

## Interactions between individuals and their environment shape populations

- A **population** is a group of individuals of a single species that simultaneously occupy the same general area.
- Populations have size and geographical boundaries.
  - The **density** of a population is measured as the number of individuals per unit area.
  - The **dispersion** of a population is the pattern of spacing among individuals within the geographic boundaries.

### Demography: The study of factors that affect the growth and decline of populations

- Additions occur through birth, and subtractions occur through death.
  - **Demography** studies the vital statistics that affect population size.
- Life tables and survivorship curves.
  - A **life table** is an age-specific summary of the survival pattern of a population.
- The best way to construct a life table is to follow a **cohort**, a group of individuals of the same age throughout their lifetime.
  - A graphic way of representing the data is a **survivorship curve**.
  - This is a plot of the number of individuals in a cohort still alive at each age.
  - A Type I curve shows a low death rate early in life (humans).
  - The Type II curve shows constant mortality (squirrels).
  - Type III curve shows a high death rate early in life (oysters).

### The exponential model of population describes an idealized population in an unlimited environment

- We define a change in population size based on the following verbal equation.

$$\text{Change in population size during time interval} = \text{Births during time interval} - \text{Deaths during time interval}$$

- Using mathematical notation we can express this relationship as follows:
  - If  $N$  represents population size, and  $t$  represents time, then  $\Delta N$  is the change in population size and  $\Delta t$  represents the change in time:
    - $\Delta N/\Delta t = B-D$
    - Where  $B$  is the number of births and  $D$  is the number of deaths
  - We can simplify the equation and use  $r$  to represent the difference in per capita birth and death rates.
    - $\Delta N/\Delta t = rN$
    - If  $B = D$  then there is **zero population growth (ZPG)**.
  - Under ideal conditions, a population grows rapidly.
    - **Exponential population growth** is said to be occurring

## The logistic model of population growth incorporates the concept of carrying capacity

- Typically, unlimited resources are rare; therefore indefinite exponential population growth is almost never the case in the real world.
  - Population growth is therefore regulated by **carrying capacity** (K), which is the maximum stable population size a particular environment can support.
- The logistic growth model
  - We can modify our model of population growth to incorporate changes in growth rate as population size reaches a carrying capacity.
  - The **logistic population growth** model incorporates the effect of population density on the rate of increase.
- The graph of this model shows an S-shaped curve.

## Population Limiting Factors

- **Density-dependent** factors increase their affect on a population as population density increases.
  - This is a type of **negative feedback**.
- A variety of factors can cause density-dependent limiting factors.
  - Resource limitation in crowded populations can stop population growth by reducing reproduction.
  - Intraspecific competition for food can also cause density-dependent behavior of populations.
  - Territoriality, defense of a space, may set a limit on density.
  - Predation may also be a factor because it can cause mortality of prey species.
  - Waste accumulation is another component that can regulate population size.
    - In wine, as yeast populations increase, they make more alcohol during fermentation.
    - However, yeast can only withstand an alcohol percentage of approximately 13% before they begin to die.
  - Disease can also regulate population growth, because it spreads more rapidly in dense populations.
- **Density-independent** factors are unrelated to population density, and there is no feedback to slow population growth.
  - Storms, earthquakes, frost, and volcano eruptions are all examples of density-independent factors.