Bharathidasan University

Programme: MSc Environmental Science and Sustainable Management

Course Title: Principles of Environmental Science and Sustainable Development

Course Code: 21PGCC01

Unit- III Ecology

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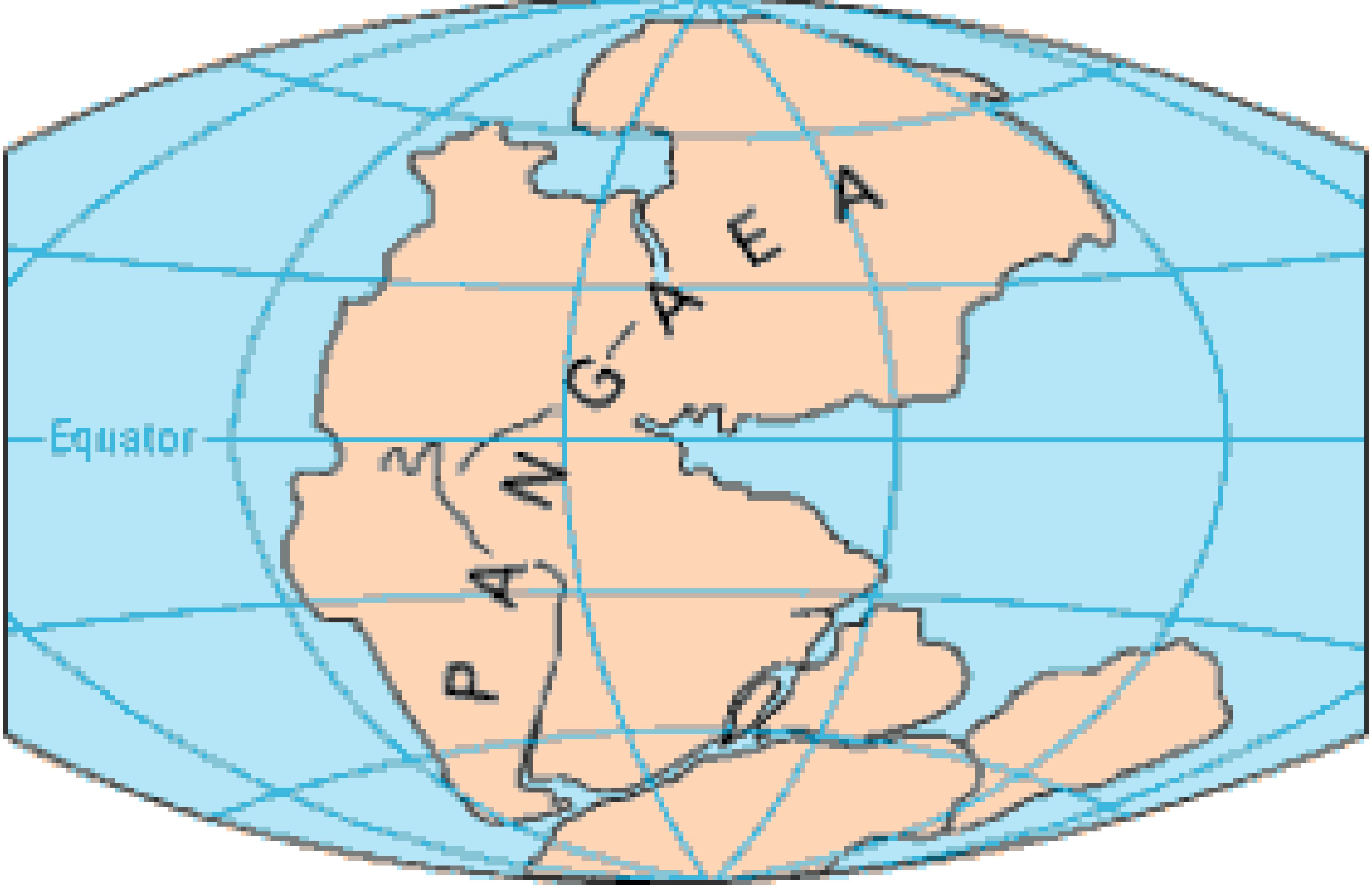
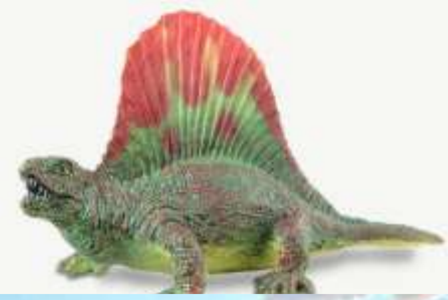
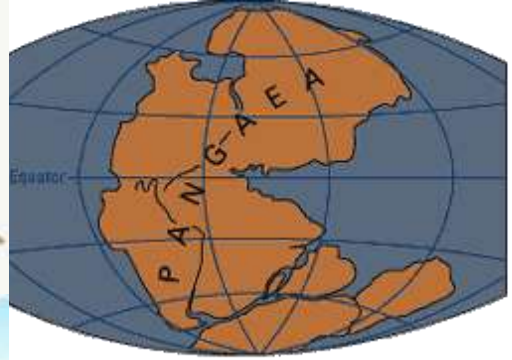
Dept. of Environmental Science and Management



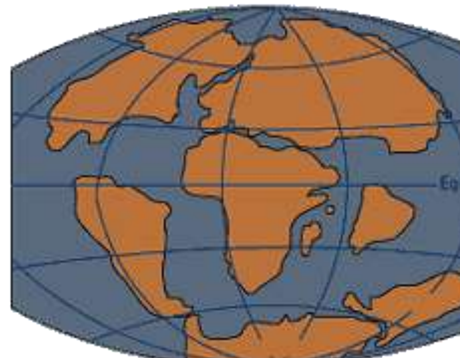
PERMIAN
225 million years ago

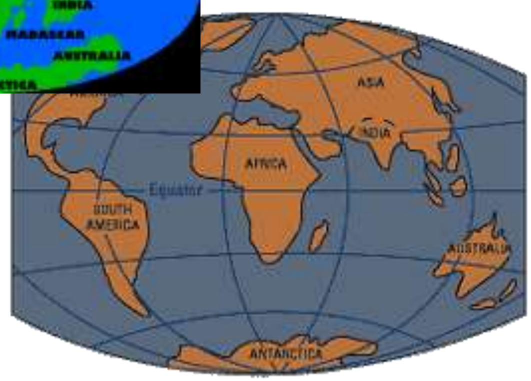




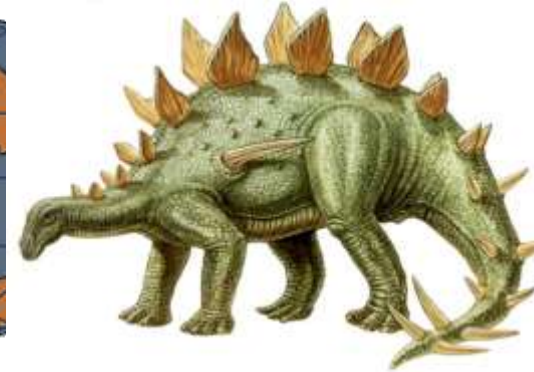
Permian Period
225 million years ago

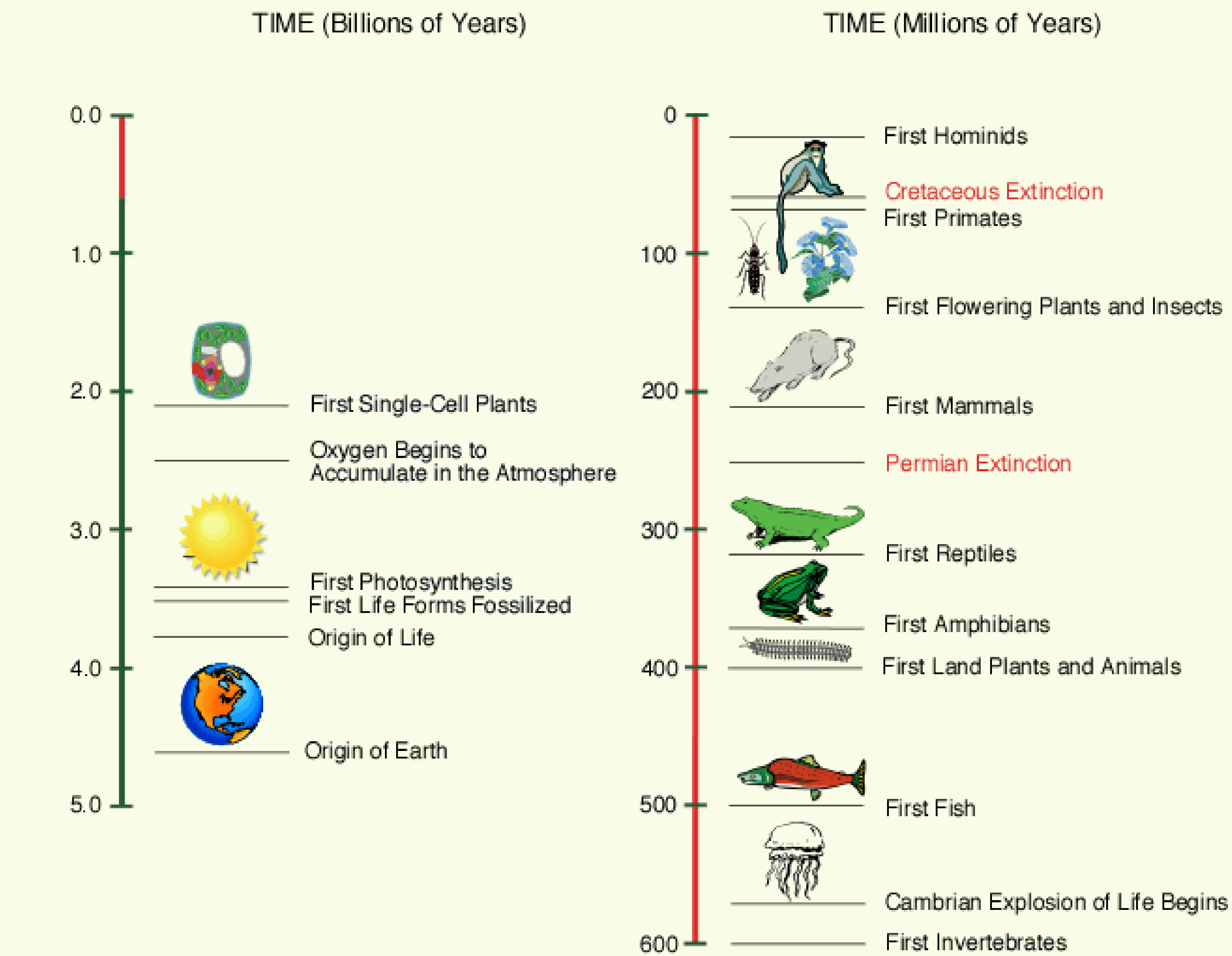
Triassic Period
200 million years ago


Cretaceous Period
65 million years ago



Present Day

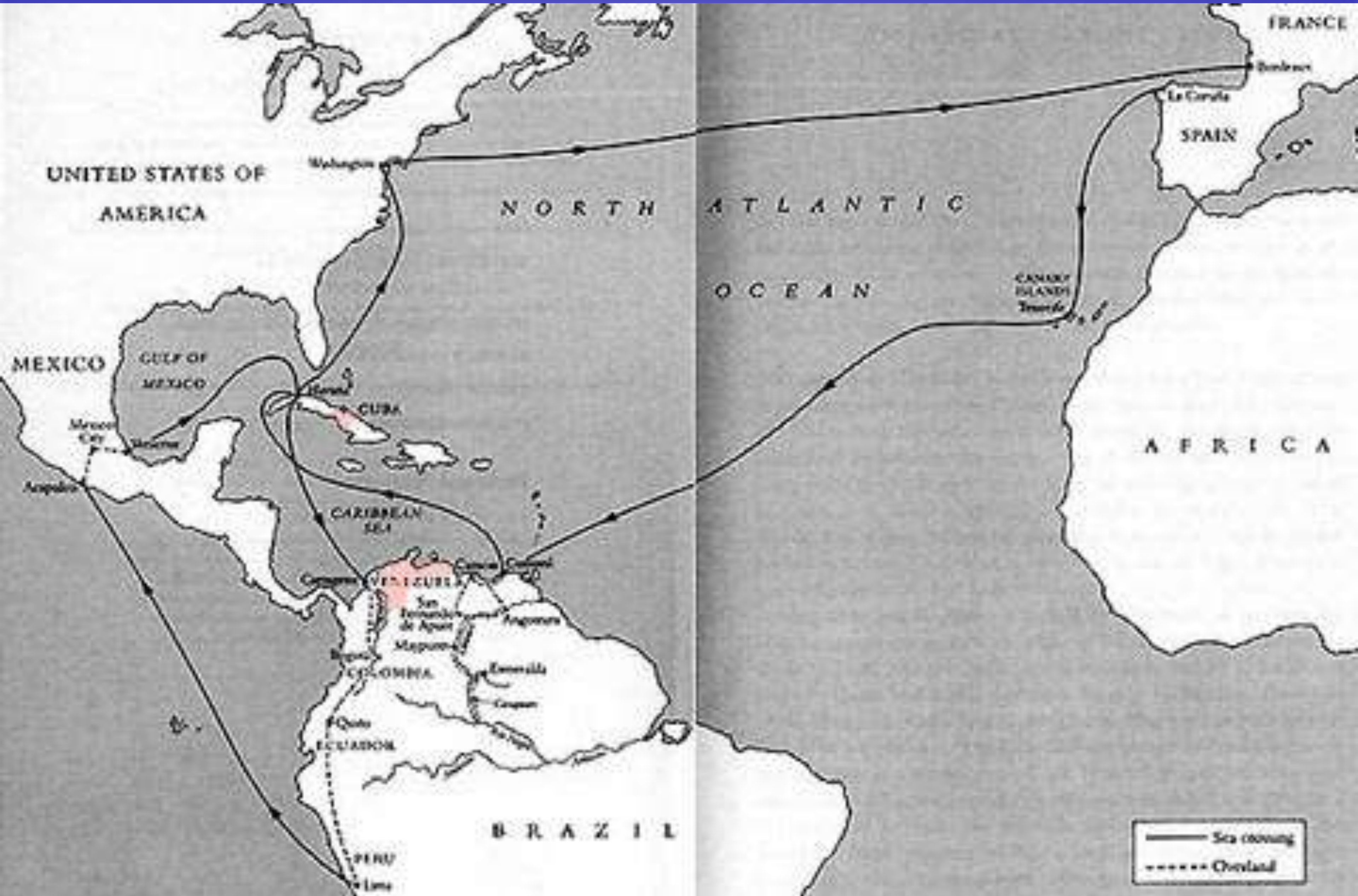




TIME (Billions of Years)
TIME (Millions of Years)
0.0
1.0
2.0
3.0
4.0
5.0
First Single-Cell Plants
Oxygen Begins to Accumulate in the Atmosphere
First Photosynthesis
First Life Forms Fossilized
Origin of Life
Origin of Earth
0
100
200
300
400
500
600
First Hominids
Cretaceous Extinction
First Primates
First Flowering Plants and Insects
First Mammals
Permian Extinction
First Reptiles
First Amphibians
First Land Plants and Animals
First Fish
Cambrian Explosion of Life Begins
First Invertebrates

Alexander von Humboldt (German, 1769-1859)

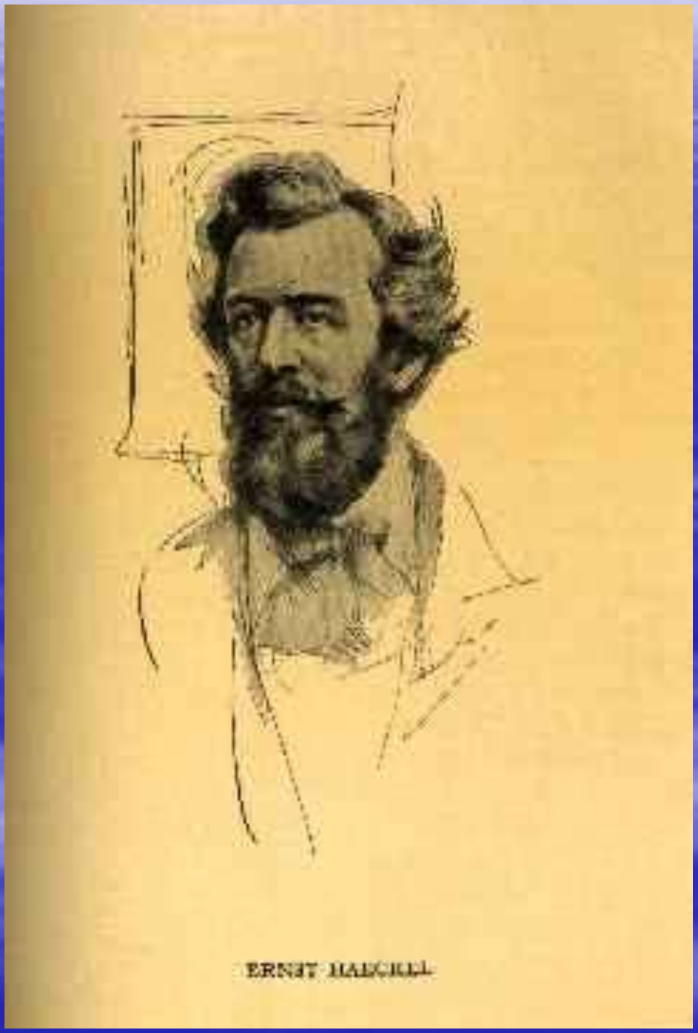
- From a well-to-do family
- Traveled extensively throughout Europe, America, and Russia
- Had a holistic view of nature


FRANCE
SPAIN
La Coruña
UNITED STATES OF AMERICA
NORTH ATLANTIC OCEAN
CANARY ISLANDS
Tenerife
MEXICO
GULF OF MEXICO
CUBA
CARIBBEAN SEA
VENEZUELA
San Fernando de Apure
Maypures
Angostura
Esmeralda
COLOMBIA
Quito
ECUADOR
PERU
Lima
BRAZIL
AFRICA
Sea crossing
Overland

Ernst Haeckel
(German, 1834-1919)

- He was the leading German disciple of Charles Darwin
- He coined the term “Ecology”
- He originally used the Greek spelling *Oecologie*, and defined it as “the science of the relations of living organisms to the external world, their habitat, customs, energies, parasites, etc.”

- Haeckel derived the new label from the same root found in the older word “economy” (“Oekonomie”): the Greek *oikos*, referring originally to the family household and its daily operations and maintenance
- The reason was that at that time, people thought that national economic affairs could be understood as an extension of the housekeeper’s budget. Haeckel thought that the Earth constituted a single economic unit



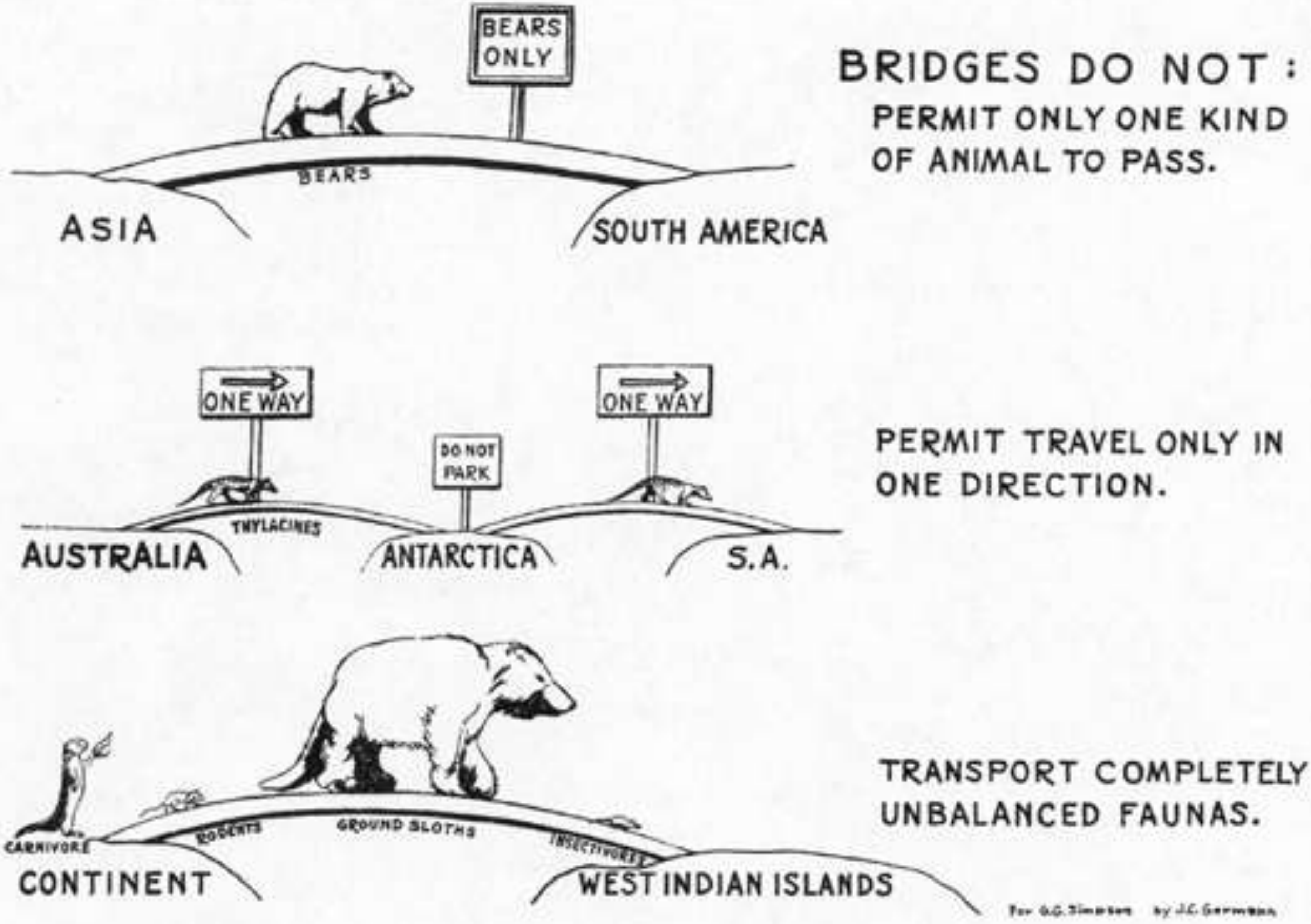
- Haeckel said in 1869 that ecology was "the body of knowledge concerning the economy of nature (...) the study of all those complex interrelations referred to by Darwin as the condition of the struggle for the existence"

- For many years the term was ignored. The use "the economy of nature" instead as in previous centuries "natural economy," was used to refer to physiology

The ecosystem: Arthur Tansley

- It was in 1935 that Arthur Tansley, the British ecologist, coined the term ecosystem, the interactive system established between the biocoenosis (the group of living creatures), and their biotope, the environment in which they live. Ecology thus became the science of ecosystems.

- Tansley's concept of the ecosystem was adopted by the energetic and influential biology educator Eugene Odum. Along with his brother, Howard Odum, Eugene P. Odum wrote a textbook which (starting in 1953) educated more than one generation of biologists and ecologists in North America.



BEARS ONLY
BEARS
ASIA
SOUTH AMERICA
BRIDGES DO NOT:
PERMIT ONLY ONE KIND OF ANIMAL TO PASS.
ONE WAY
DO NOT PARK
ONE WAY
THYLACINES
AUSTRALIA
ANTARCTICA
S.A.
PERMIT TRAVEL ONLY IN ONE DIRECTION.
CARNIVORE
RODENTS
GROUND SLOTHS
INSECTIVORES
CONTINENT
WEST INDIAN ISLANDS
TRANSPORT COMPLETELY UNBALANCED FAUNAS.


AFRICA
NOT HOLDERS OF TICKETS
DISAPPOINTED TICKET HOLDERS
N
THE WINNING TICKETS
PALEOCENE ··· TENRECS
EOCENE ······ LEMURS
OLIGOCENE ··· FOSSAS
MIOCENE ···· MICE
PLIOCENE ·· NO DRAWING
PLEISTOCENE ·· HIPPOPOTAMUS
LIONS
ELEPHANTS
APES
ANTELOPES
ZEBRAS
RODENTS
SHREWS
SMALL MONKEYS
SMALL CATS
MADAGASCAR
MICE
FOSSAS
LEMURS
TENRECS
The African – Malagasy SWEEPSTAKES

Light Energy is Converted into Chemical Energy

The Laws of Thermodynamics Govern Energy Flow

- Potential Energy: stored energy capable and available for performing work.
- Kinetic energy: energy of an object in motion.
- The First Law of Thermodynamics: energy is neither created or destroyed.
  - It can only be converted from one form to another.

The Laws of Thermodynamics Govern Energy Flow

- Entropy: the reduction in the amount of energy available to do work as a result of energy loss through heat during transfer.
- The Second Law of Thermodynamics: when energy is transferred or transformed, part of the energy assumes a form that cannot pass on any further.
  – Living things do not conform to the 2^{nd} law because we are part of an open system, not a closed system

Energy Fixed in the Process of Photosynthesis Is Primary Production

- Primary productivity: the rate at which radiant energy is converted by photosynthesis to organic compounds.
  - Gross primary productivity: the total rate of photosynthesis, or energy assimilated by autotrophs/
  - Net primary productivity: the rate of energy storage as organic matter after respiration costs.
  - Standing crop biomass: the amount of accumulated organic matter found in an area at a given time.
    - Net primary production can be estimated by measuring the change in SCB over time.

Physical and chemical factors influence life

- The most important abiotic factors that determine the biosphere's structure and dynamics include
  - solar energy
  - water
  - temperature
  - Nutrients

Ecosystems Use Sunlight As Their Source of Energy

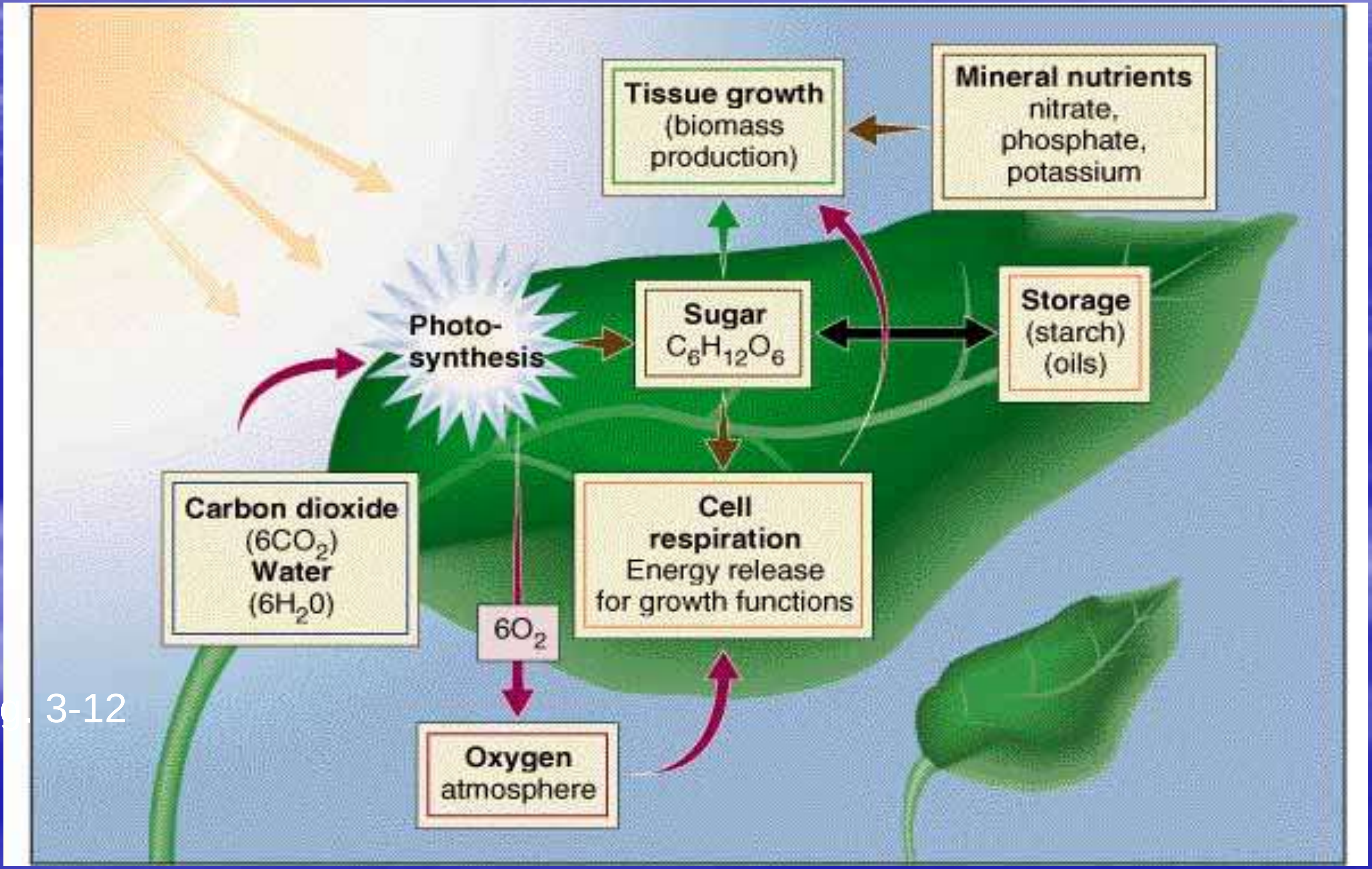


Fig. 3-12

- Most climatic variations are due to the uneven heating of Earth's surface
  - This is a result of the variation in solar radiation at different latitudes

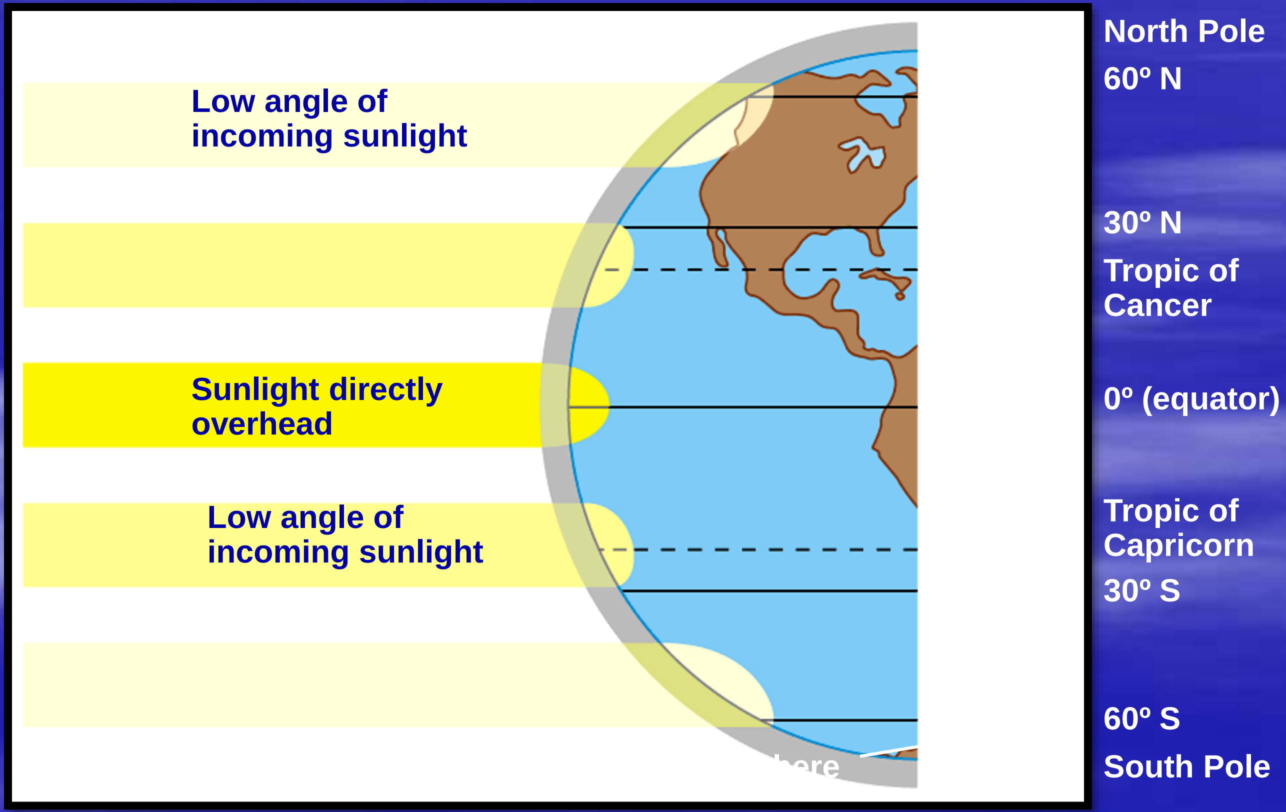
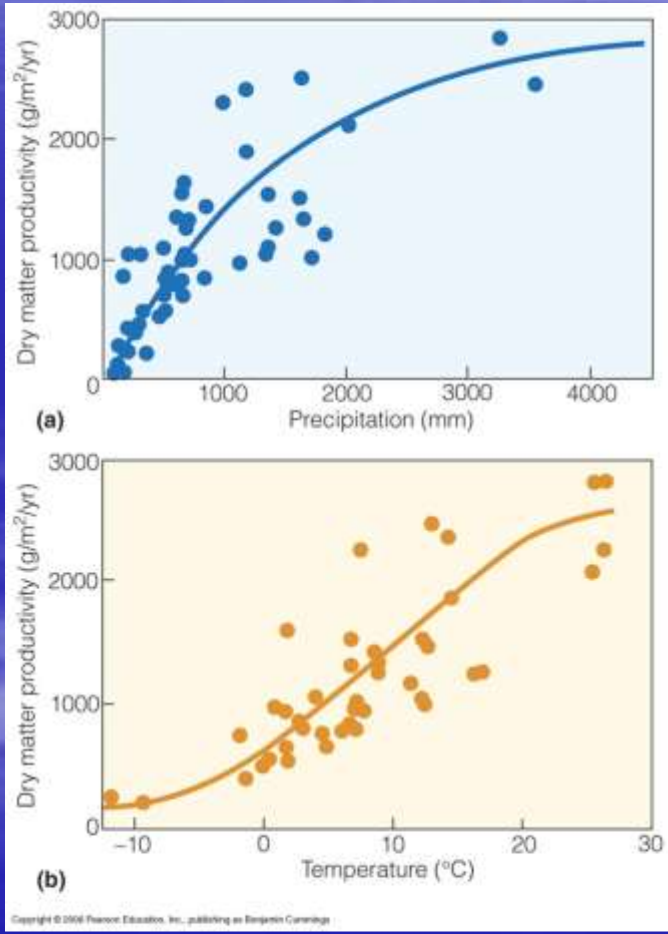


Figure 34.6A

Tropical forests cluster near the equator

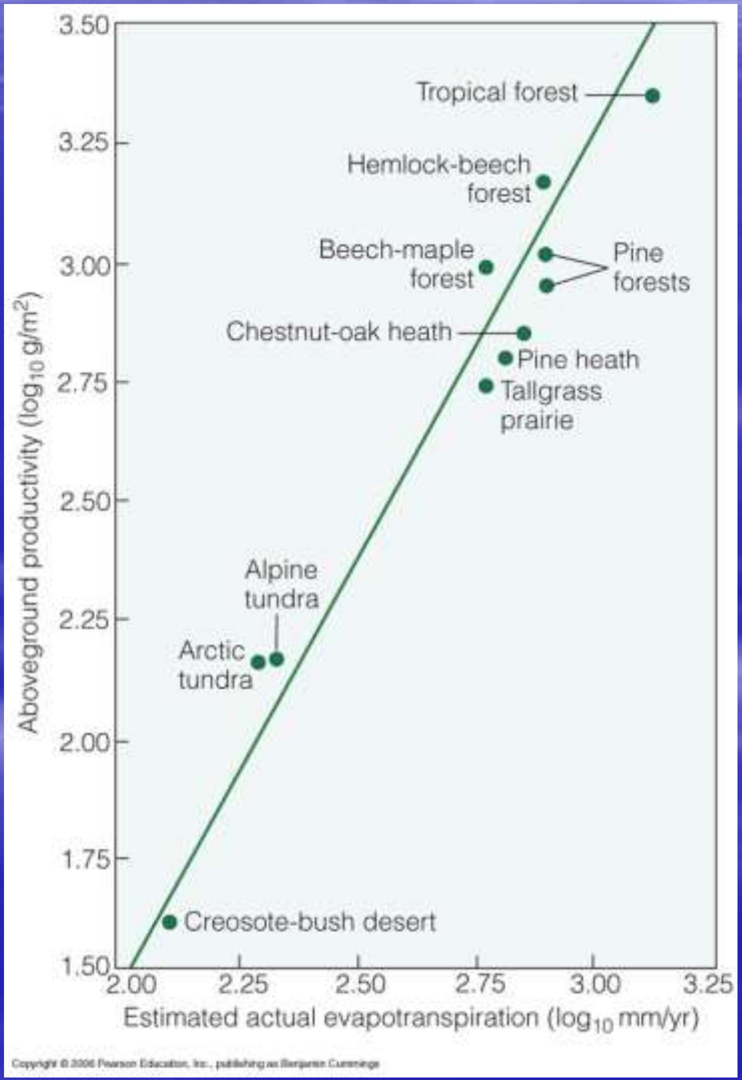
Temperature, Water, and Nutrients Control Primary Production in Terrestrial Ecosystems

- Net primary productivity increases with increasing mean annual temperature and rainfall.

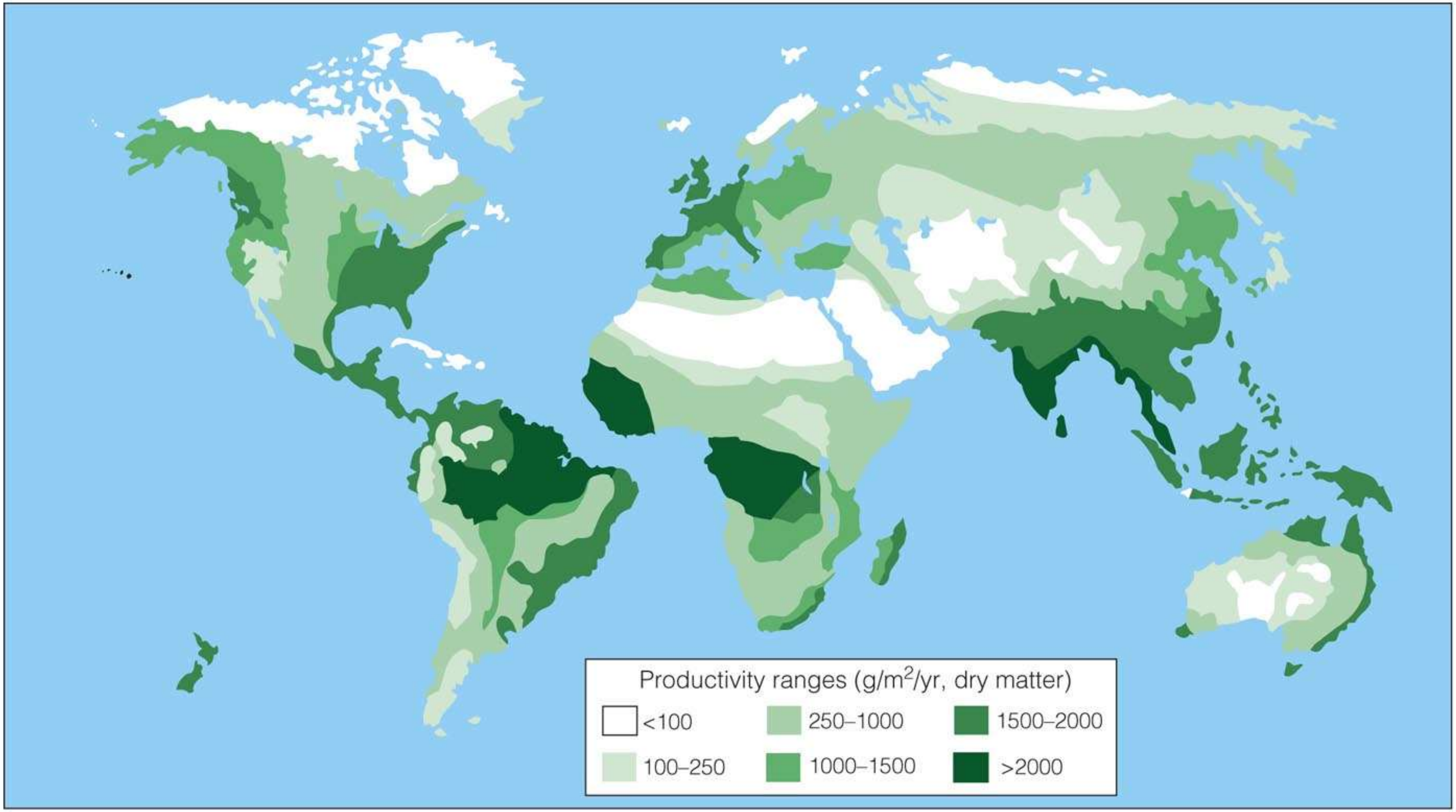


Temperature, Water, and Nutrients Control Primary Production in Terrestrial Ecosystems

- The combination of high temp and high rainfall result in the highest prim pro. Why?



Temperature, Water, and Nutrients Control Primary Production in Terrestrial Ecosystems



Net Primary Productivity Use

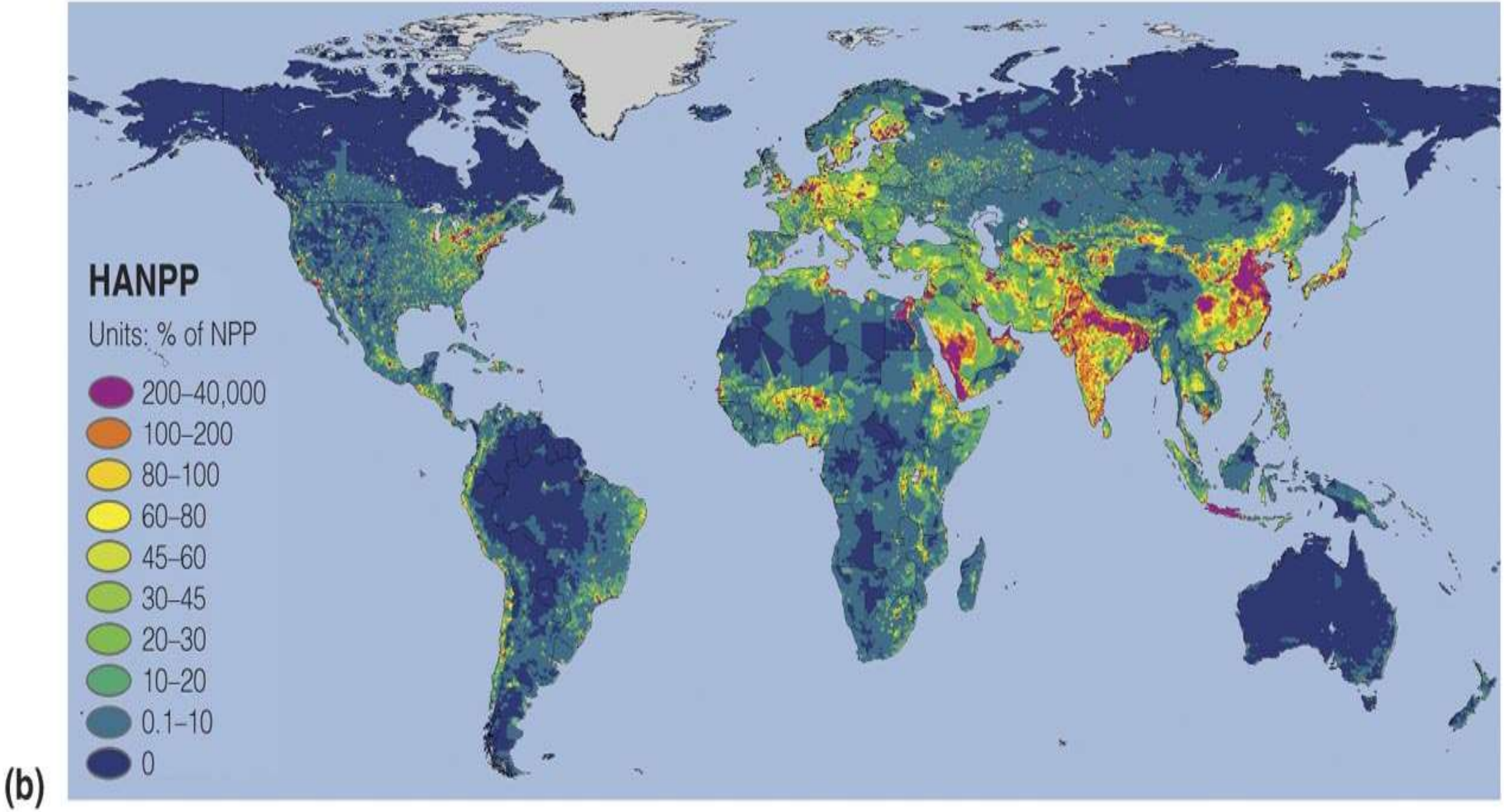
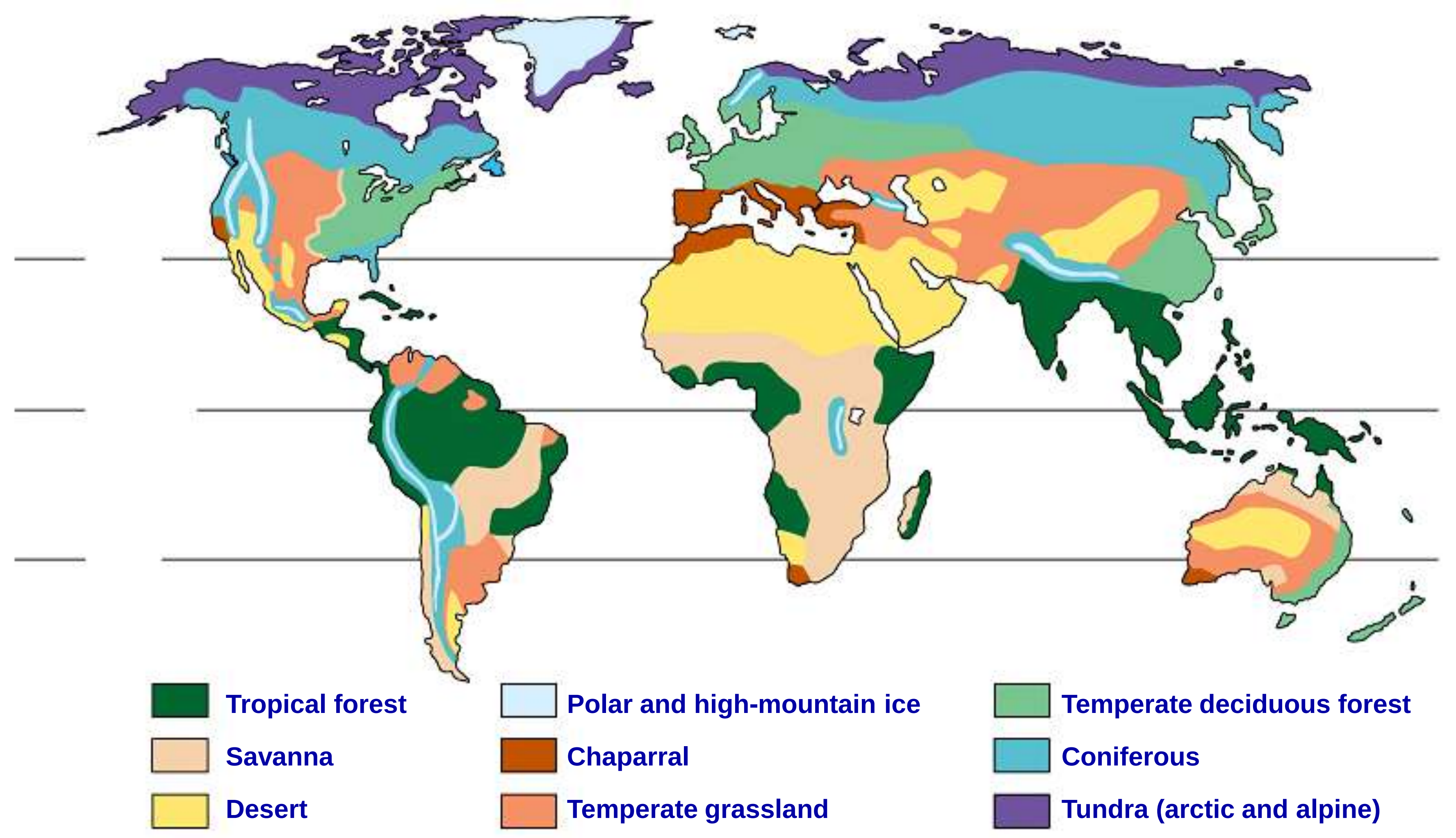


Table 20.1 | Net Primary Production and Plant Biomass of World Ecosystems

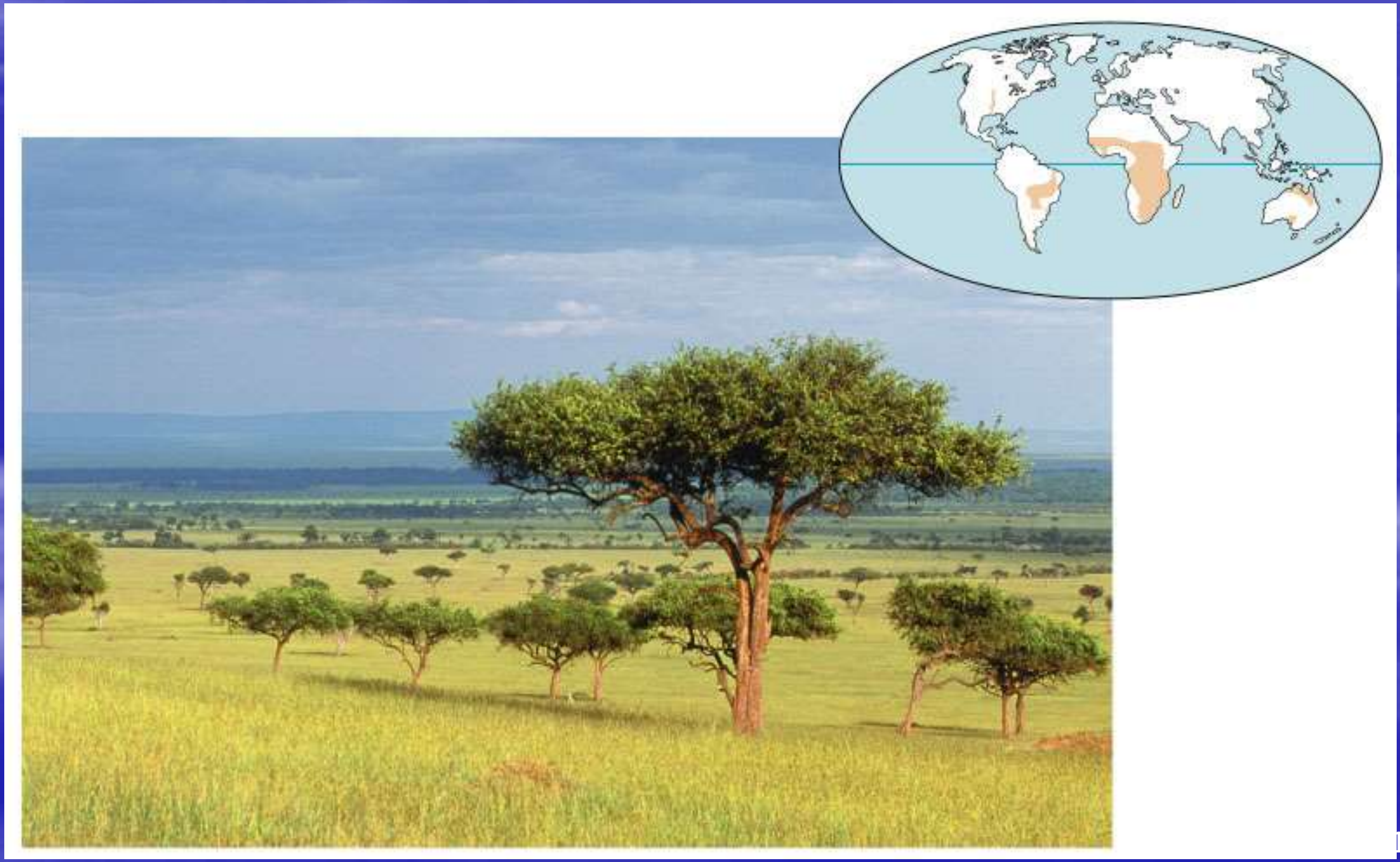
Ecosystems (in Order of Productivity)	Area (10^6 km^2)	Mean Net Primary Production per Unit Area (g/m^2/yr)	World Net Primary Production (10^9 Mt/yr)	Mean Biomass per Unit Area (kg/m^2)
Continental				
Tropical rain forest	17.0	2000.0	34.00	44.00
Tropical seasonal forest	7.5	1500.0	11.30	36.00
Temperate evergreen forest	5.0	1300.0	6.40	36.00
Temperate deciduous forest	7.0	1200.0	8.40	30.00
Boreal forest	12.0	800.0	9.50	20.00
Savanna	15.0	700.0	10.40	4.00
Cultivated land	14.0	644.0	9.10	1.10
Woodland and shrubland	8.0	600.0	4.90	6.80
Temperate grassland	9.0	500.0	4.40	1.60
Tundra and alpine meadow	8.0	144.0	1.10	0.67
Desert shrub	18.0	71.0	1.30	0.67
Rock, ice, sand	24.0	3.3	0.09	0.02
Swamp and marsh	2.0	2500.0	4.90	15.00
Lake and stream	2.5	500.0	1.30	0.02
Total continental	149.0	720.0	107.09	12.30
Marine				
Algal beds and reefs	0.6	2000.0	1.10	2.00
Estuaries	1.4	1800.0	2.40	1.00
Upwelling zones	0.4	500.0	0.22	0.02
Continental shelf	26.6	360.0	9.60	0.01
Open ocean	332.0	127.0	42.00	0.003
Total marine	361.0	153.0	55.32	0.01
World total	**510.0**	**320.0**	**162.41**	**3.62**

Source: Adapted from Whittaker 1975.

- Major terrestrial biomes



Savannas are grasslands with scattered trees



Deserts are defined by their dryness

- Deserts are the driest of all terrestrial biomes
  - They are characterized by low and unpredictable rainfall

  - Desertific
    is a signif
    environm
    problem

Spiny shrubs dominate the chaparral

- The chaparral biome is a shrubland with cool, rainy winters and dry, hot summers
- Chaparral vegetation is adapted to periodic fires

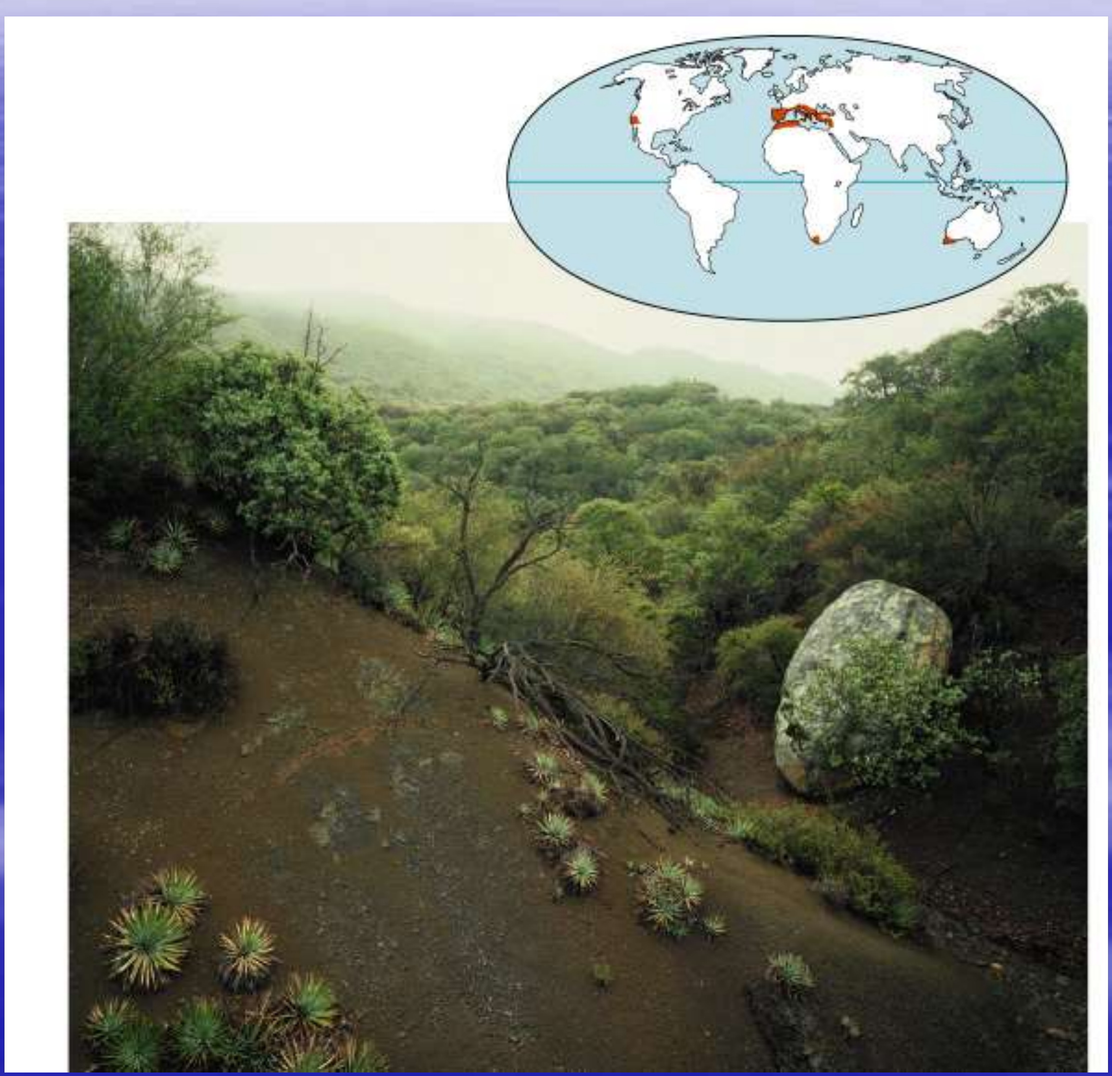


Figure 34.14

Temperate grasslands include the North American prairie

- Temperate grasslands are found in the interiors of the continents, where winters are cold
- Drought, fires, and grazing animals prevent trees from growing
  - Farms have replaced most of North America's temperate grasslands

Deciduous trees dominate temperate forests

- Temperate deciduous forests grow where there is sufficient moisture to support the growth of large trees
  - Nearly all of the original deciduous forests in North America have been drastically altered by agriculture and urban development

Figure 34.16

Coniferous forests are often dominated by a few species of trees

- The northern coniferous forest, or taiga, is the largest terrestrial biome on Earth

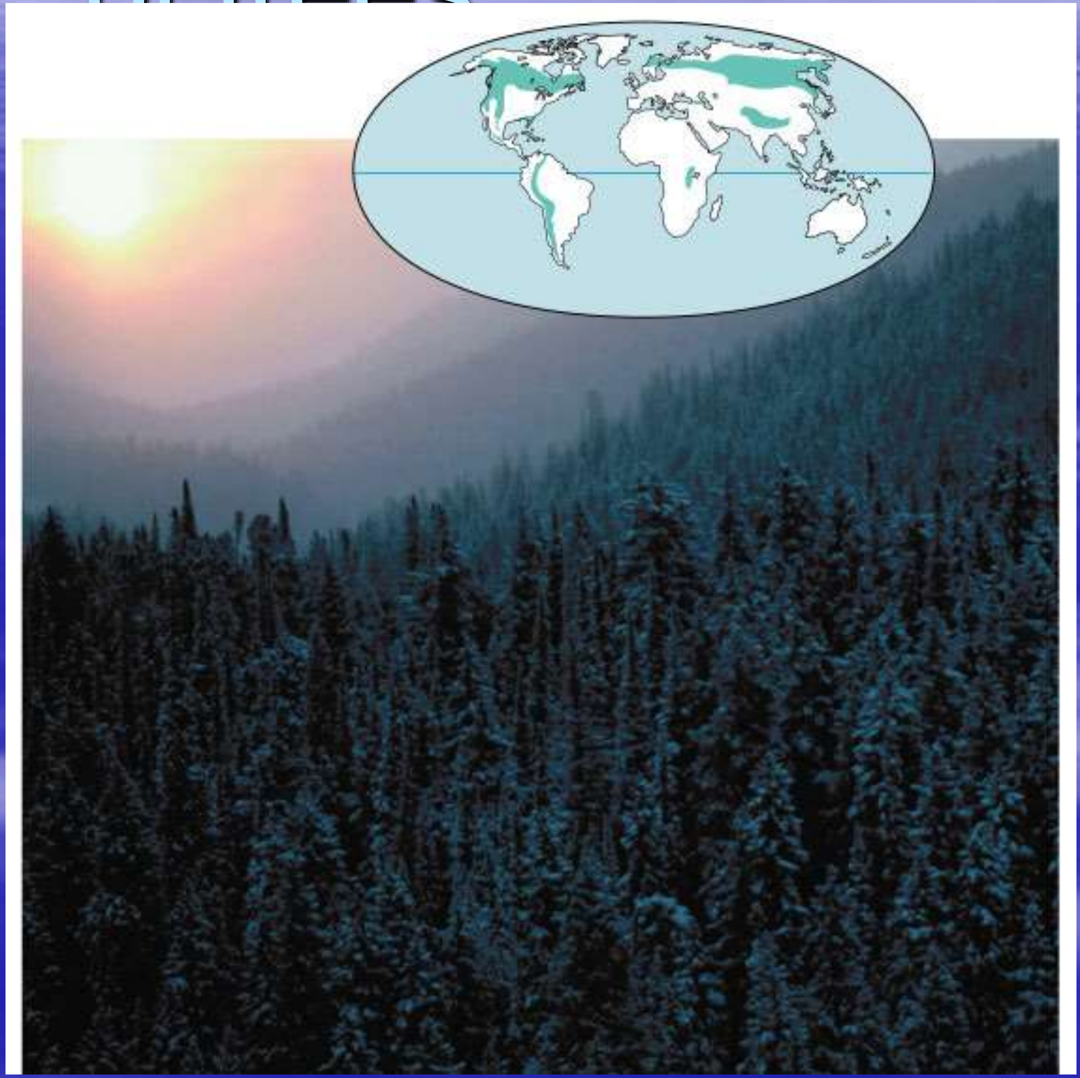


Figure 34.17

- The taiga is characterized by long, cold winters and short, wet summers
- Coastal coniferous forests of the Pacific Northwest are actually temperate rain forests

Long, bitter-cold winters characterize the tundra

- The arctic tundra lies between the taiga and the permanently frozen polar regions
  - It is a treeless biome characterized by extreme cold, wind, and permafrost
  - Permafrost is continuously frozen subsoil

Figure 34.18

The biosphere is the total of all of Earth's ecosystems

- The global ecosystem is called the biosphere
  - It is the sum of all the Earth's ecosystems
  - The biosphere is the most complex level in ecology

Figure 34.2A

- The biosphere is self-contained
  - except for energy obtained from the sun and heat lost to space
- Patchiness characterizes the biosphere
  - Patchiness occurs in the distribution of deserts, grasslands, forests, and lakes
  - Each habitat has a unique community of species

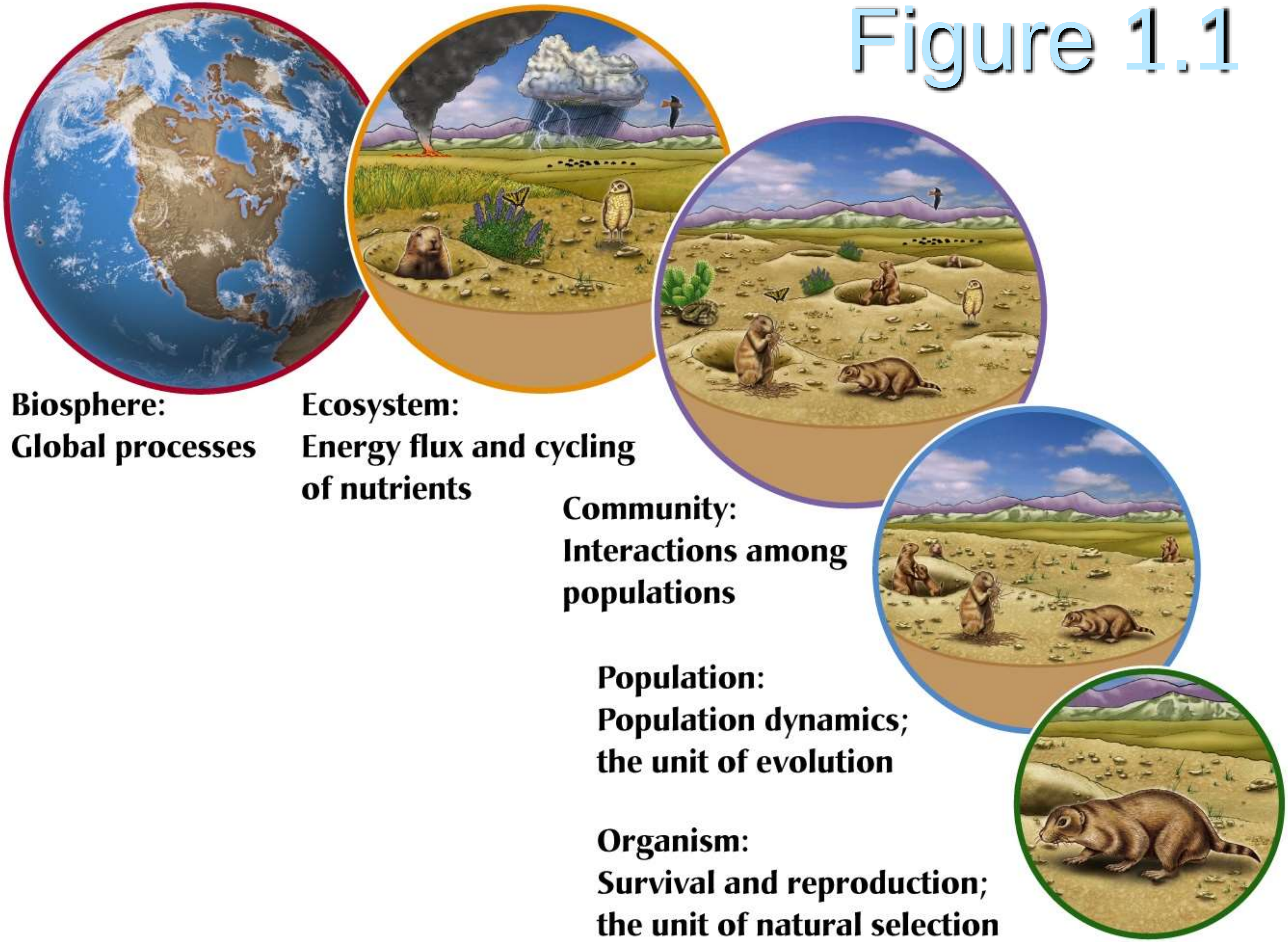
Abiotic components:

- ABIOTIC components:
- Solar energy provides practically all the energy for ecosystems.
- Inorganic substances, e.g., sulfur, boron, tend to cycle through ecosystems.
- Organic compounds, such as proteins, carbohydrates, lipids, and other complex molecules, form a link between biotic and abiotic components of the system.

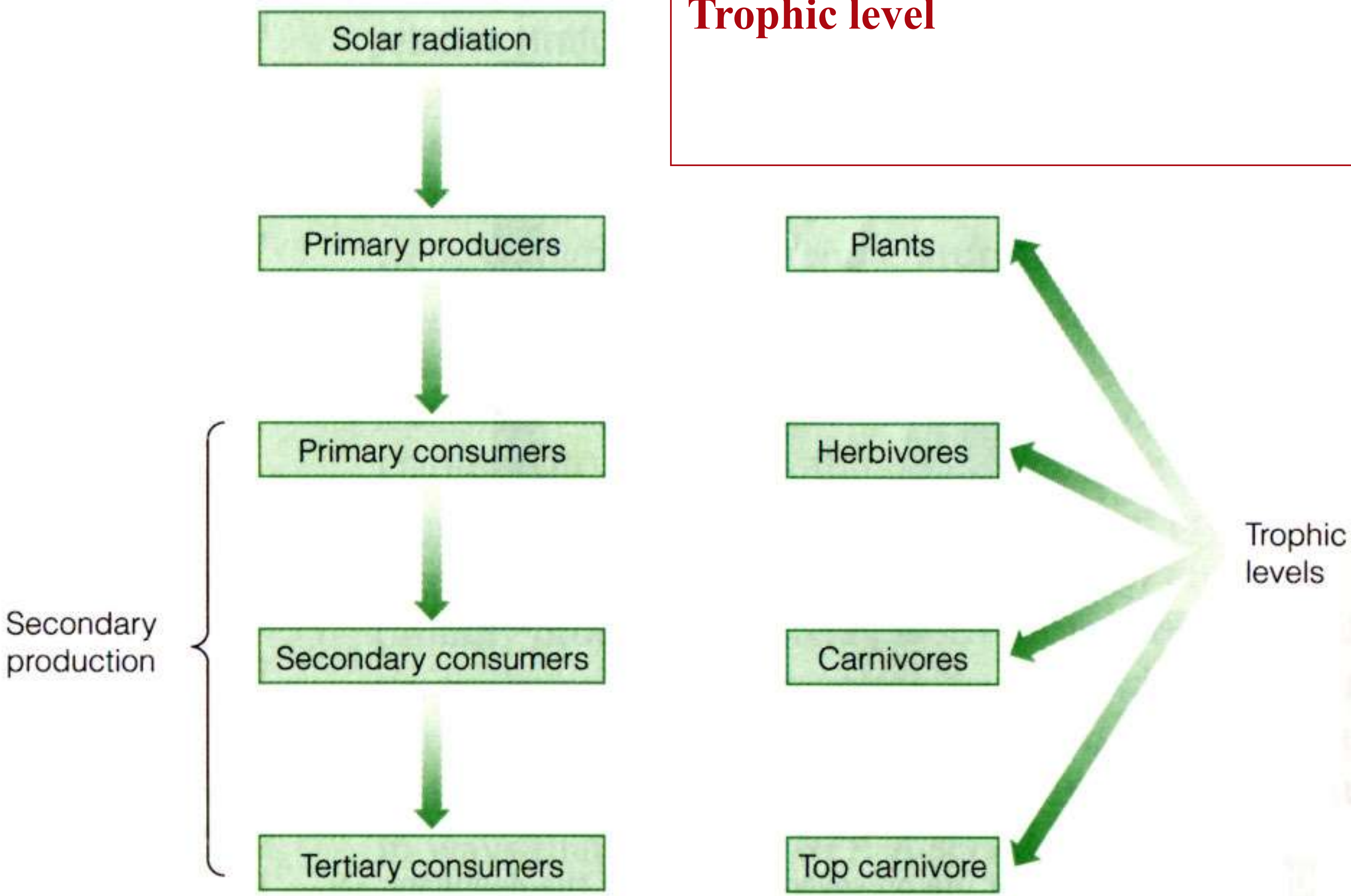
BIOTIC components

- The biotic components of an ecosystem can be classified according to their mode of energy acquisition.
- In this type of classification, there are:
- Autotrophs and Heterotrophs
- Organisms that produce their own food from an energy source, such as the sun, and inorganic compounds.
- Organisms that consume other organisms as a food source.

Figure 1.1


Biosphere:
Global processes
Ecosystem:
Energy flux and cycling
of nutrients
Community:
Interactions among
populations
Population:
Population dynamics;
the unit of evolution
Organism:
Survival and reproduction;
the unit of natural selection

Trophic level

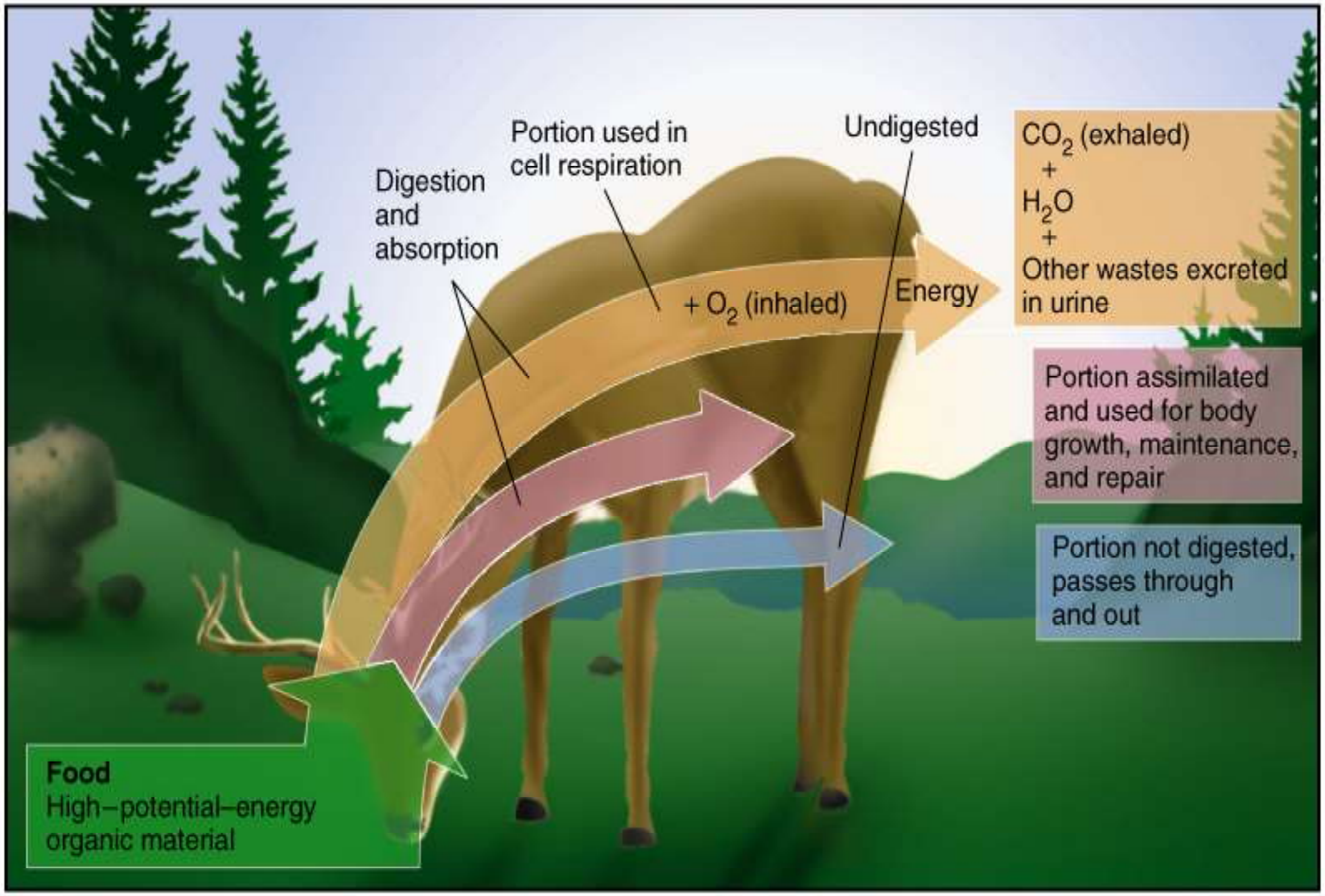


The schematic structure of a food chain. Each trophic level may contain many species.

Trophic Levels

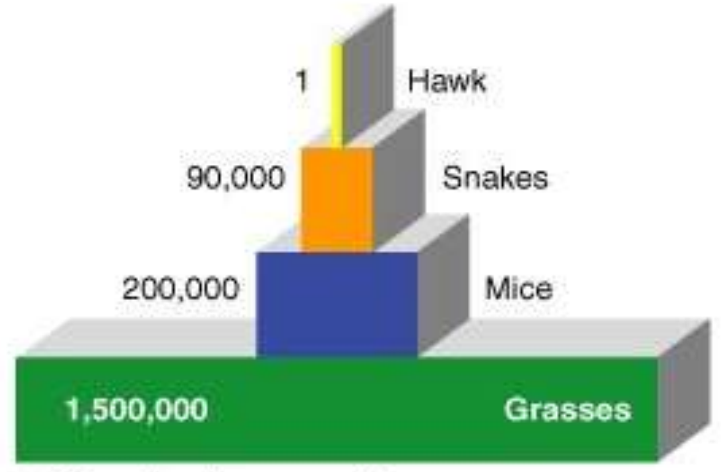
- A trophic level is the position occupied by an organism in a food chain.
- Trophic levels can be analyzed on an energy pyramid.
- **Producers** are found at the base of the pyramid and compromise the **first trophic level.**
- **Primary consumers** make up the **second trophic level.**
- **Secondary consumers** make up the **third trophic level**.
- Finally **tertiary consumers** make up the **top trophic level**.

Food Assimilation in Consumers

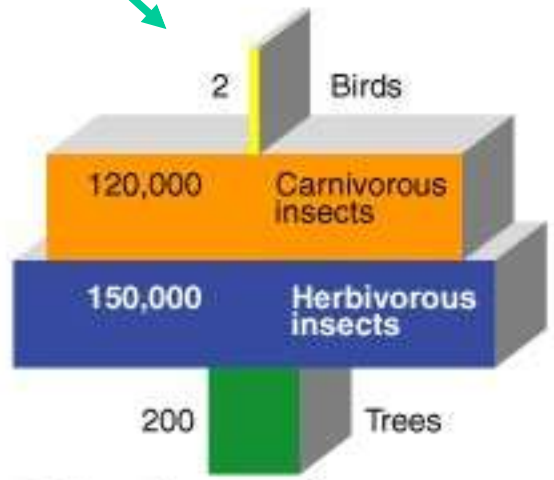


Trophic Structure Reminder

- Eltonian pyramids
- Number of individuals per species
- Is this pyramid stable?



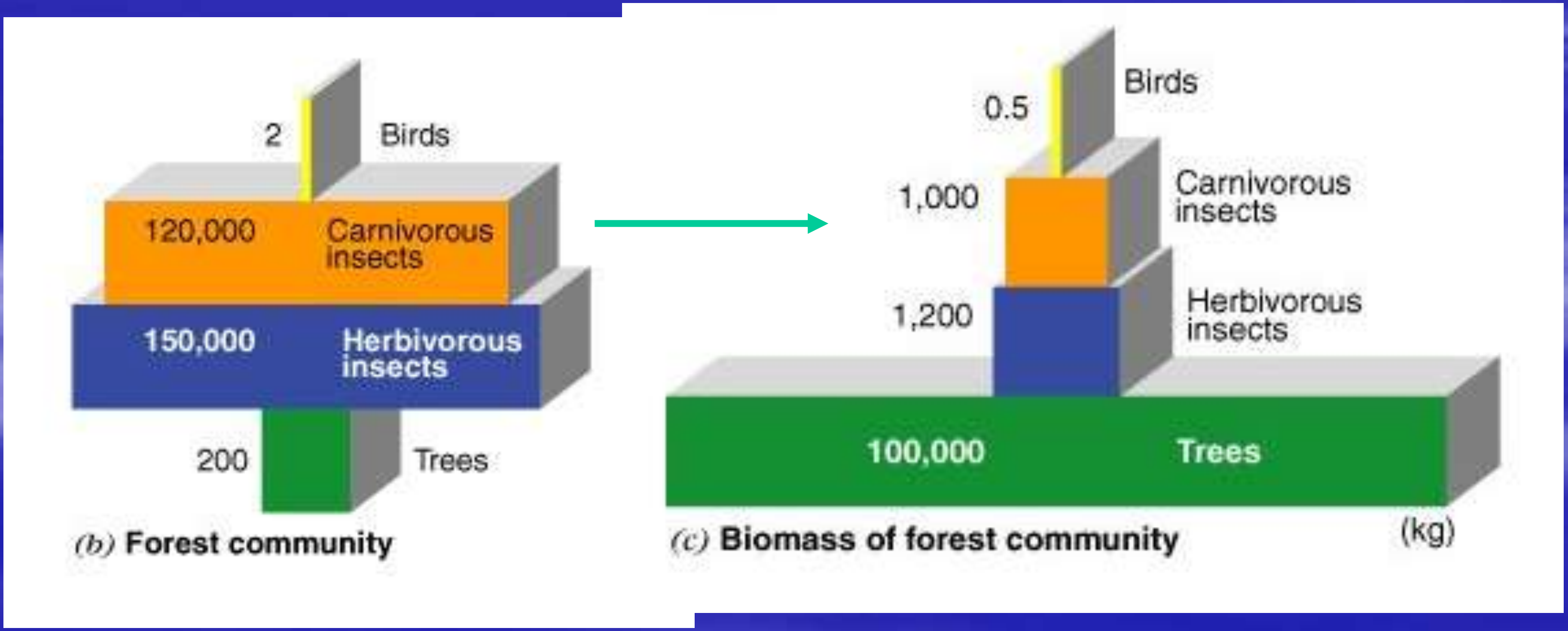
(a) **Grassland community**



(b) **Forest community**

Trophic Structure Reminder

- What if we transformed each species into biomass instead of absolute numbers?



(b) Forest community

(c) Biomass of forest community

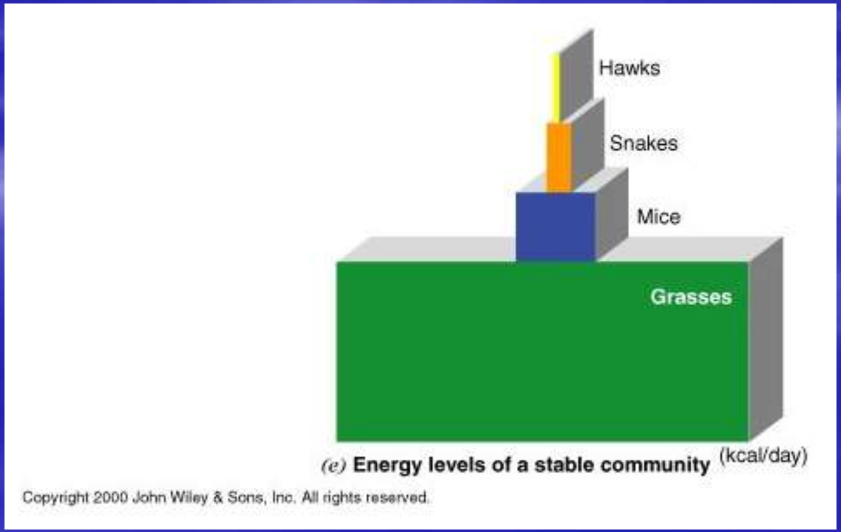
Biomass

- Energy is sometimes considered in terms of biomass, the mass of all the organisms and organic material in an area.
- There is **more** biomass at the trophic level of **producers** and **fewer** at the trophic level of tertiary **consumers**. (There are more plants on Earth than there are animals.)
- **Bio=life Mass=weight**
- **Bio + Mass = Weight of living things within an ecosystem.**

Trophic Structure Reminder

- Express trophic structure as energy transfer
- Energy pyramids can never be inverted
- Is there room for anyone else

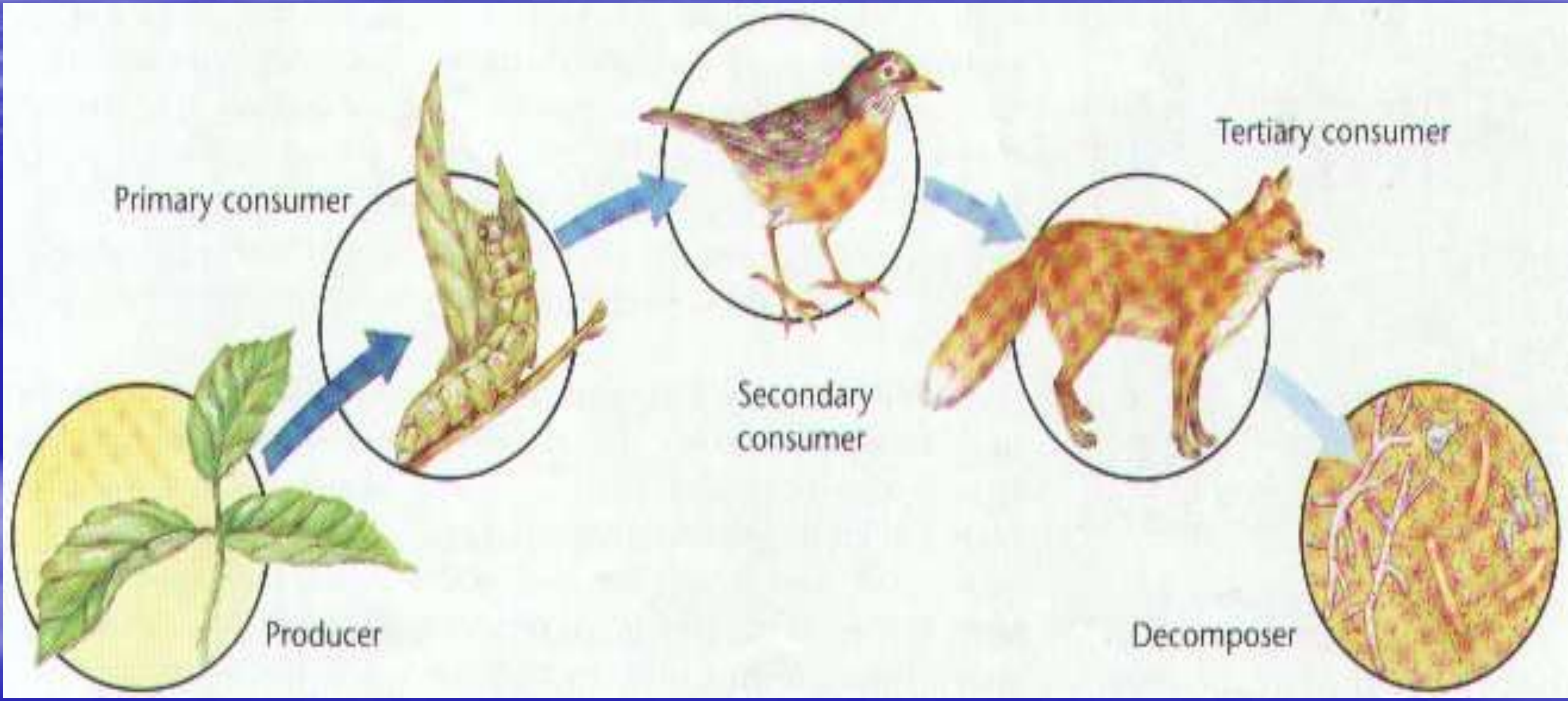
at the top of this food chain?



Food Chains

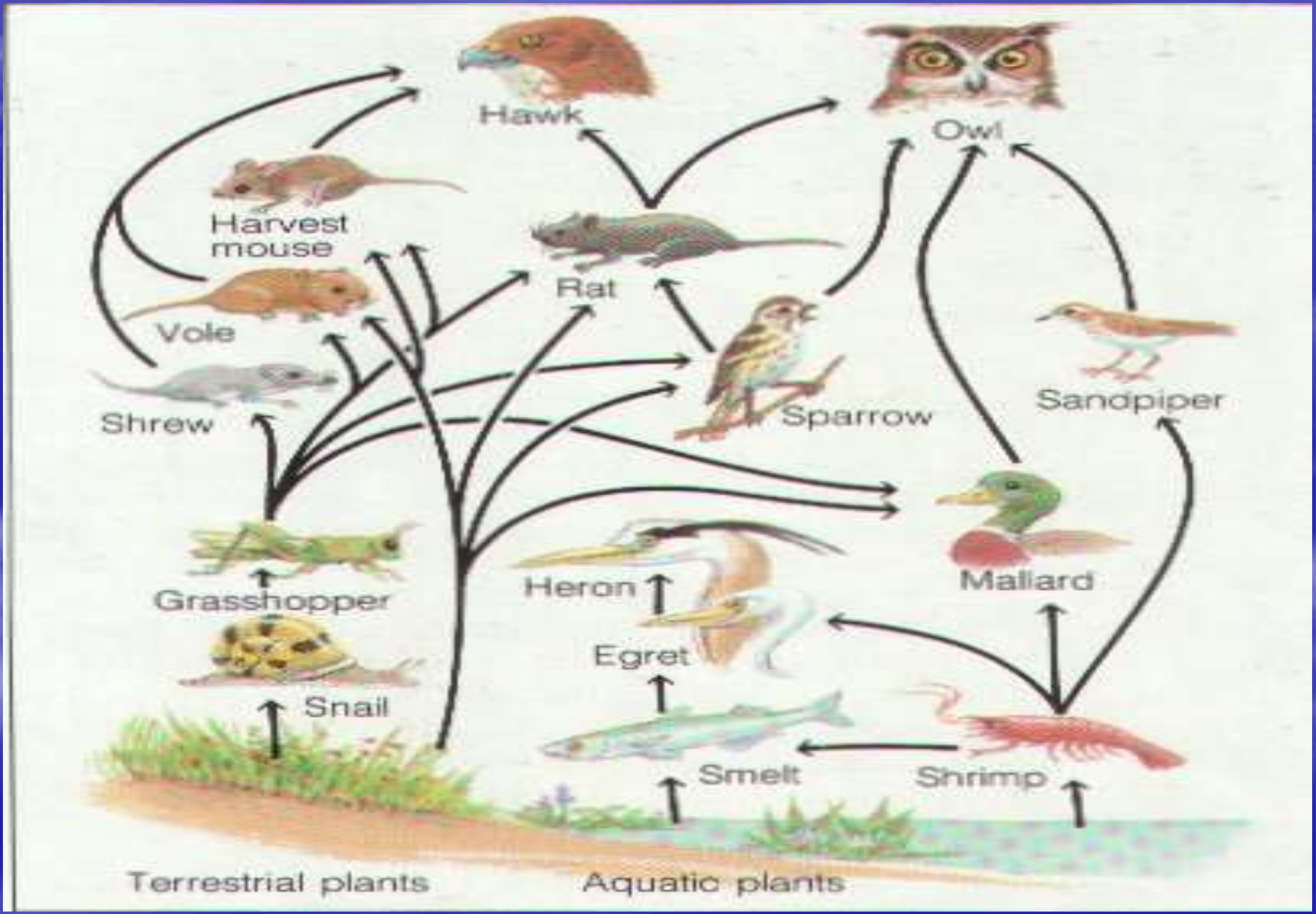
- The producers, consumers, and decomposers of each ecosystem make up a food chain.
- There are many food chains in an ecosystem.
- Food chains show where energy is transferred and not who eats who.

Example of a Food Chain



Food Webs

- All the food chains in an area make up the **food web** of the area.



Food web of a hot spring

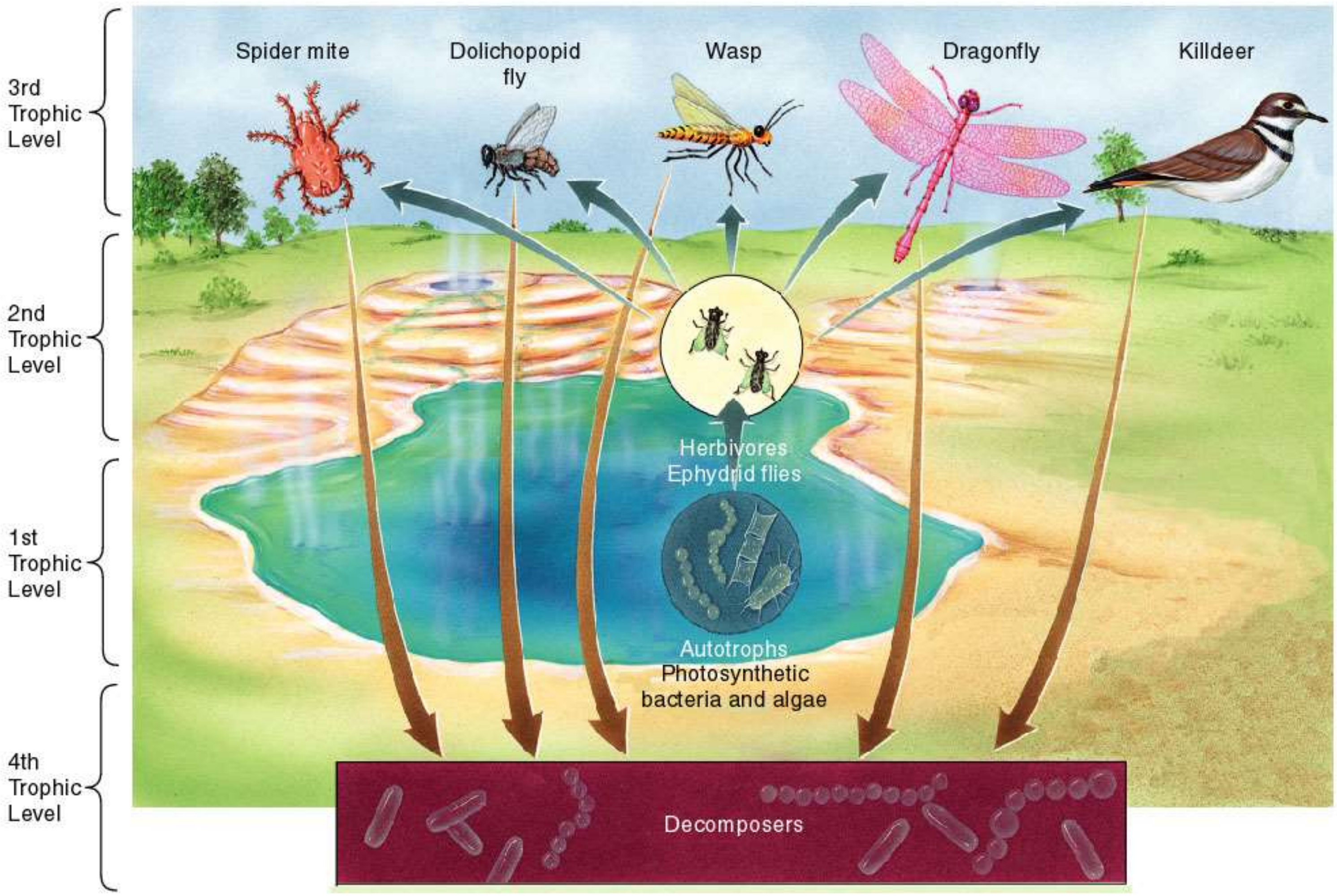
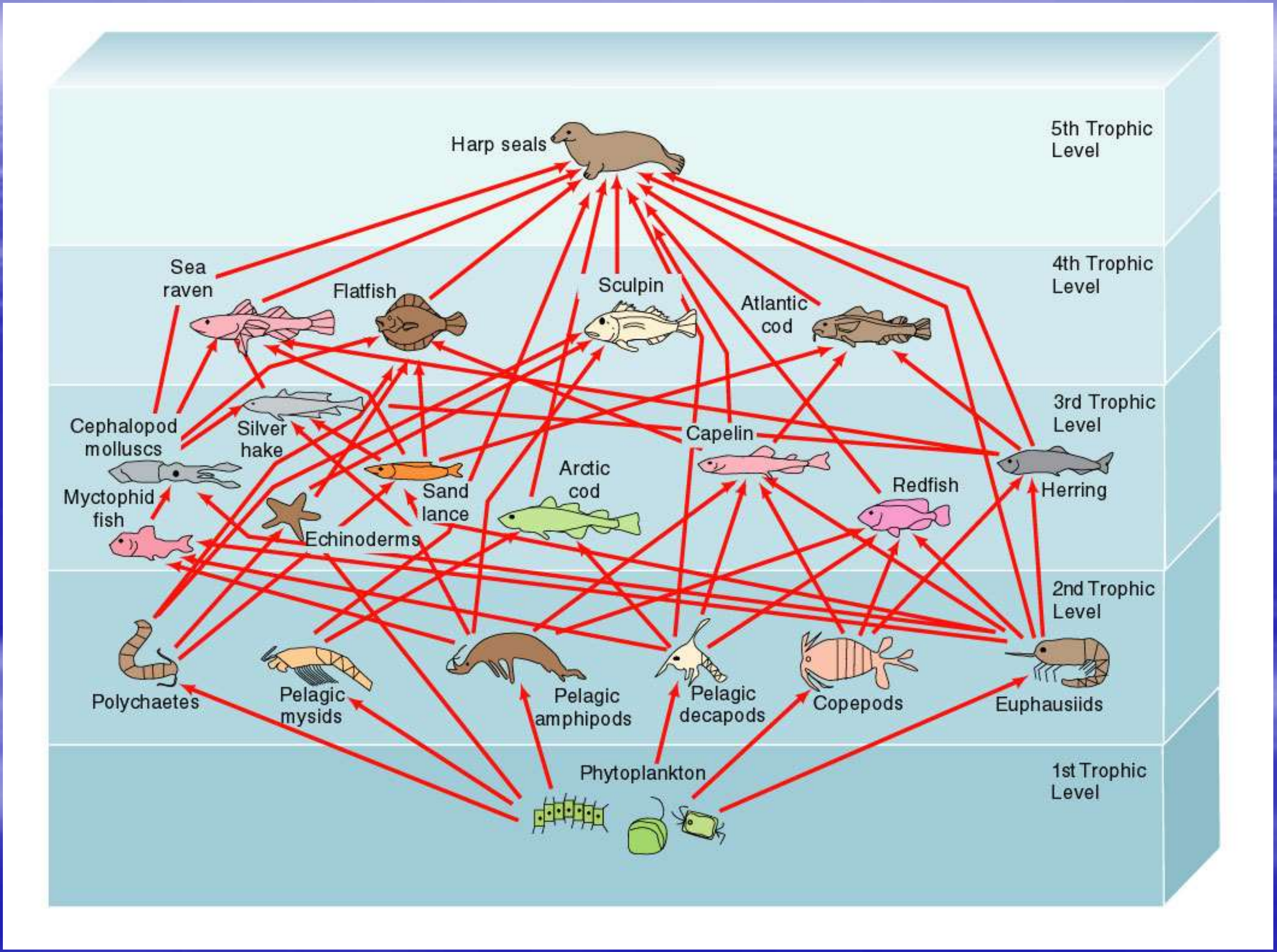


Fig 6.5 Food web of the harp seal.



Ecology

is

The study of the distribution and abundance of organisms,

AND

the flows of energy and materials between abiotic and biotic components of ecosystems.