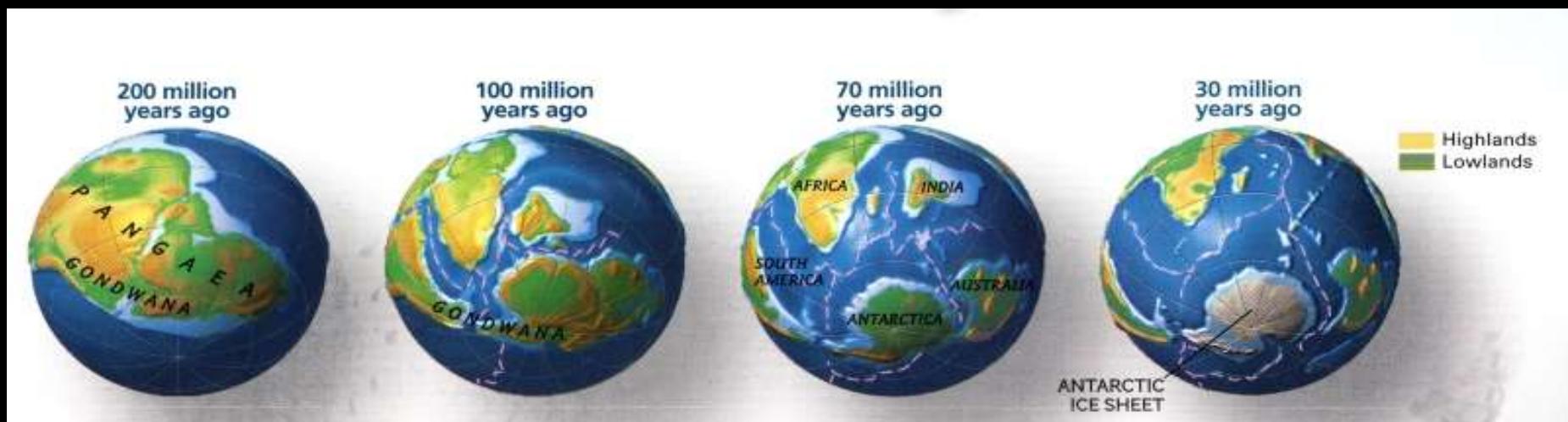


# Continental drift theory

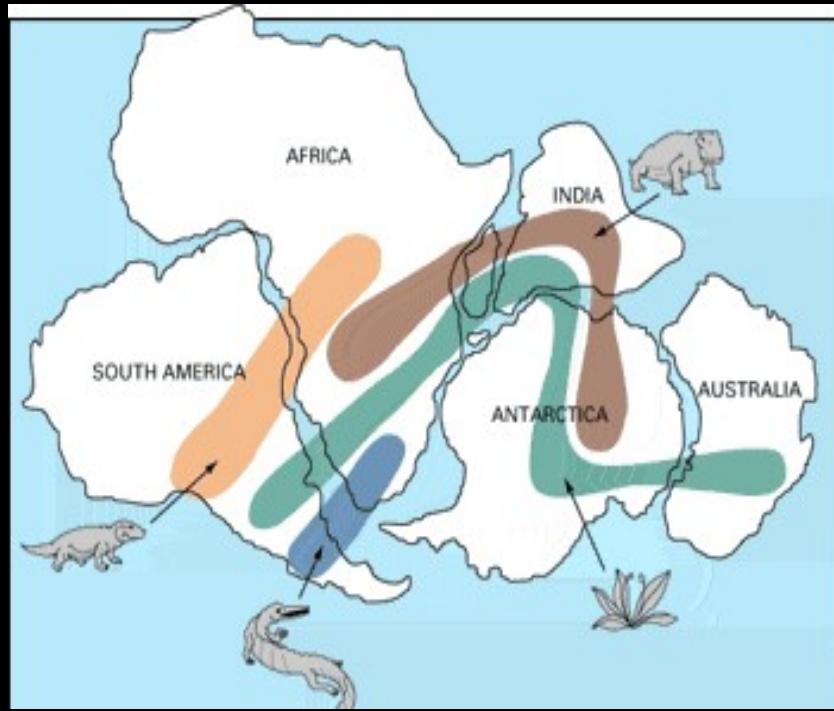
Evidence: Continents “fit together” like puzzle pieces



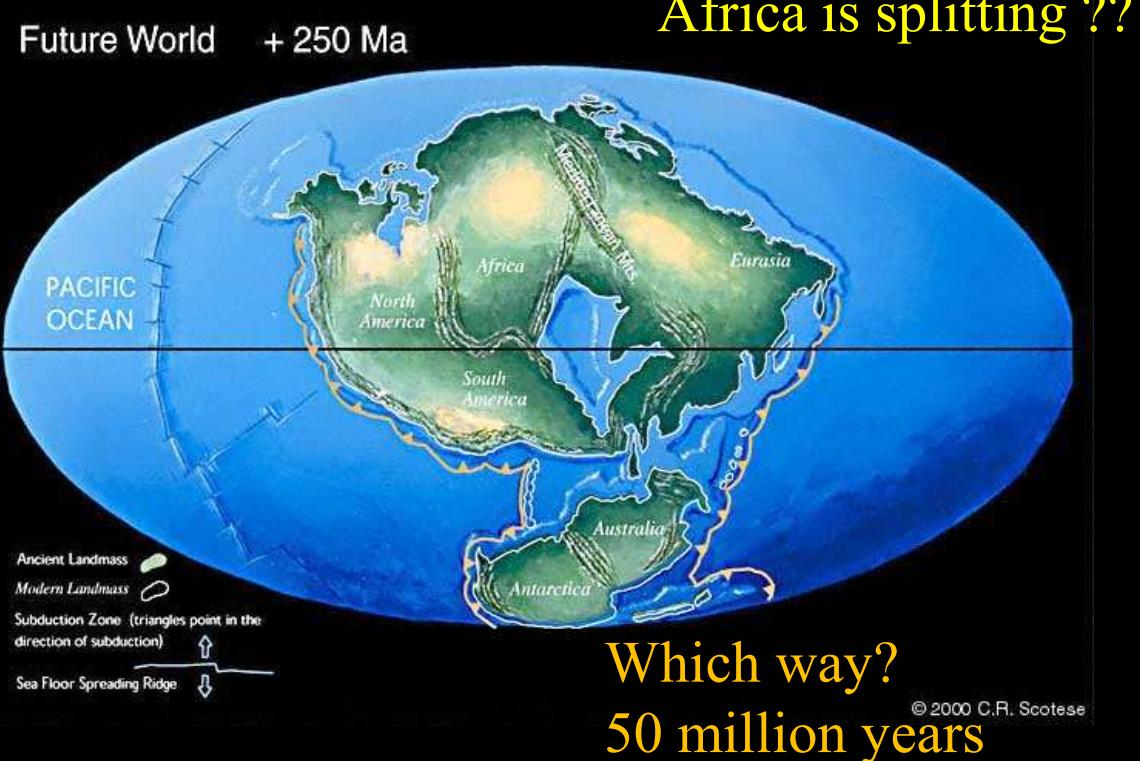
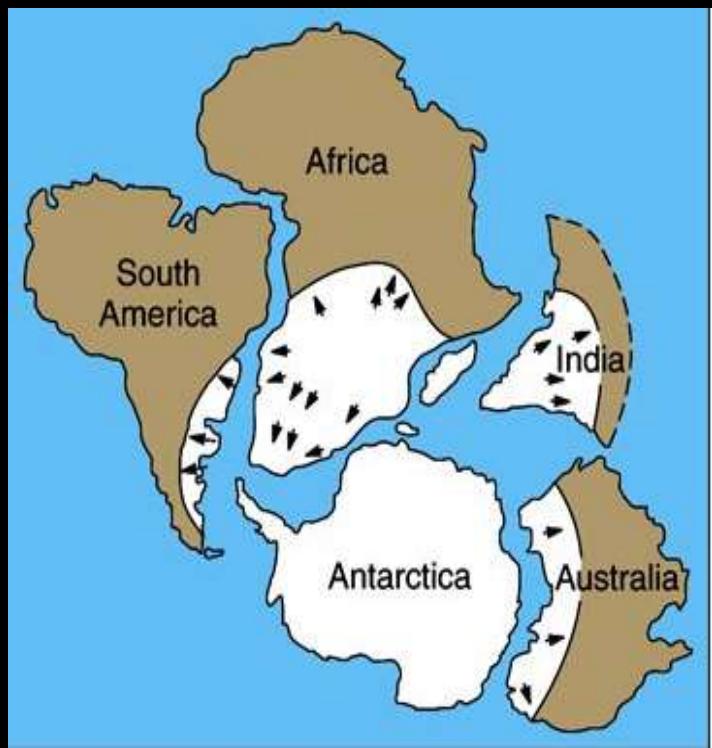
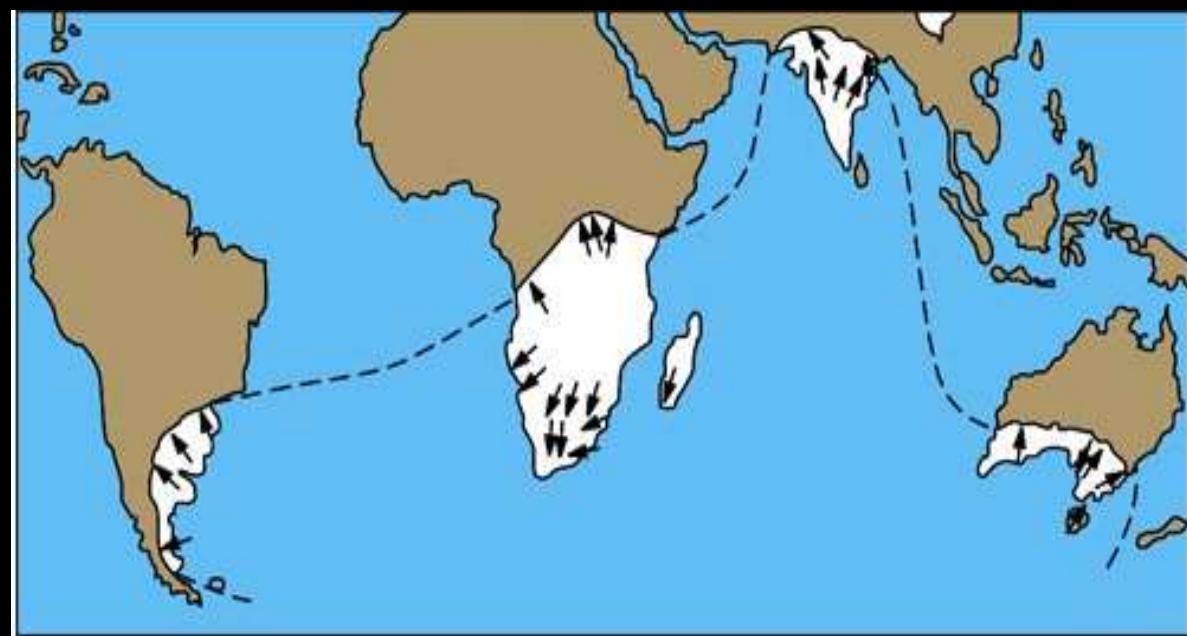
150 My Reconstruction



# Fossil Evidence

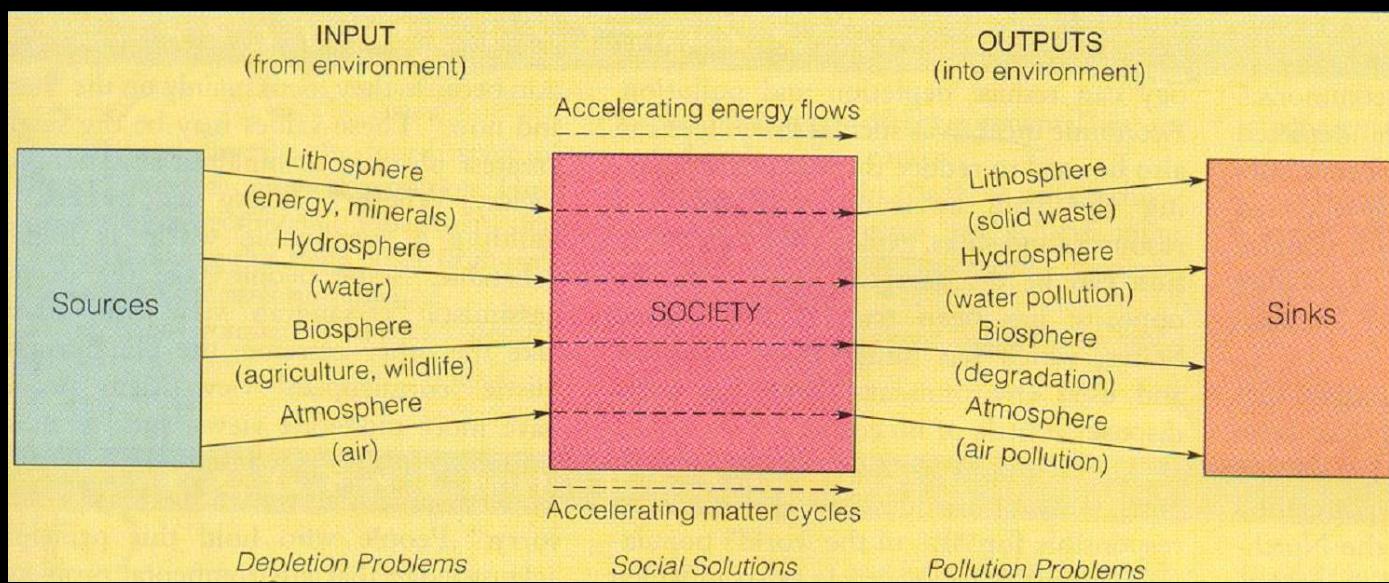


# Climate Evidence



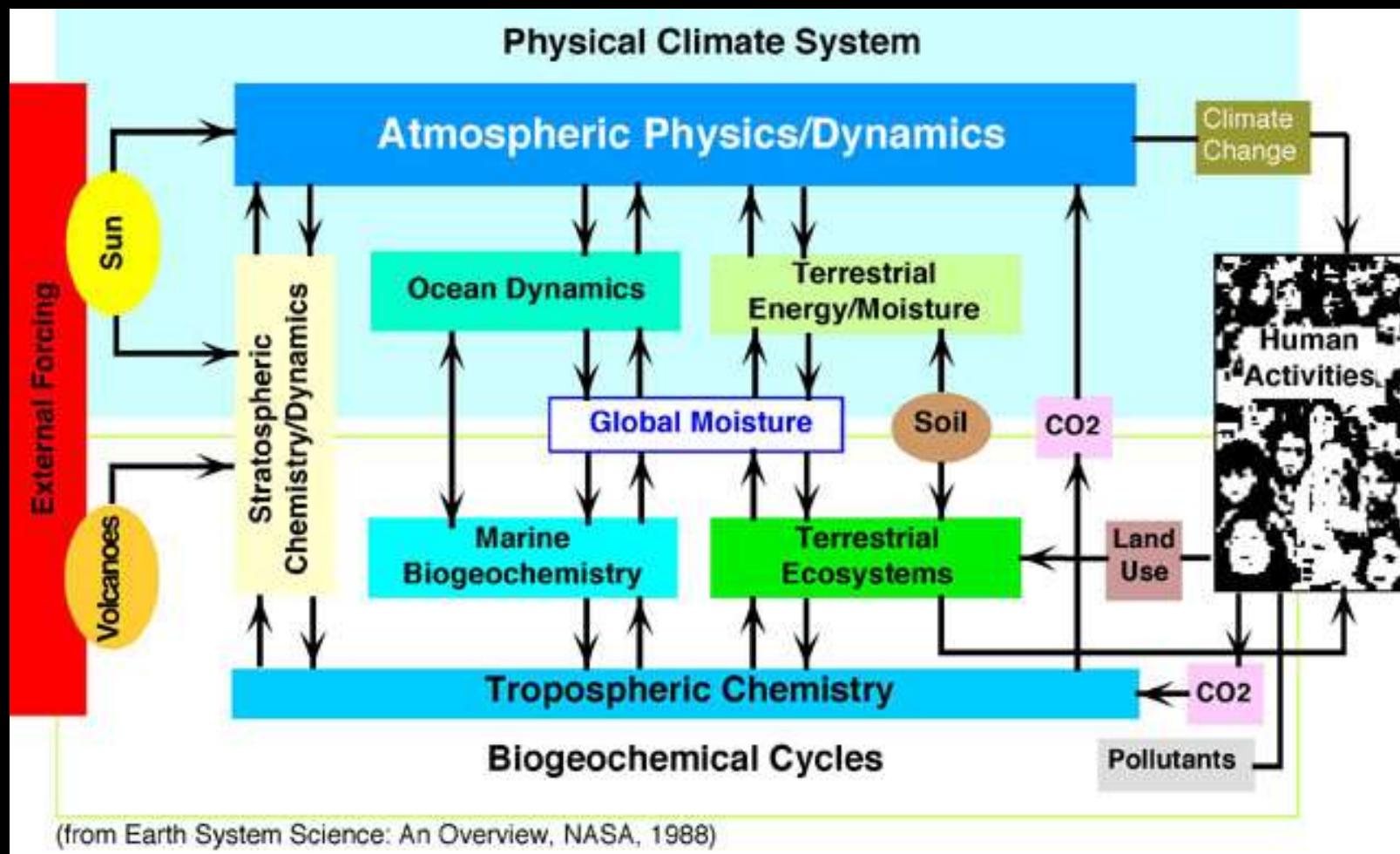
# Earth System Science

Earth System Science is the study of how the four spheres of the Earth system interact continually, each affecting the others.



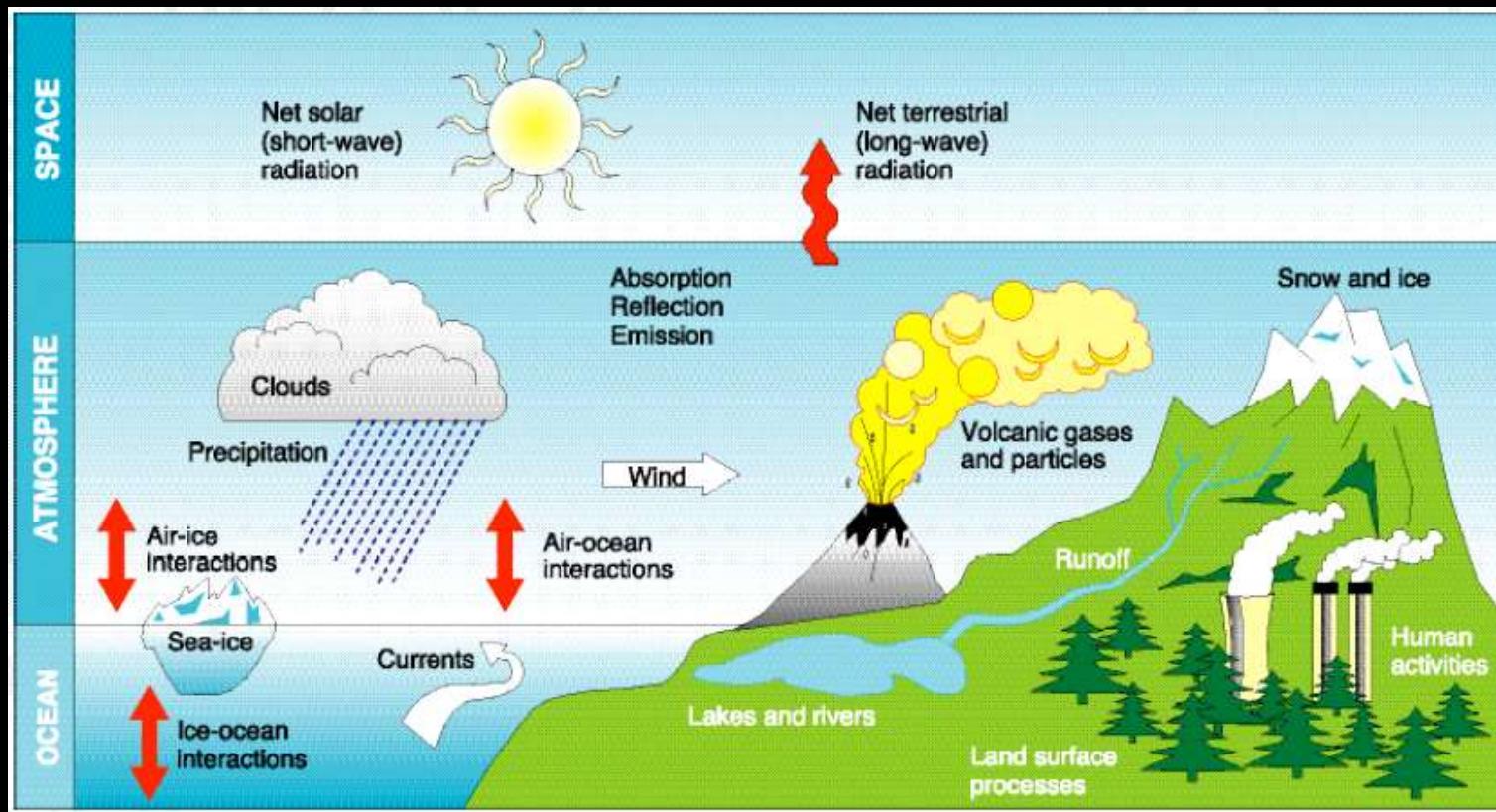
# Earth System Science

- ... treats the entire Earth as a system
- this system evolves as a result of positive and negative feedbacks between many different systems
- gives scientists the ability to explain the past and possible future behaviour of the Earth system



# What is Earth System Modelling?

*Interacting components on the environment are modeled in unison to understand how feedbacks between the components influence the properties of the whole system.*



*Gaia theories explain the behaviour of the Earth system in terms of the influence of the biosphere*

# The GAIA hypothesis: Lovelock's "Discovery" of Gaia

Gas	Earth	Venus	Mars
CO <sub>2</sub>	0.03%	96.5%	95%
O <sub>2</sub>	21%	Trace	0.13%
N <sub>2</sub>	79%	3.5%	2.7%



James Lovelock



Lynn Margulis

Interpretation?  
Temperature regulation  
Traditional evolutionary theory  
Lovelock's theory  
Bacteria: heavy lifters of Gaia - Margulis  
What is GAIA HYPOTHESIS

# What is Gaia?

*GAIA (if it exists!) is a collection of negative feedback loops  
These loops stabilize the Earth's physical environment  
The physical environment is maintained in a condition favorable  
to life.*

*In other words*

*Life itself is responsible for maintaining the stability of Earth's  
climate. The Earth has remained habitable because in some sense it  
is "alive" Biota manipulate their environment to optimize conditions  
for life*

The criticism that developed the Daisy world model

*Biota would need to possess the capacity for foresight if the  
Earth's system were to be self-regulated.*

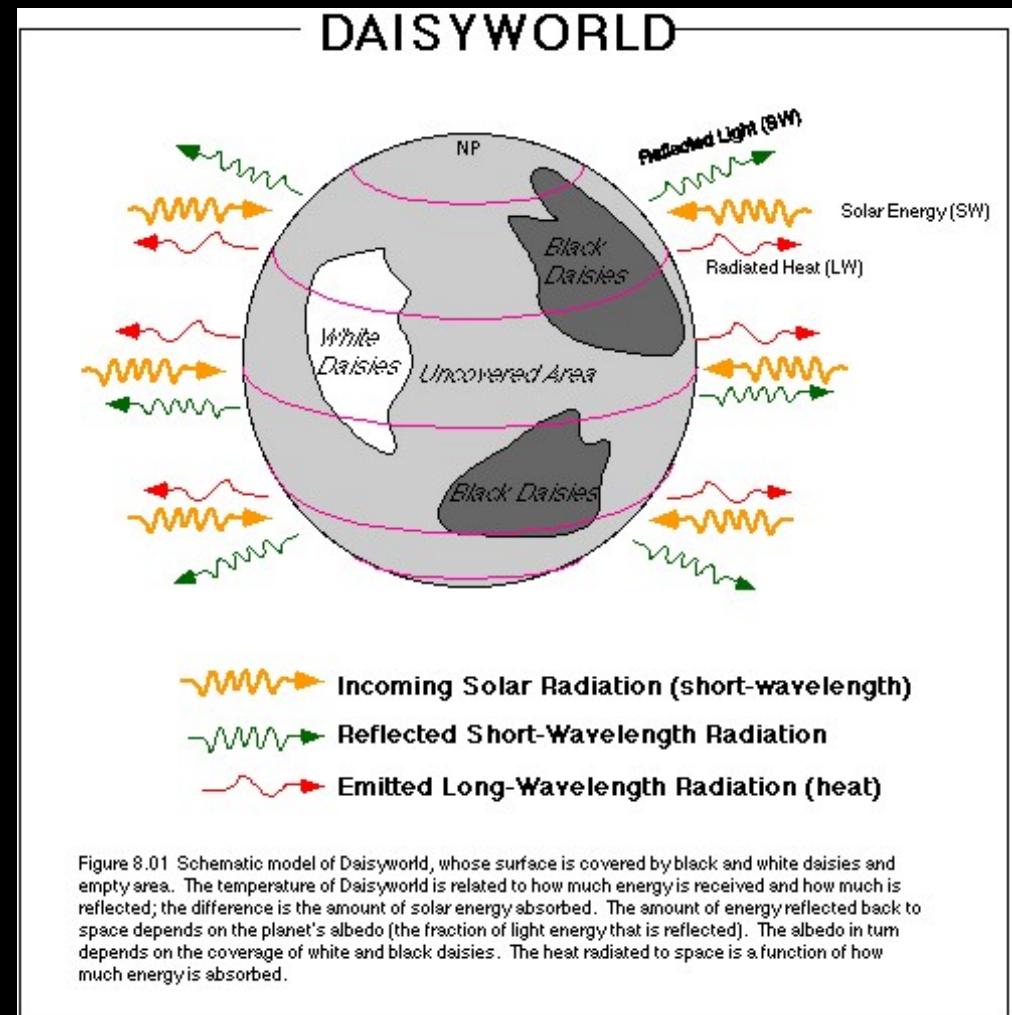
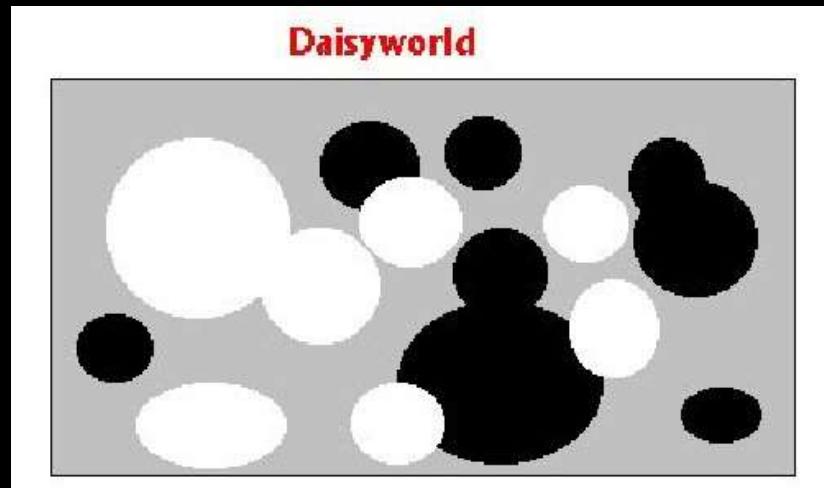
*The Daisy world model demonstrates that a system can be self-  
regulating without the need of foresight. This is done through  
the simulation of a feedback control system*

# Daisy world

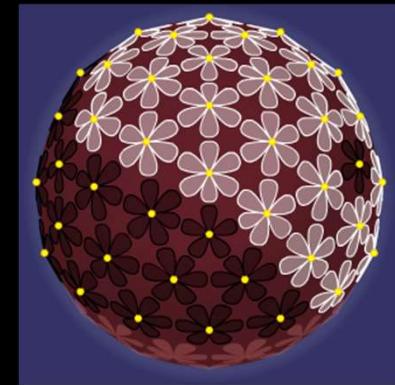
Lovelock used this computer simulation to demonstrate the hypothesis

Hypothetical world orbiting a sun whose temperature is slowly increasing in the simulation

Planet has two different species of daisy as its only life form: black daisies and white daisies



Both black and white daisies grow best at 22.5 °C  
Air is slightly warmer over black daisy patches  
Air is slightly cooler over white daisy patches



# Daisy world simulation

*First, run the model long enough for Daisy world temperature to reach equilibrium*

*Then, apply a sudden change in solar input*

*Observe how Daisy world reacts to restore its temperature*

When Daisy world is cool...

*Air temperature over the black patches is higher*

*Black patches grow more*

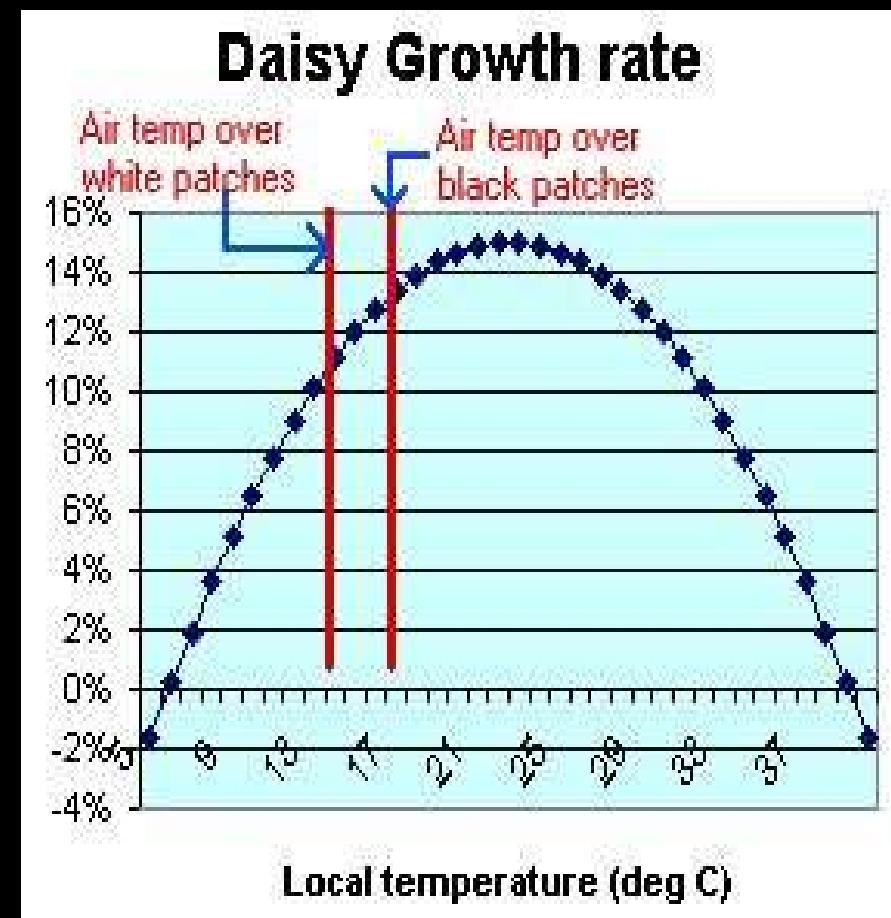
*Overall planet color becomes darker*

*Planet albedo decreases*

*Planet absorbs more sunlight and gets warmer*

*Daisies have altered the climate!*

*Daisy world temperature is closer to optimal temperature for daisies*



# When Daisy world is warm...

*Air temperature over the black patches  
is higher*

*White patches grow more*

*Overall planet color becomes lighter*

*Planet albedo increases*

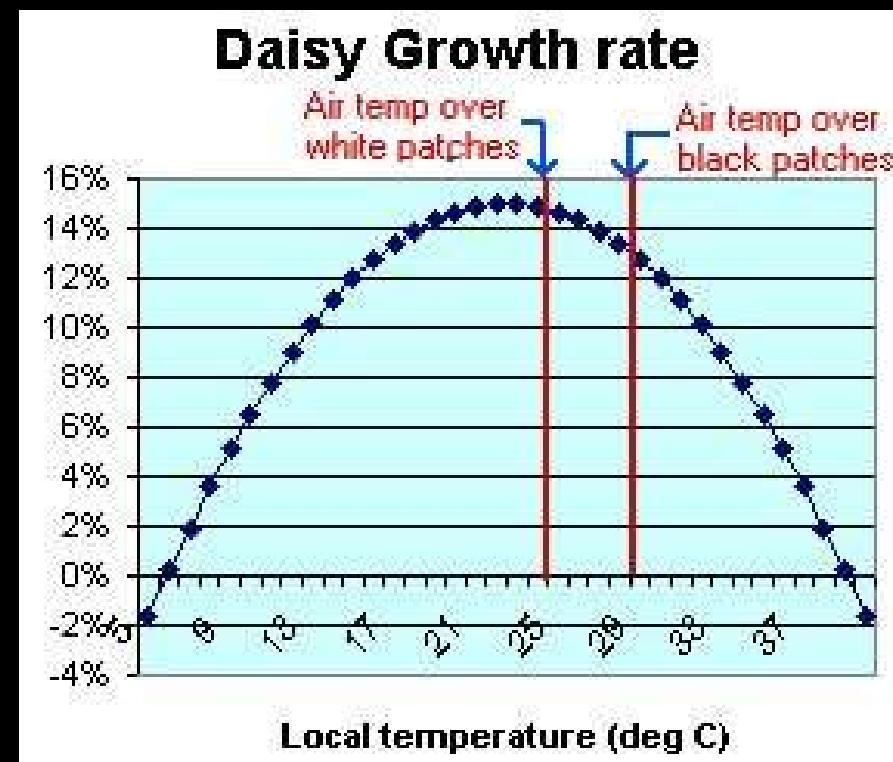
*Planet absorbs less sunlight and gets  
cooler*

*Daisies have altered the climate!*

*Daisy world temperature is closer to  
optimal temperature for daisies*

*Daisies have created a negative  
feedback loop!*

*This process is what might have created  
GAIA.*



## Hypothesis

*One of the reasons that the Gaia Hypothesis sparked debate in scientific circles has to do with scientists' ability to test hypotheses. The traditional scientific method relies on refuting a hypothesis, proving it wrong, as the means for eliminating possible explanations.*

## No testable hypothesis

*The single largest complaint lodged against the strong Gaia hypothesis is that experiments can't be designed to refute it (or test it at all, for that matter.)*

*The strong Gaia hypothesis states that life creates conditions on Earth to suit itself. Life created the planet Earth, not the other way around. As we explore the solar system and galaxies beyond, it may one day be possible to design an experiment to test whether life indeed manipulates planetary processes for its own purposes or whether life is just an evolutionary processes that occurs in response to changes in the non-living world.*

*At present, we cannot falsify the Gaia Hypothesis*

# Ecology

(in view of Gaia theory)

*When the activity of an organism favors the environment as well as the organism itself, then its spread will be assisted; eventually the organism and the environmental change associated with it will become global in extent.*

*The reverse is also true, and any species that adversely affects the environment is doomed; but life goes on.*

# Ecology

Ecology is the scientific study of the interactions between organisms and their environment.

a. Interactions determine distribution and abundance of organisms.

b. An organism's environment has both abiotic and biotic components.

An ecosystem consists of all abiotic factors plus all organisms that exist in a certain area à Ecosystem ecology.

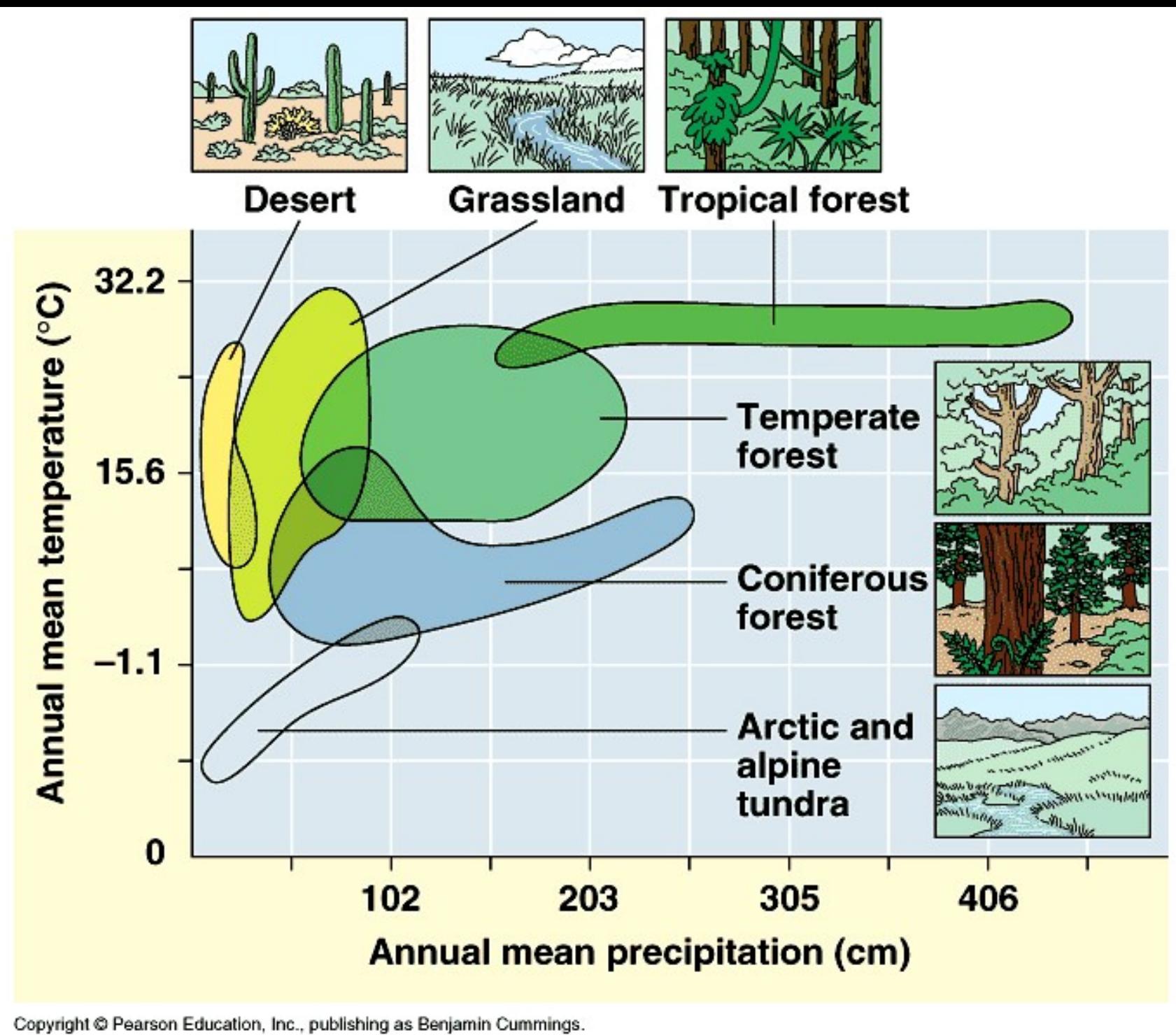
Landscape ecology- interactions among ecosystems.

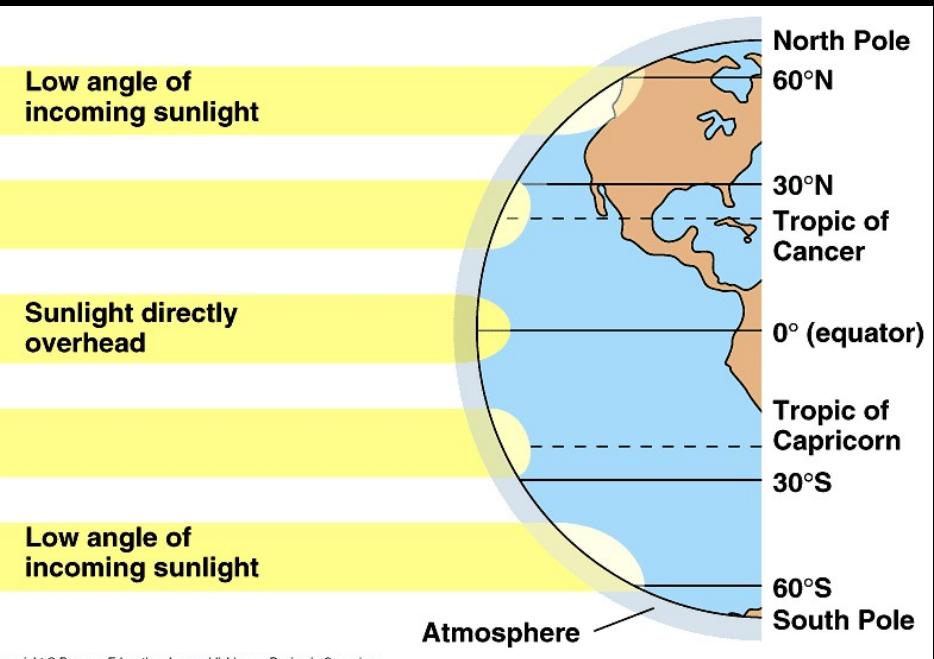
The biosphere is the global ecosystem. Global climate research is an example of ecology at the biosphere scale.

Abiotic factors affect distribution

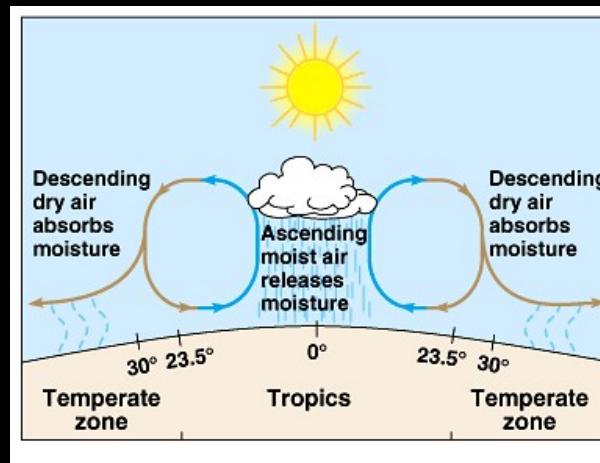
Temperature (range from 0 to 45 C),

Water, Sunlight , Wind(increases heat & water loss) Rocks and soil

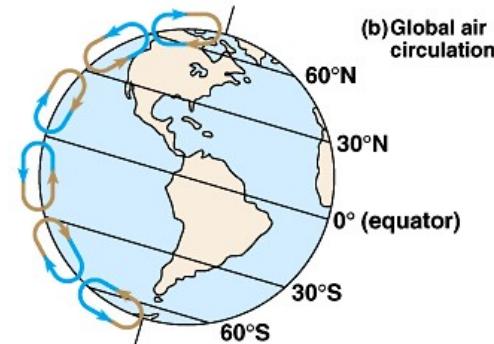




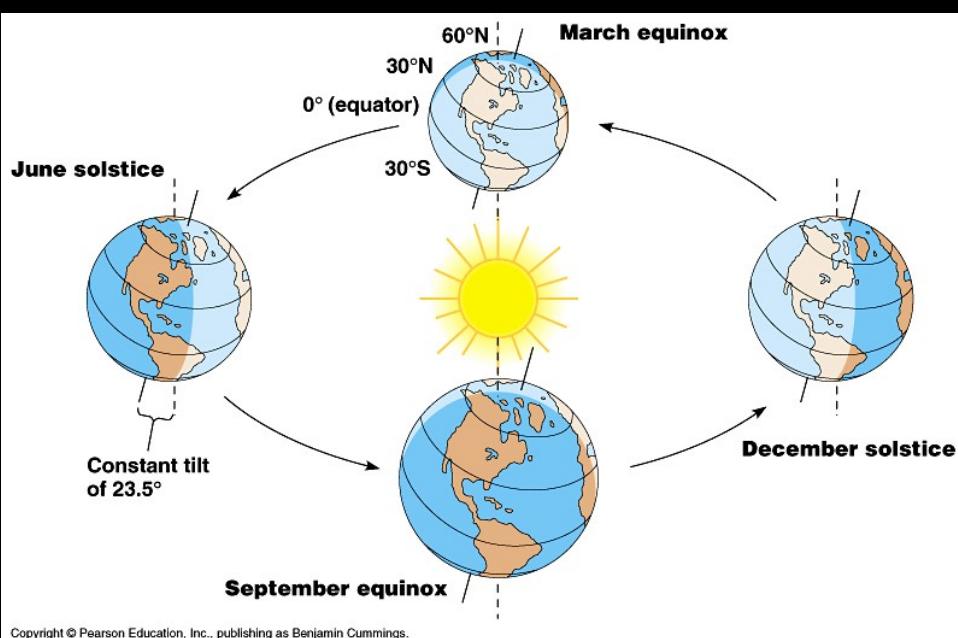
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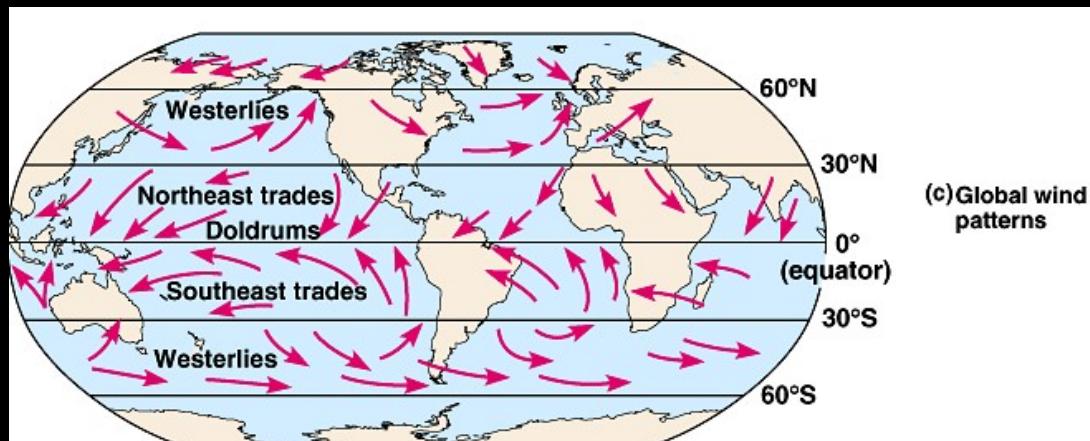
(a) Air circulation and precipitation near the equator



(b) Global air circulation



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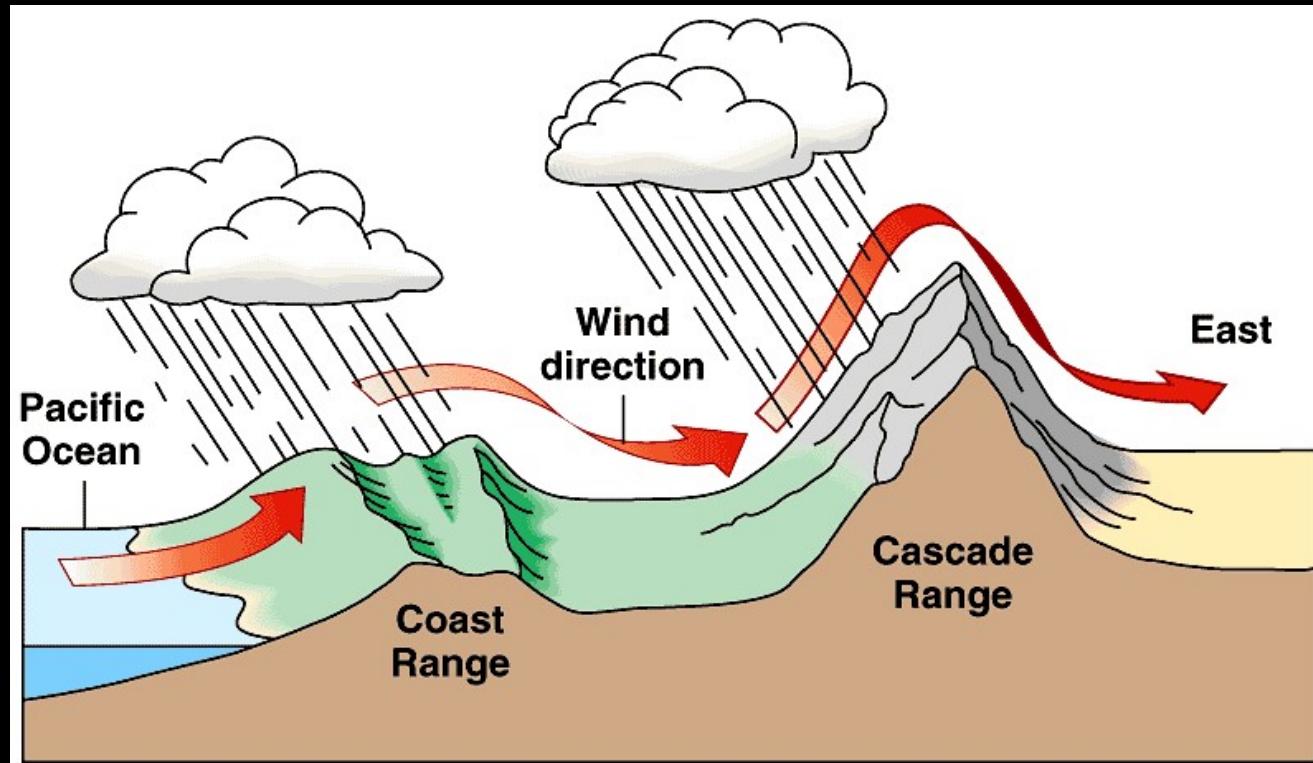
(c) Global wind patterns

Local and seasonal effects on climate.

Bodies of water and topographic features such as mountain ranges can affect local climates.

Ocean currents can influence climate in coastal areas.

Mountains affect rainfall greatly.

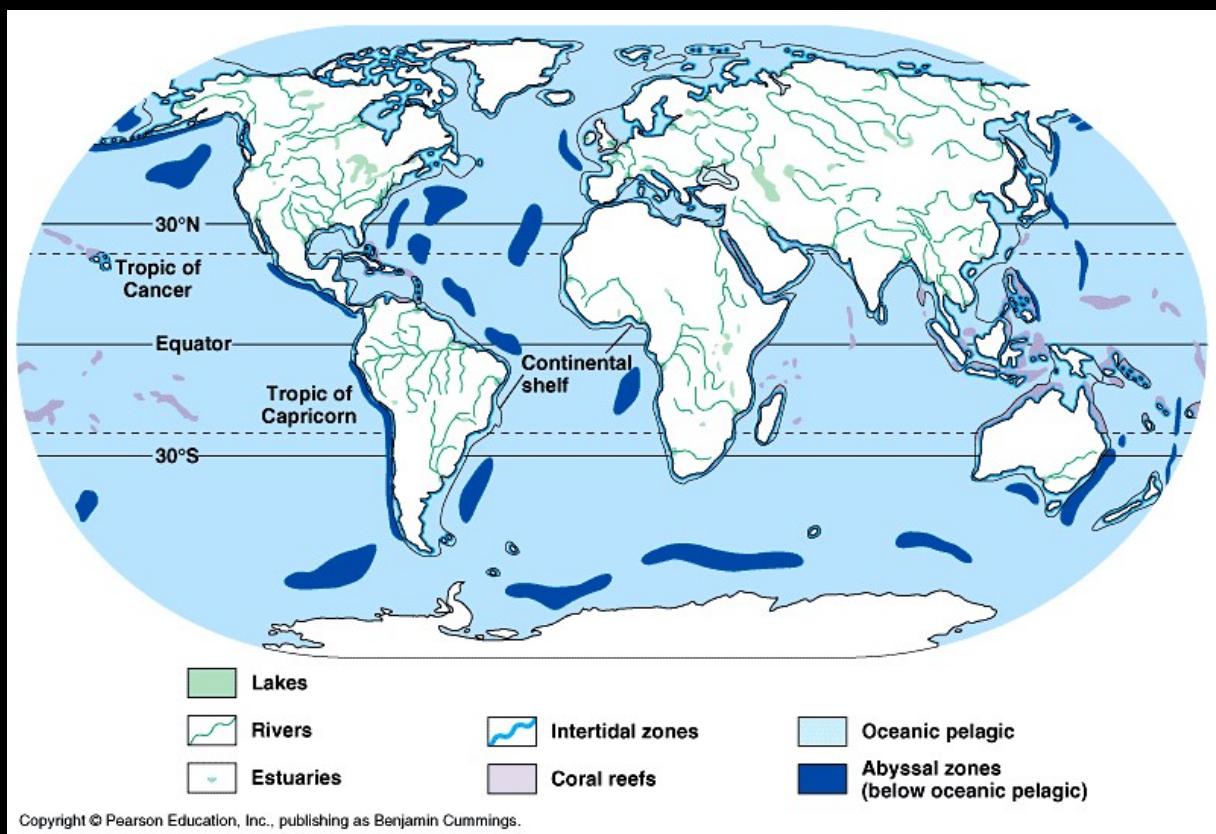


# Aquatic and terrestrial biomes

(Biome = major ecosystem type)

A. Aquatic biomes cover about 75% of the earth's surface

- Wetlands
- Lakes
- Rivers, streams
- Intertidal zones
- Oceanic pelagic biome
- Coral reefs
- Benthos



Oligotrophic Lake:



Wetlands



Eutrophic lake

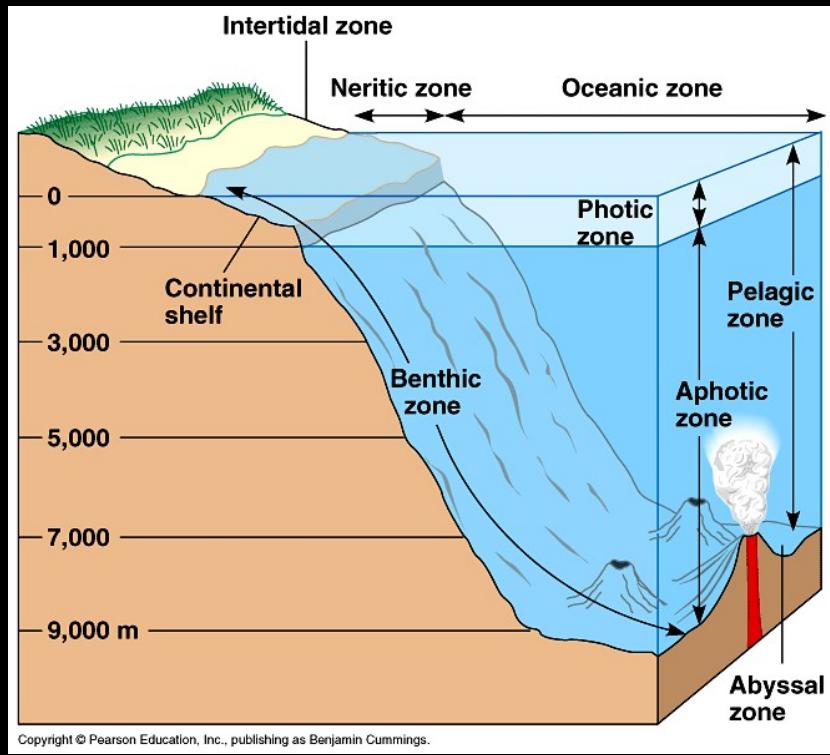


Rivers and Streams:



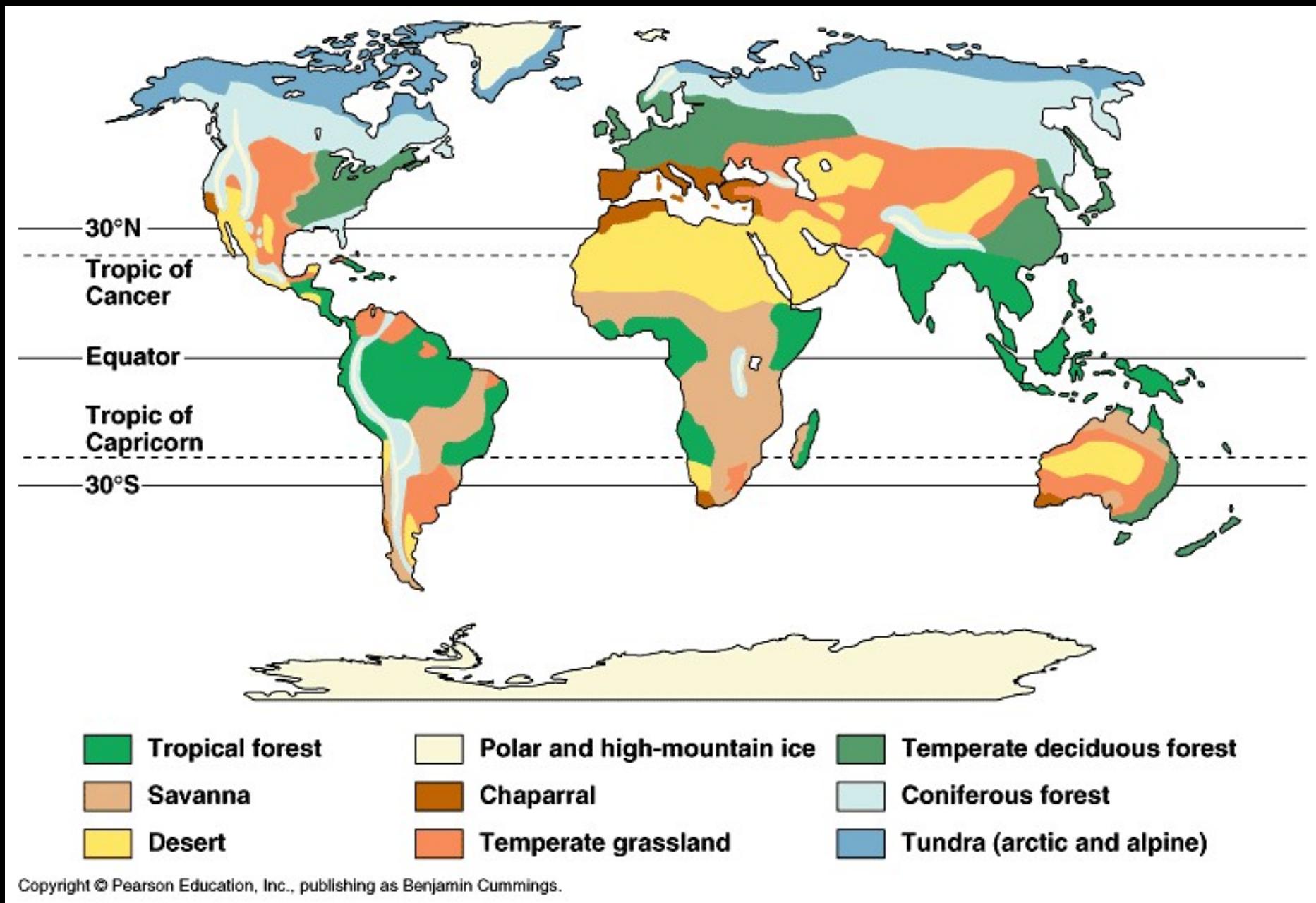
Estuary:





## Marine environment with zonation.

## B. Terrestrial biomes

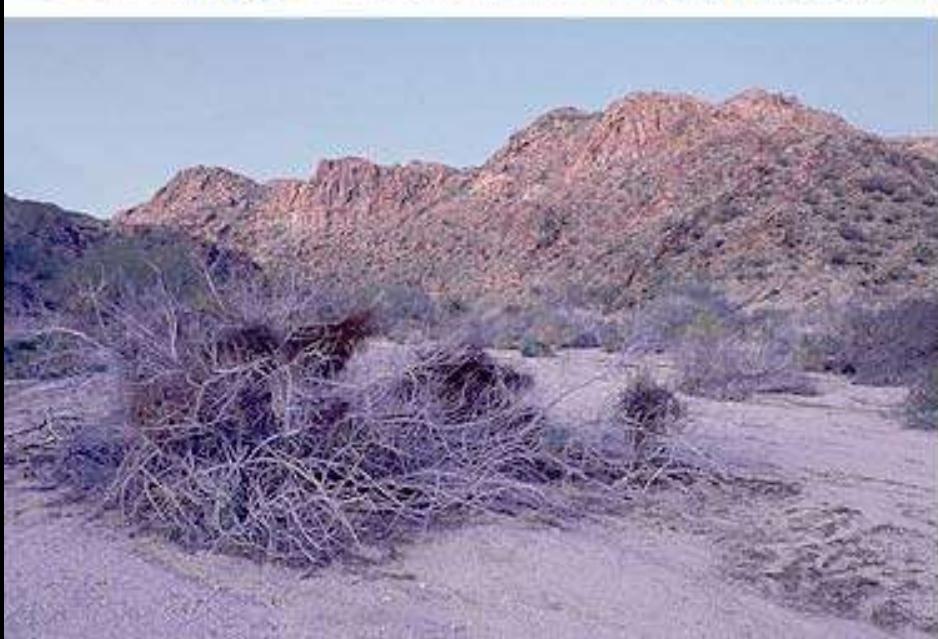


# Tropical Forest:



# Tropical, Dry Forest





Desert: Sparse rainfall (< 30 cm per year), plants and animals adapted for water storage and conservation. Can be either very, very hot, or very cold (e.g. Antarctica)

**Chaparral:**



**Temperate Grassland**

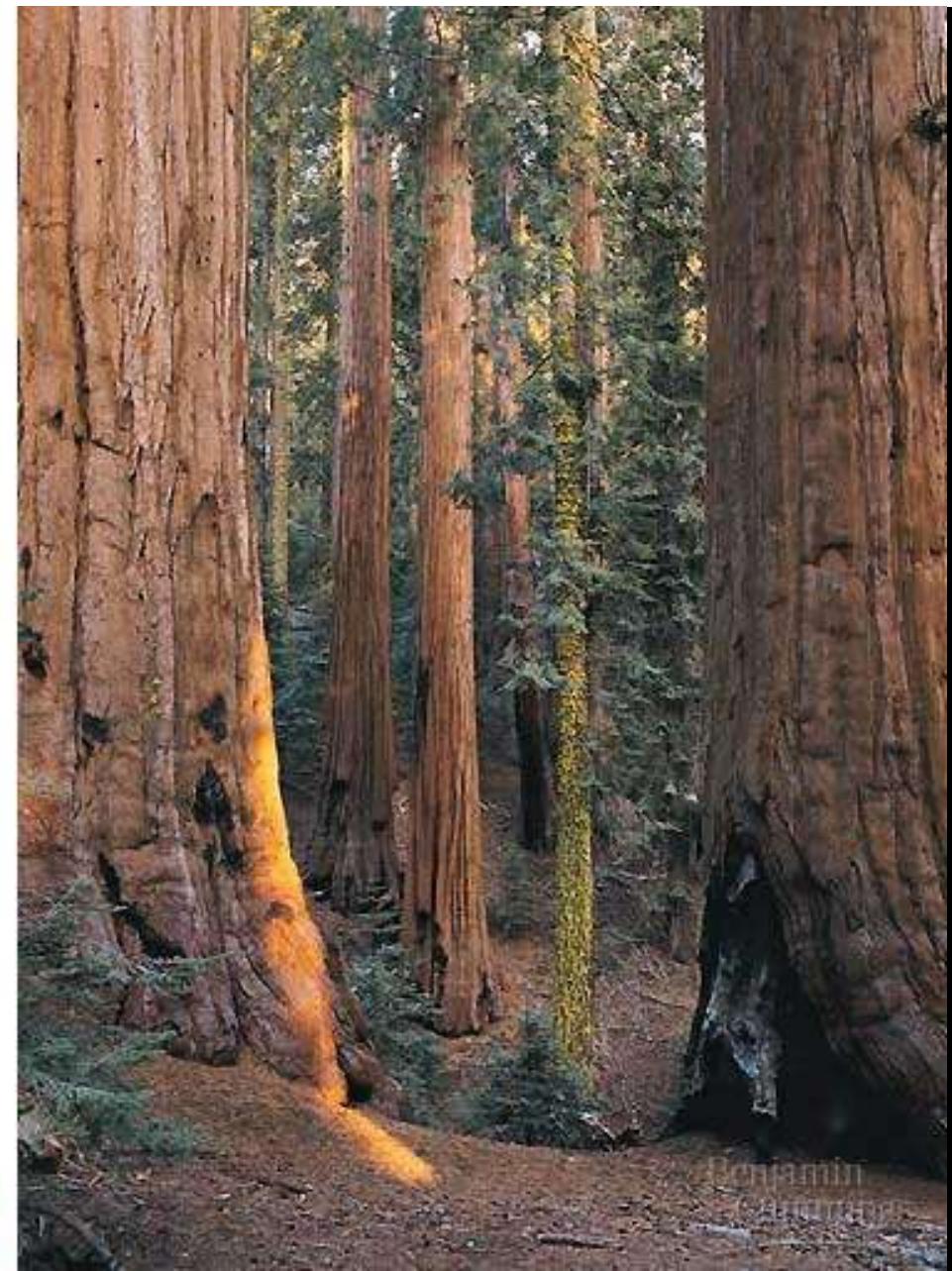
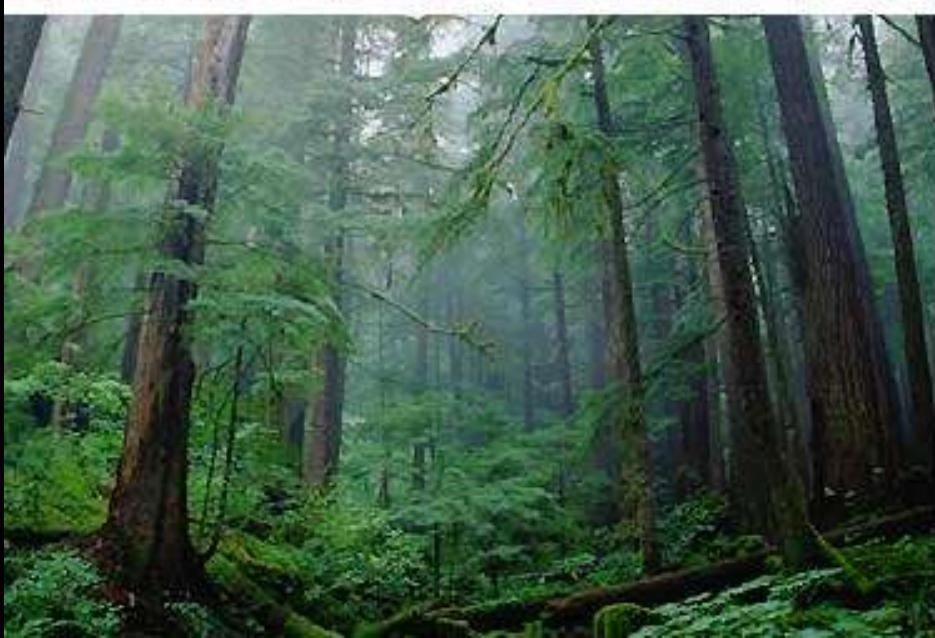


**Temperate Deciduous Forest**



**Tundra**





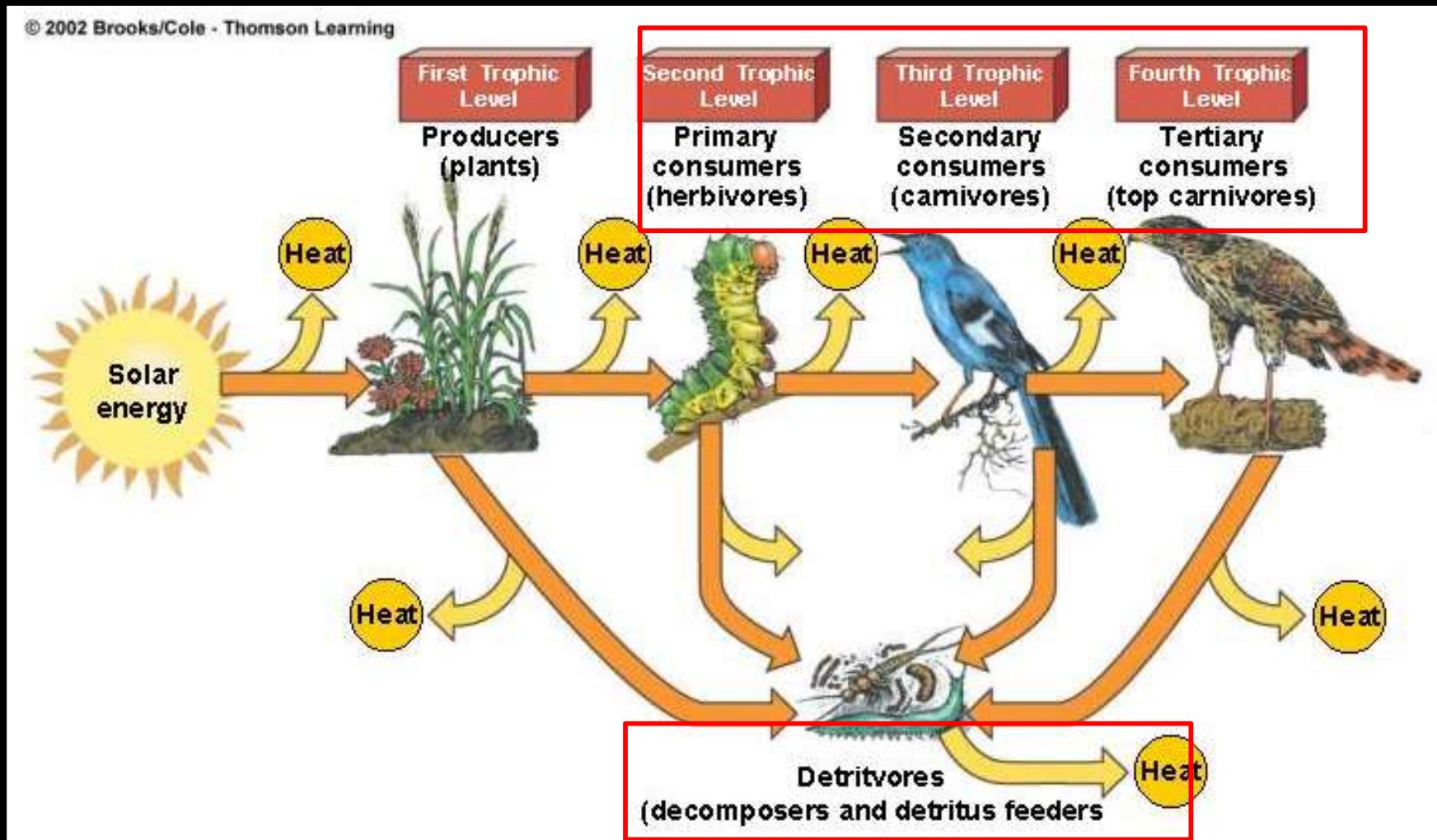
Coniferous forest: Largest terrestrial biome on earth, old growth forests rapidly disappearing, usually receives lots of moisture as rain or snow.



# Food Chains

The concept of food chains was developed by Charles Elton based on his observations on Spitzbergen Island in the 1920s.

## *Trophic Levels*



# Ecological Pyramids

Pyramid of : biomass,  
energy flow,  
Trophic cascade? numbers

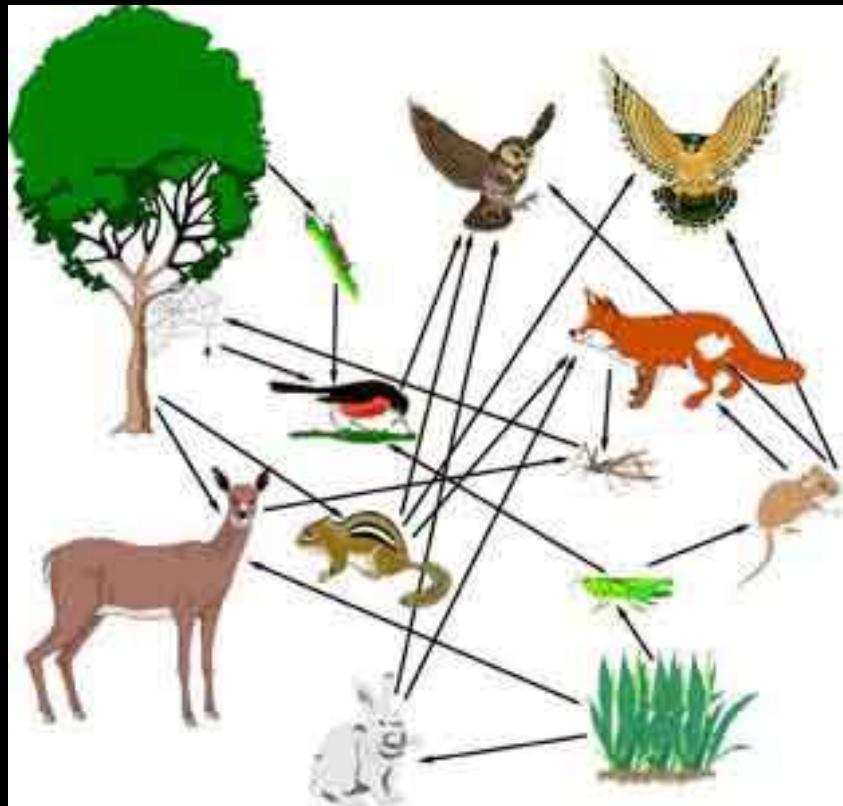
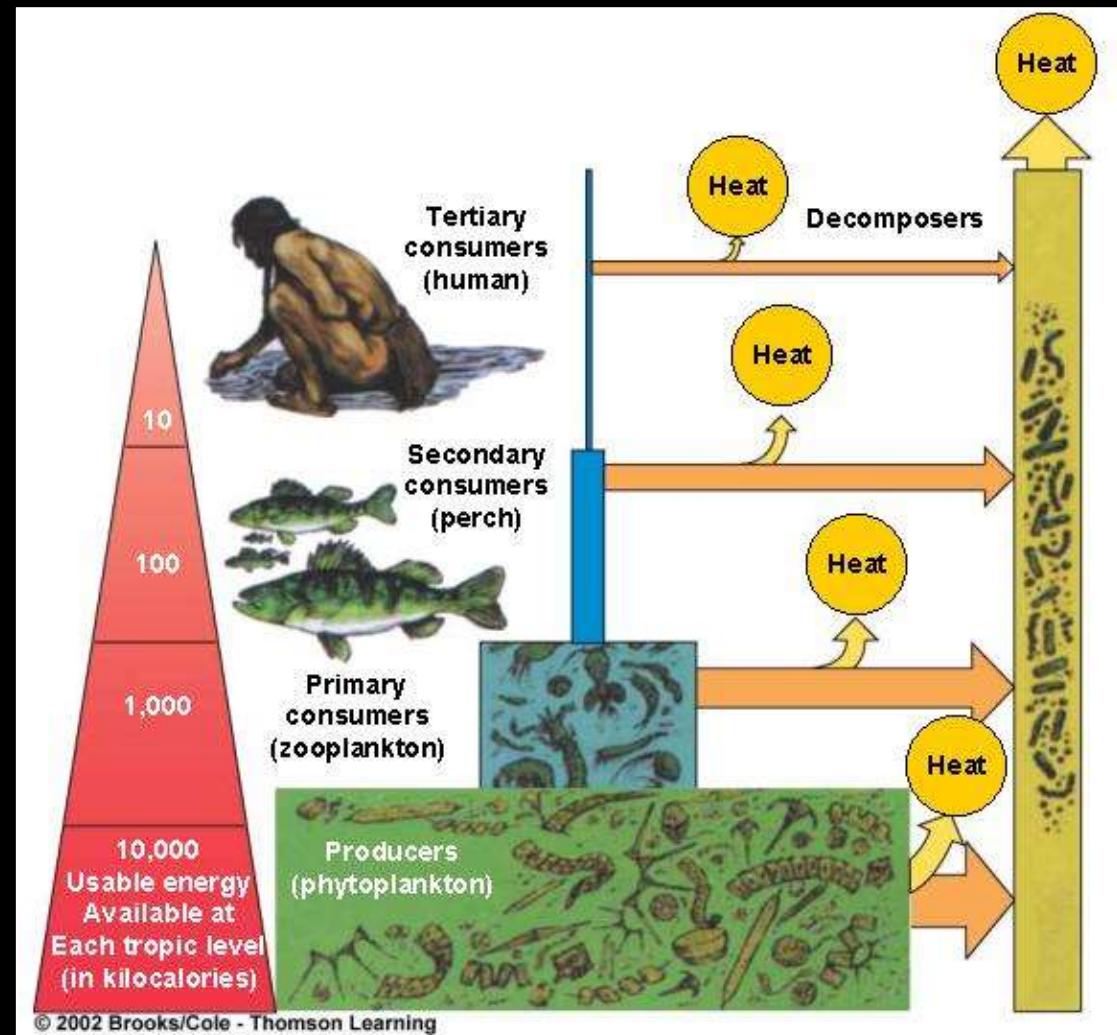
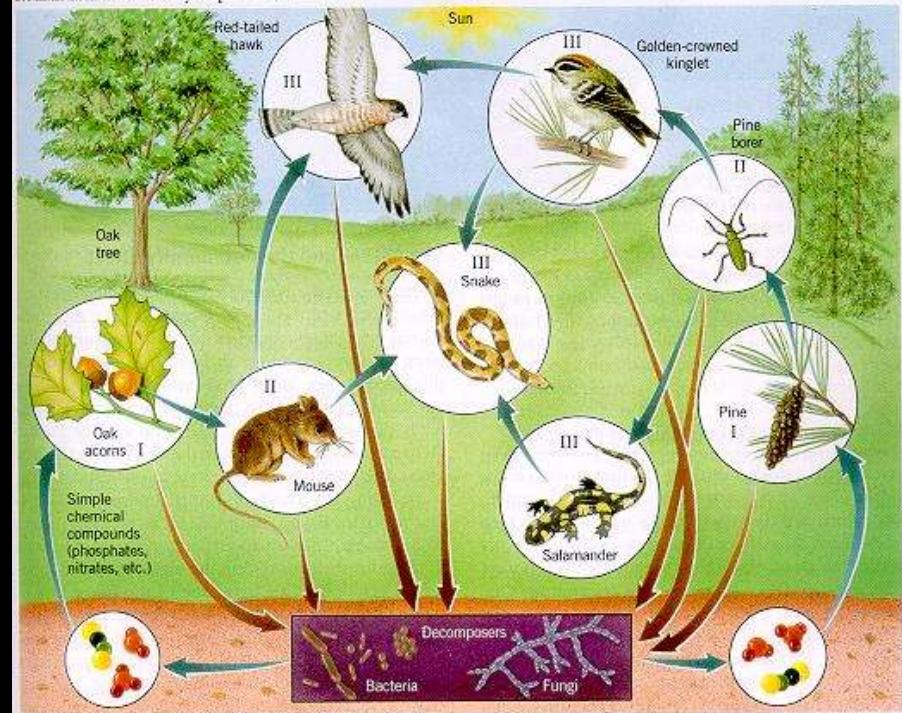
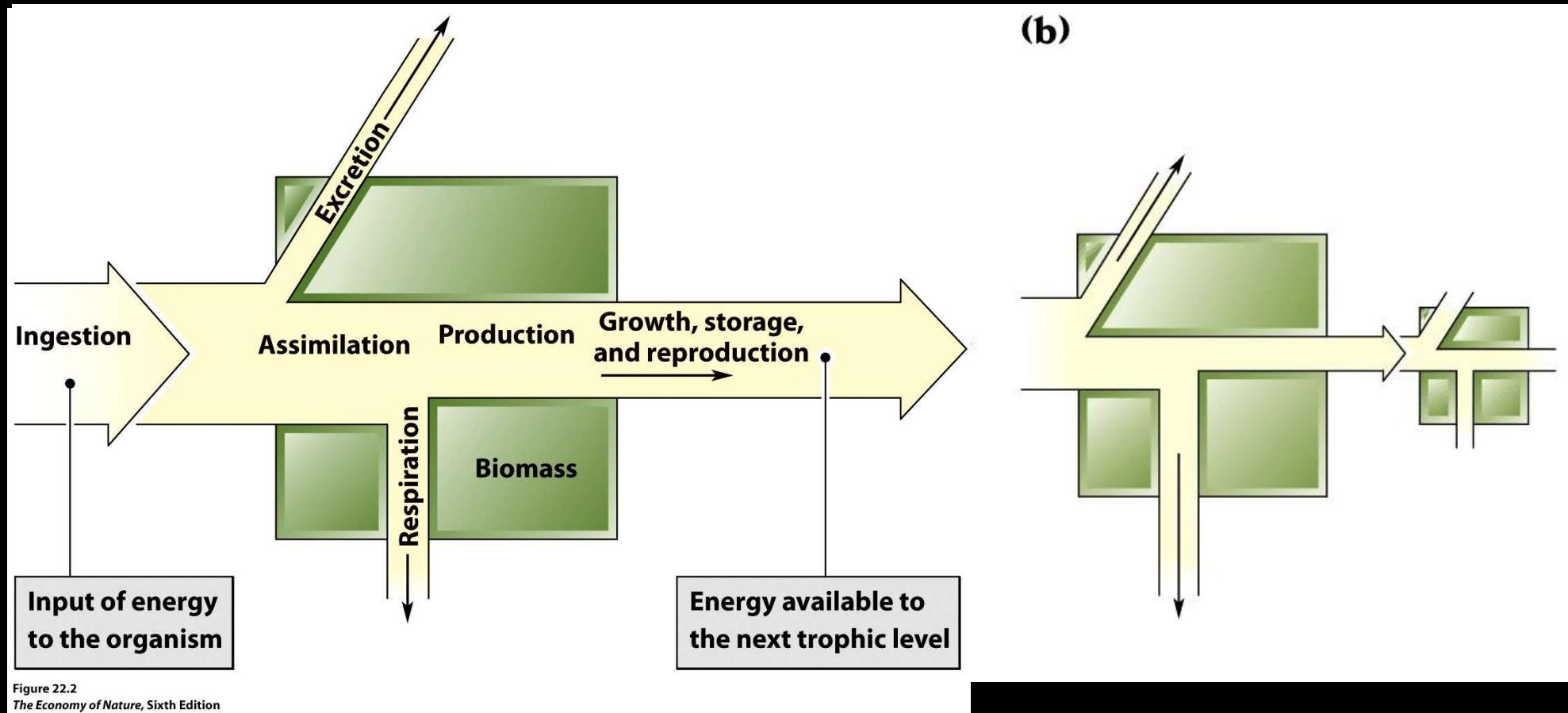


FIGURE 6.5 Food webs: (a) a typical terrestrial food web. Roman numerals identify trophic levels.



# *Models of ecological energy flow*



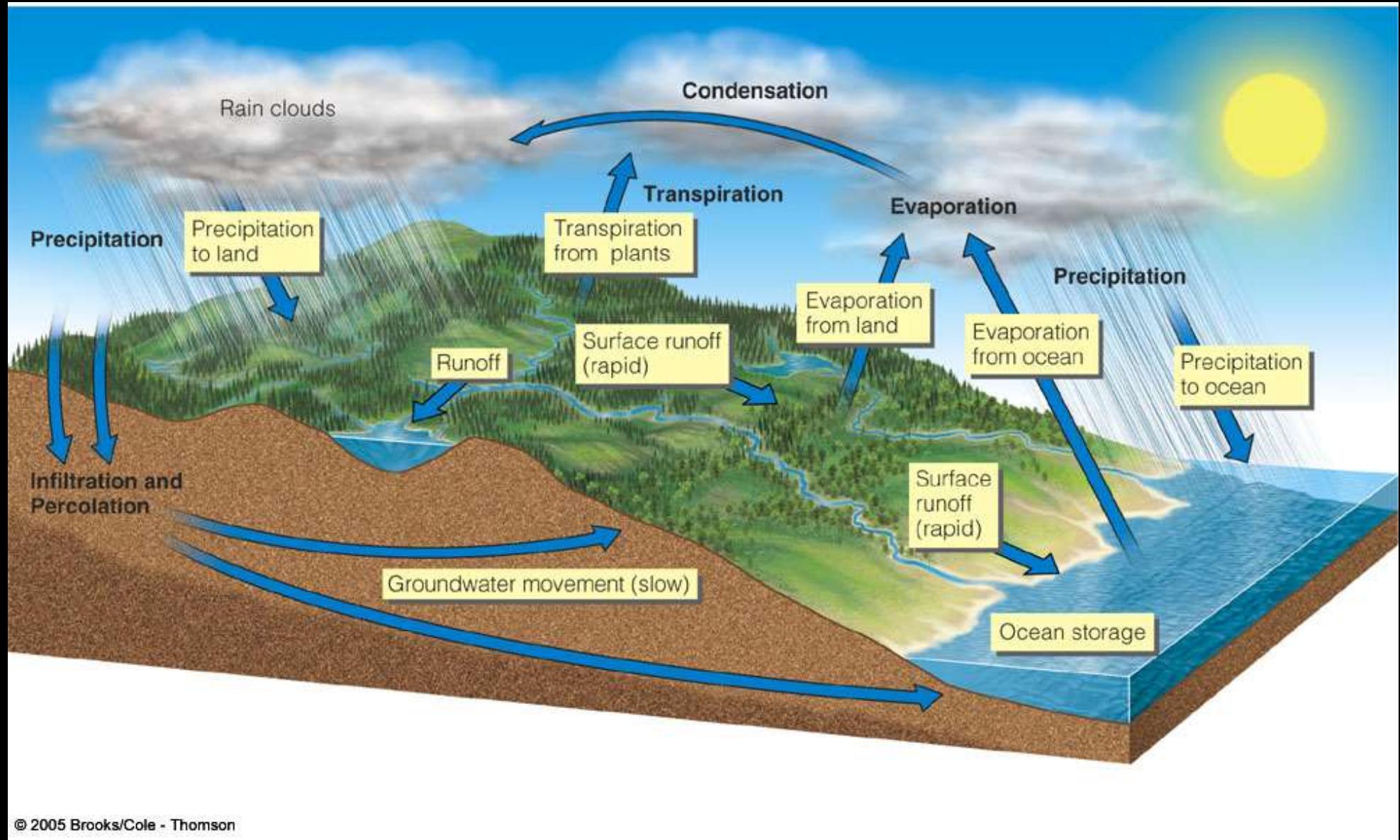
A single trophic level

A food chain

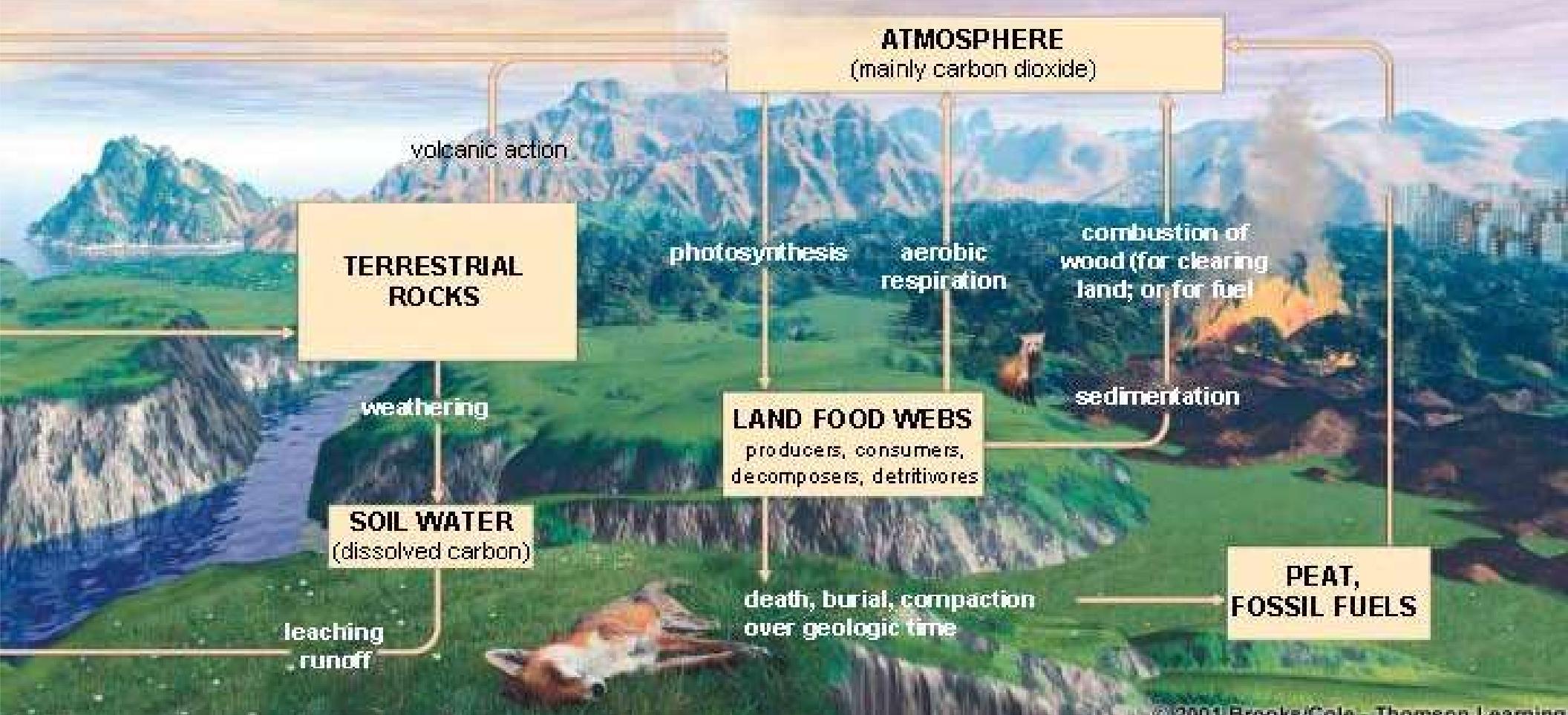
Figure 22.2  
The Economy of Nature, Sixth Edition  
© 2010 W.H. Freeman and Company

# Matter Cycling in Ecosystems : Biogeochemical cycles

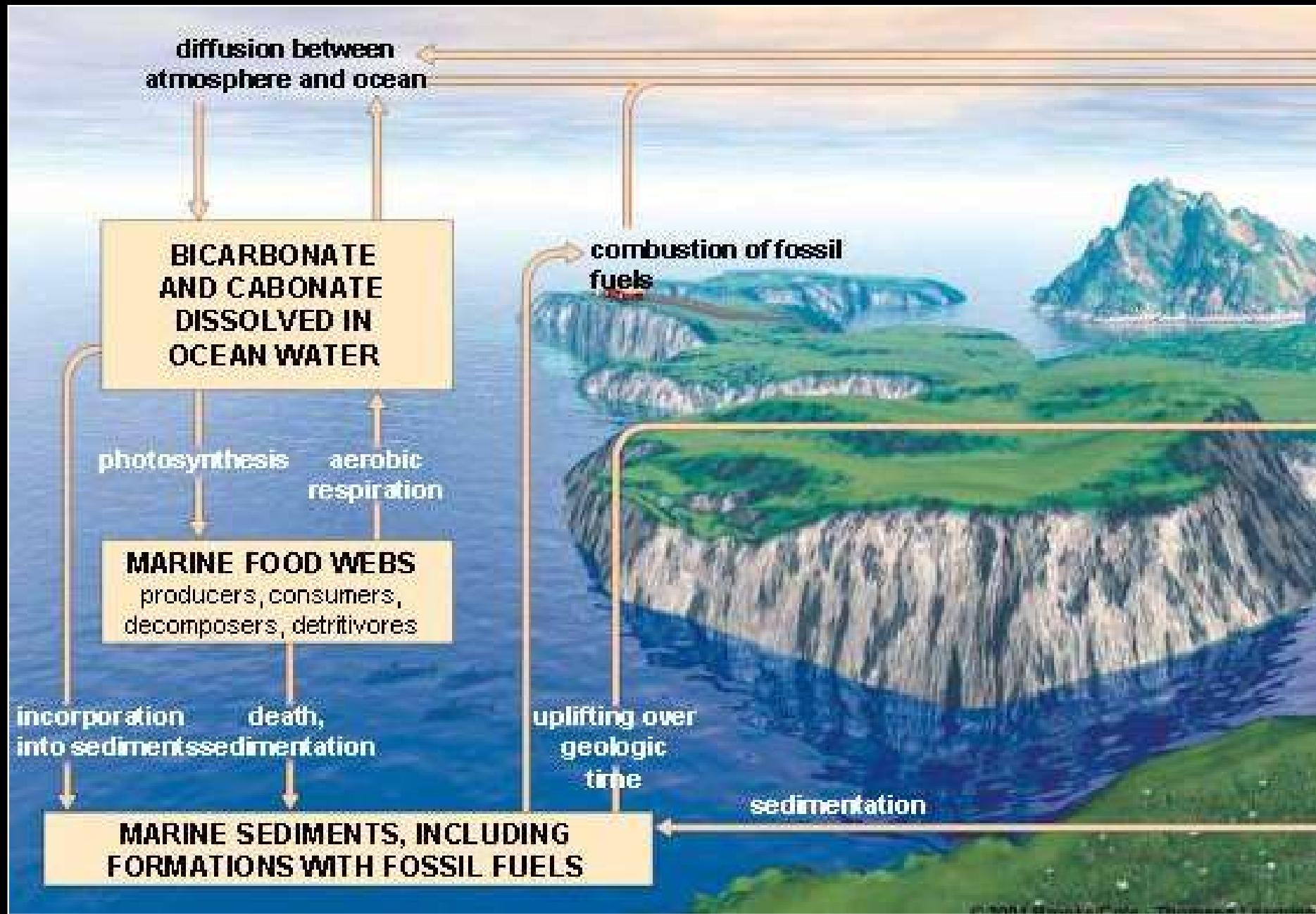
## Hydrologic (Water) Cycle



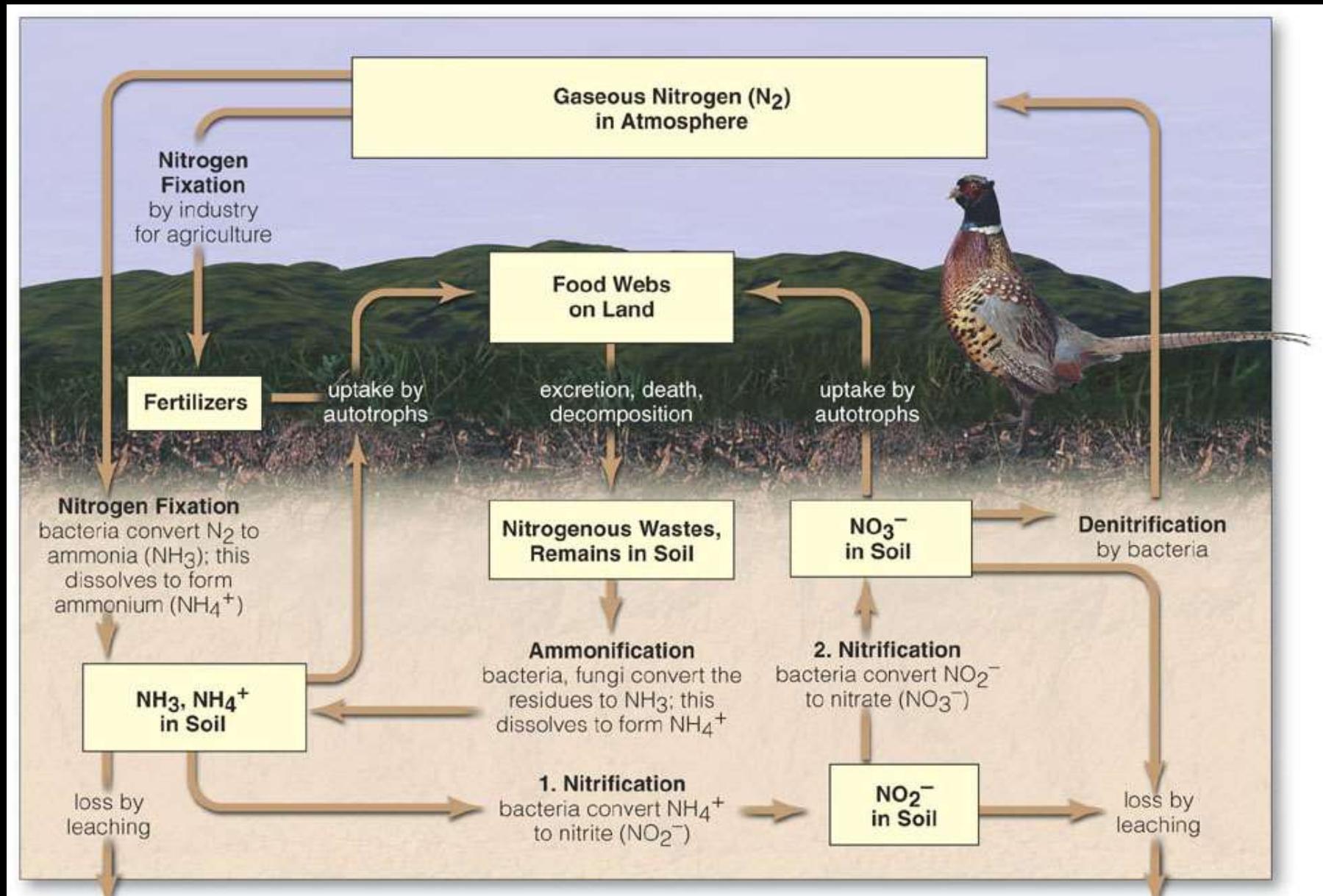
# The Carbon Cycle (Terrestrial)



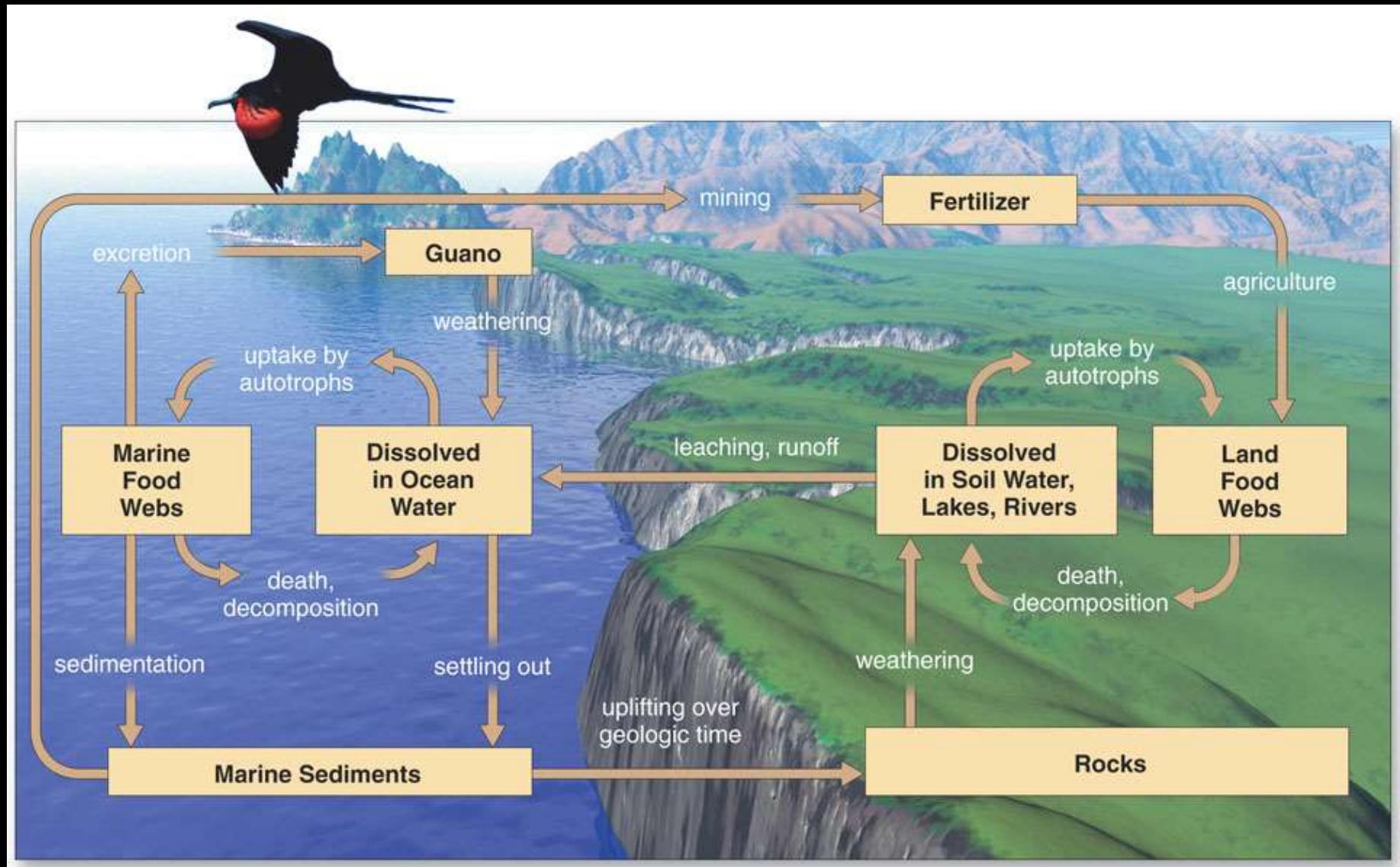
# The Carbon Cycle (Marine): Group



# The Nitrogen Cycle



# The Phosphorus Cycle



<https://missionwolf.org/trophic-cascade/>

<https://www.youtube.com/watch?v=yvqMamiu2b4>

<https://www.youtube.com/watch?v=I47vhzErOCE>

[https://www.youtube.com/watch?v=\\_Rxp3HQDUvY](https://www.youtube.com/watch?v=_Rxp3HQDUvY)

<https://www.youtube.com/watch?v=XVB2VNxRuHM>