POPULATION ECOLOGY

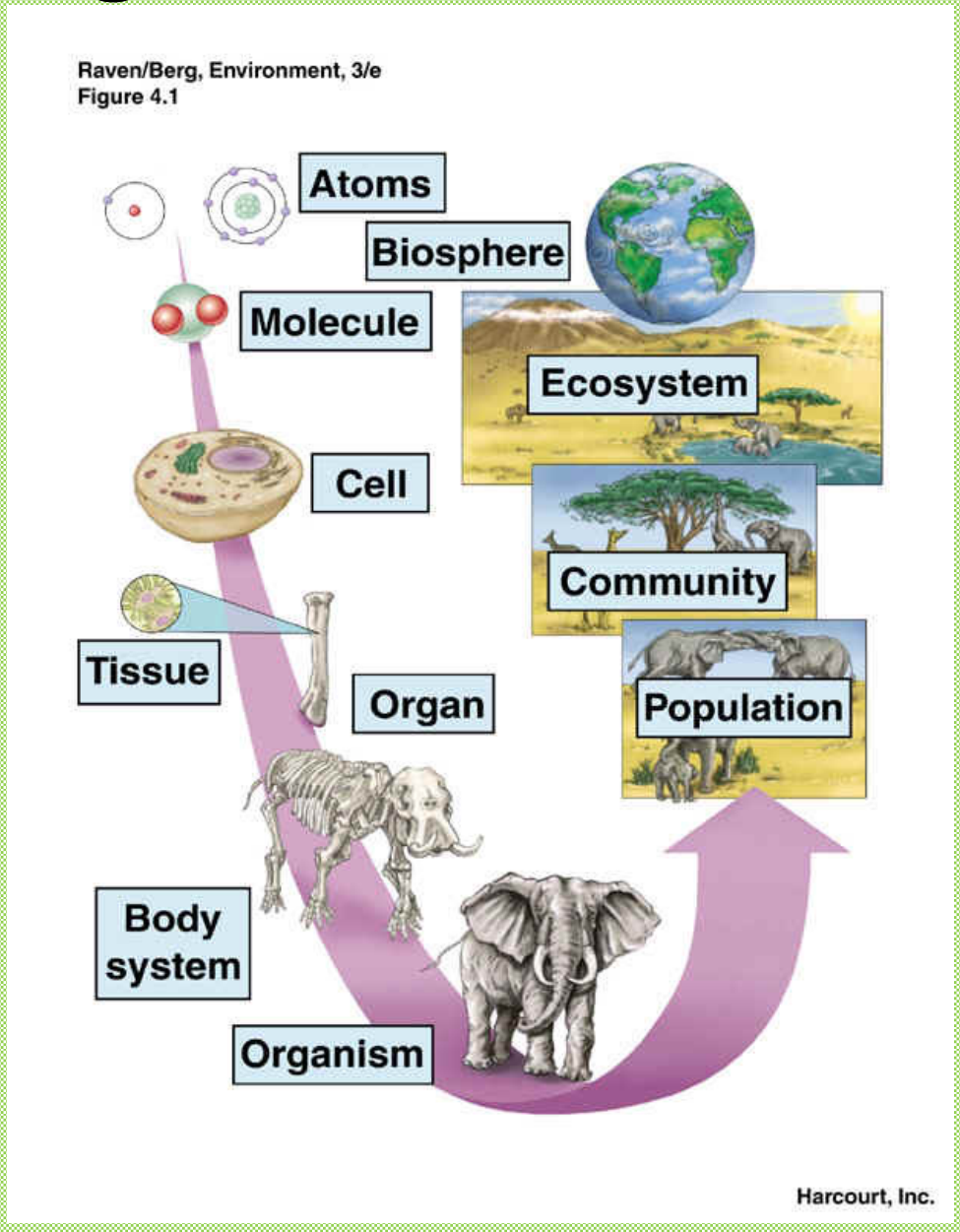
Learning Objectives:

- Understand the basic concept of ecological niche and its adaptations.
- Understand the ecology of populations.
- Explain the population properties.
- Describe the significance of population dynamics.

Levels of Organization

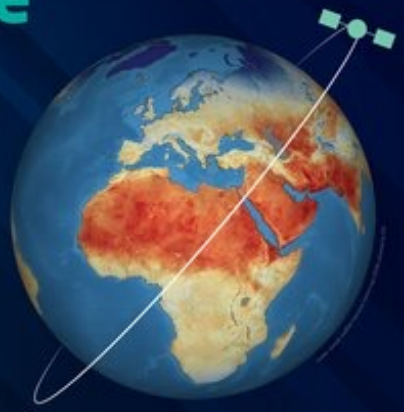
Let's Review

- **Ecology** – the study of the **interactions** of organisms with their environment
- **Abiotic Factors**
- **Biotic Factors**



Weather versus Climate

The difference between weather and climate is a matter of time



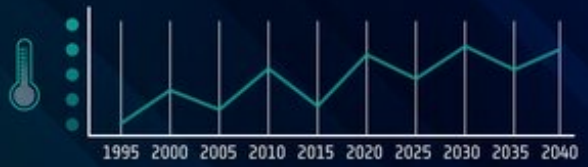
Weather

refers to short-term changes in the atmosphere.
It can change minute-to-minute, hour-to-hour and day-to-day

Climate

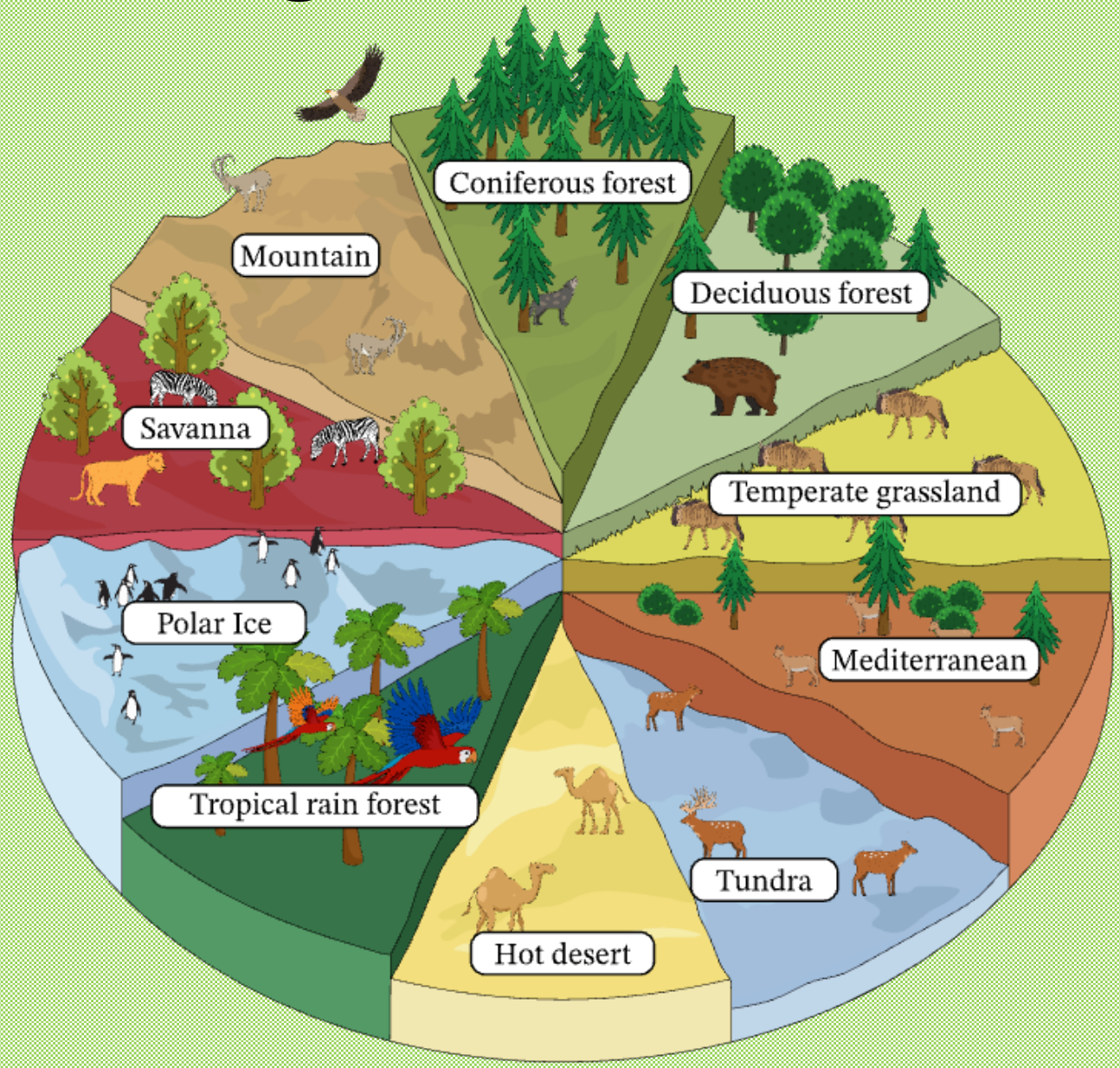
describes the average weather conditions in a specific area over a long period of time – 30 years or more

Satellites measure several aspects of Earth's weather as well as provide essential data over decades to monitor how our climate is changing

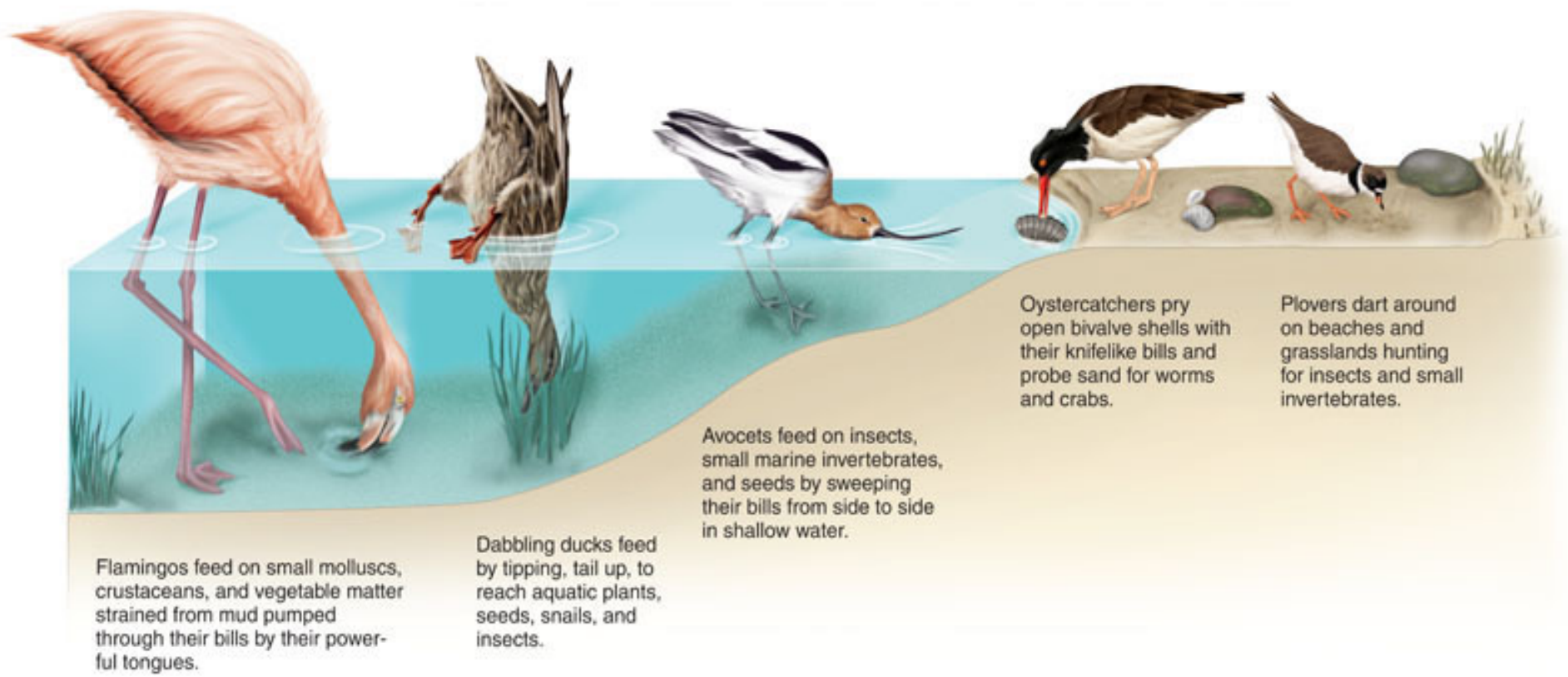


For more information, visit space for our climate:
www.esa.int/climate

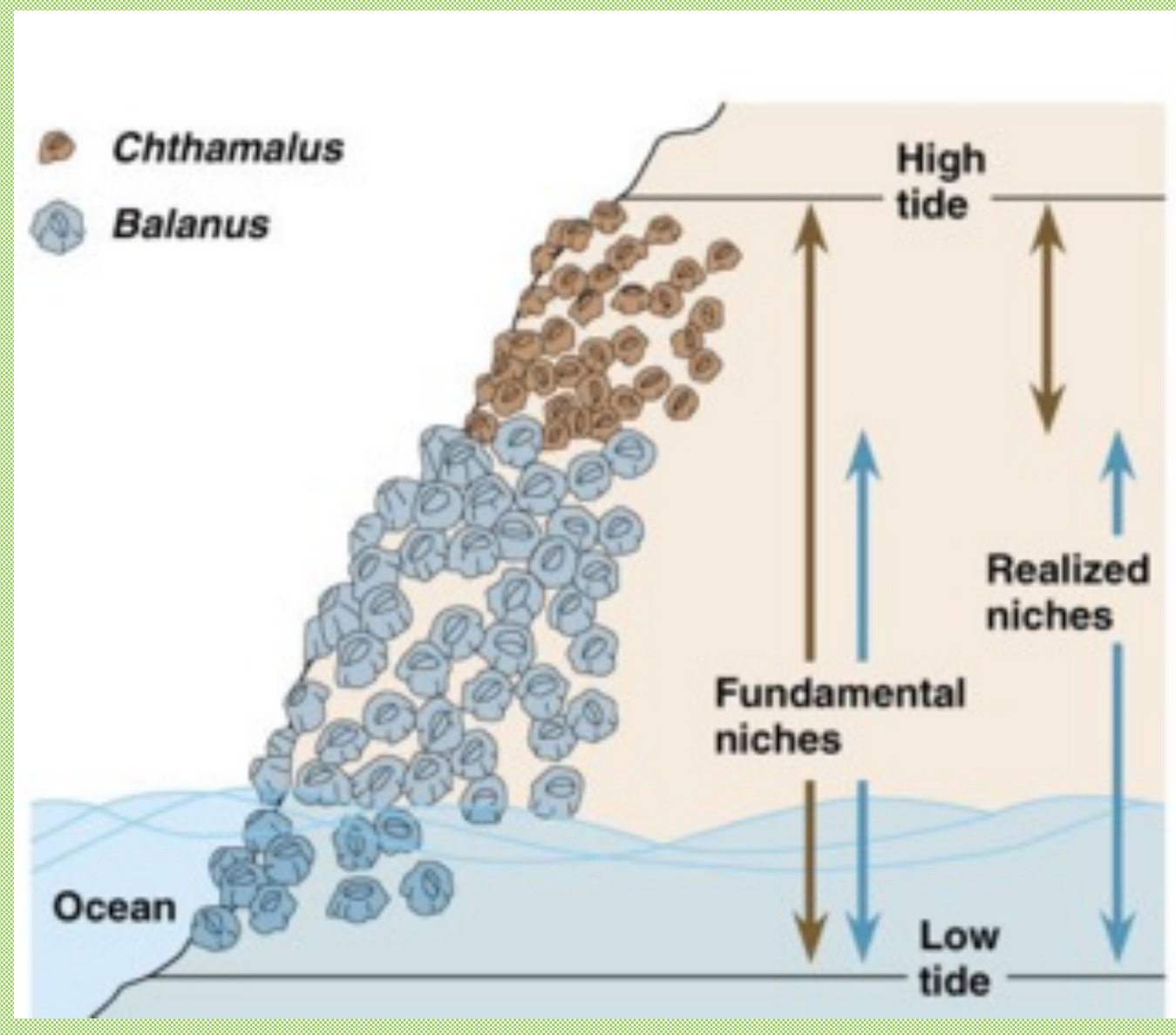
Organisms Habitat



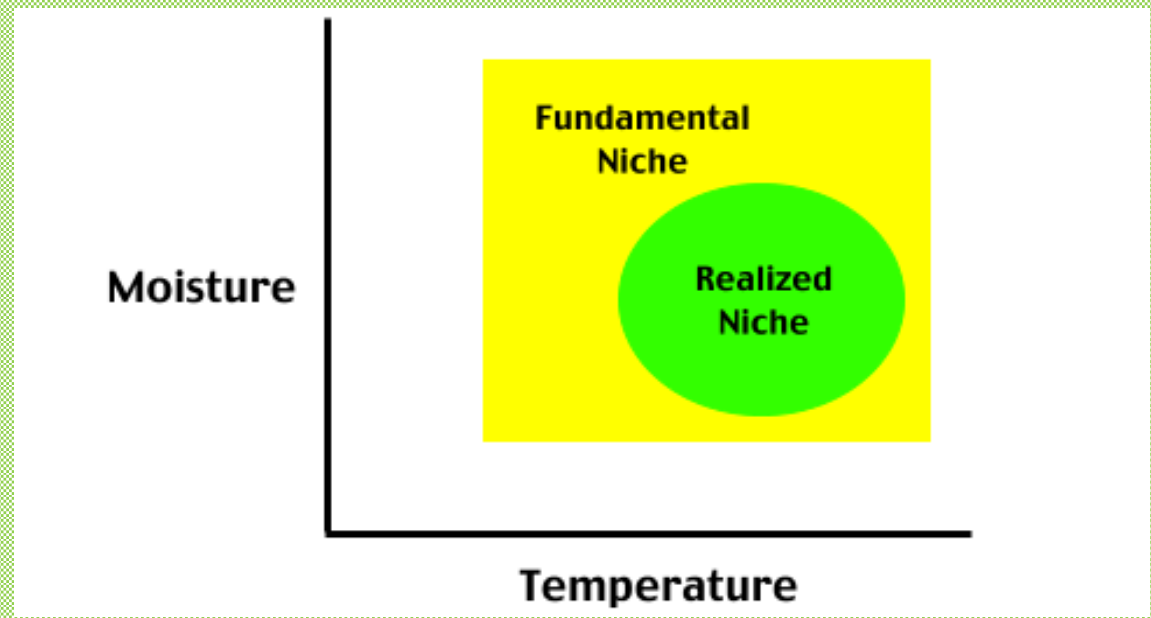
Ecological Niche

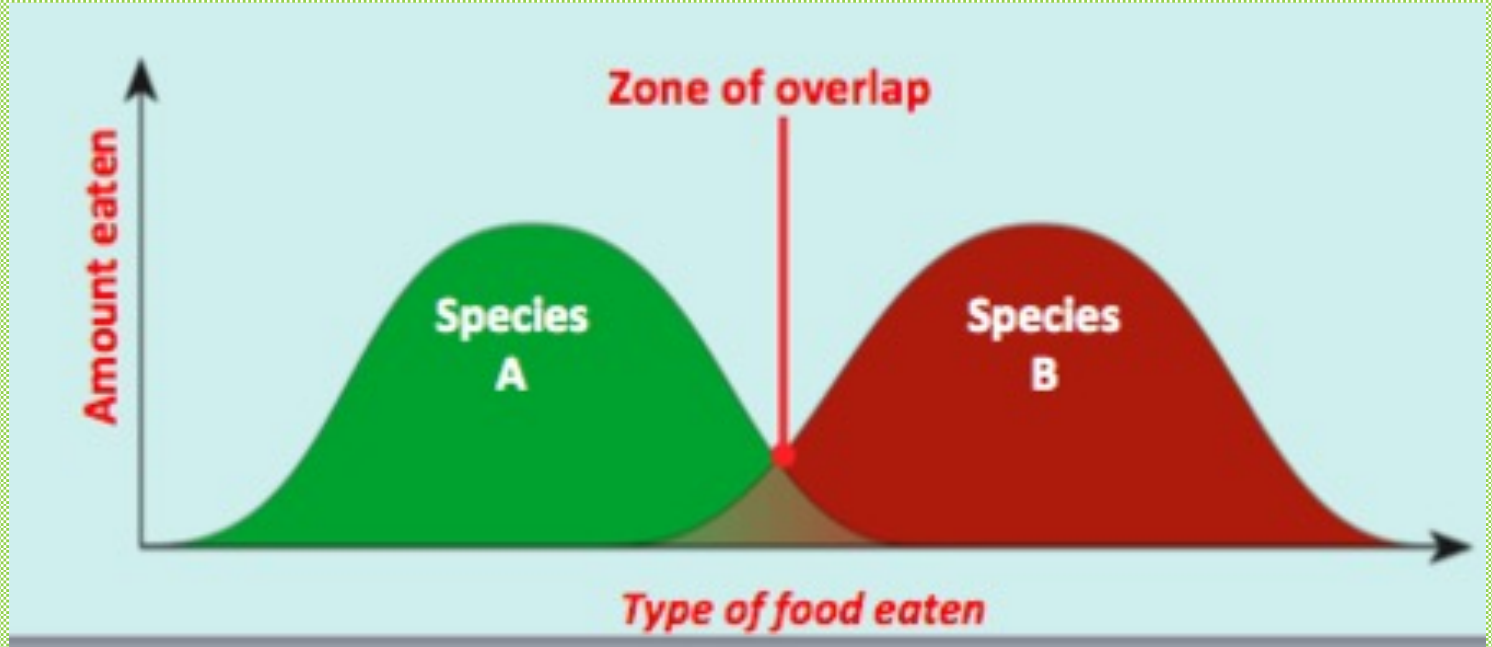


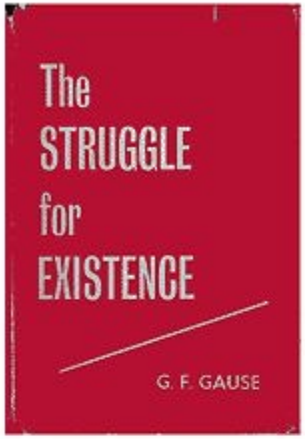
Fundamental Niche



Organisms Niche



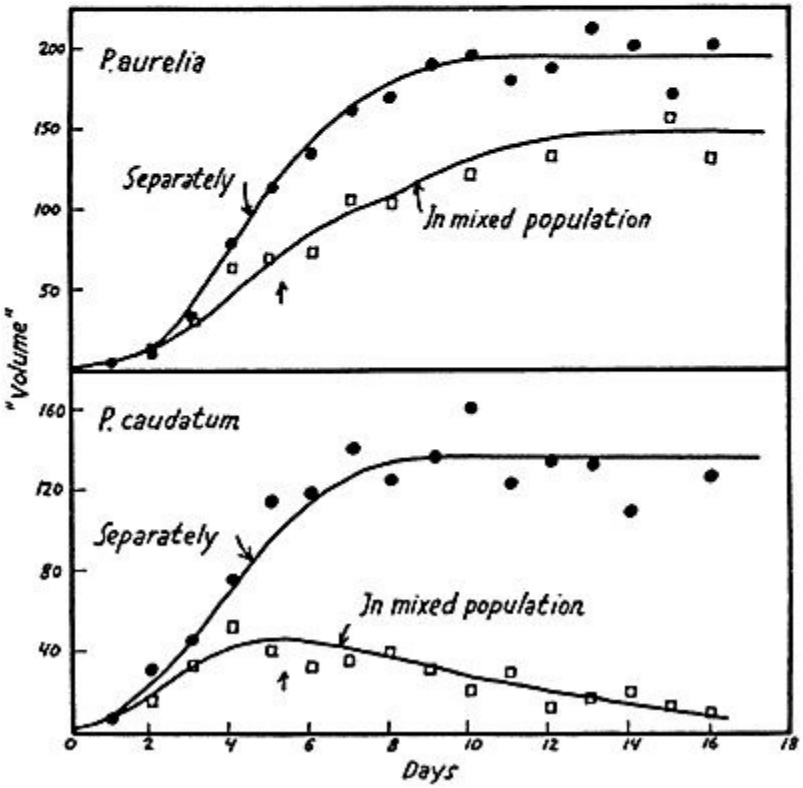




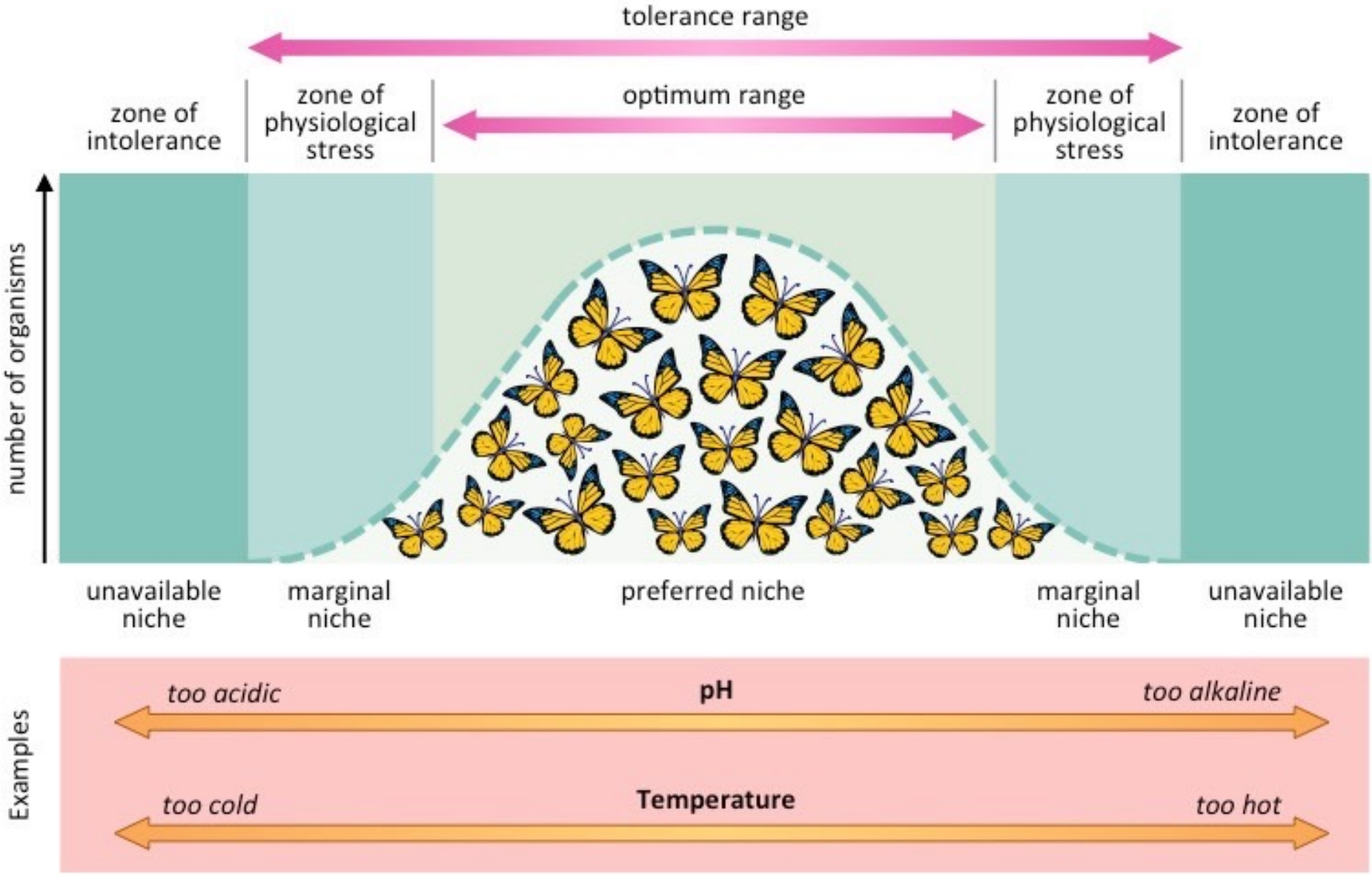
Gause's law

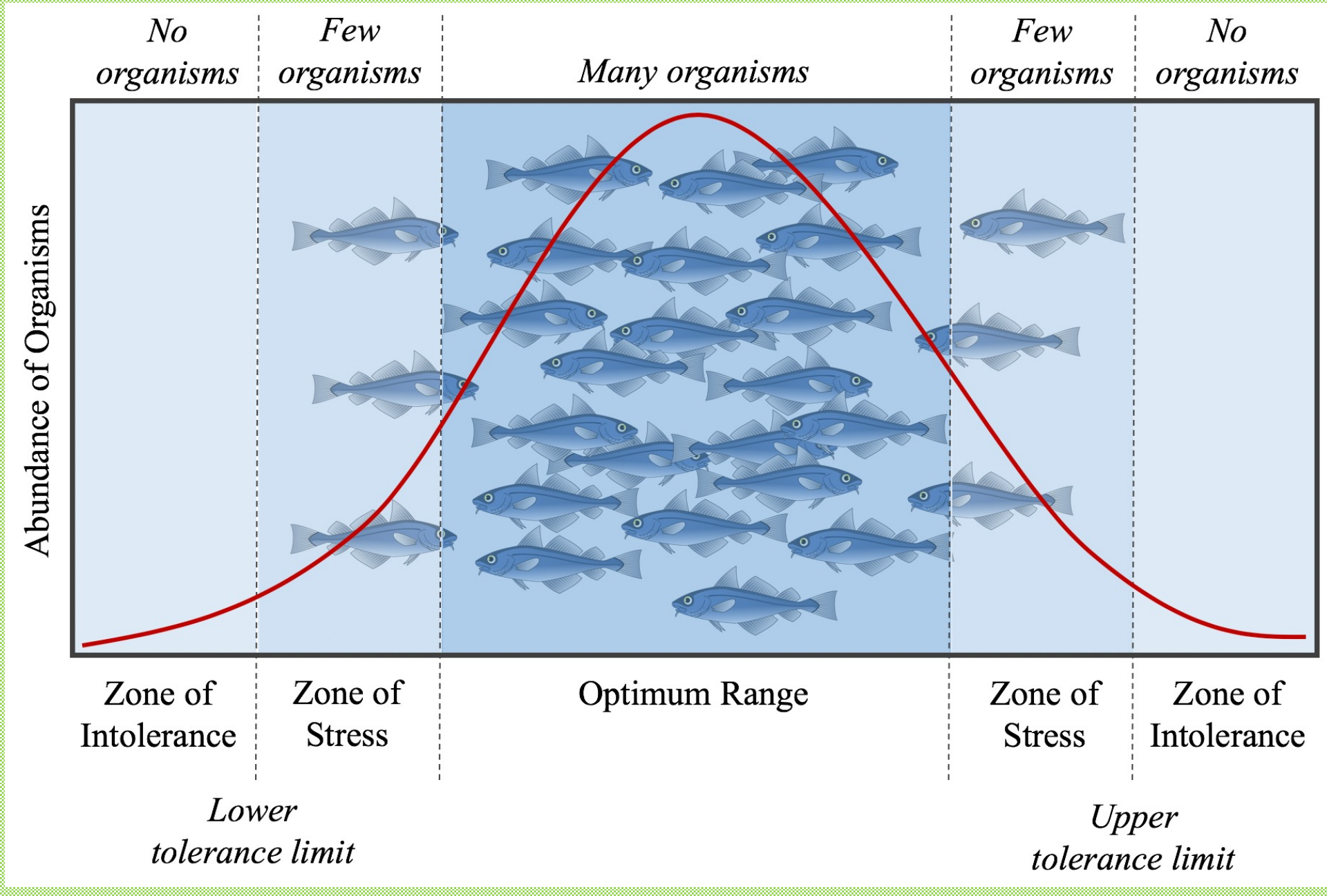
Two species competing for the same resource cannot coexist if all other ecological factors are constant

(http://www.ggause.com)

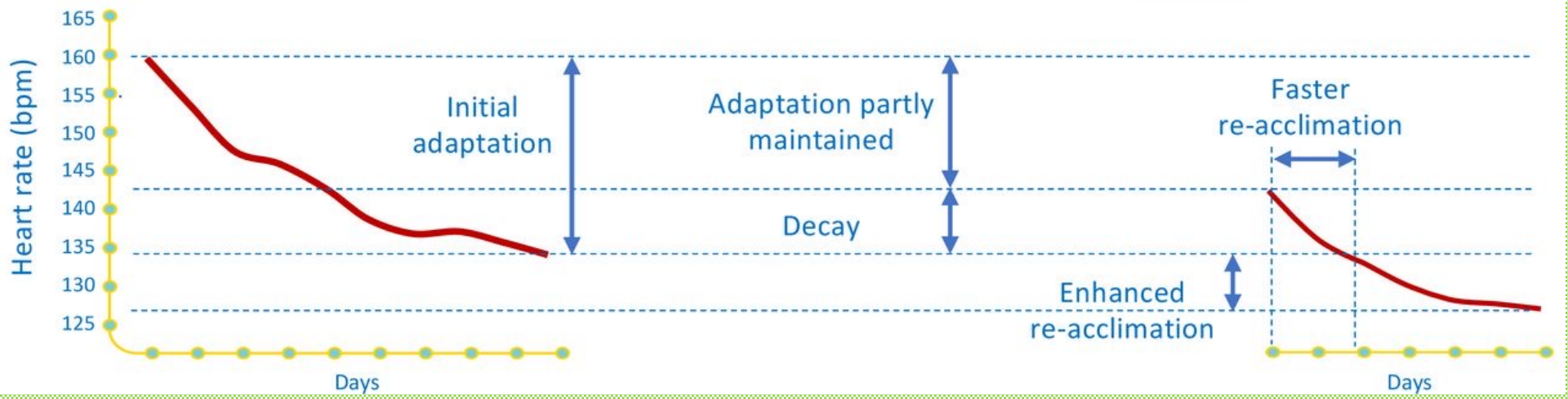


Organisms Tolerance




No organisms
Few organisms
Many organisms
Few organisms
No organisms
Abundance of Organisms
Zone of Intolerance
Zone of Stress
Optimum Range
Zone of Stress
Zone of Intolerance
Lower tolerance limit
Upper tolerance limit

Acclimation vs. Adaptation



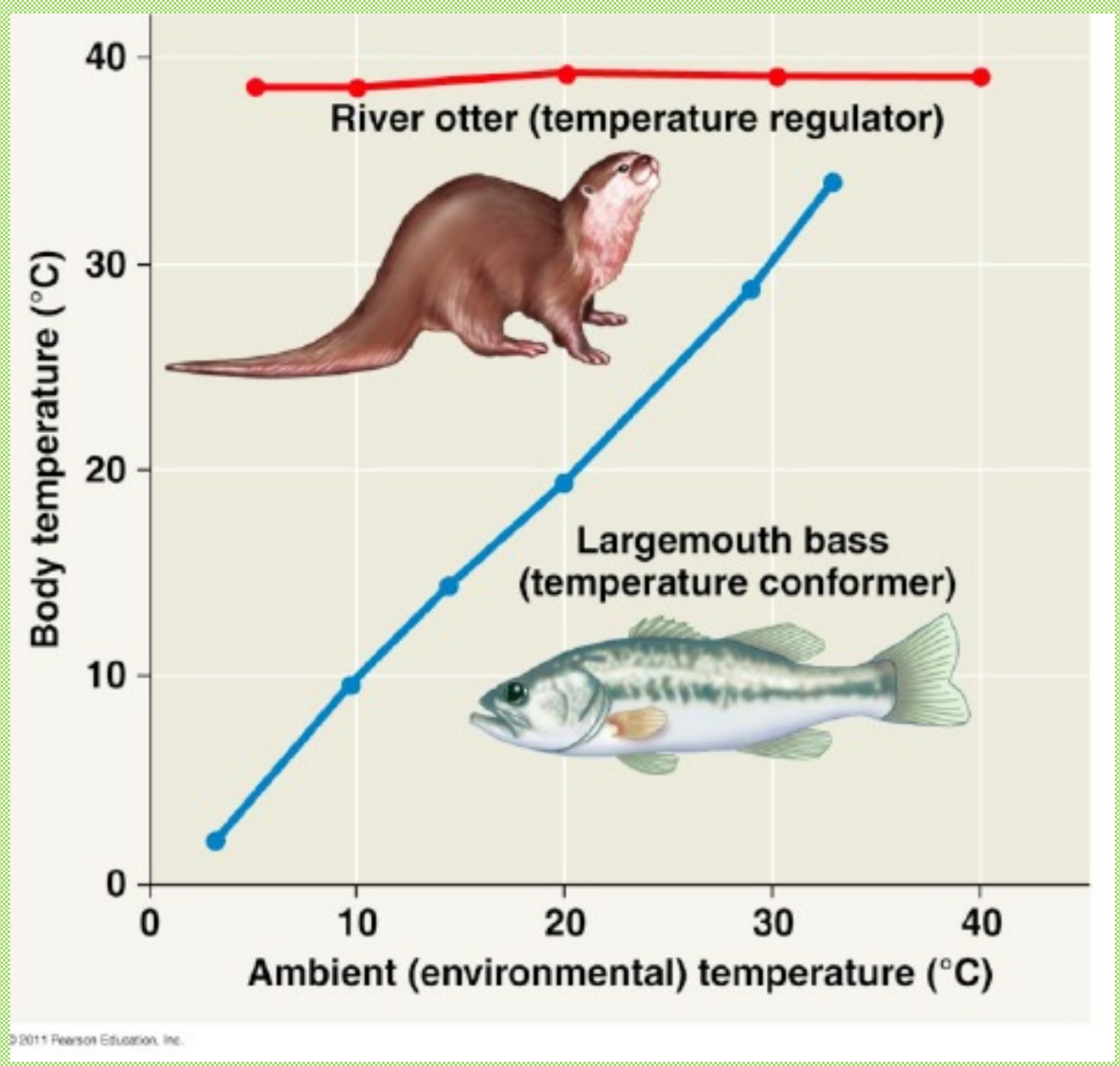
Learning Activity 5.0

Adaptation

- Give at least 3 examples for each type of adaptations below and explain each examples:
  - Physical Adaptation (plants/animals)
  - Behavioral Adaptation (plants/animals)
- Type written activity
- Times New Roman-12
- One page-pdf copy

Organisms responses to changes in the Biotic and Abiotic environment

Conformers vs. Regulators



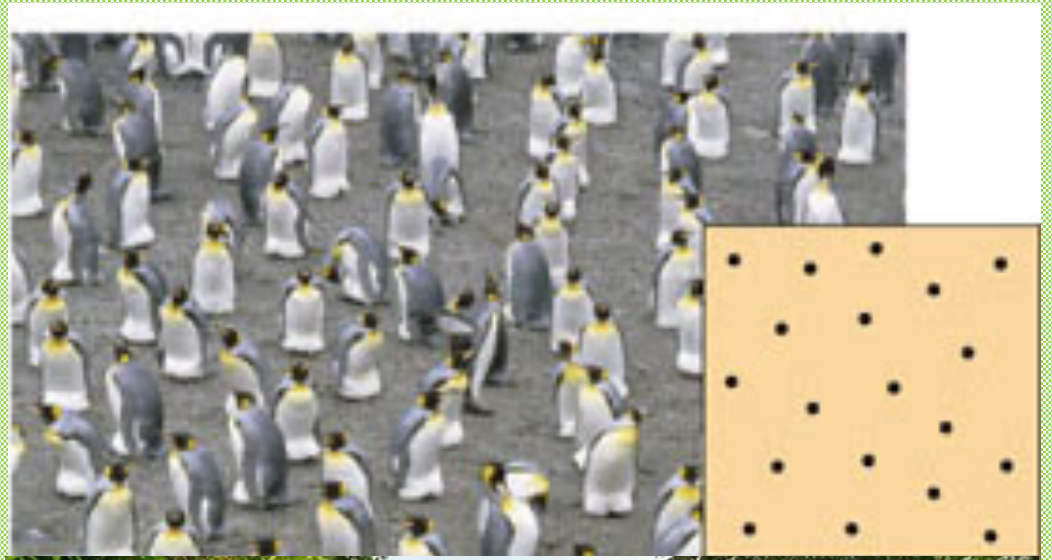
Population

- population / land group of organisms that live in the same place and can **reproduce**
- **<u>Population Density</u>** number of individuals per unit area
  - Total number of d area(km^2)

Dispersion

- Pattern of **spacing** of individuals within the boundaries of the population
  - **Clumped** – most common
    - Usually because of resources
    - Humans
  - **Uniform**
    - Interactions between the individuals in the population
    - Territoriality
  - **Random**
    - Inconsistent
    - Plants – windblown seeds

Uniform Dispersion

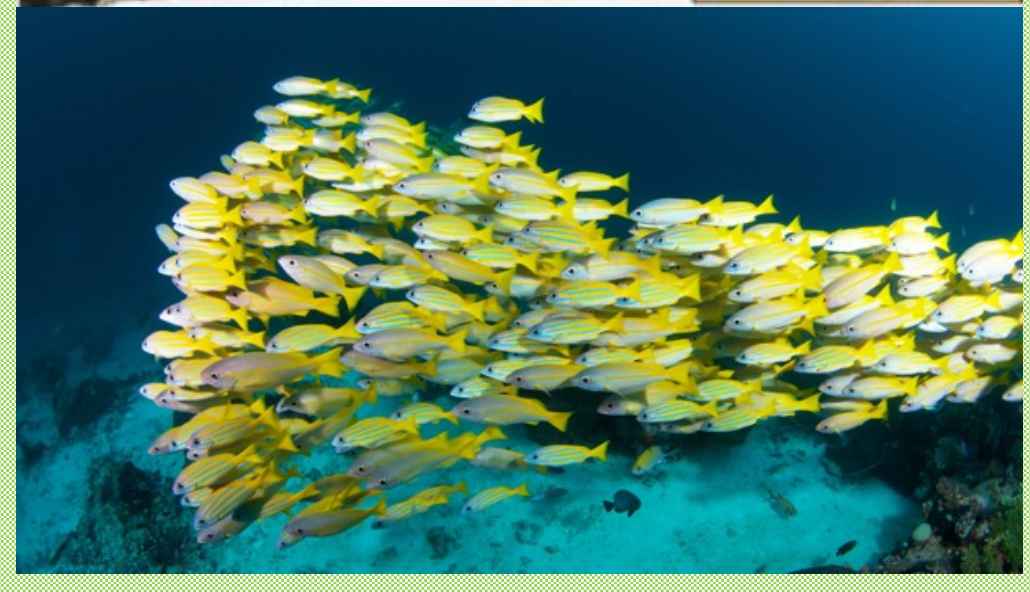


- individuals of a population are spaced more or less evenly
- **allelopathy**

Random Dispersion

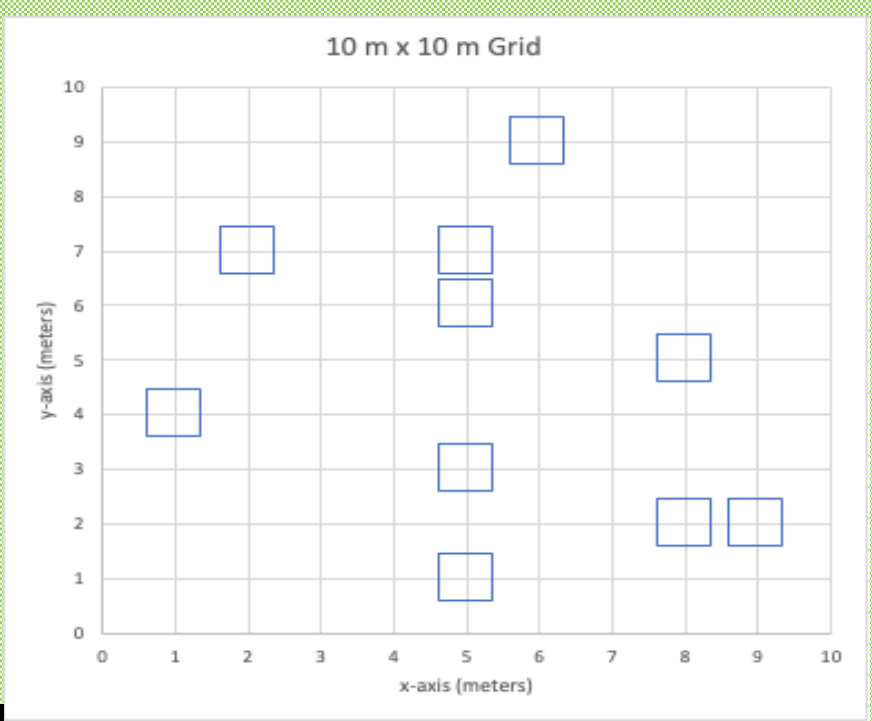
- distributed randomly, without a predictable pattern

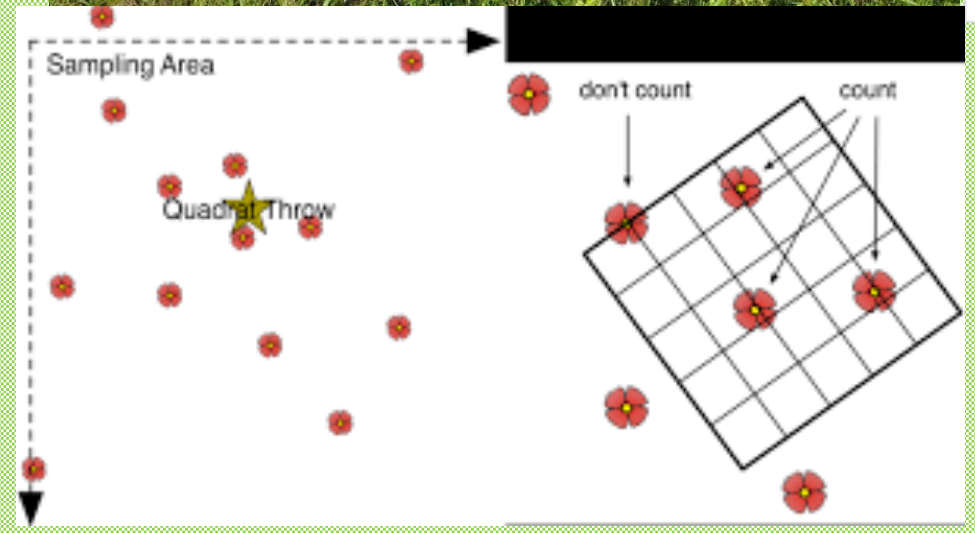
Clumped Dispersion



- individuals are clustered in groups

Determining Population Size





Quadrat sampling

Determining Population Size

- **Capture and recapture**
  - **mark - recapture**
  - Allows for calculation of migration



Image credit: Population demography by OpenStax College, Biology, CC BY.4.0; originals: left, modification of work by Neal Herbert, NPS; middle, modification of work by Pacific Southwest Region USFWS; right, modification of work by Ingrid Taylar.

=(total number captured) x (number marked) / (total number recaptured with a mark)

Example:

$$\frac{\text{number marked first catch } (M)}{\text{total population } (N)} = \frac{\text{number marked second catch } (x)}{\text{total number of second catch } (n)}$$

$$\frac{M}{N} = \frac{x}{n}$$

Next, we rearrange the equation:

$$N = \frac{nM}{x}$$

N=(100total second catch)(80marked first catch
(20 marked second catch)
=400 wild boar

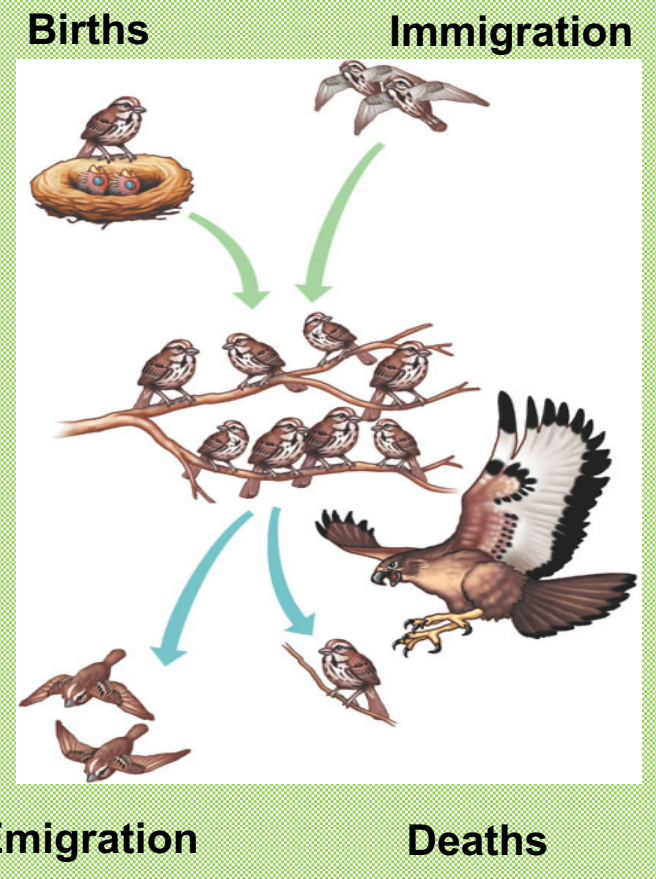
Cons of capture and recapture Sampling

- bias sampling
- may harm the species

Population Growth Rate

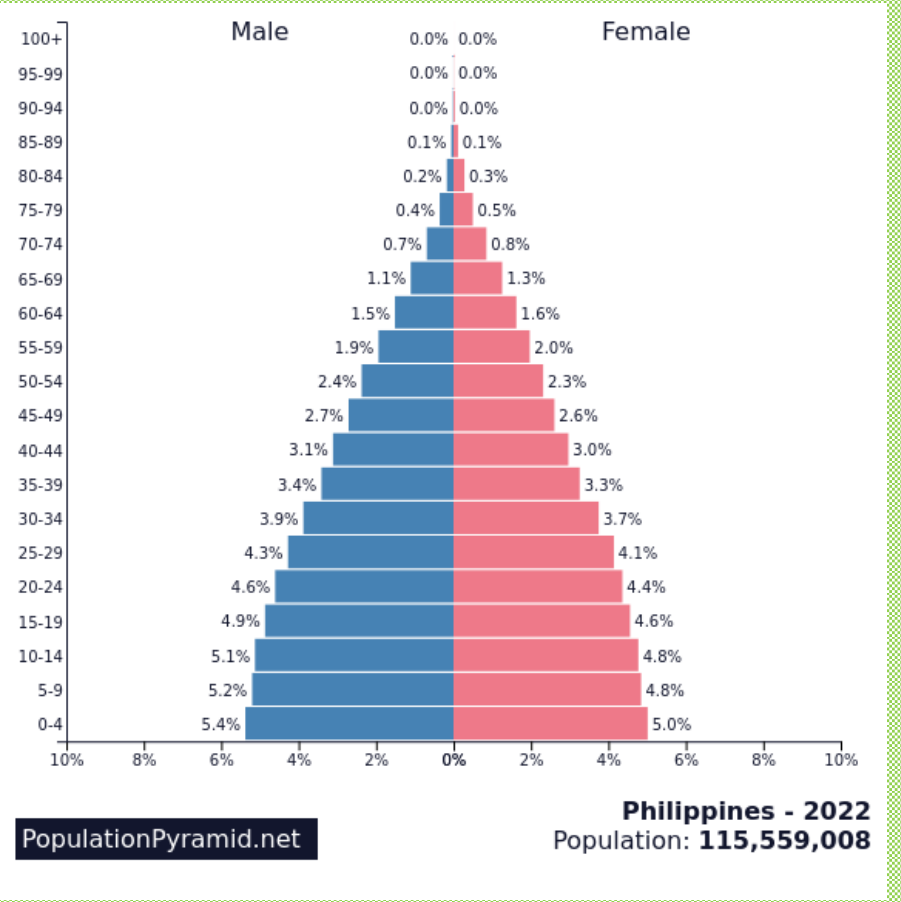
- Birth Rate - fecundity
- Death Rate - mortality
- Migration (immigration and emigration)
- Age Structure
- Survivorship Curves (patterns of mortality)

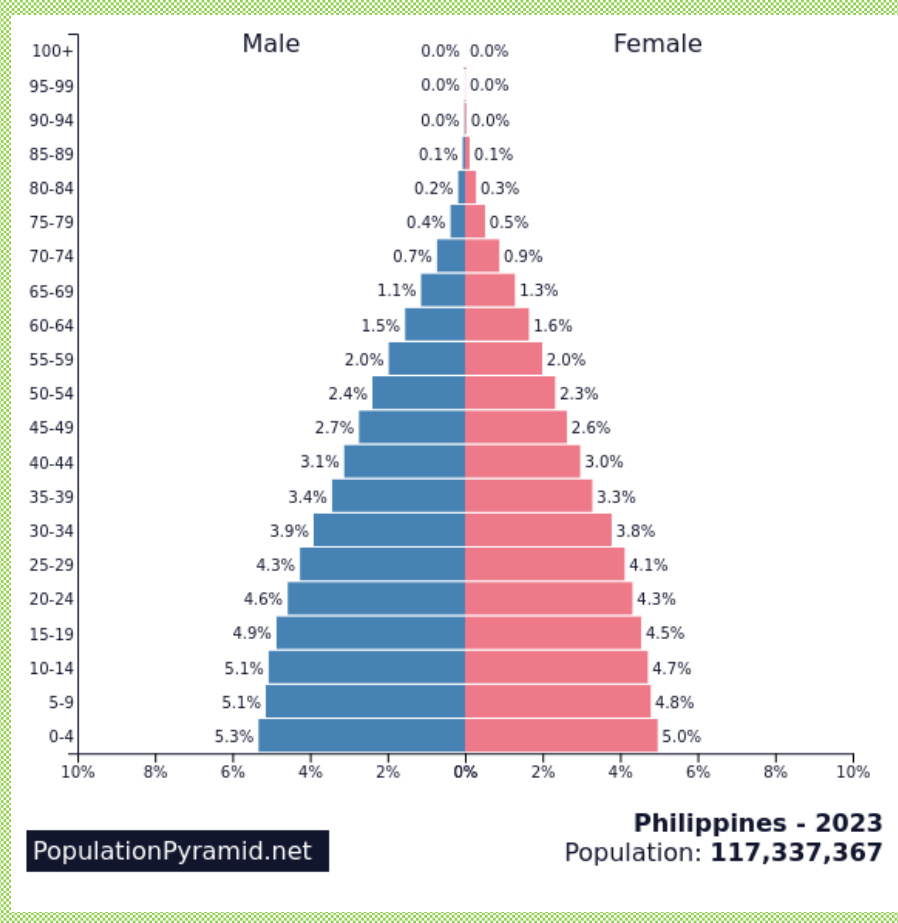
Births and immigration add individuals to a population.



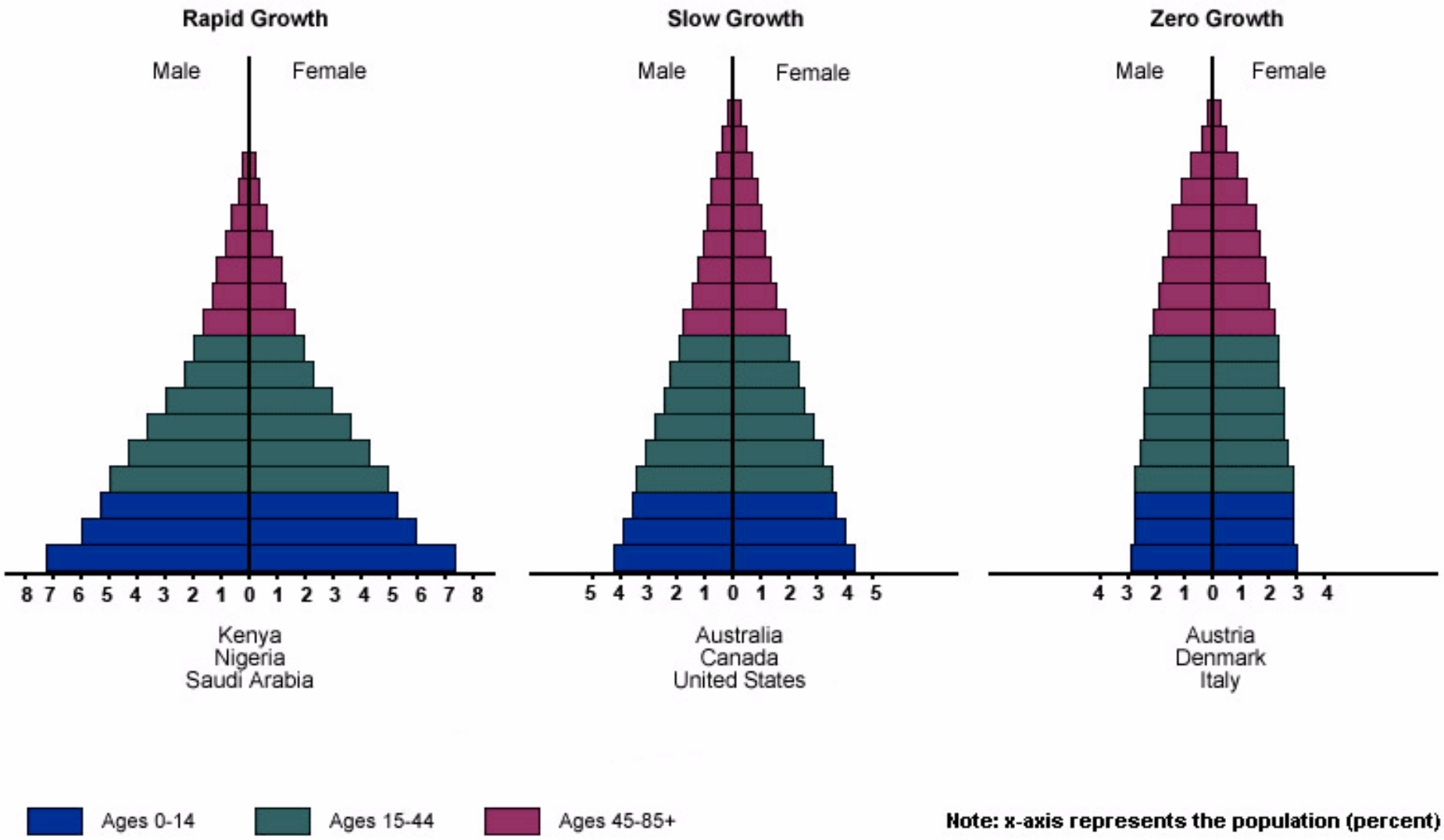
Deaths and emigration remove individuals from a population.

Age-Sex Pyramid



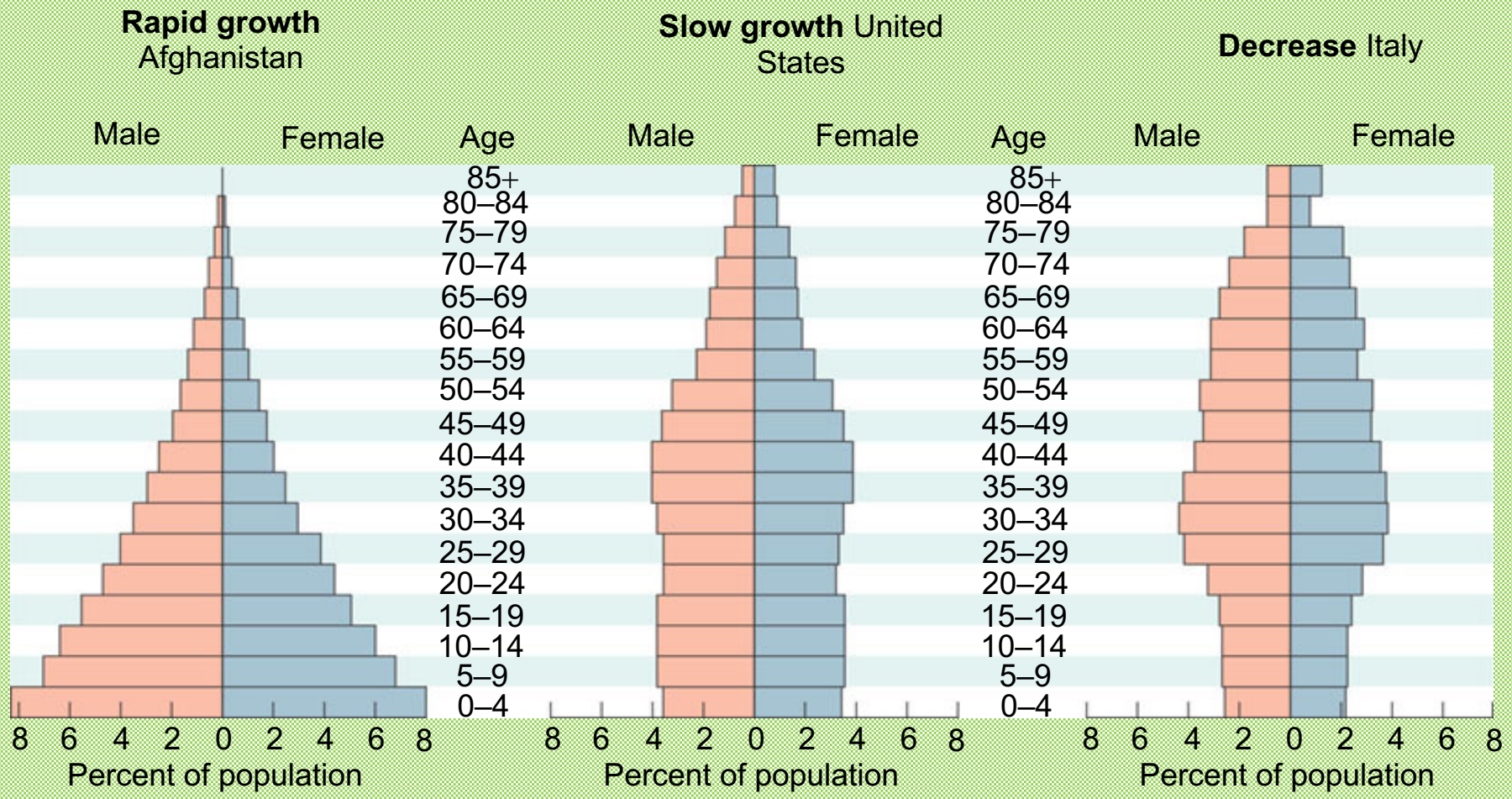


Age-Sex Pyramid



Age Structure

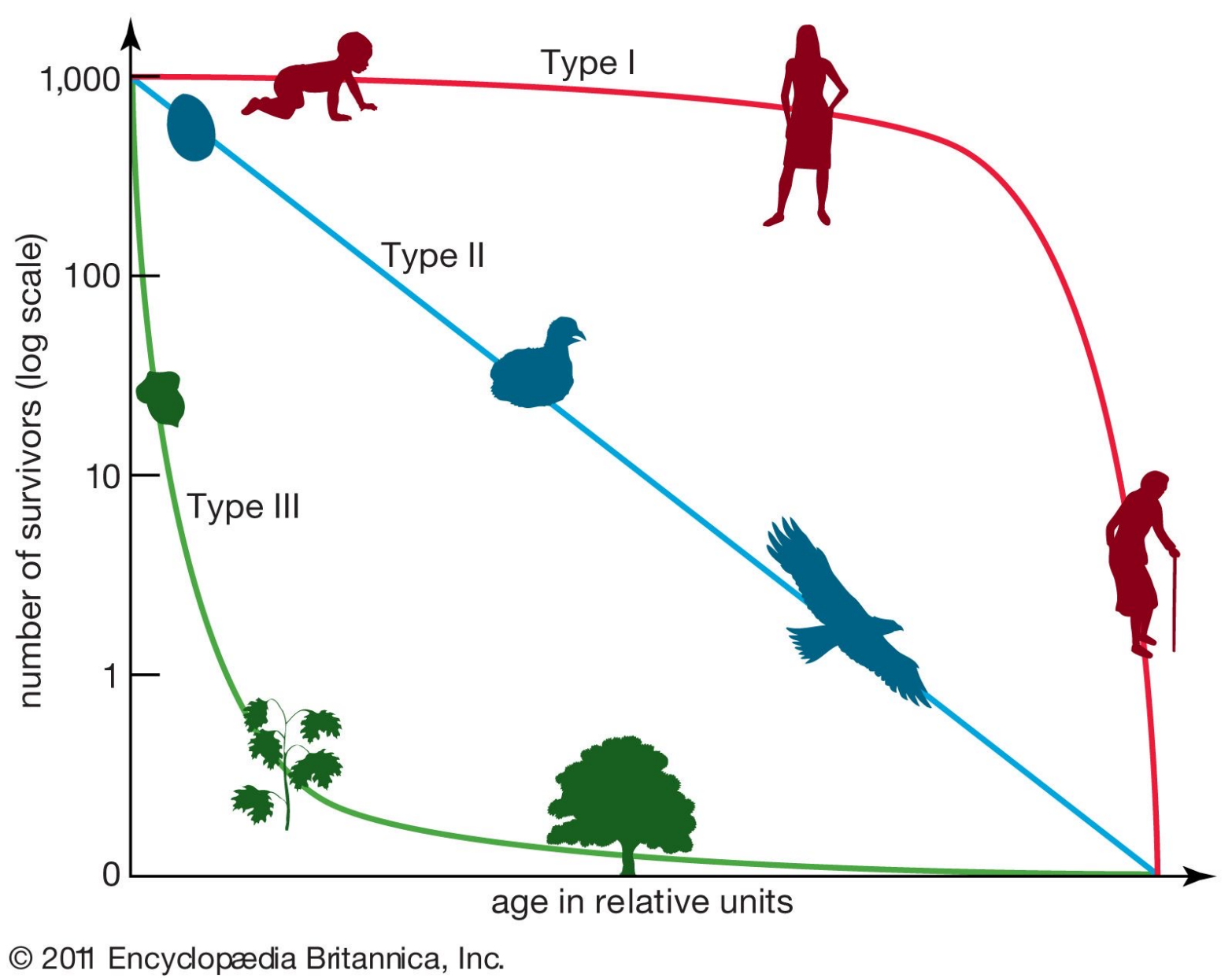
- ***Greater number of young individuals means greater potential for growth.***



Declining Fertility rate

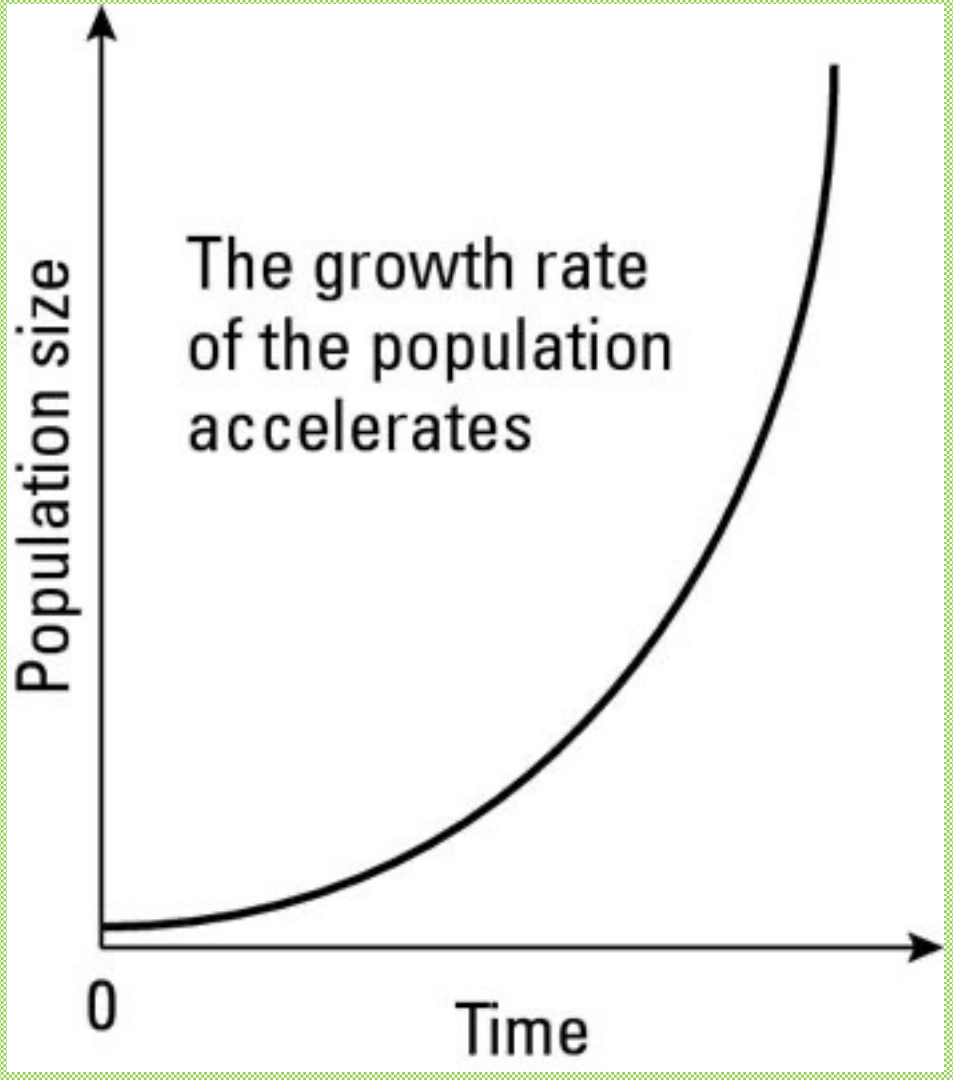
- current fertility rate for Philippines in 2023 is 2.454 births per woman, a 1.01% decline from 2022 (PSA,2023)
- social structure, religious beliefs, economic prosperity and urbanization, abortion rates,
- developed countries tend to have a lower fertility rate due to lifestyle choices

Survivorship Curves

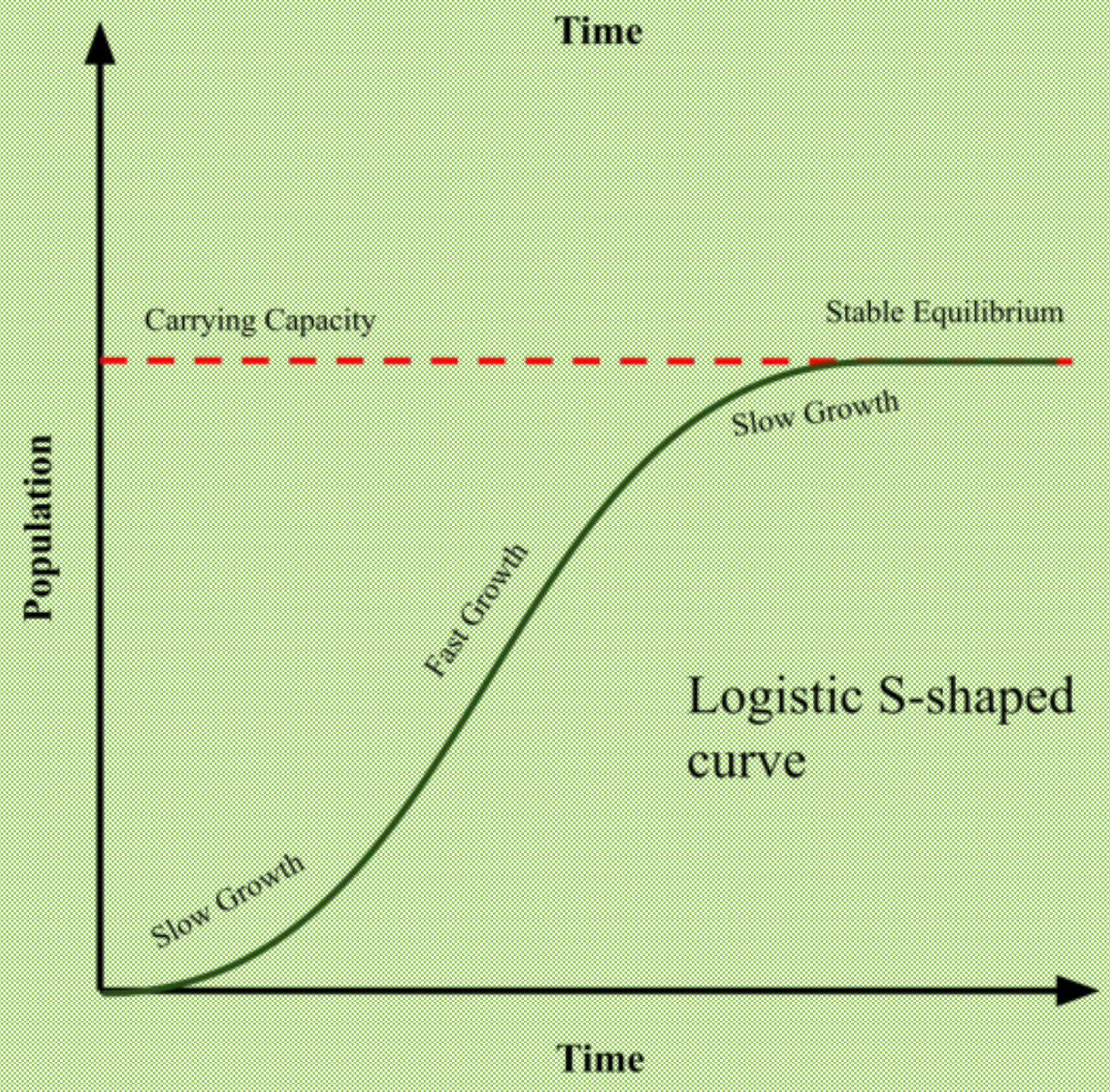


Exponential Growth

- **$dN / dt = r_{max}N$ (d refers to instant change in time)**
- dN = change in number of individuals
- dt = change in time
- r = rate of growth (birthrate – death rate)/N
  - Higher r = short generations
  - Lower r = longer generations
- N = population size



Logistic Growth



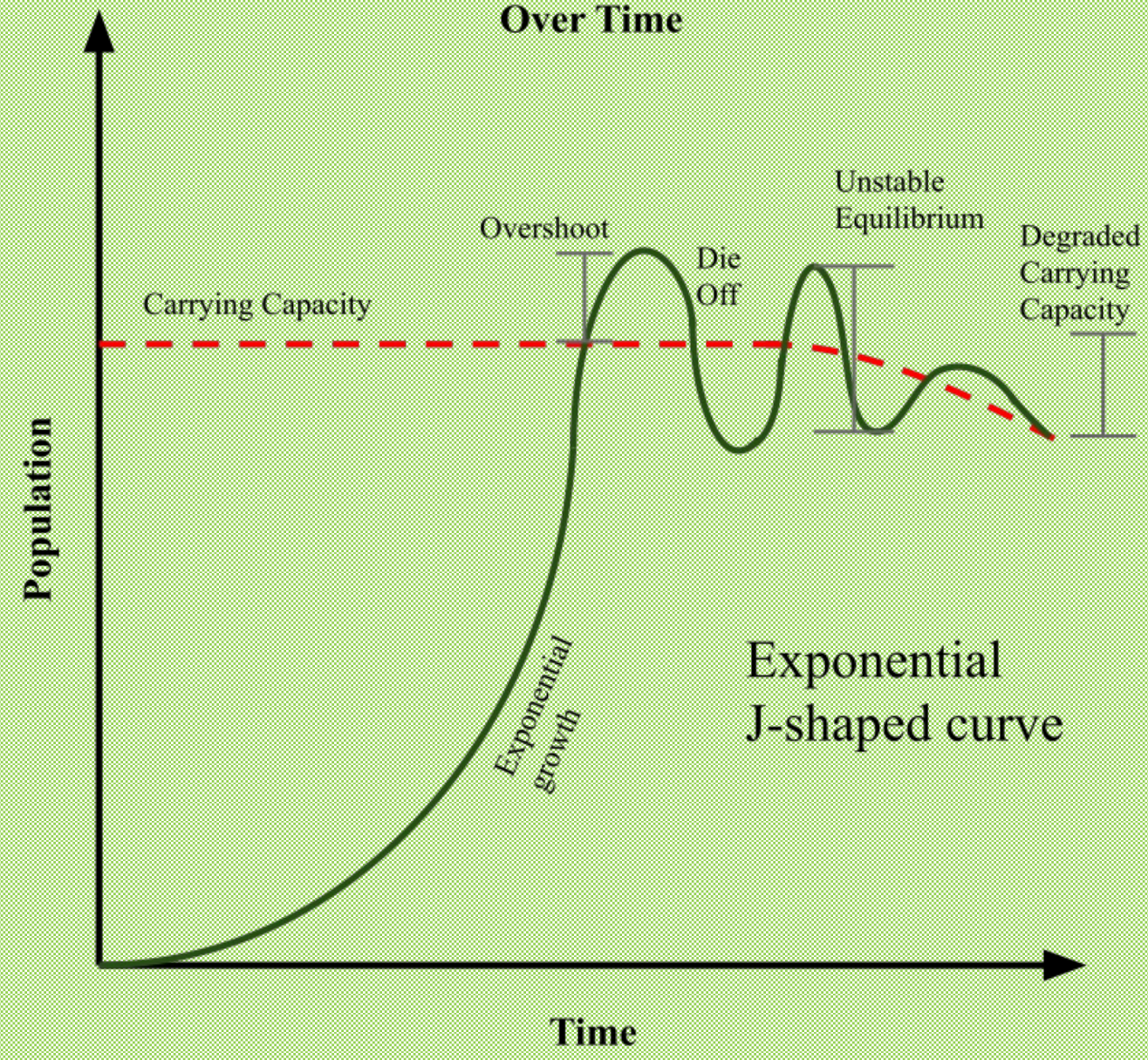
Carrying capacity is the amount of organisms within a region that the environment can support sustainably

Stable equilibrium is met when the population aligns with the carrying capacity line

Slow growth occurs when natality is slightly above mortality, for fast growth natality is drastically greater than mortality

The S-shaped logistic curve is formed when growth rate decreases as carrying capacity is approached by the population

Figure 1: Exponential Growth of Population Size Over Time



Carrying capacity is the amount of organisms within a region that the environment can support sustainably

Overshoot occurs when the population growth exceeds the carrying capacity, leading to a die off for the individuals in the population

Unstable equilibrium is the fluctuation of the population above and below the carrying capacity, changing based on the relationship between natality and mortality

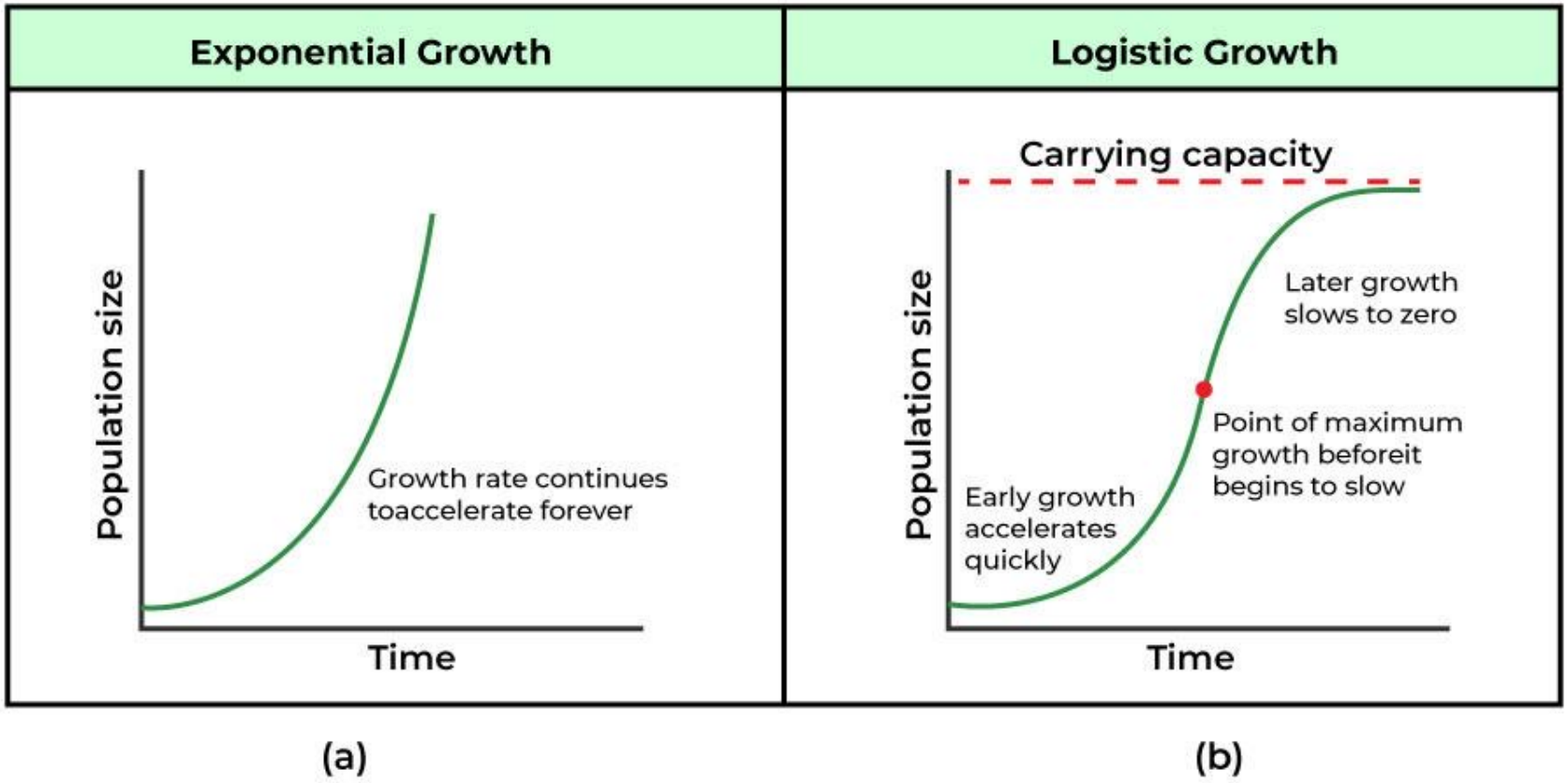
Degraded carrying capacity may be due to resource destruction during an overshoot, carrying capacity is not static

Carrying Capacity of an Ecosystem

- Food supply
- Water supply
- Habitat space
- Competition
- Chemical factors
- Physical factors
- Anthropogenic factors

Population Growth

- **<u>Exponential Model</u>** – increases continually **without limiting factors** – assumes resources are unlimited



Population Growth

- **Logistic Model** – account for limiting factors and **limited resources**
- **Carrying Capacity** – the number of individuals that can occupy the habitat (K)
  - $\mathbf{dN / dt = r_{max} N (1-N)/CP)}$

dN/dt	=	rate of population change
r	=	maximum population growth rate
N	=	population size
K	=	population carrying capacity
CP	=	Change in Population size

Population Density

- **D=P/A**
  - Where D is the density
  - P is the population number
  - A is the area
- key metric in understanding not only the economics and logistics involved in an area

- Using the exponential model to predict population size in the future

$$N_t = N_0 e^{rt}$$

N_t = Number of individuals in the population at time = t

N_0 = Number of individuals in the population at start

E = base of natural logs

r = per capita rate of increase

t = time

If you know N_0 and r, you can predict N_t

$dN/dt = r N [(K - N)/K]$

For: r=0.1 K=100

if N = 10

$dN/dt = .1 (10) [(100 - 10)/100]$
$= .1 (10) (.9)$
$= .9$

if N = 99

$dN/dt = .1 (99) [(100 - 99)/100]$
$= .1 (99) (.01)$
$= .099$

Factors that limit population growth

Density Dependent Factors

- birth rate and death rate change with population size
- larger the population gets the more competition (**intraspecific/interspecific**)
  - Resources
  - Territoriality
  - Disease
  - Predation
  - Toxic waste (metabolic)
  - Intrinsic Factors

Factors that limit population growth

Density Independent Factors

- size of the population does not effect the birth rate or death rate
- **Natural disasters** – will occur regardless of population size
  - Fire
  - Flood
  - Weather

Reproduction

- **Semelparity**
  - 1 single large reproductive effort
    - big bang" reproduction, since the single reproductive event of semelparous organisms is usually large as well as fatal
  - Harsh environments
  - Low survival rate for long periods of time
  - Insects, annual plants, salmon

Reproduction

- **<u>Iteroparity</u>** – multiple smaller reproductive effort
  - Occurs in organisms that survive for long periods of time once established
  - Mammals, perennial plants

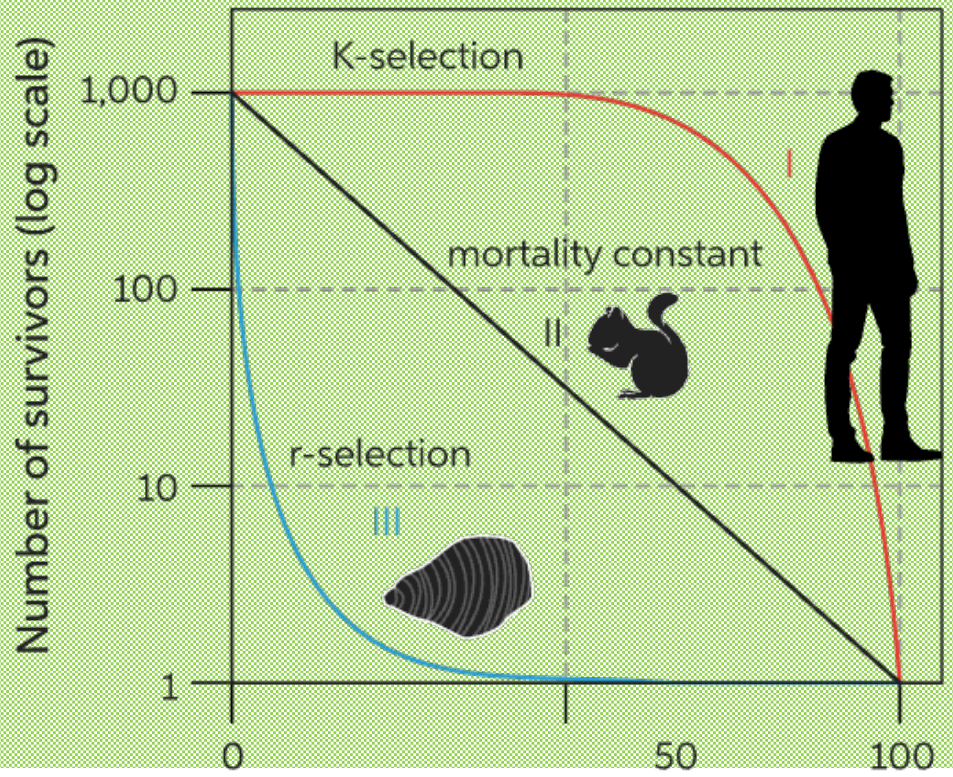
Reproductive Strategies - Selection

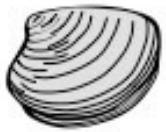
r – selected

- Maximum growth rate **below carrying capacity**
  - **Exponential growth**
  - Opportunistic populations
  - Early reproduction
  - Semelparity
  - Short life span
  - High mortality rate
  - Little or no parental care
  - Large numbers of offspring
    - Fish
    - Grasshoppers
    - Flies

k – selected

- Maximizes population size **at or near carrying capacity**
  - **Logistic growth**
  - Equilibrial populations
  - Late reproduction
  - Iteroparity
  - Long life span
  - Low mortality rate
  - Lots of parental care
  - Few offspring
    - Sharks
    - Elephants
    - Humans





Oyster
500 million a year

Fish (Tuna)
6,000 a year

Frog
200 a year

Hare
12 a year

Large Cat (Puma)
2 a year

Chimpanzee
1 every 5 years

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