Population Ecology and the Distribution of Organisms

Essential Knowledge Objectives

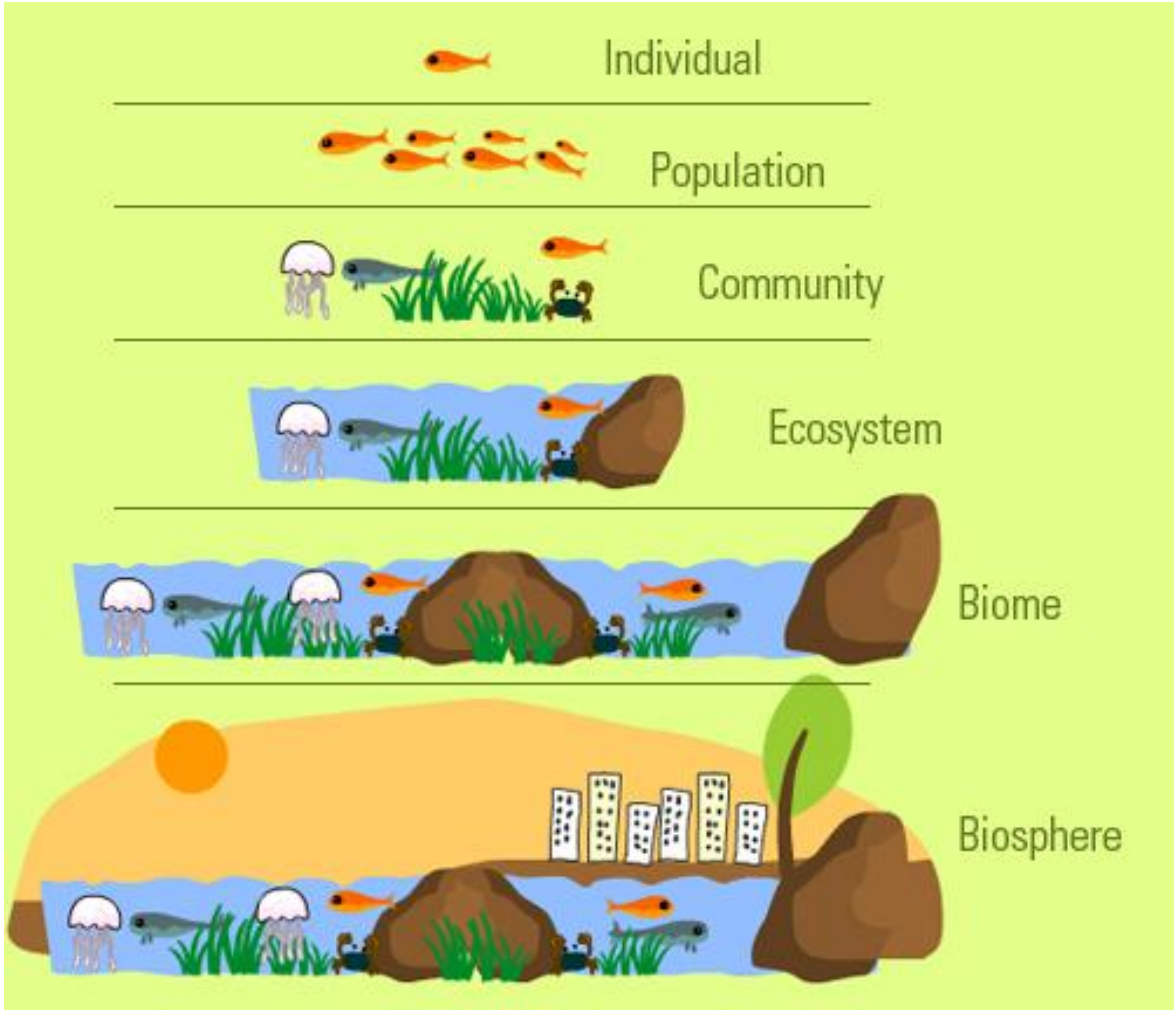
2.D.1 (a-c), 4.A.5 (c), 4.A.6 (e)

Ecology

- The scientific study of the interactions between organisms and the environment
- Ecological hierarchy from global ecology to organismal ecology
- Why is it important to study ecology?

Ecological Hierarchy

- Organism
- Population
- Community
- Ecosystem
- Biome
- Biosphere



Population

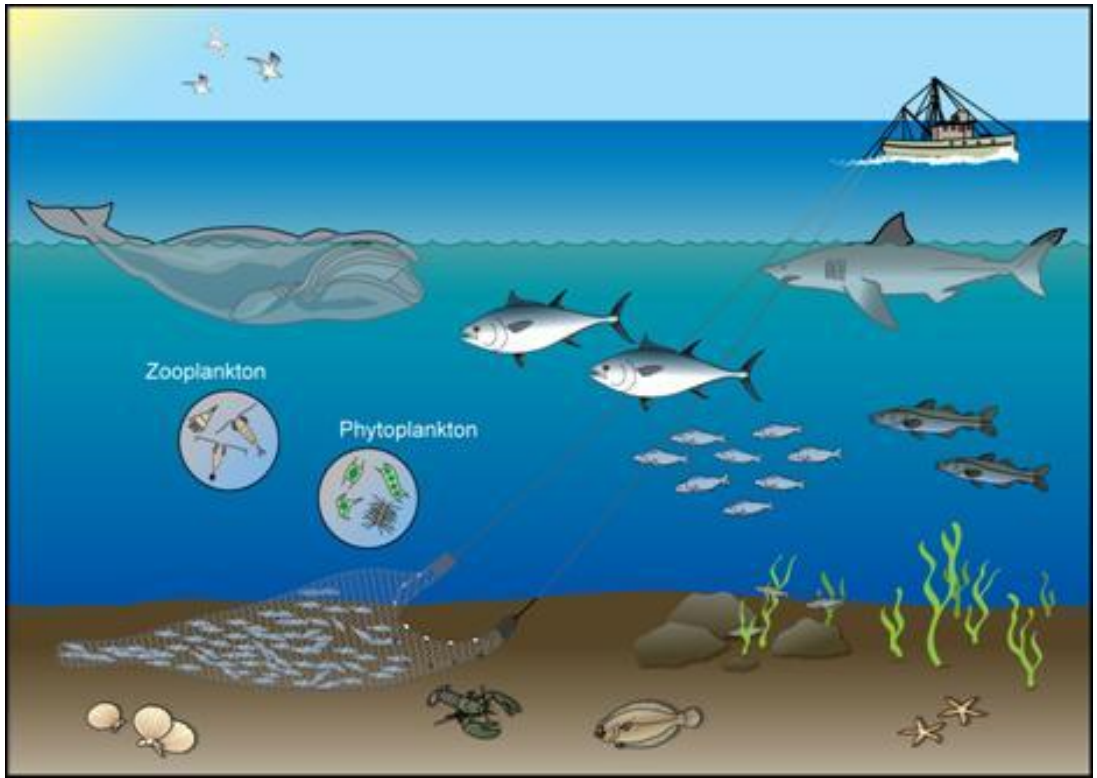
- A group of individuals of the same species living in an area

Community

- A group of populations of different species in an area

Ecosystem

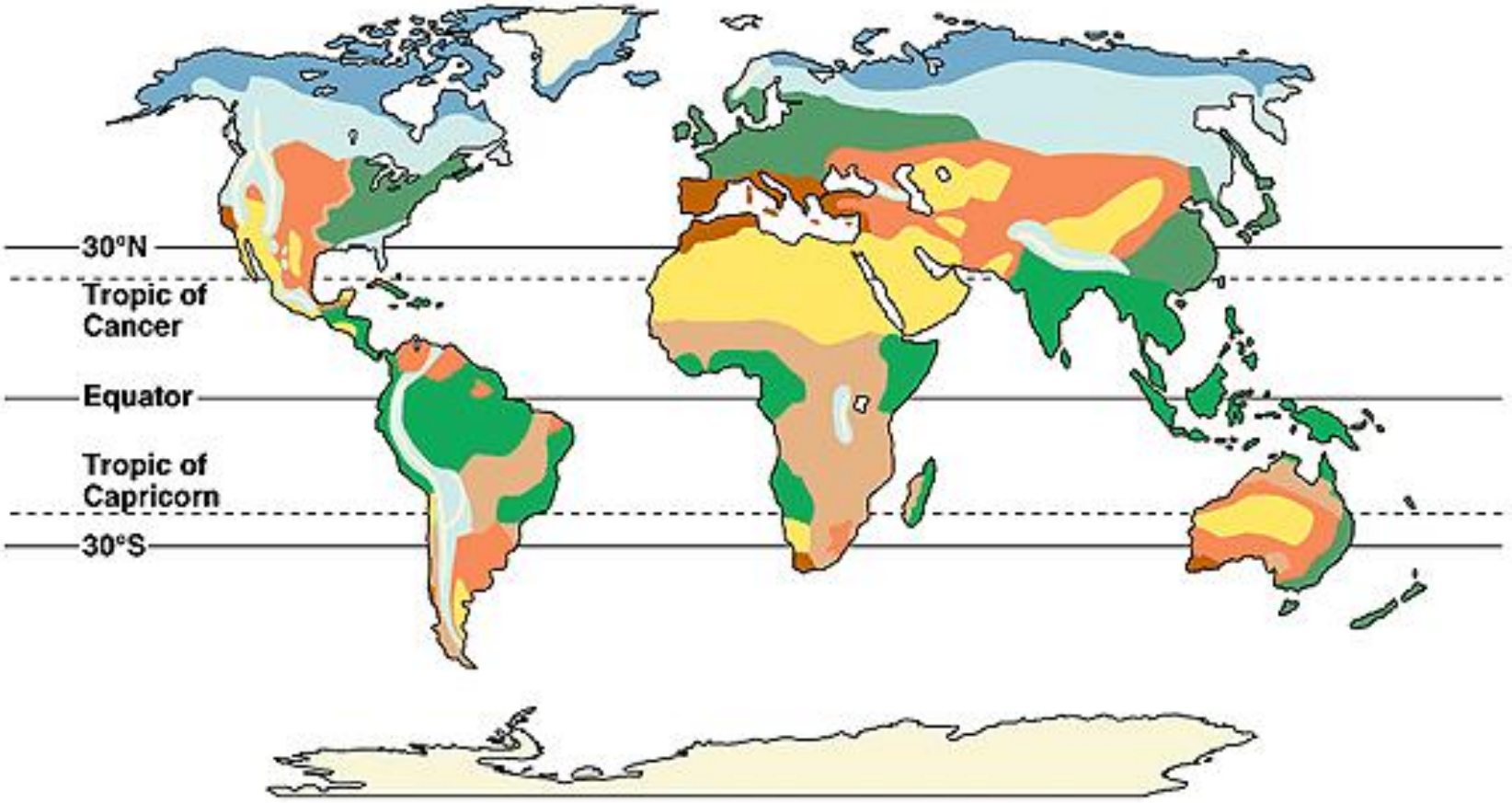
- A community of organisms (biotic) in an area and the physical factors (abiotic) with which those organisms interact



Biome

- Major life zones characterized by vegetation type (terrestrial) or by the physical environment (aquatic biomes)

Terrestrial Biomes



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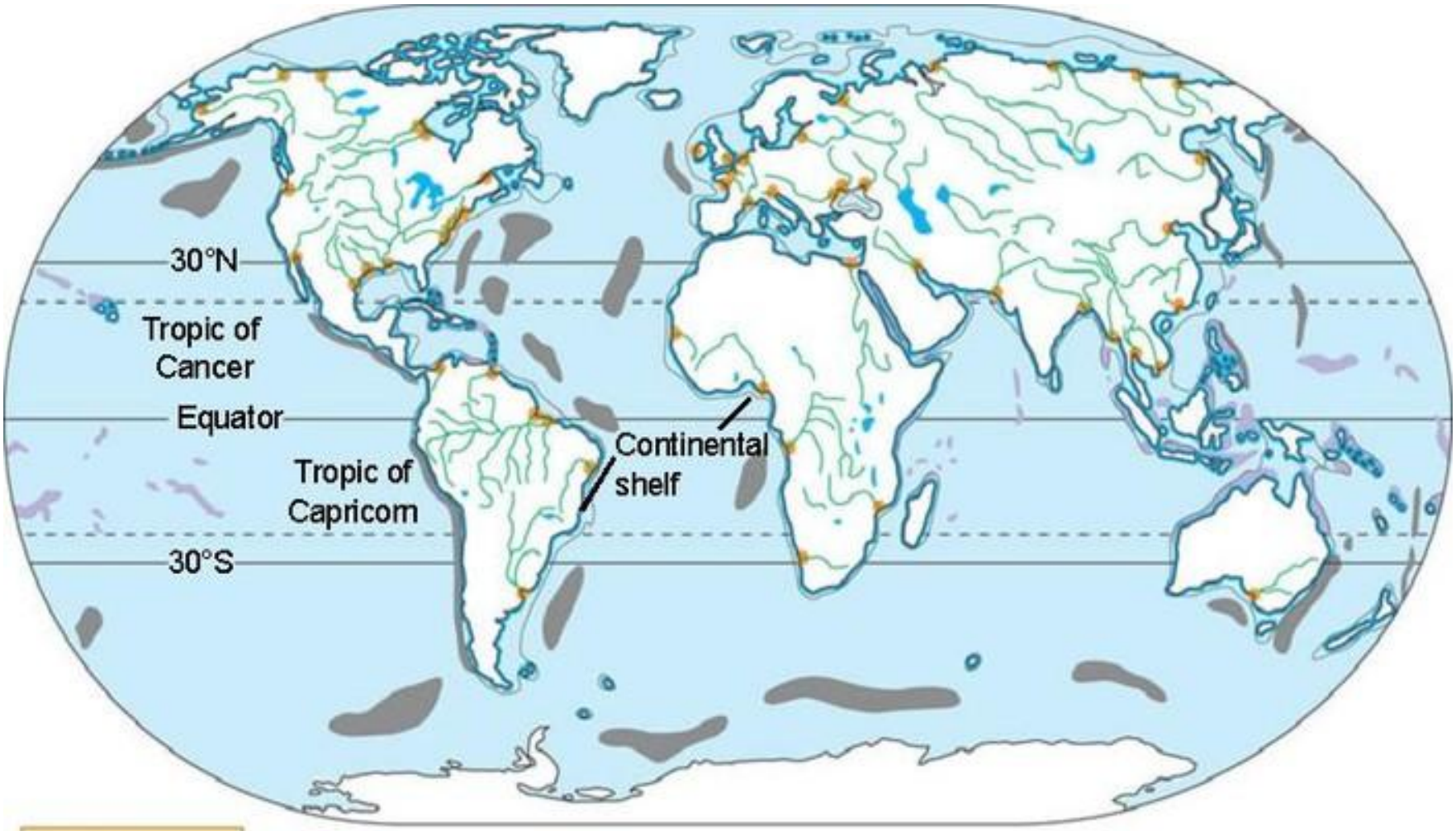
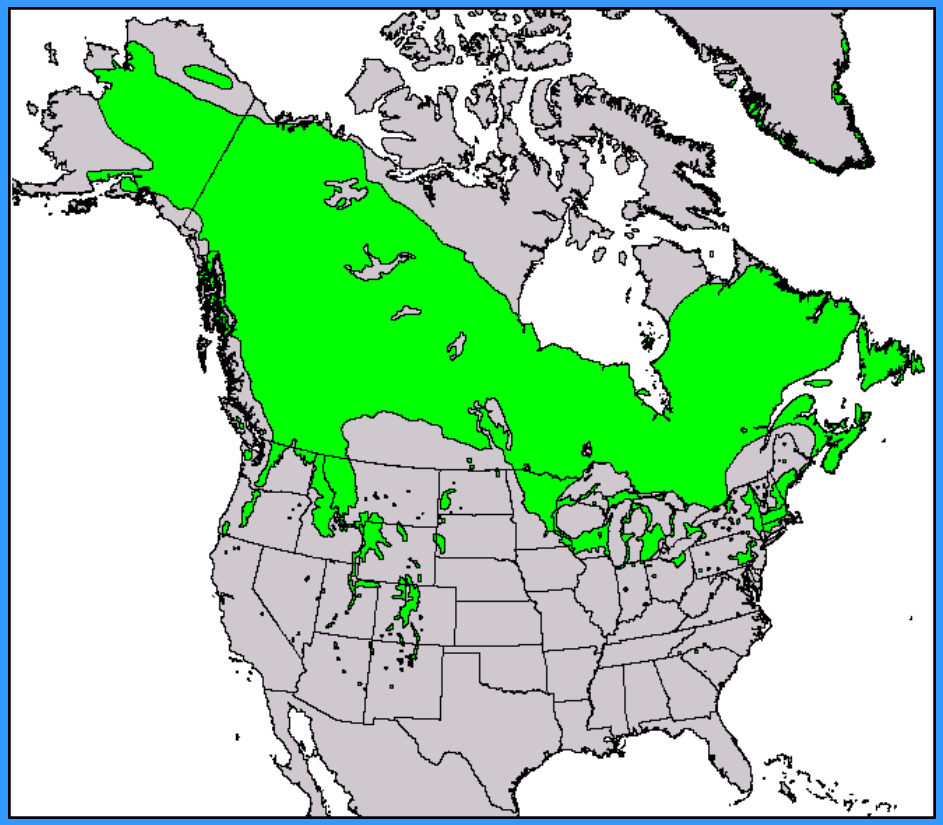
Aquatic Biomes



Biosphere

- The global ecosystem – the sum of all the planet's ecosystems and landscapes

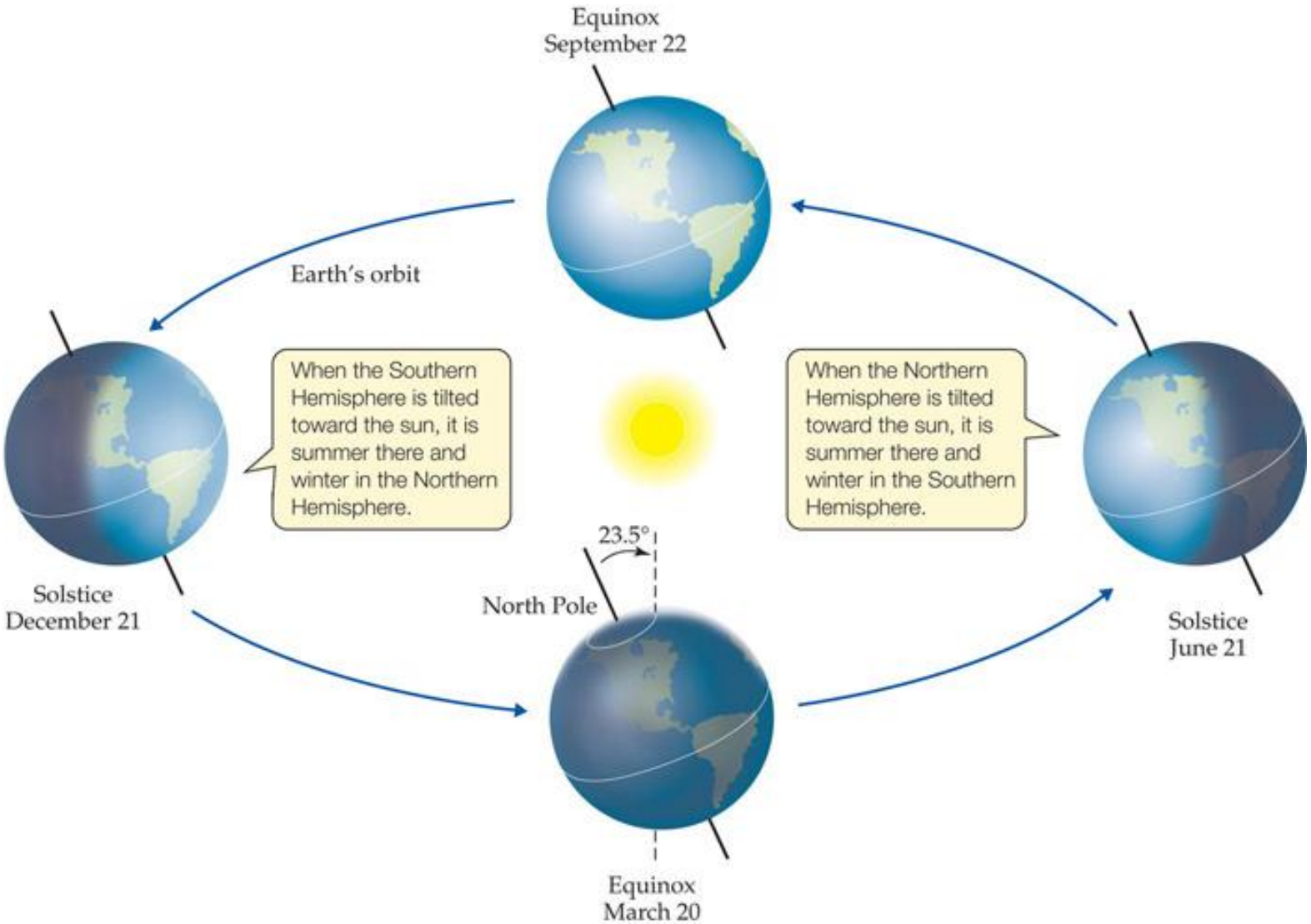
Distribution of Organisms



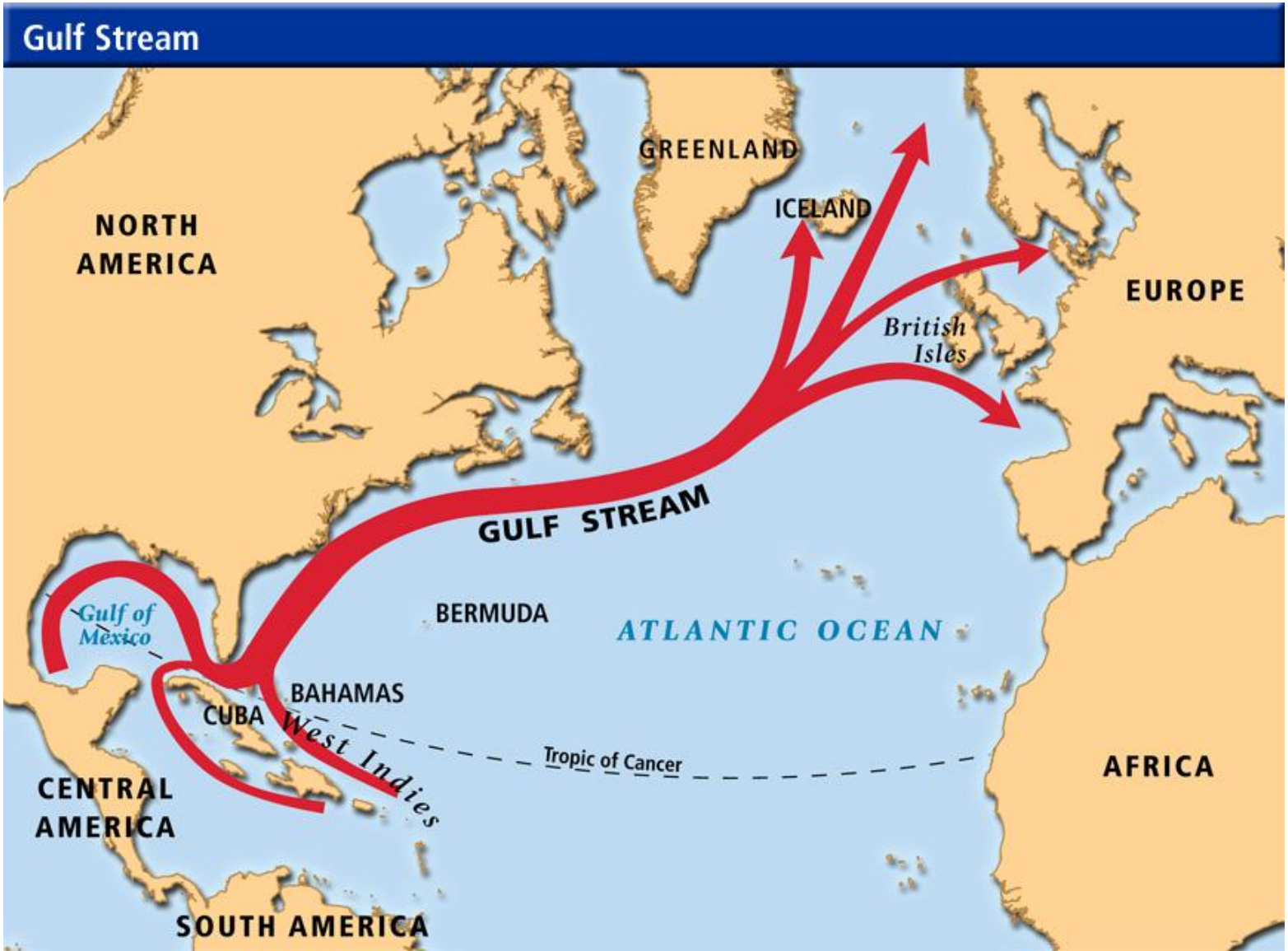
Distribution of Organisms

- Abiotic and biotic factors influence the distribution of organisms on Earth
- **Climate** is a significant factor affecting organism distribution (temperature, precipitation, sunlight, wind)
- Climate is moderated by large bodies of water and mountains, seasonal variations in climate

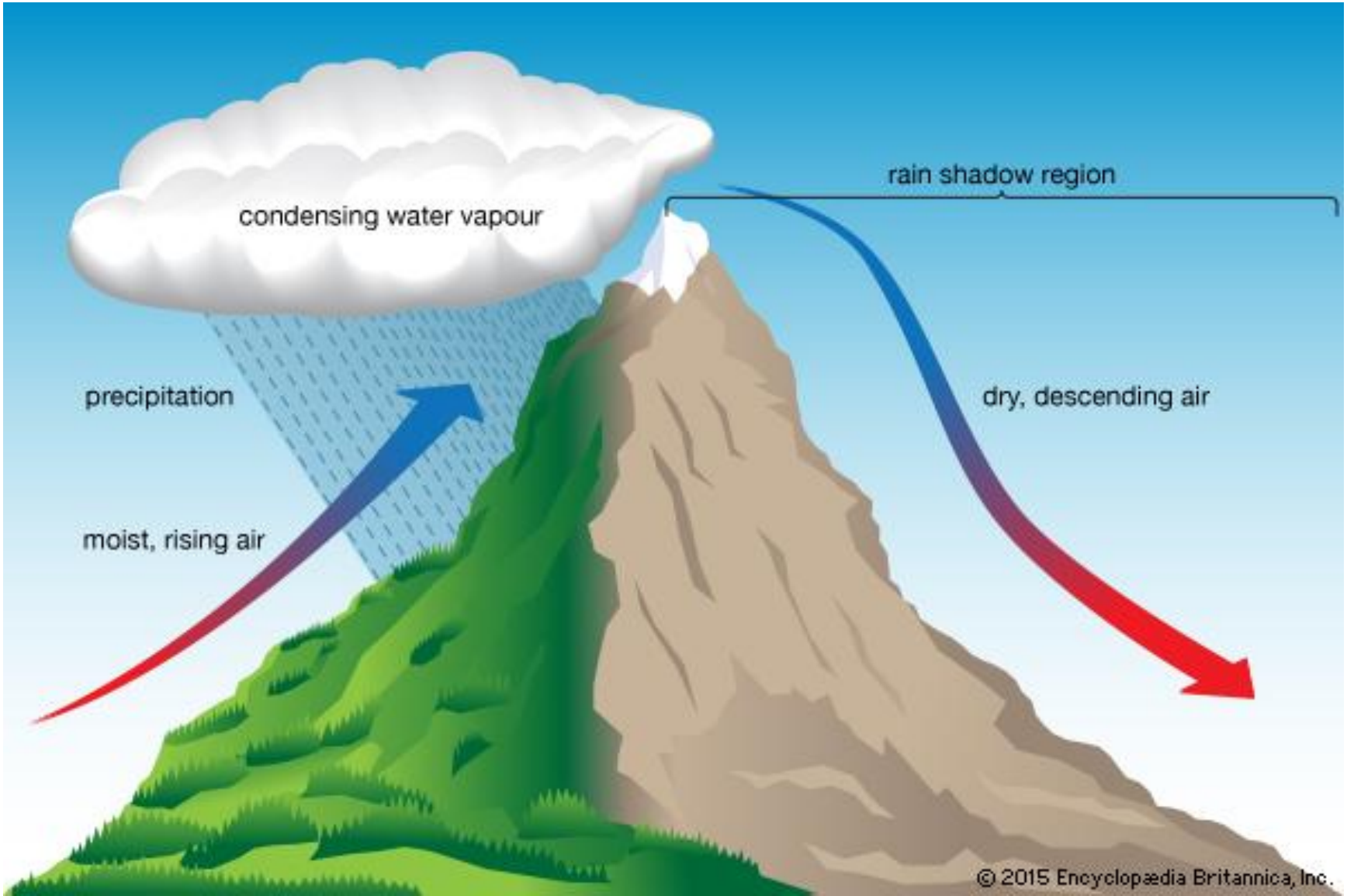
Seasonal Variation in Sunlight Intensity



Ocean Moderates Climate



Mountains: Rain Shadow Effect



Abiotic Factors

- Non-living physical and chemical factors that affect an organisms ability to survive and reproduce

Look at the coral reef ecosystem on the next slide. Provide a few examples of abiotic factors that affect the organisms of this ecosystem.

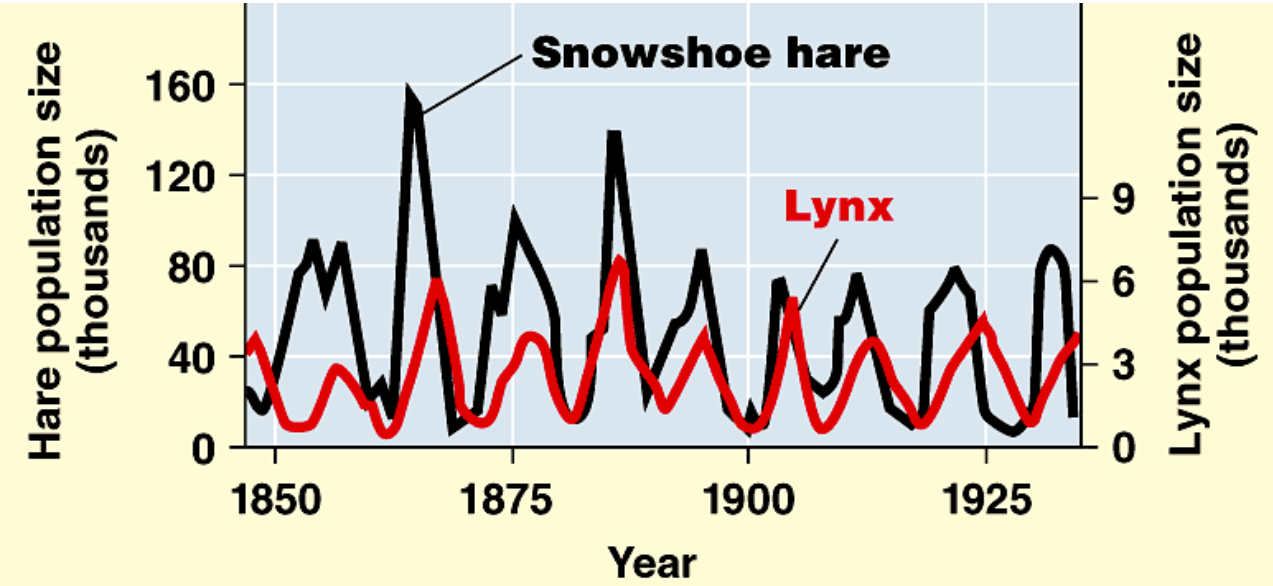
Biotic Factors

- Living things or their materials that directly or indirectly affect an organism in its environment

Look at the forest ecosystem on the next slide. Provide a few examples of biotic factors that affect the organisms of this ecosystem.

Abiotic and Biotic Factors

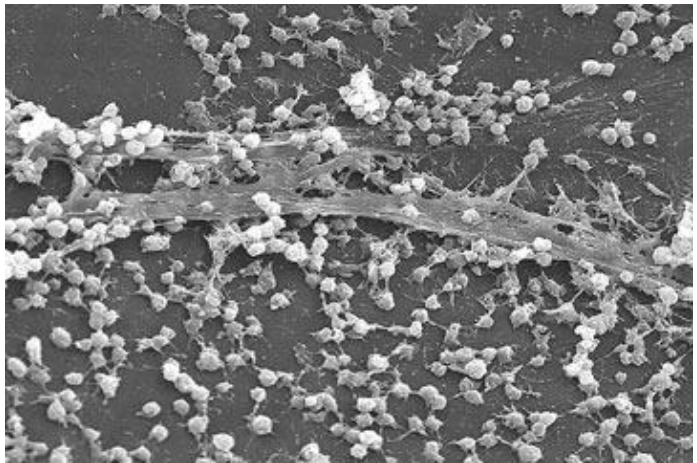
- Cellular activities are affected by interactions with biotic and abiotic factors
- Organism activities are affected by interactions with biotic and abiotic factors



Abiotic Factors Affect Cellular Activities

Biofilm

- Communities of surface-associated microorganisms encased in a self-produced extracellular matrix
- Found on almost all natural and artificial surfaces
- **Dental plaque** and **slime on watery surfaces**



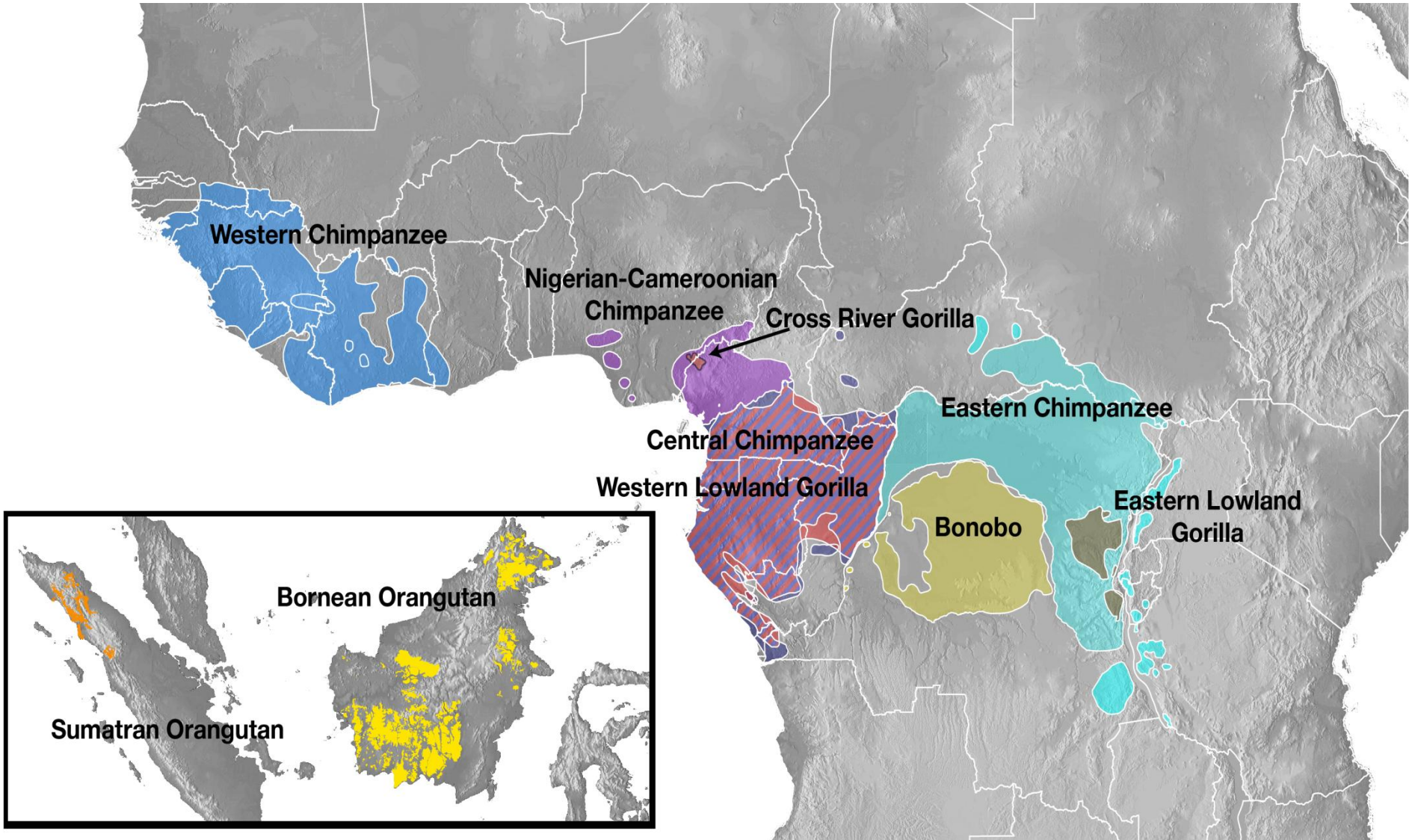
Abiotic and Biotic Factors Affect Organism Activities

Abiotic and Biotic Factors Affect Stability

- The stability of populations, communities and ecosystems is affected by interactions with abiotic and biotic factors

- Examples: food chains and food webs, algal blooms, species diversity, population density

Global Distribution of Apes

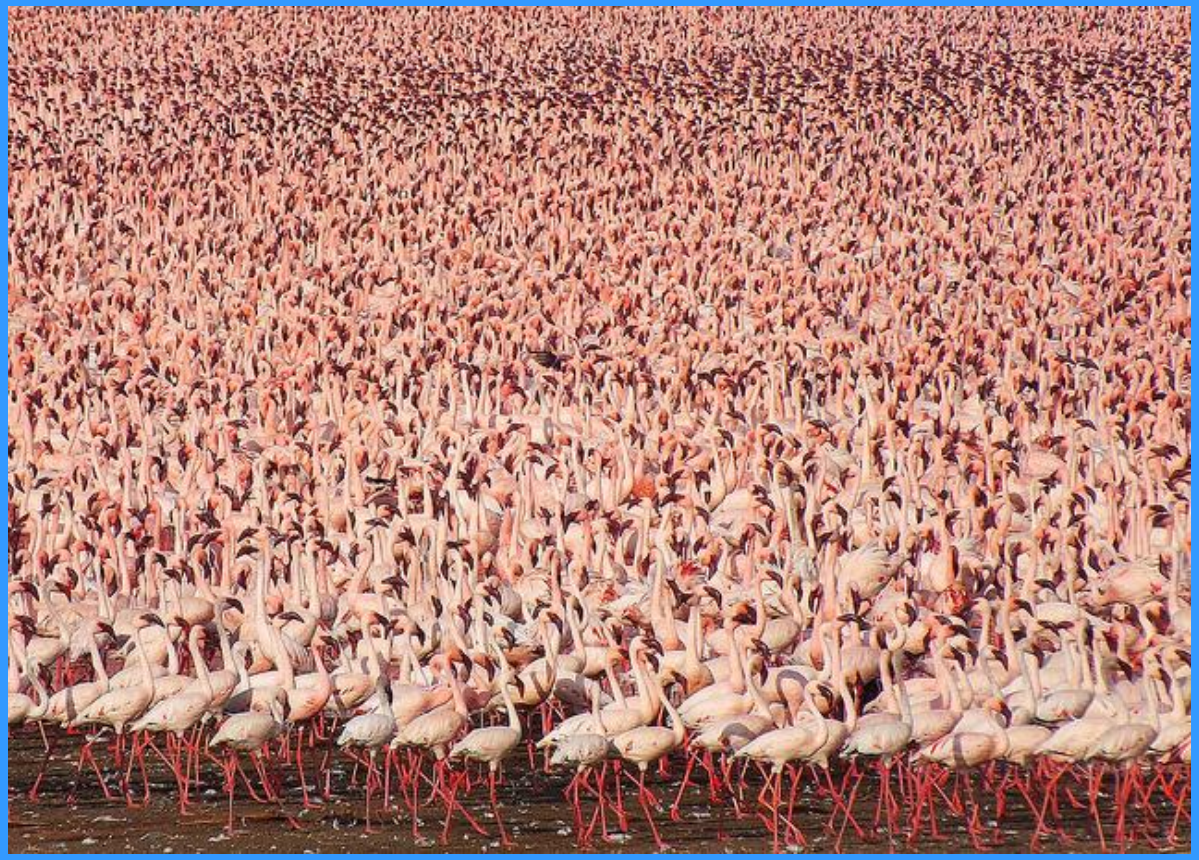


Distribution of Species

- Interactions between populations affect the **geographic distributions** and abundance of populations

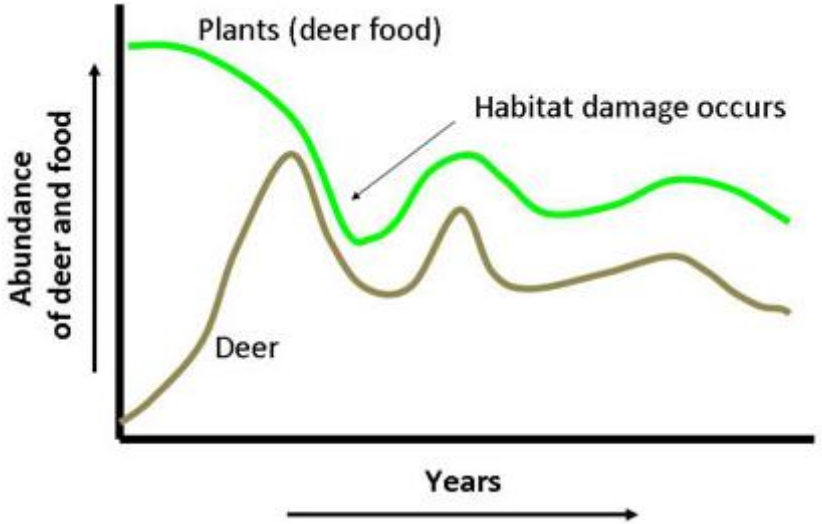
Example: Flowers and pollinators, parasites and their hosts

Properties of Populations



Population Dynamics

- **Population dynamics** is the branch of life sciences that studies the size and age composition of **populations** as dynamic systems, and the biological and environmental processes driving them

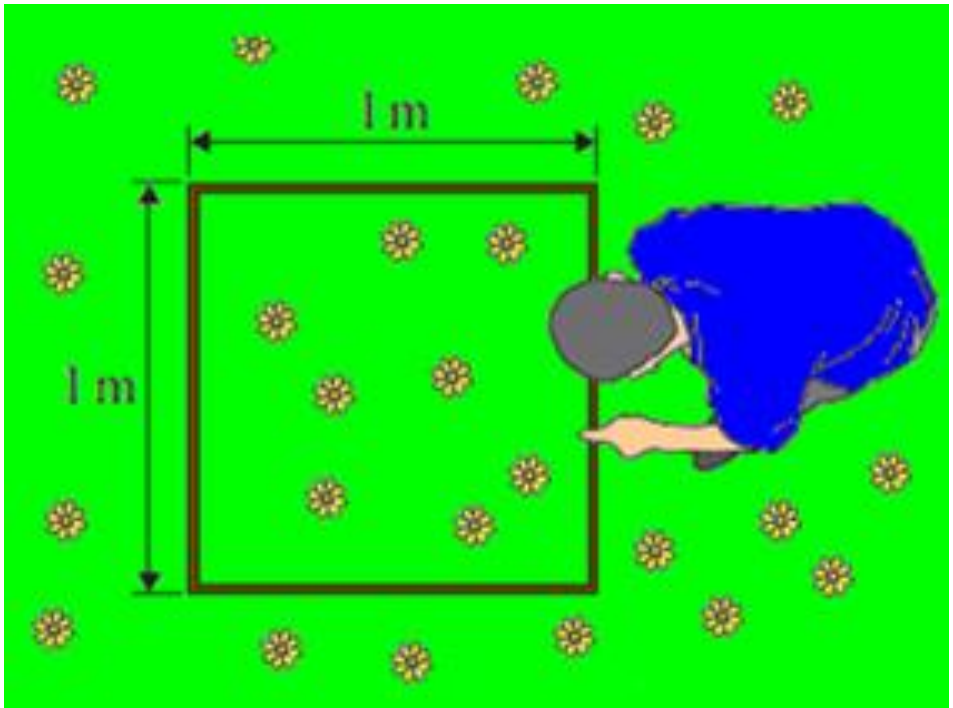


Properties of Populations

- Population Size
- Population Density
- Births, Deaths, Immigration and Emigration
- Distribution and Dispersion
- Survivorship Curves
- Age Structure Diagrams

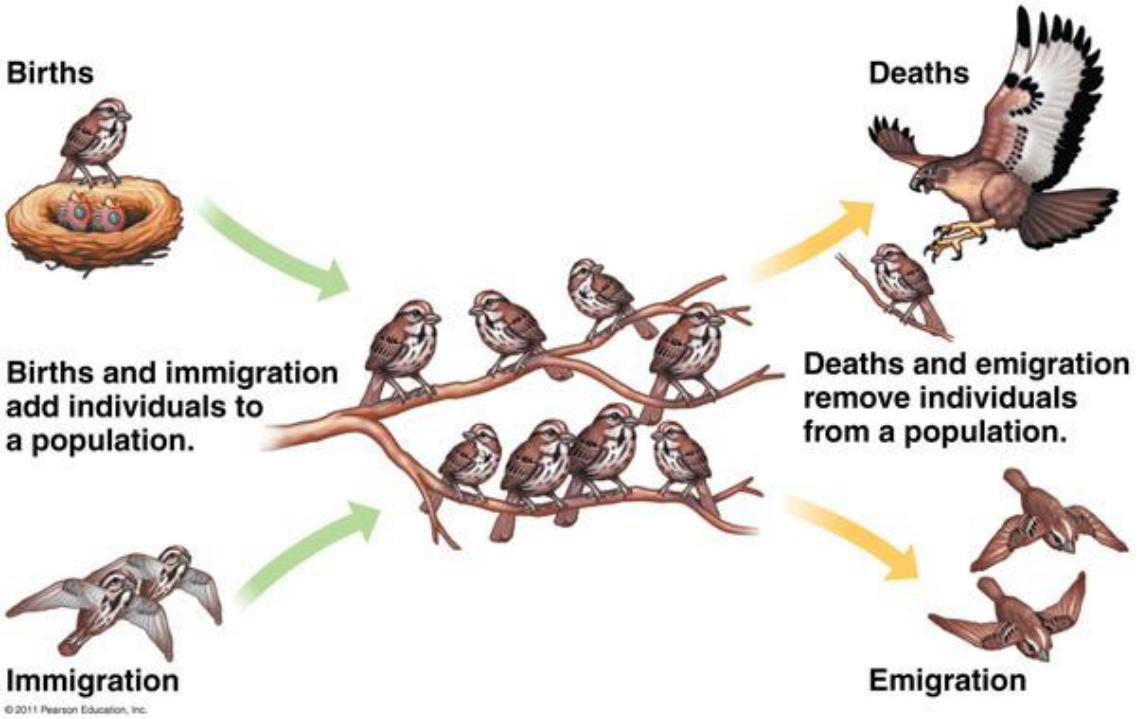
Population Density

- **Density:** Number of individuals per unit area or volume
- How do we determine population density?

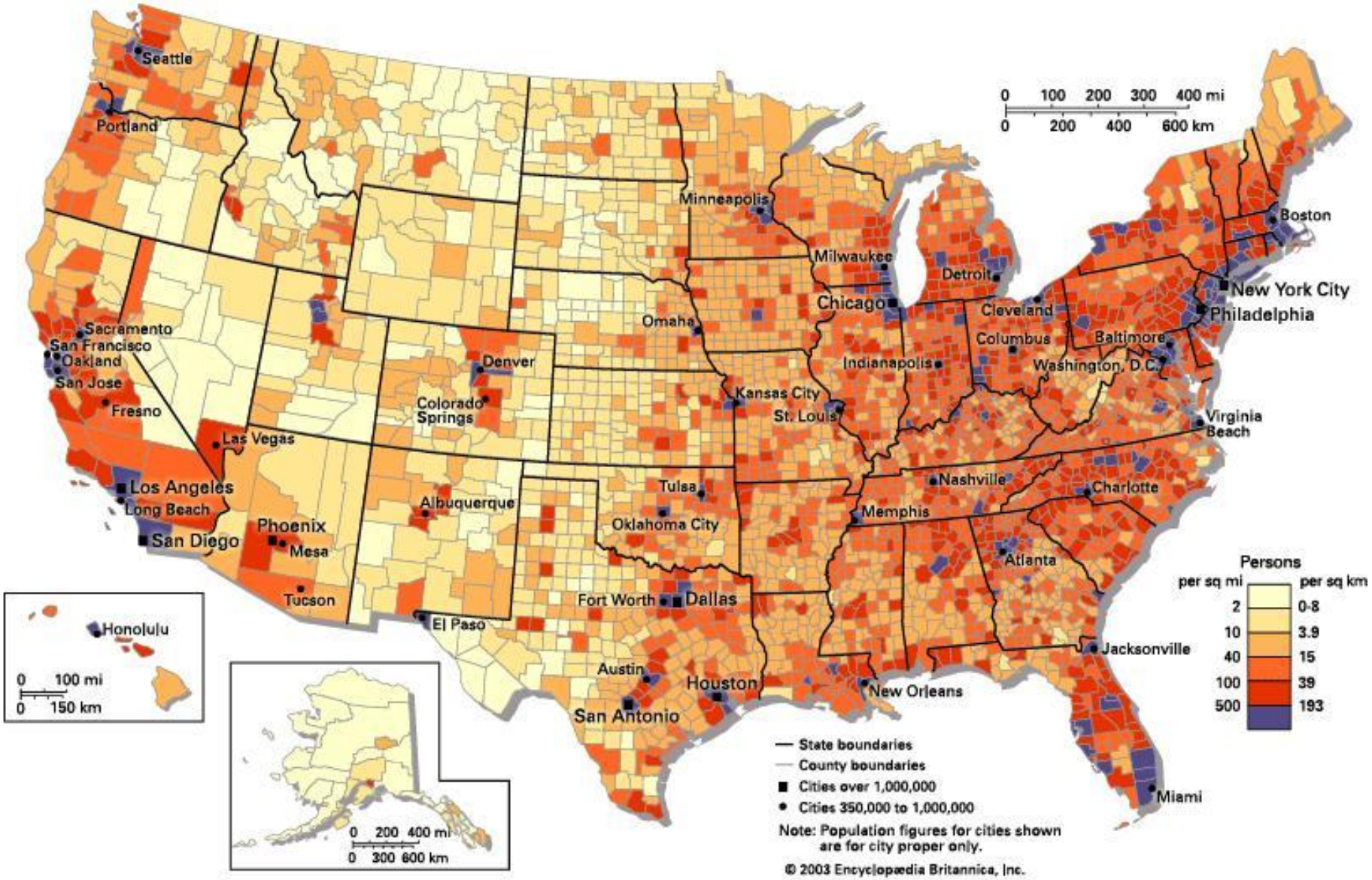


Factors Affecting Population Density

- Density changes as individuals are added or removed from a population
- Births, deaths, immigration and emigration

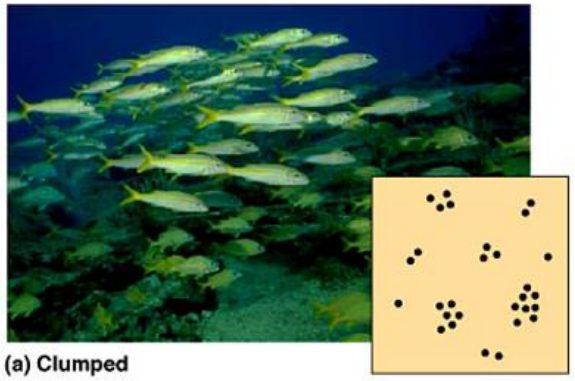


Population Density of the US

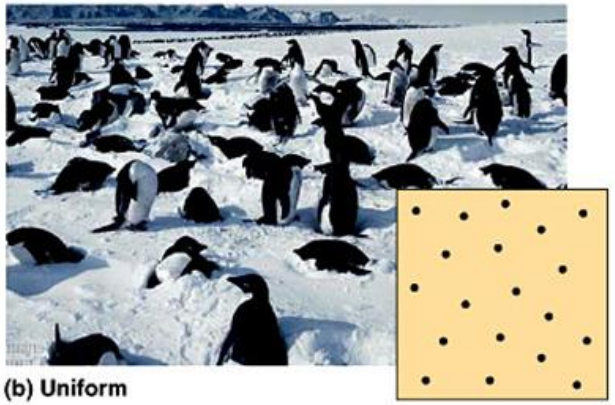


Dispersion Patterns

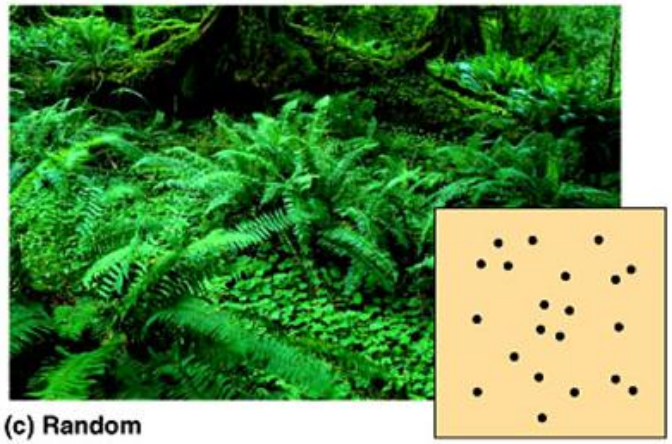
- Interactions between populations affect their distribution within a geographic area



(a) Clumped



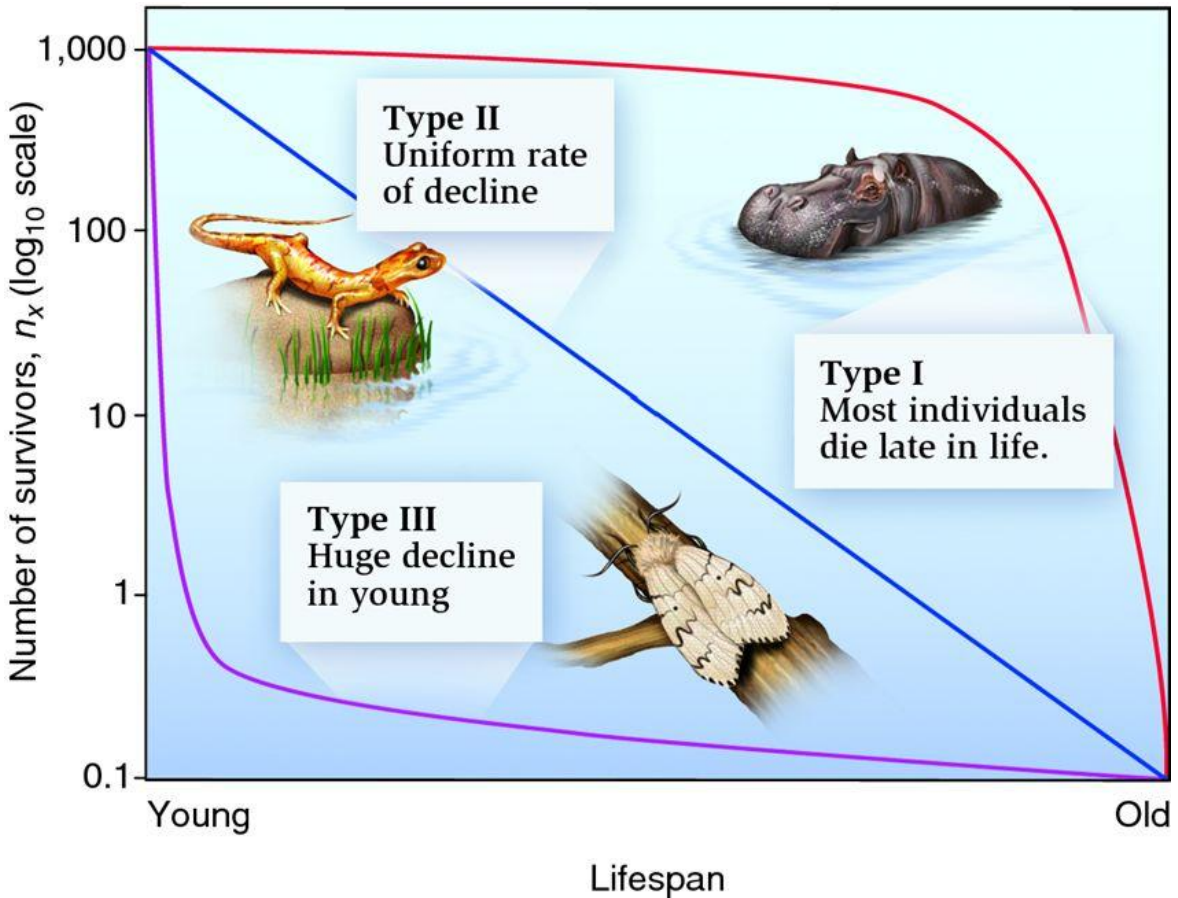
(b) Uniform



(c) Random

Survivorship Curves

- Graph showing the number or proportion of individuals surviving to each age for a given species

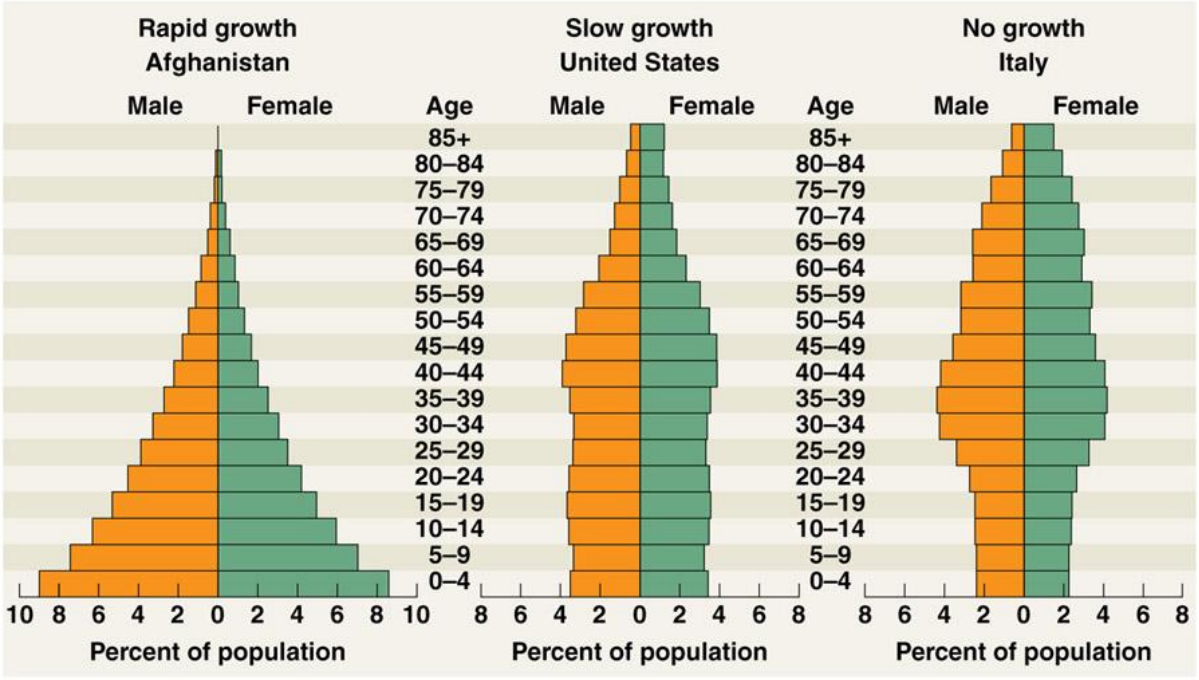


Survivorship Curves

- **Type I** – low death rate early in life, death rates increase rapidly in old age (humans, large mammals)
- **Type II** – constant death rate over the organism's life span (birds)
- **Type III** – high death rate early, produce large numbers of offspring but provide little or no care (fish, plants)

Age Structure Diagrams

- Diagrams that show the relative numbers of individuals at each age and fecundity (ability to produce abundant healthy offspring)
- Used to predict human population changes



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Population Growth

Population Growth Patterns

- Mathematical models and graphical representations are used to illustrate **population growth patterns** and interactions

- **What are two population growth patterns?**

Birth Rate and Death Rate

- **Birth rate (B):** number of offspring produced per unit time

  34/1000 = 0.034 (per capita birth rate)

- **Death rate (D):** number of individuals that die per unit time

  16/1000 = 0.016 (per capita death rate)

- Used to estimate population growth

Exponential Growth

- Reproduction without constraints (such as?)
- Rapid, unrestricted growth

- r_{max} = max per capita growth
- N = population size

Exponential Growth

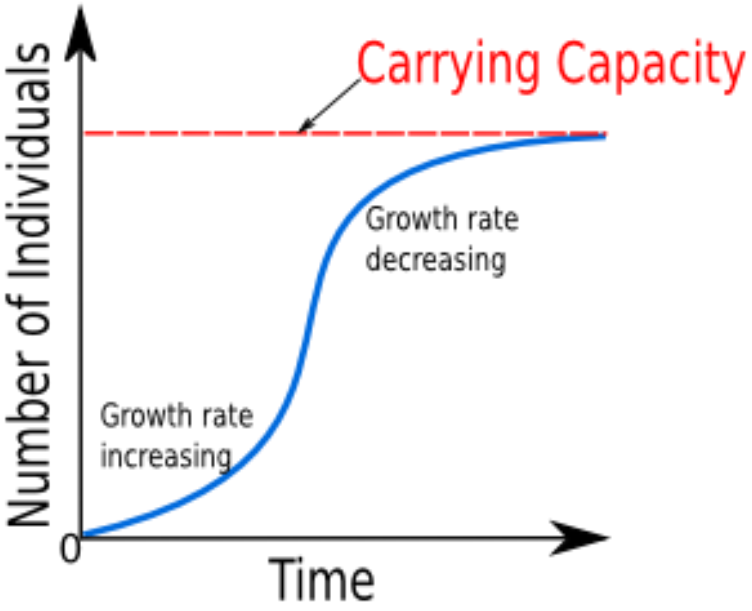
$$\frac{dN}{dt} = r_{max}N$$

Logistic Growth

- Growth is limited due to density-dependent and density-independent factors
- Rate of population growth slows as the population size (N) approaches the carrying capacity (K)

Logistic Growth

$$\frac{dN}{dt} = r_{max} N \left(\frac{K - N}{K} \right)$$



Logistic Growth

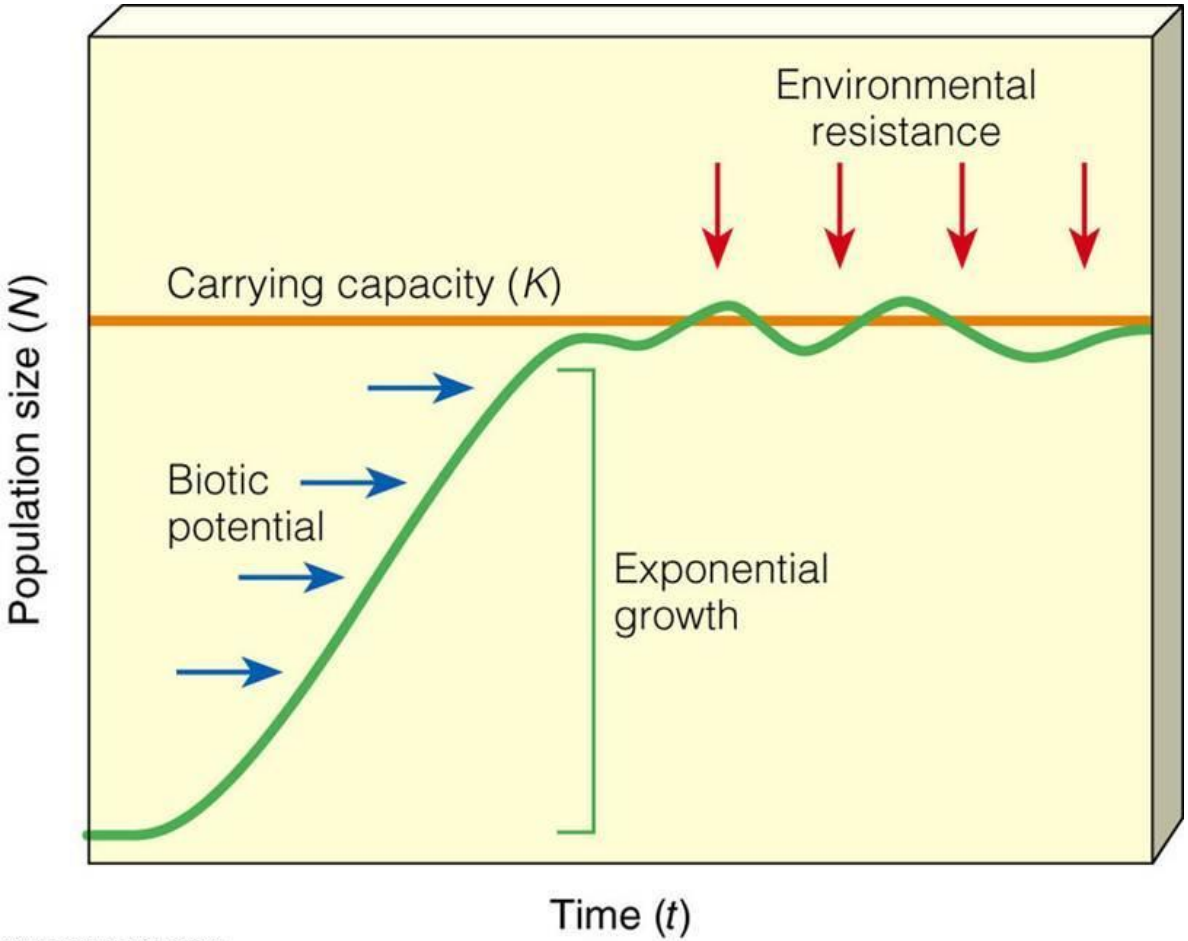
- r_{max} = maximum growth rate of a population under ideal conditions

- K-N = number of individuals the environment can support

- (K-N)/K = fraction of the carrying capacity that is still available for population growth

Carrying Capacity (K)

- The maximum number of individuals that a given environment can support



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Limiting Factors

- Factors that prevent a population from growing any larger or cause a population to decrease

What are the two categories of limiting factors?

Density-Dependent Factors

- Factors that are dependent on the number of individuals in a given area (population size)
- Often biotic factors

Examples: competition for resources, disease, predation

Density-Independent Factors

- Factors that affect all populations in similar ways regardless of population size (density)
- Often abiotic factors

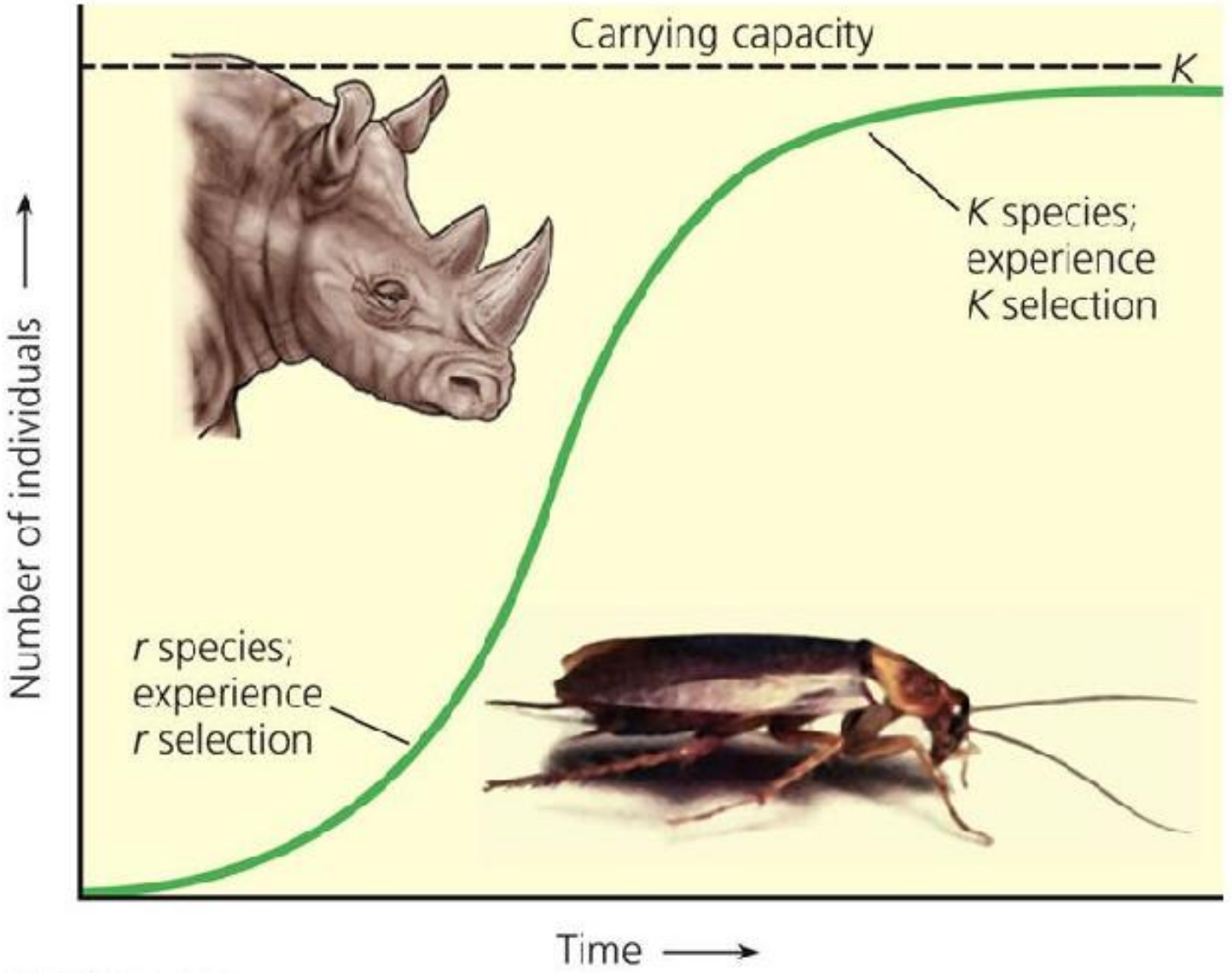
Examples: drought, extreme temperatures, natural disasters

Trade Offs and Life Histories

- Traits that affect an organism's schedule of reproduction and survival make up its **life history**
- Trade off between quantity (reproduction) and quality of offspring (survival)
- Natural selection decides

K-selection **r-selection**

r and K Selected Species



K-selected

- **K** for carrying capacity
- Population lives at a density near the carrying capacity, stronger competition
- Produce few “expensive” offspring and live in stable environments

r-selected

- **r** for reproduction, maximize reproductive success
- Density of population is well below the carrying capacity, minimal competition
- Produce many “cheap” offspring and live in unstable environments

Life Histories

r Unstable environment, density independent	K Stable environment, density dependent interactions
small size of organism	large size of organism
energy used to make each individual is low	energy used to make each individual is high
many offspring are produced	few offspring are produced
early maturity	late maturity, often after a prolonged period of parental care
short life expectancy	long life expectancy
each individual reproduces only once	individuals can reproduce more than once in their lifetime
type III survivorship pattern in which most of the individuals die within a short time but a few live much longer	type I or II survivorship pattern in which most individuals live to near the maximum life span