

国外动物学38-

Ecology

- **Ecology** investigates the interactions among organisms and between organisms and their environment.

Hierarchy of Ecology

- **Organism** level studies focus on individuals.
  - Physiological or behavioral ecology
- **Population** level studies examine groups of **conspecific** organisms living in a particular area.

Hierarchy of Ecology

- **Community** level studies investigate interactions between the populations of various species in an area.
  - **Species diversity** - # of different species
  - Interactions – predation, parasitism, competition, symbiotic associations.
- **Ecosystem** level studies examine how a community interacts with the physical environment.

Environment and Niche

- An animal's **environment** includes all of the conditions that affects survival and reproduction.
  - **Abiotic** factors (nonliving) – soil, air, water, sunlight, temperature, pH etc.
  - **Biotic** factors (living) – food items, predators, parasites, competitors, mates, hosts etc.

Environment and Niche

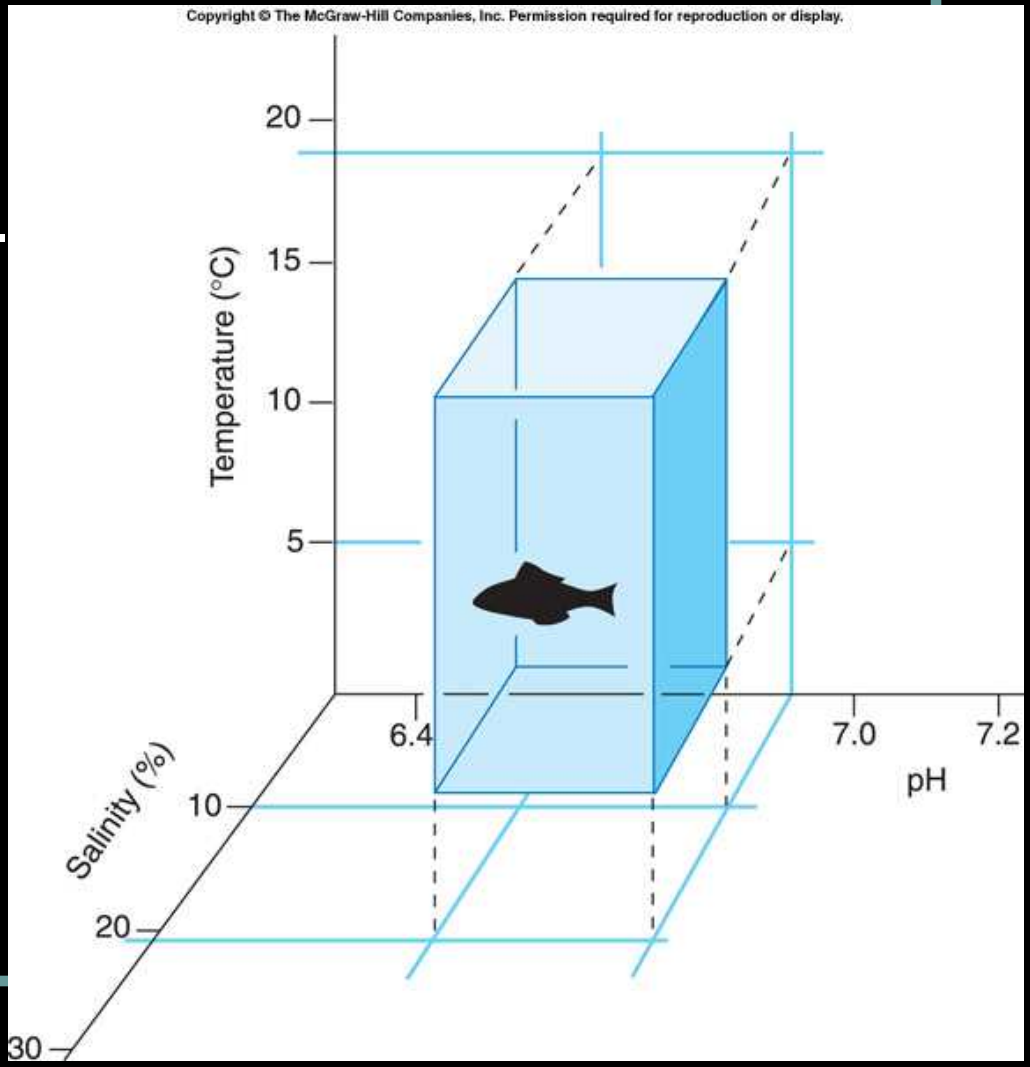
- Environmental factors that are directly utilized by an animal are **resources**.
  - Space (nonexpendable)
  - Food (expendable)

Environment and Niche

- An animal's **habitat** is the space where it lives.
  - Size is variable
    - Rotten log is a habitat for carpenter ants.
    - Forest & adjacent meadow is a habitat for deer.

Environment and Niche

- The habitat must meet the requirements for life.
  - Temp, salinity, pH etc.
  - The unique multidimensional relationship of a species with its environment is its **niche**.

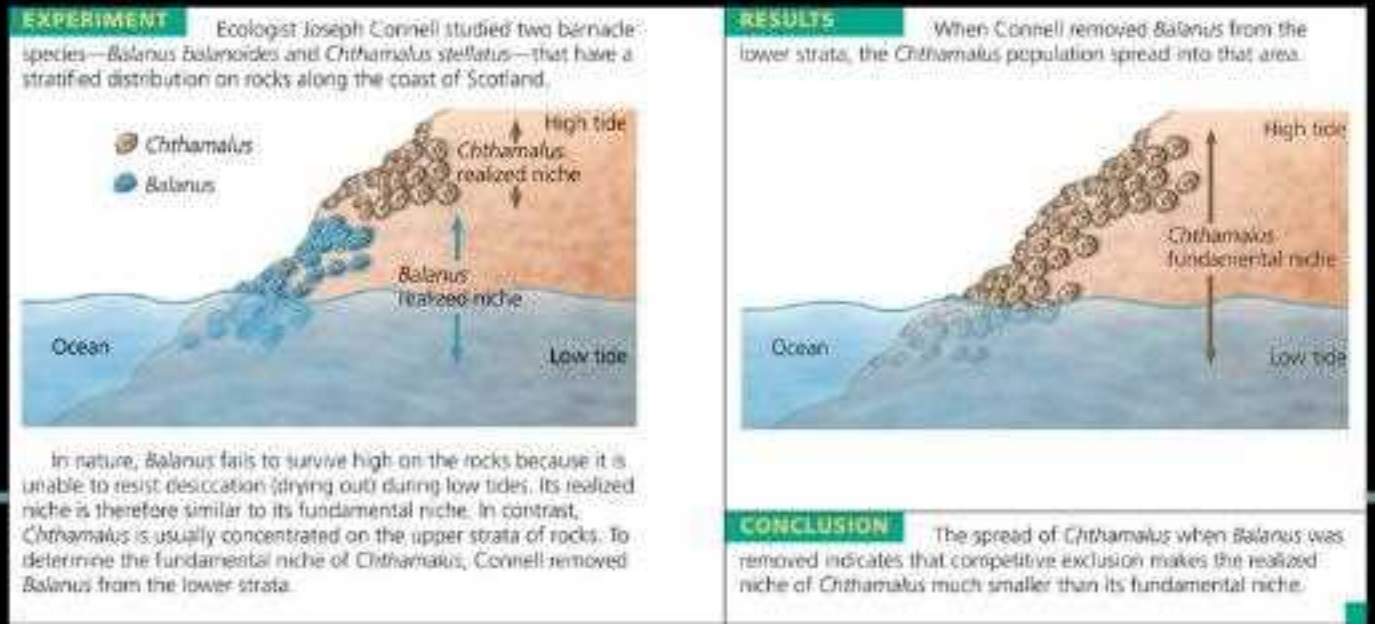


Environment and Niche

- **Generalists** can withstand a variety of environmental conditions.
- **Specialists** can only tolerate a narrow range.

Environment and Niche

- The **fundamental niche** describes the total potential role that an organism could fill under ideal circumstances.
- The **realized niche** describes the actual role an organism fills.
  - Subset of the fundamental niche.
  - Affected by competition



Population Ecology

- **Population ecology** is the study of populations in relation to environment, including environmental influences on population density and distribution, age structure, and variations in population size.

Populations

- A **population** is a reproductively interactive group of animals of a single species.
  - A few individuals may migrate between populations.
    - Adds gene flow
    - Prevents speciation.
  - Numerous small populations may be connected in this way.
    - **Metapopulation**

Life Tables

- A **life table** is an age-specific summary of the survival pattern of a population.
  - Life tables usually follow the fate of a **cohort** – a group of individuals of the same age – from birth until all have died.

Table 52.1 Life Table for Belding's Ground Squirrels (*Spermophilus beldingi*) at Tioga Pass, in the Sierra Nevada Mountains of California*

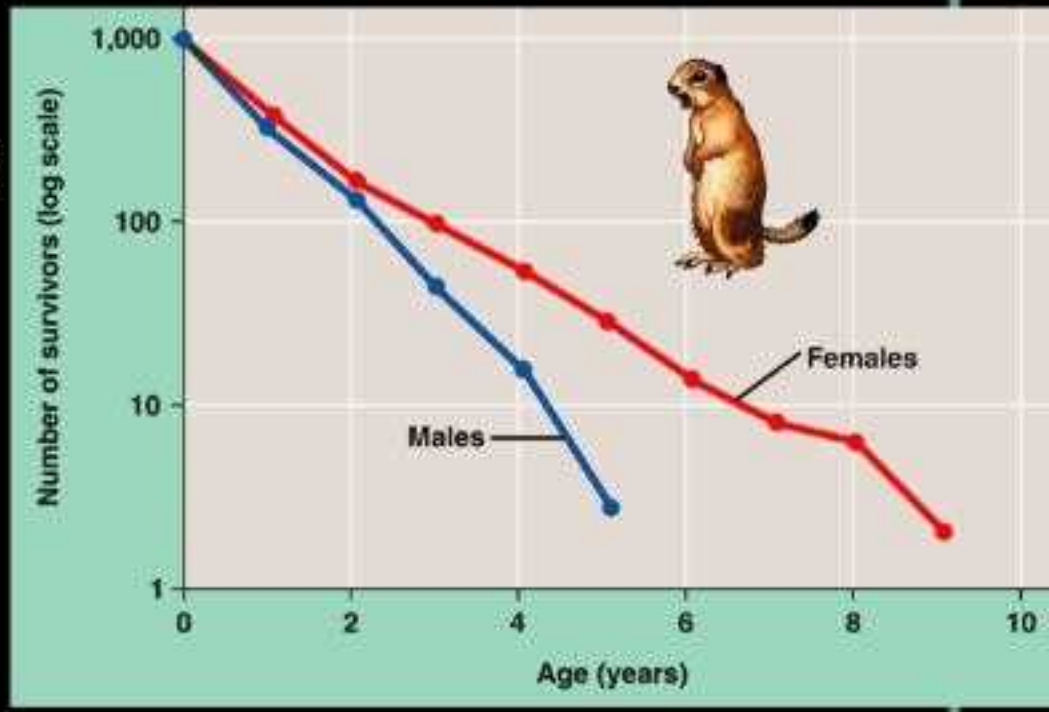
	FEMALES					MALES				
Age (years)	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate†	Average Additional Life Expectancy (years)	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate†	Average Additional Life Expectancy (years)
0–1	337	1.000	207	0.61	1.33	349	1.000	227	0.65	1.07
1–2	252‡	0.589	125	0.50	1.36	248‡	0.550	140	0.56	1.12
2–3	127	0.297	60	0.47	1.60	108	0.152	74	0.69	0.93
3–4	67	0.156	32	0.48	1.50	34	0.080	23	0.68	0.89
4–5	35	0.054	16	0.46	1.56	11	0.015	9	0.82	0.66
5–6	19	0.020	10	0.53	1.50	2	0.003	0	0.00	0.50
6–7	9	0.014	4	0.44	1.61	0				
7–8	5	0.008	1	0.20	1.50					
8–9	4	0.006	3	0.75	0.75					
9–10	1	0.002	1	1.00	0.50					

*Males and females have different mortality schedules, so they are tallied separately.
†The death rate is the proportion of individuals dying in the specific time interval.
‡Includes 122 females and 129 males first captured as two-year-olds and therefore not included in the count of squirrels age 0–1

Source: Data from P. W. Sherman and M. L. Morton, "Demography of Belding's ground squirrel," Ecology 65(1984): 1617–1628.

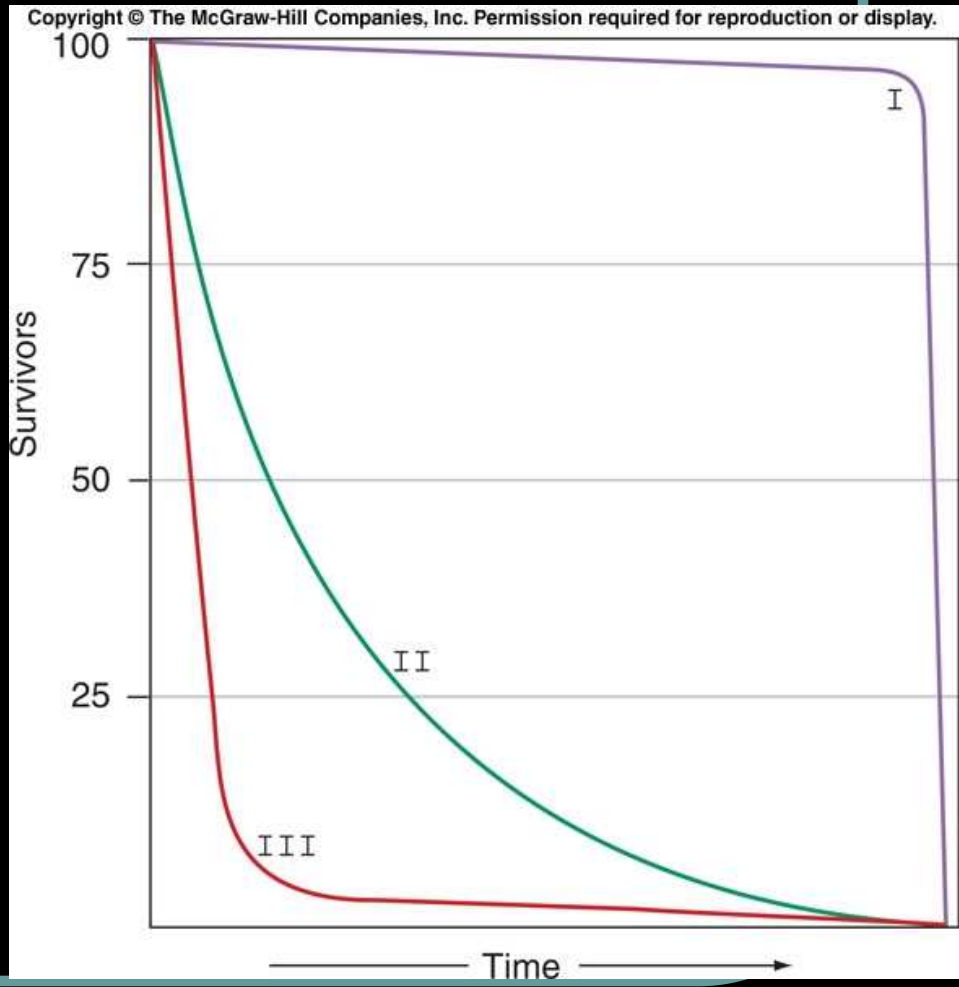
Survivorship Curves

- A **survivorship curve** is a graphic way of representing the data in a life table.
- The survivorship curve for Belding's ground squirrels shows that the death rate is relatively constant.



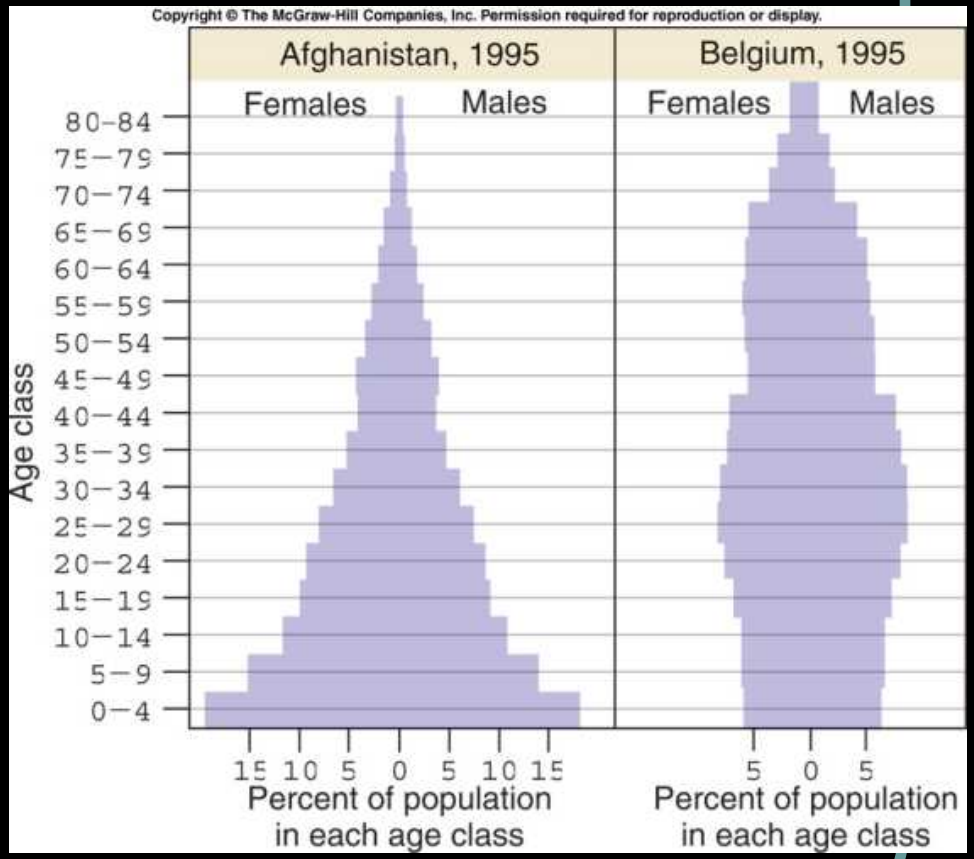
Survivorship Curves

- **Survivorship curves** can be classified into three general types
  - **Type I** – high survival early in life indicates parental care of fewer offspring.
  - **Type II** – constant death rate over life span
  - **Type III** – drops sharply at start indicating high death rate for young; lots of young, no care.



Age Structure

- Populations that contain multiple cohorts exhibit **age structure**.
  - More individuals in the younger cohorts indicates a growing population.



Life History Diversity

- Species that exhibit **semelparity**, or "big-bang" reproduction reproduce a single time and die.
  - Salmon
  - Agave
  - Favored in unpredictable climates.



Life History Diversity

- Species that exhibit **iteroparity**, or repeated reproduction, produce offspring repeatedly over time.
  - Lizards often start reproducing during their second year and will produce eggs every year of their lives.
  - Favored in more predictable environments.

Population Growth

- It is useful to study population growth in an idealized situation in order to understand the capacity of species for increase and the conditions that may facilitate this type of growth.

Population Growth

- If immigration and emigration are ignored, a population's **growth rate** equals birth rate minus death rate.

Population Growth

- **Zero population growth** occurs when the birth rate equals the death rate.
- The **population growth equation** can be expressed as:

$$\frac{dN}{dt} = rN$$

Exponential Growth

- **Exponential population growth** is population increase under idealized conditions.
  - Unlimited resources.
- Under these conditions, the rate of reproduction is at its maximum, called the **intrinsic rate of increase (r_{max}).**

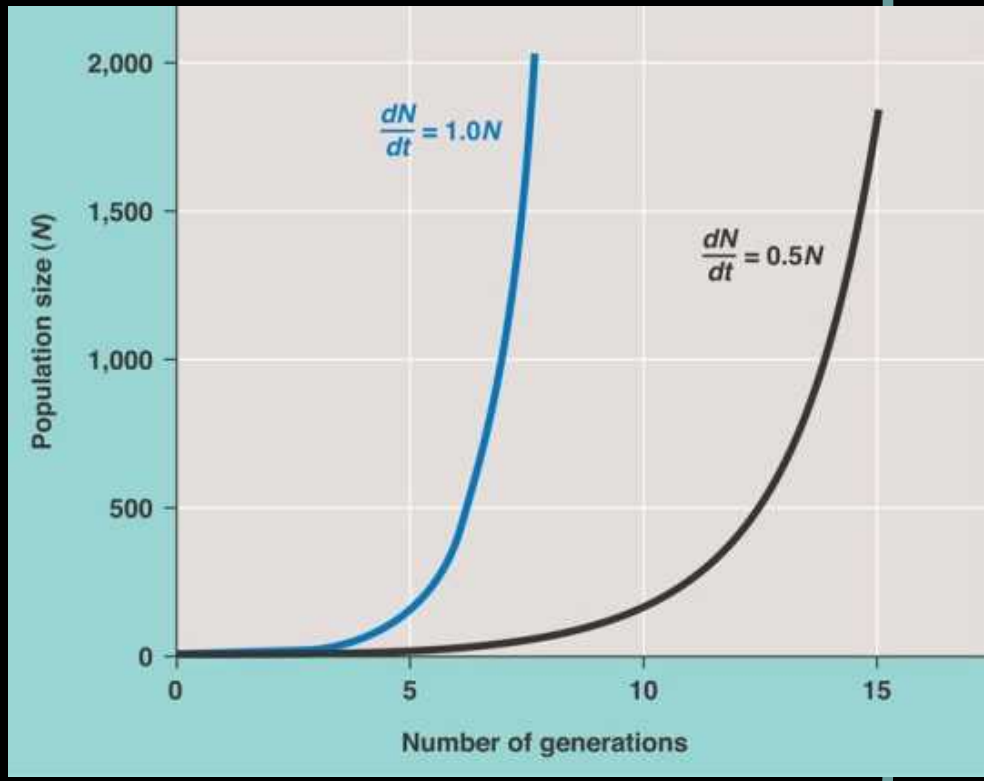
Exponential Growth

- The equation of **exponential population growth** is:

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

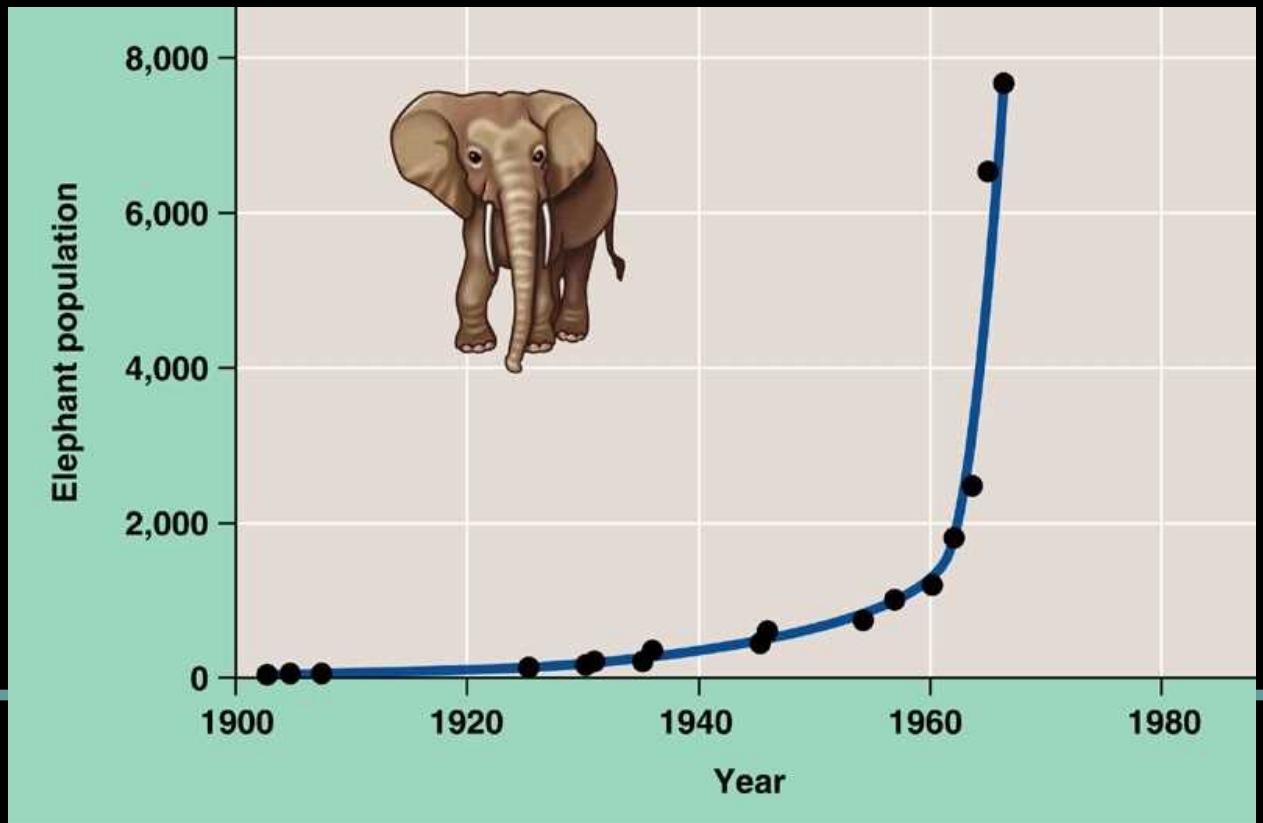
Exponential Growth

- Exponential population growth results in a **J-shaped curve**.



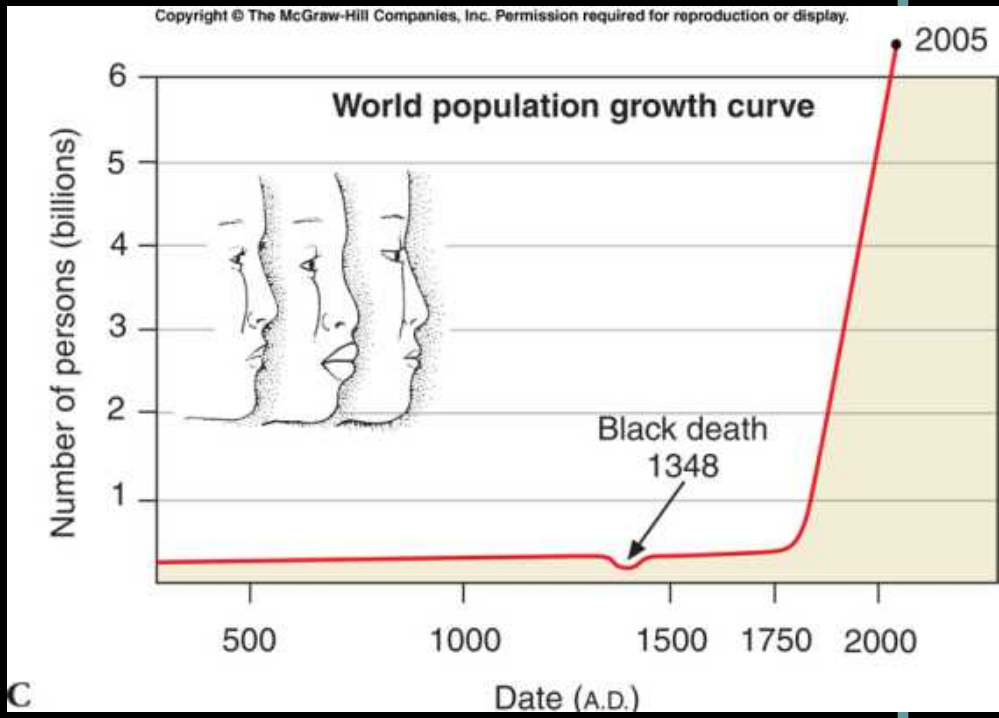
Exponential Growth

- The J-shaped curve of exponential growth is characteristic of some populations that are rebounding.



Exponential Growth

- The global human population has been in exponential growth for a long time.
- At what point will we surpass the carrying capacity for our planet?



Logistic Growth

- Exponential growth cannot be sustained for long in any population.
  - Depends on unlimited resources.
  - In reality, there are one or more **limiting resources** that prevent exponential growth.

Logistic Growth

- A more realistic population model limits growth by incorporating **carrying capacity**.
- **Carrying capacity (K)** is the maximum population size the environment can support.

The Logistic Growth Model

- In the **logistic growth model**, the per capita rate of increase declines as carrying capacity is reached.

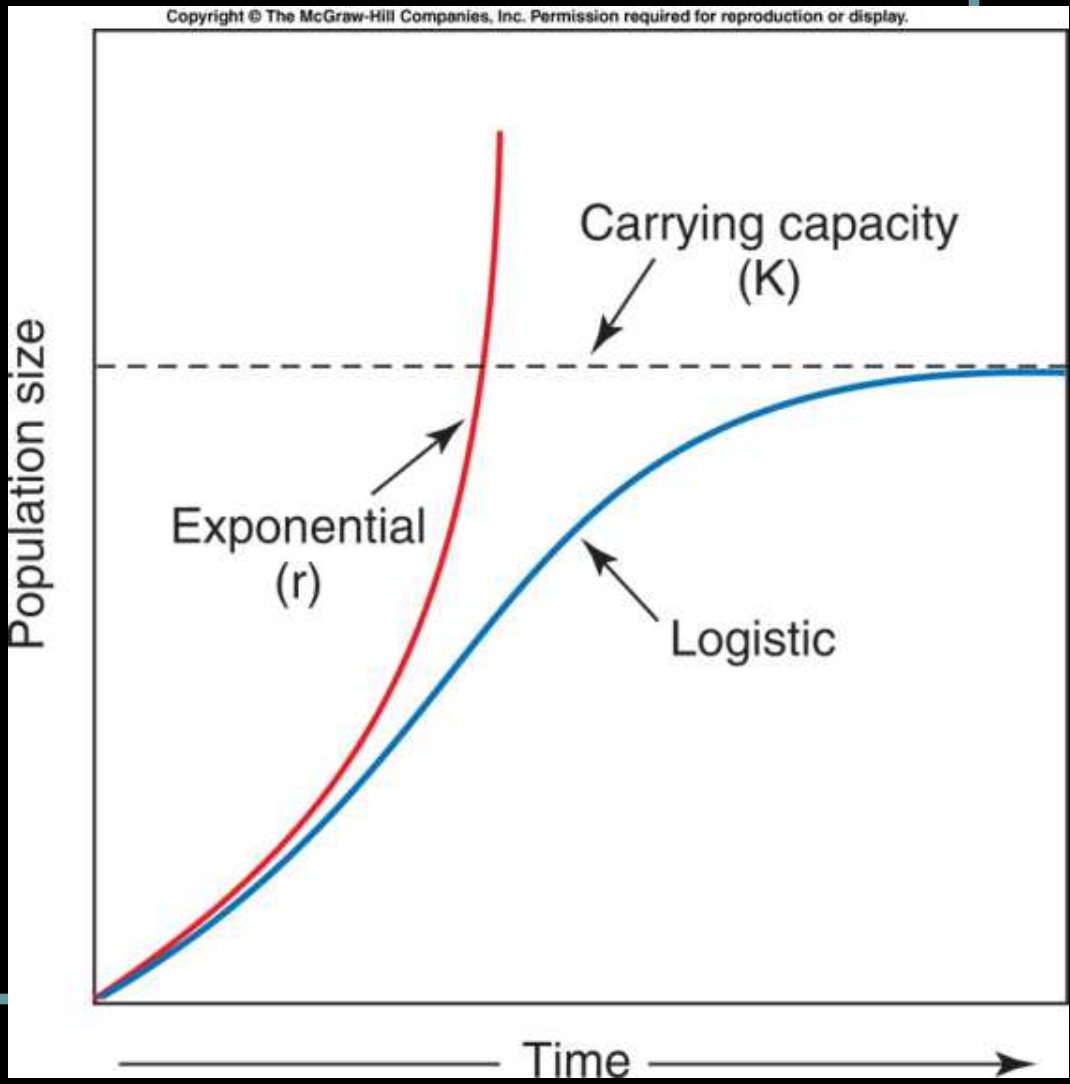
The Logistic Growth Model

- The logistic growth equation includes K, the carrying capacity.

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

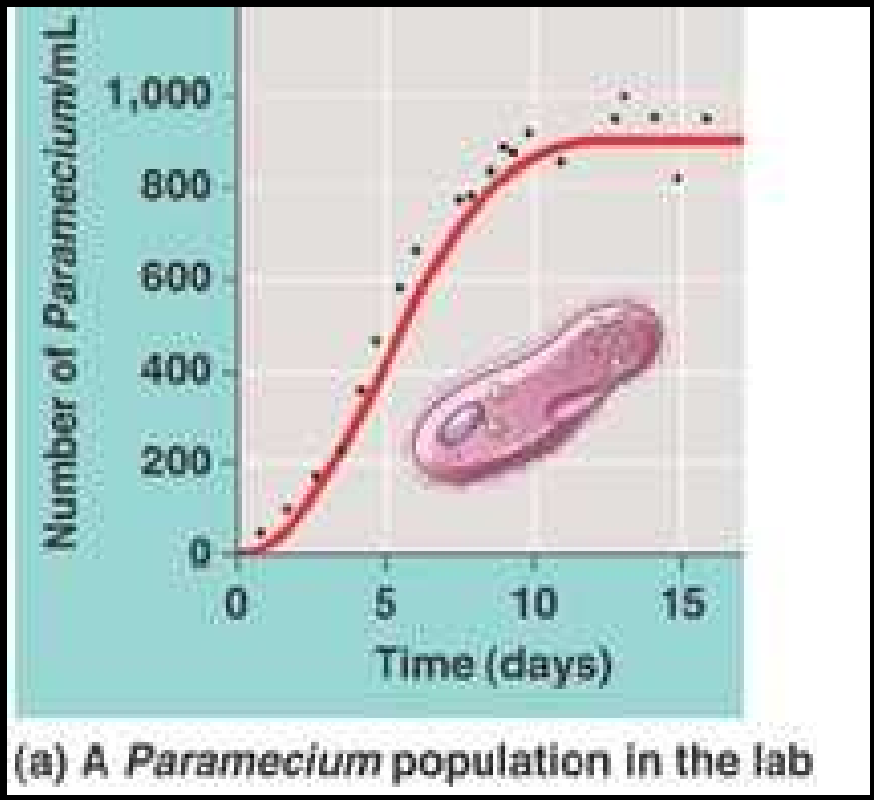
The Logistic Growth Model

- The logistic model of population growth produces an **S-shaped curve**.



The Logistic Model and Real Populations

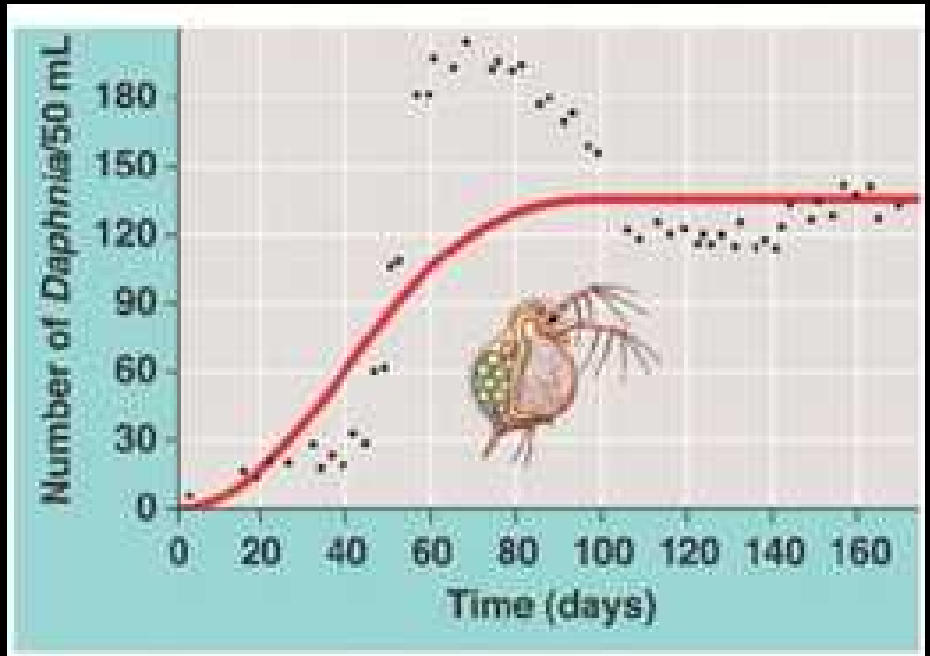
- The growth of laboratory populations of *Paramecia* fits an S-shaped curve.



(a) A *Paramecium* population in the lab

The Logistic Model and Real Populations

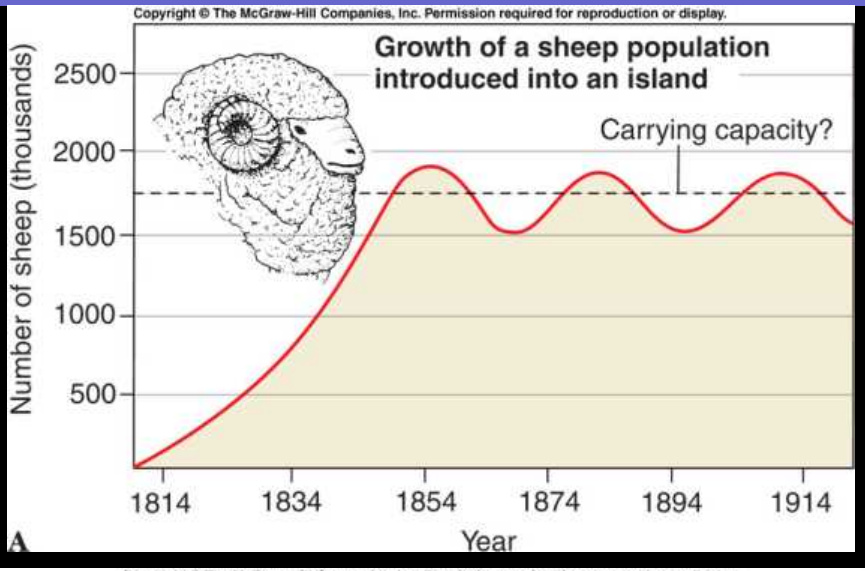
- Some populations overshoot K before settling down to a relatively stable density.

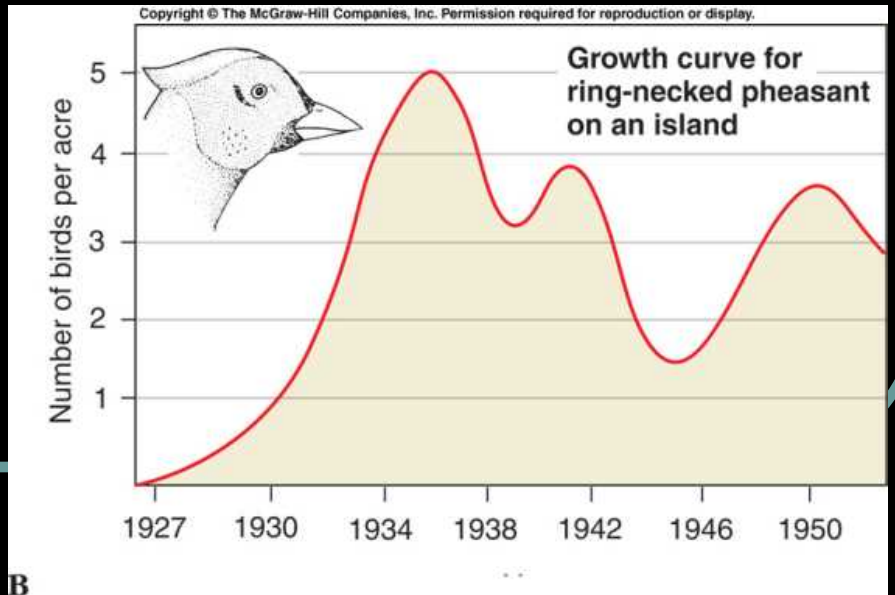


(b) A *Daphnia* population in the lab

The Logistic Model and Real Populations

- Some populations fluctuate greatly around K.





The Logistic Model and Real Populations

- The logistic model fits few real populations, but is useful for ***estimating*** possible growth.

The Logistic Model and Life Histories

- Life history traits favored by natural selection may vary with population density and environmental conditions.

K and r Selection

- **K-selection**, or density-dependent selection, selects for life history traits that are sensitive to population density.
  - Few, but larger offspring, parental care.
- **r-selection**, or density-independent selection, selects for life history traits that maximize reproduction.
  - Many small offspring, no parental care.

Extrinsic Limits to Growth

- What environmental factors stop a population from growing?
- Why do some populations show radical fluctuations in size over time, while others remain stable?

Extrinsic Limits to Growth

- Abiotic limiting factors such as a storm or a fire are **density-independent** – their effect does not change with population density.
- Biotic factors such as competition or predation or parasitism act in a **density-dependent** way – the effect does change with population density.

Community Ecology

- **Community ecology** examines the interactions among the various populations in a community.

Interactions

- Populations of animals that form a community can interact in various ways.
  - Beneficial for one, negative for the other
    - **Predation, Parasitism, Herbivory**

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