Population Dynamics, Carrying Capacity, and Conservation Biology

Population Dynamics -

changes in populations as a result of

- environmental stress and,
- changes in environmental conditions.

Characteristics of a Population

- **Population** - individuals inhabiting the same area at the same time

- **Population Dynamics:** Population change due to
  - **Population Size** - number of individuals
  - **Population Density** - population size in a certain space at a given time
  - **Population Dispersion** - spatial pattern in habitat
  - **Age Structure** - proportion of individuals in each age group in population

Population Size

- **Natality**
  - Number of individuals added through reproduction
- **Mortality**
  - Number of individuals removed through death

Changes in Population Size: Entrances and Exits

- Populations **increase** through births and immigration (I=into!)

$$\text{Population change} = (\text{Births} + \text{Immigration}) - (\text{Deaths} + \text{Emigration})$$

- Populations **decrease** through deaths and emigration (E=exit!)

Characteristics of a Population

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Population Density

- Population Density (or ecological population density) is the amount of individuals in a population per unit habitat area
  - Some species exist in **high** densities - Mice
  - Some species exist in **low** densities - Mountain lions
- Density depends upon
  - social/population structure
  - mating relationships
  - time of year

Population Density

- *Density-<u>independent</u> population controls*
  - Affect a population's size regardless of its population density.
    - Floods, fires, hurricanes habitat destruction
- *Density-<u>dependent</u> population controls*
  - Factors that have a greater effect as a population's density grows
    - Competition of resources, predation, parasitism, disease

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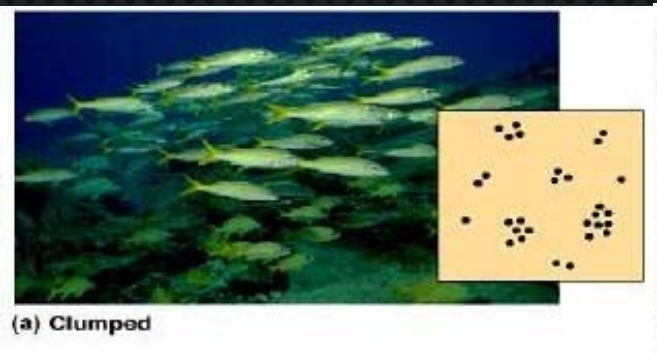
Population Dispersion

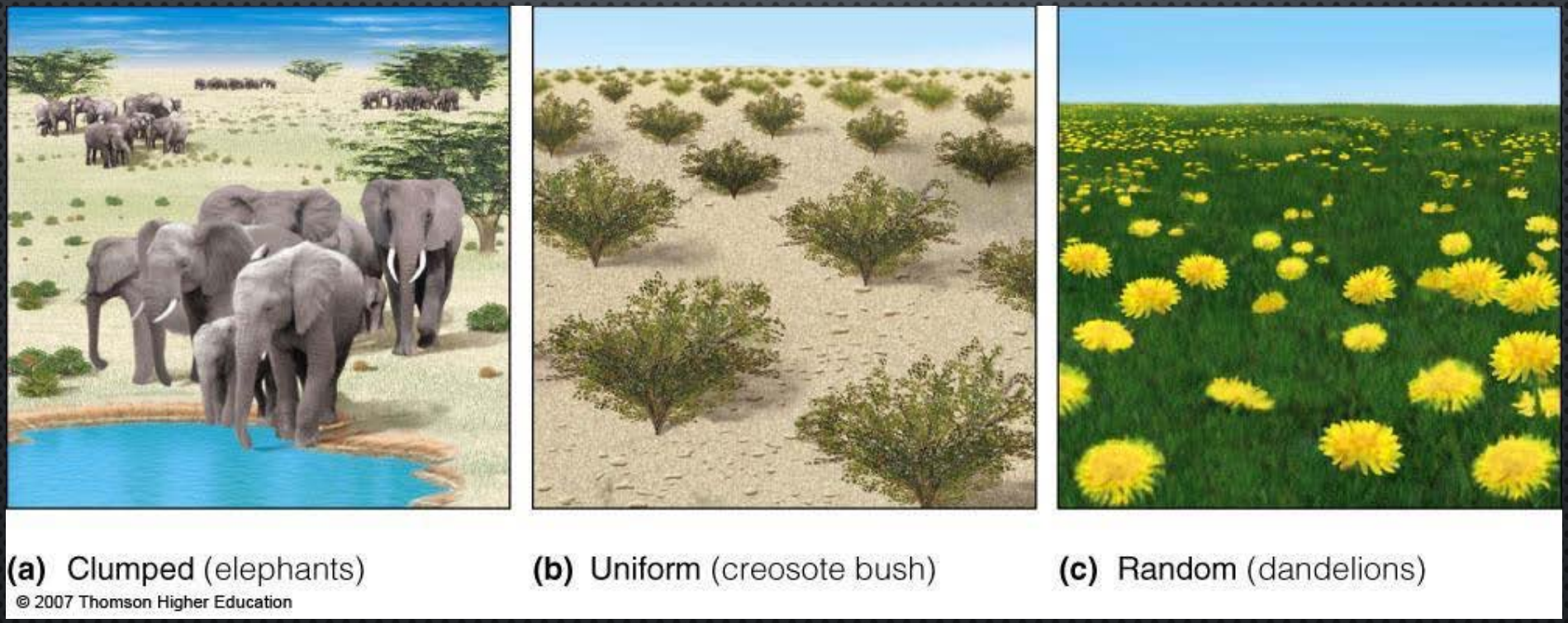
- **Random**
  - No pattern, ex: forest
- **Uniform**
  - Evenly spaced, ex: territorial animals, plants
- **Clumped**
  - Enhances feeding opportunities, protection from predators. Ex: schooling fish, flocking birds, herding mammals


(a) Clumped


(b) Uniform


(c) Random

Dispersion Patterns



- Most populations live in **clumps** although other patterns occur based on resource distribution.

Characteristics of a Population

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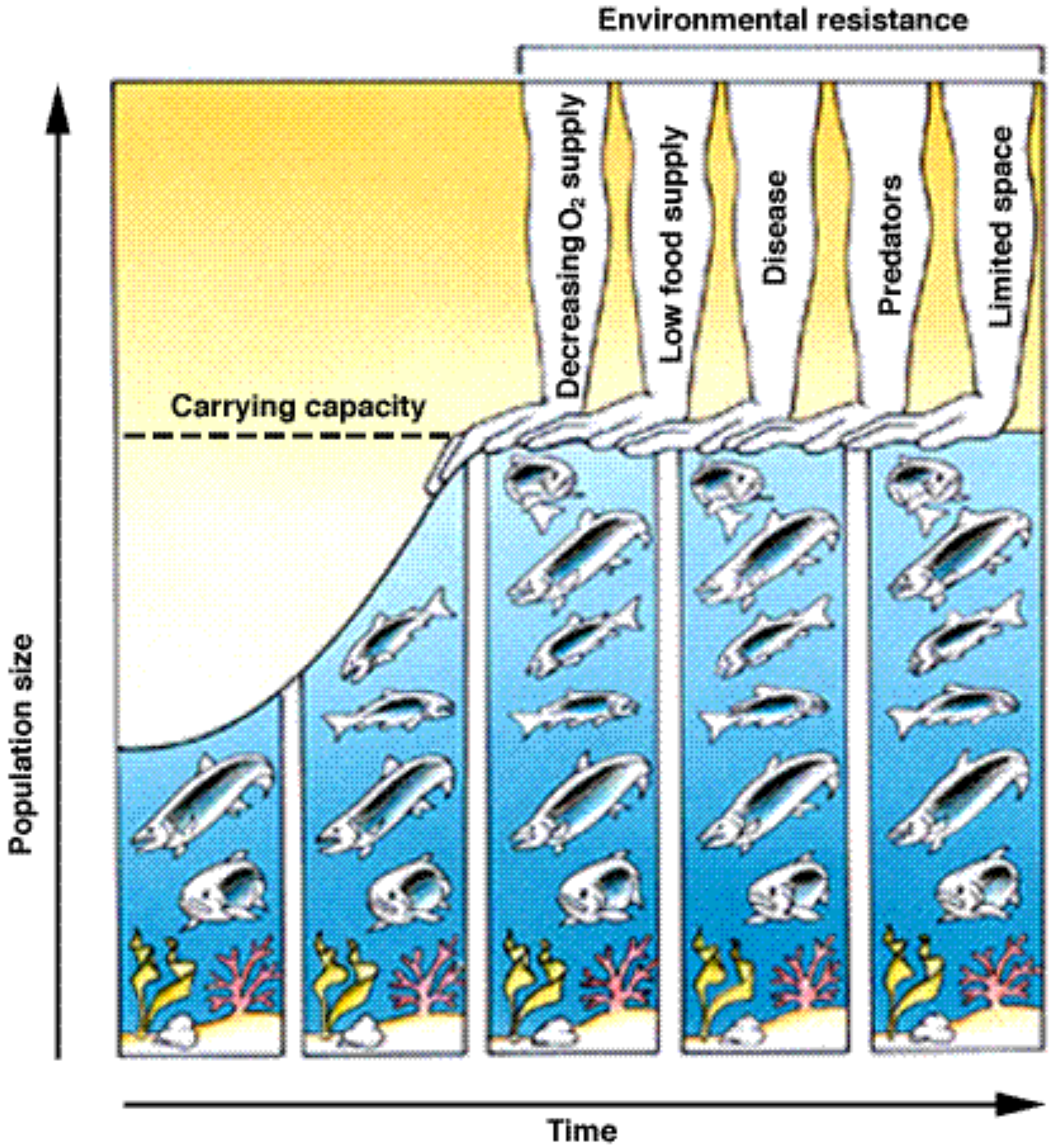
Population Growth

- Populations show two types of growth
  - Exponential
    - J-shaped curve
    - Growth is independent of population density
  - Logistic
    - S-shaped curve
    - Growth is not independent of population density

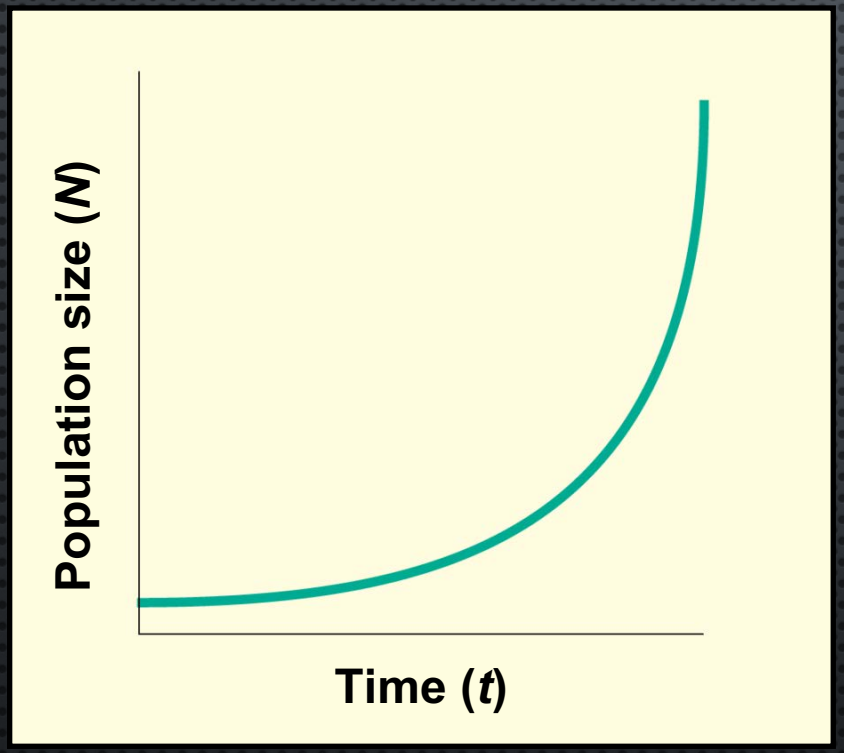
Carrying Capacity (K)

- the number of individuals of a given species that can be sustained indefinitely in a given space.

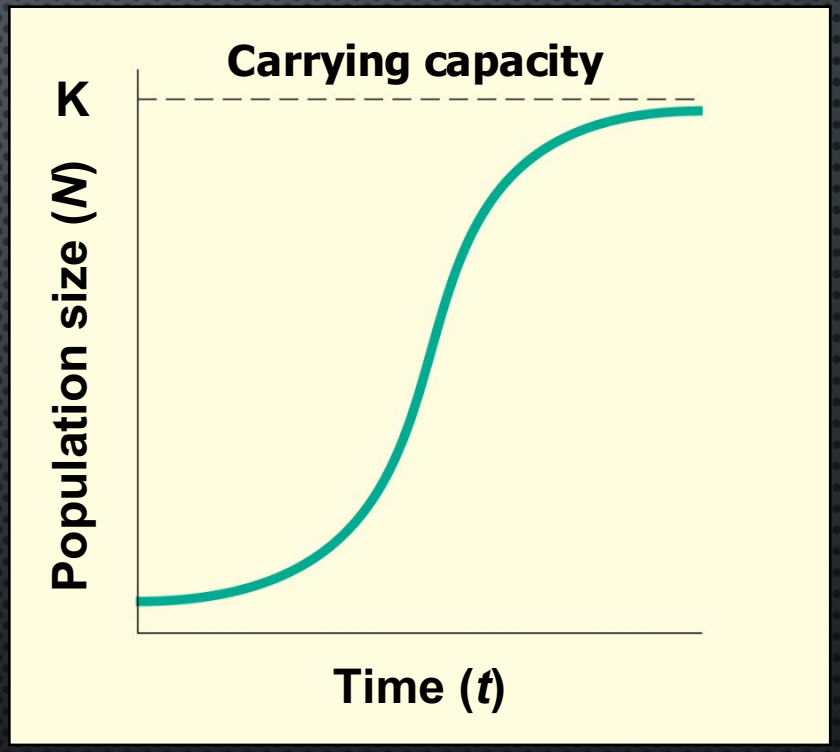
Carrying Capacity



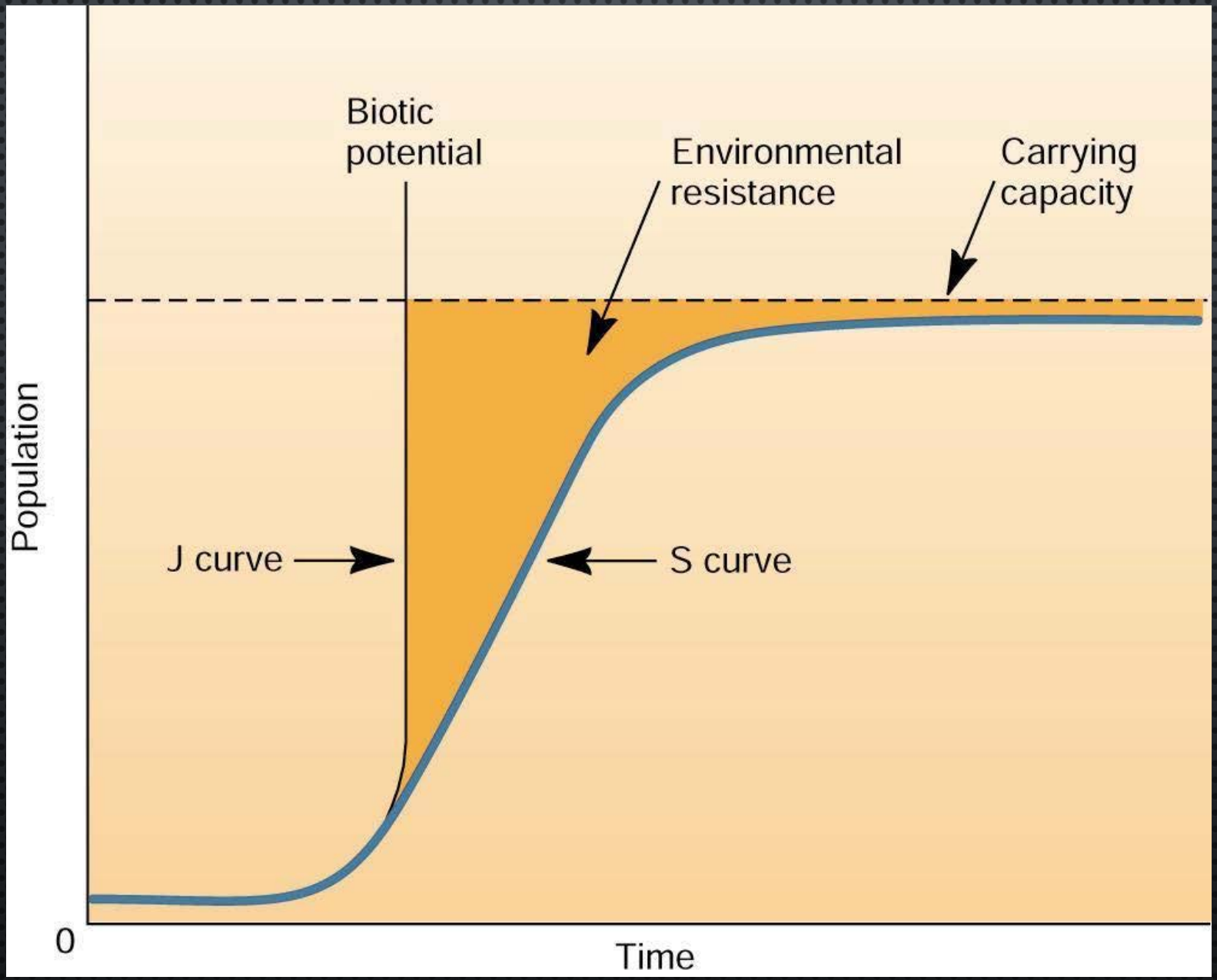
Population Growth Curves



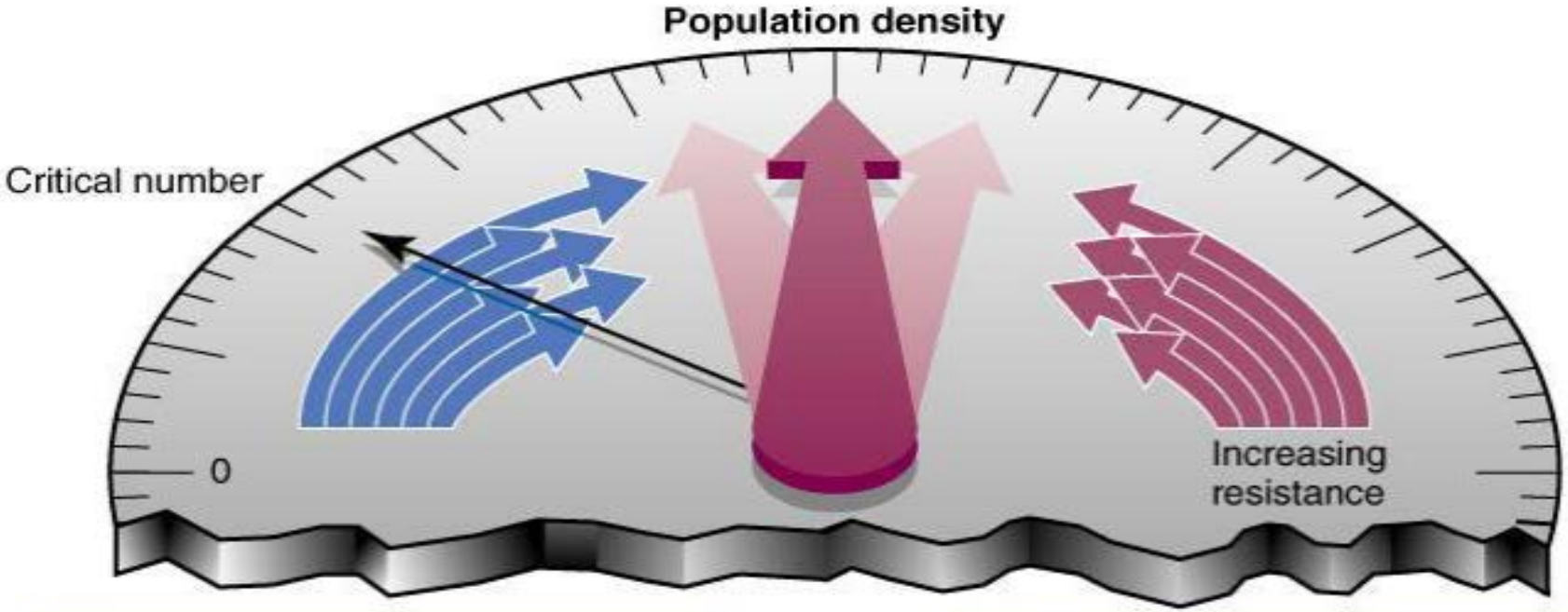
Exponential Growth



Logistic Growth


Biotic
potential
Environmental
resistance
Carrying
capacity
Population
J curve
S curve
0
Time

- **Biotic Potential**
  - factors allow a population to increase under ideal conditions, potentially leading to exponential growth
- **Environmental Resistance**
  - affect the young more than the elderly in a population, thereby affecting recruitment (survival to reproductive age)



Biotic Potential

- Reproductive rate
- Ability to migrate (animals) or disperse (seeds)
- Ability to invade new habitats
- Defense mechanisms
- Ability to cope with adverse conditions

Environmental Resistance

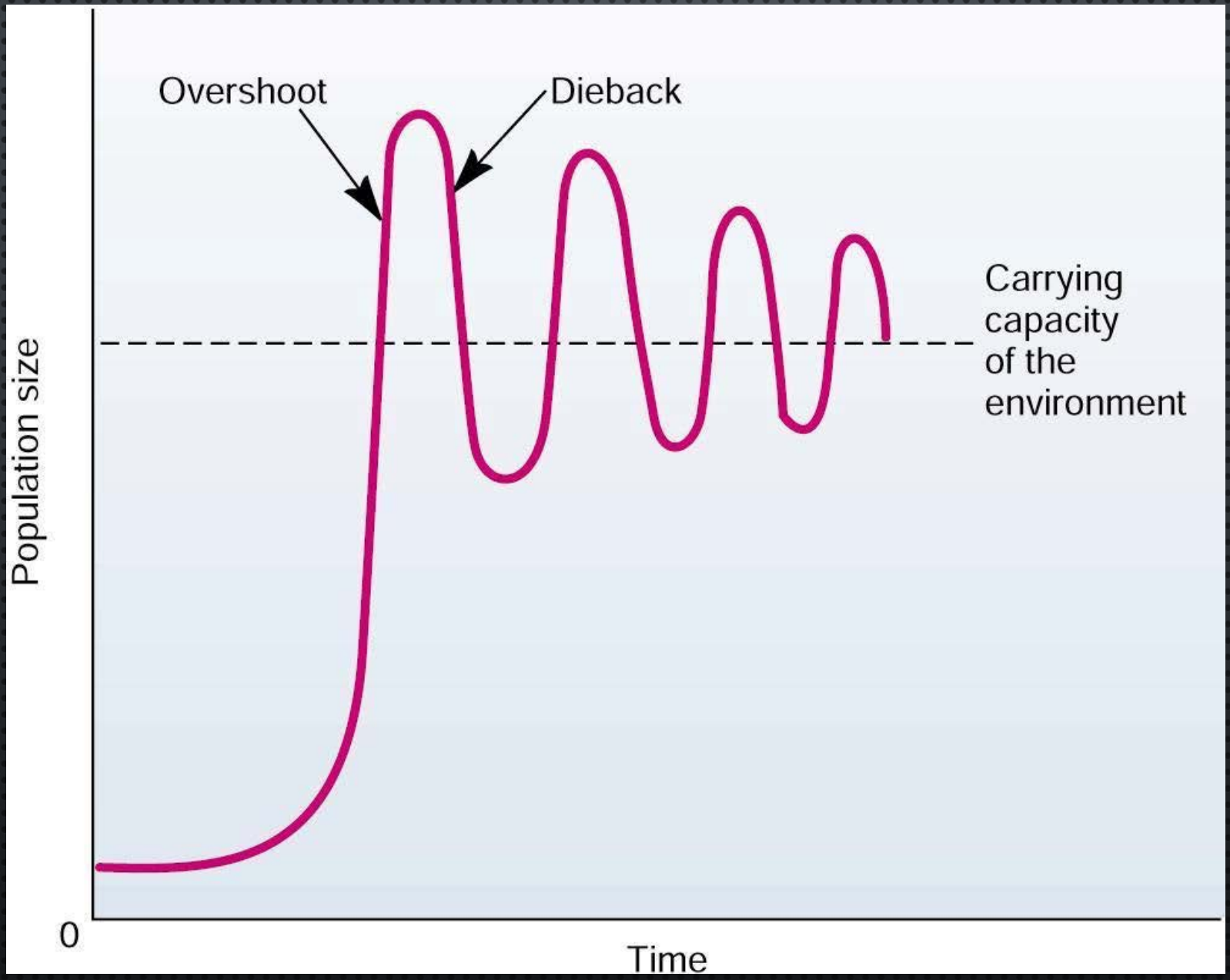
- Lack of food or nutrients
- Lack of water
- Lack of suitable habitat
- Adverse weather conditions
- Predators
- Disease
- Parasites
- Competitors

Biotic Potential

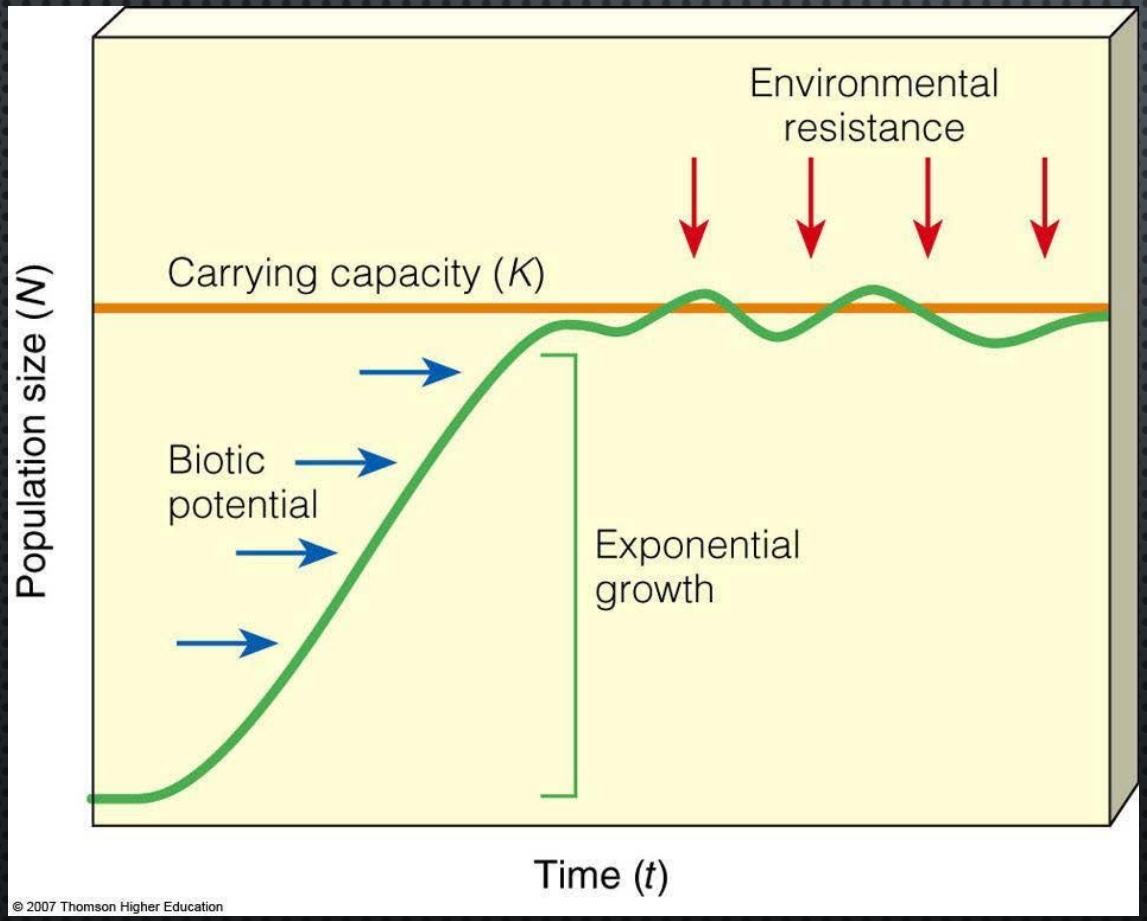
- Ability of populations of a given species to increase in size
  - Abiotic Contributing Factors:
    - Favorable light
    - Favorable Temperatures
    - Favorable chemical environment - nutrients
  - Biotic Contributing Factors:
    - Reproductive rate
    - Generalized niche
    - Ability to migrate or disperse
    - Adequate defense mechanisms
    - Ability to cope with adverse conditions

Environmental Resistance

- Ability of populations of a given species to increase in size
  - Abiotic Contributing Factors:
    - Unfavorable light
    - Unfavorable Temperatures
    - Unfavorable chemical environment - nutrients
  - Biotic Contributing Factors:
    - Low reproductive rate
    - Specialized niche
    - Inability to migrate or disperse
    - Inadequate defense mechanisms
    - Inability to cope with adverse conditions

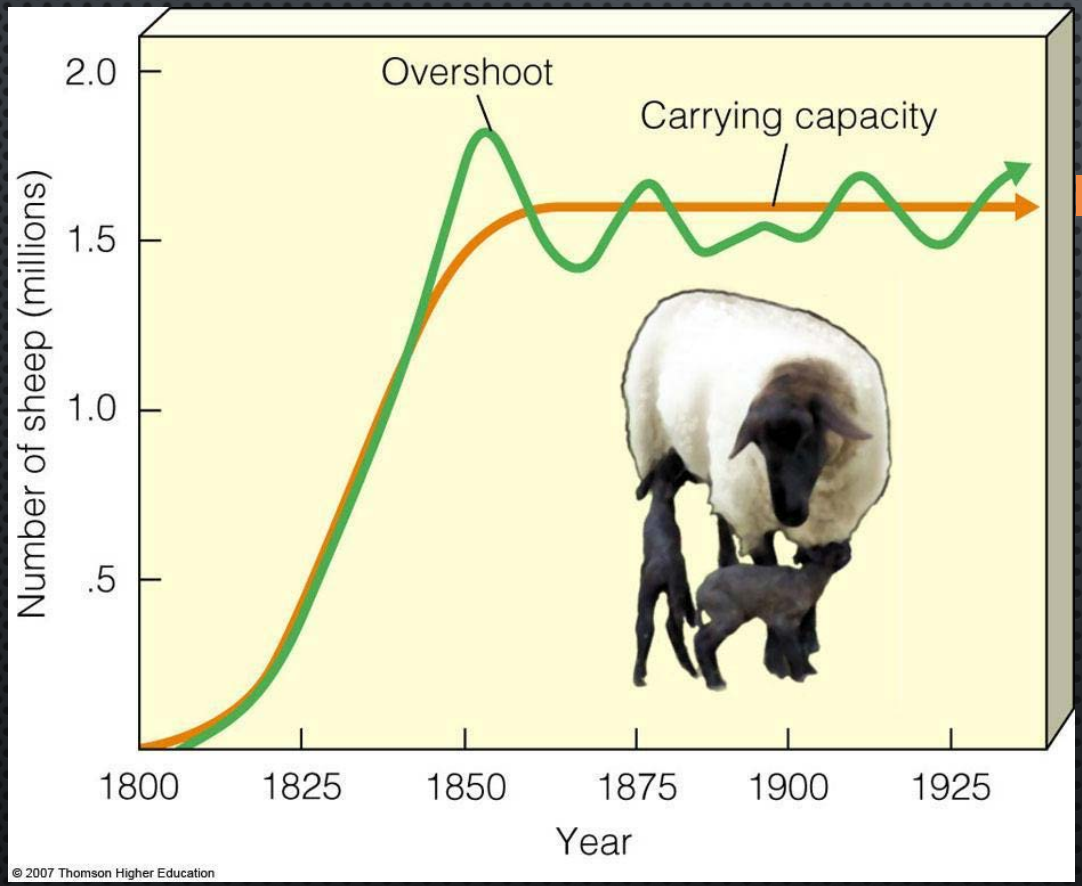

Overshoot
Dieback
Carrying capacity of the environment
Population size
0
Time

Exponential and Logistic Population Growth: J-Curves and S-Curves



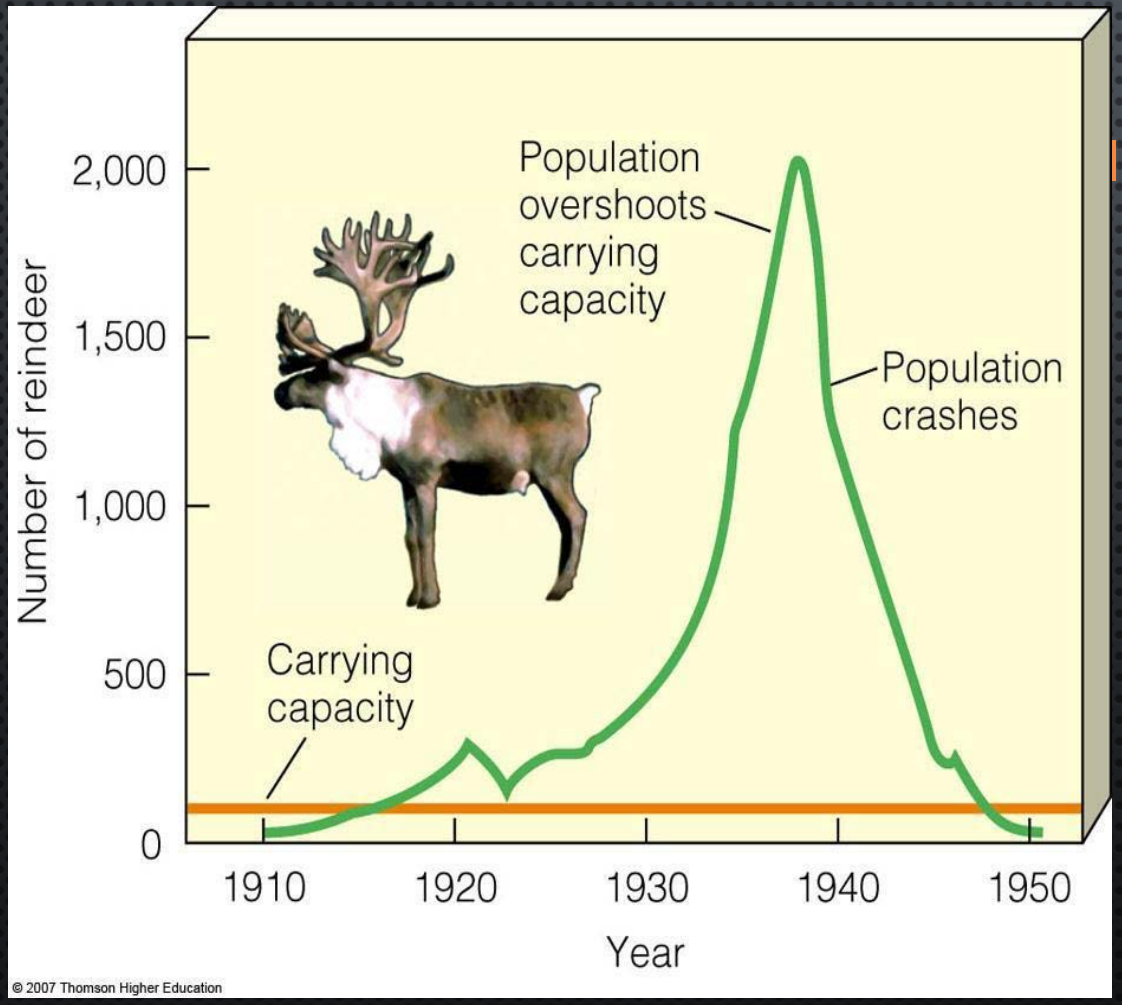
- Populations **grow rapidly with ample resources**, but as resources become limited, its **growth rate slows and levels off**.

Exponential and Logistic Population Growth: J-Curves and S-Curves

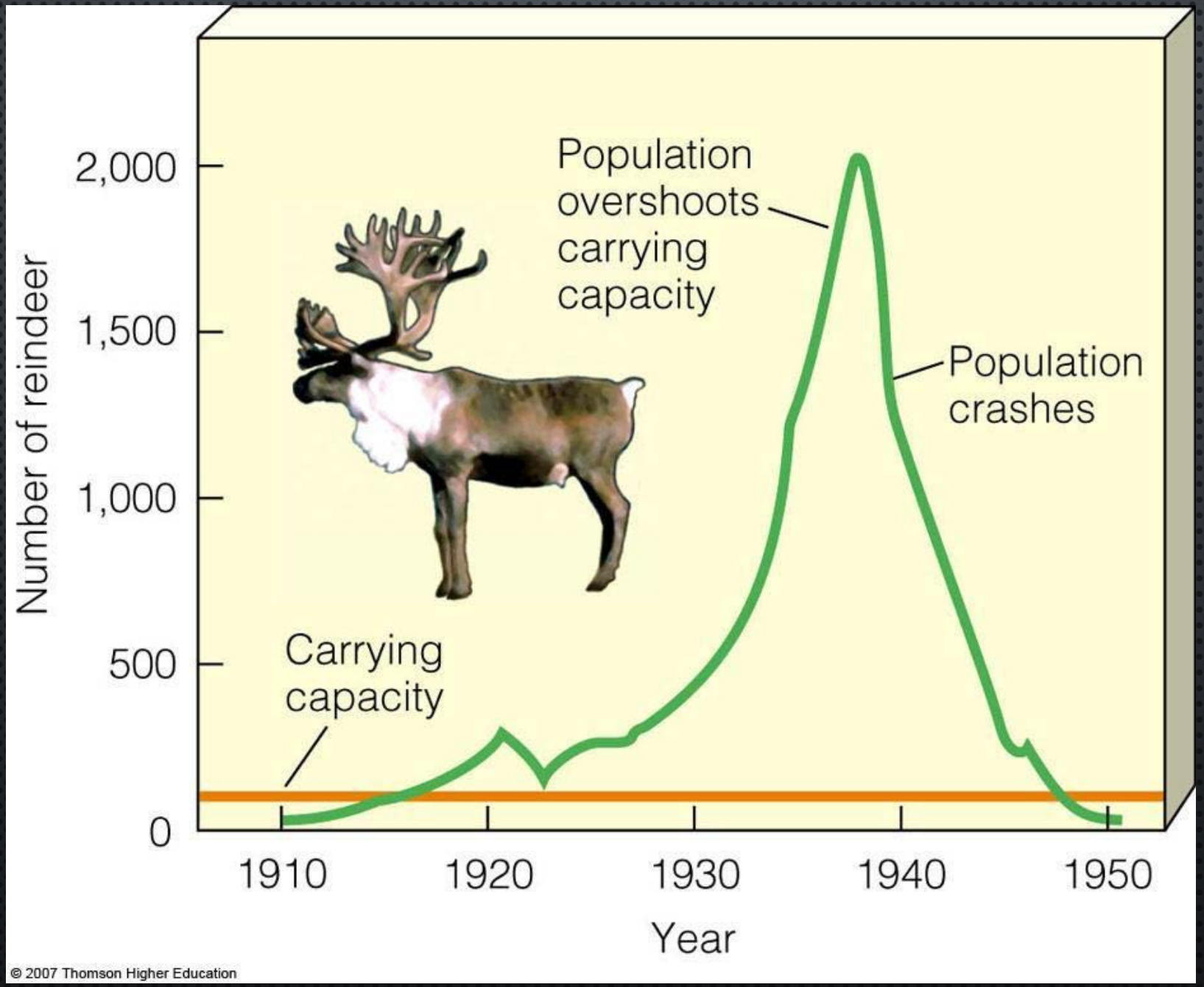


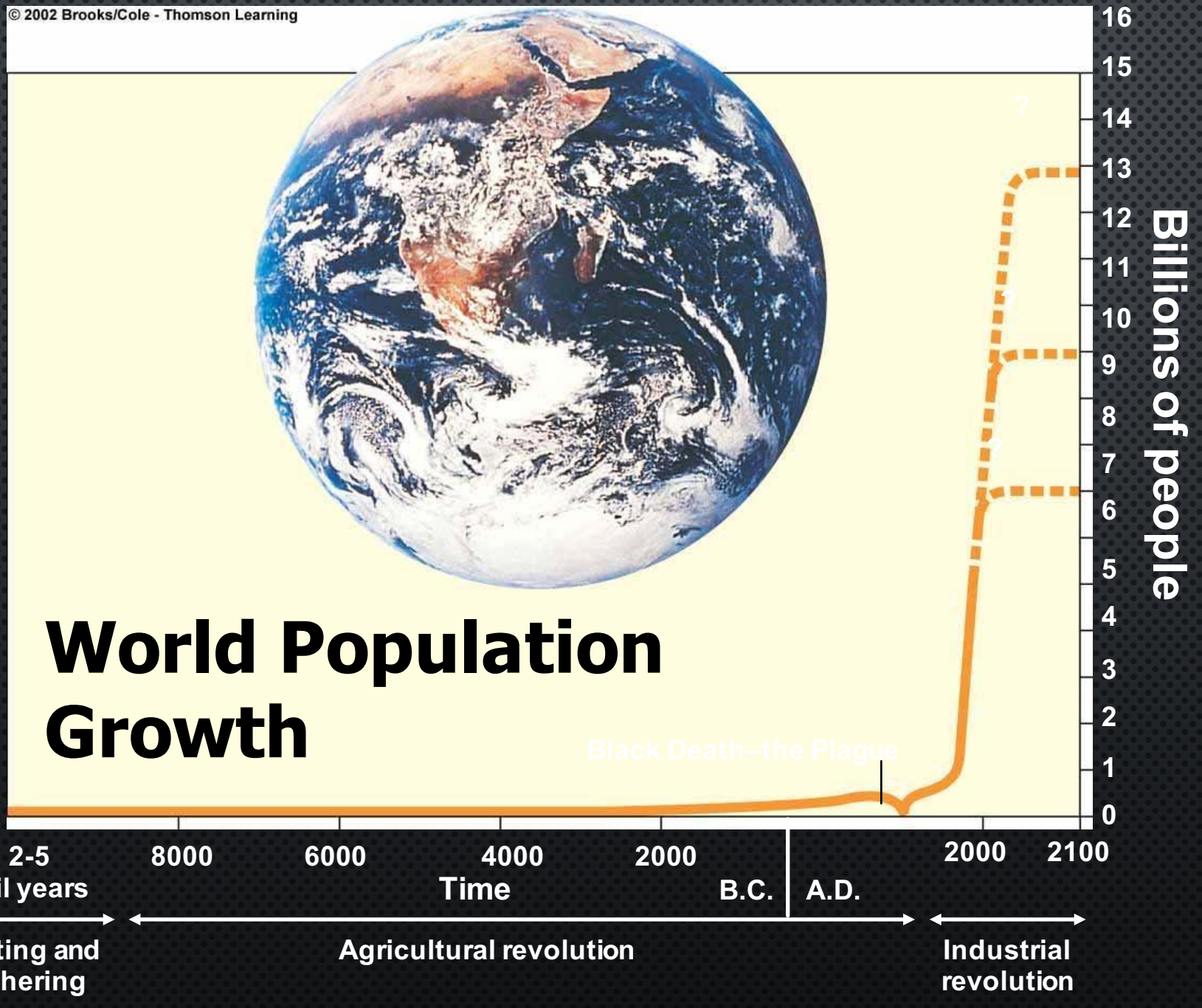
- As a population levels off, it often fluctuates slightly above and below the carrying capacity.

What Happens When Populations Exceed Carrying Capacity



Members of populations which exceed their resources will die unless they adapt or move to an area with more resources.

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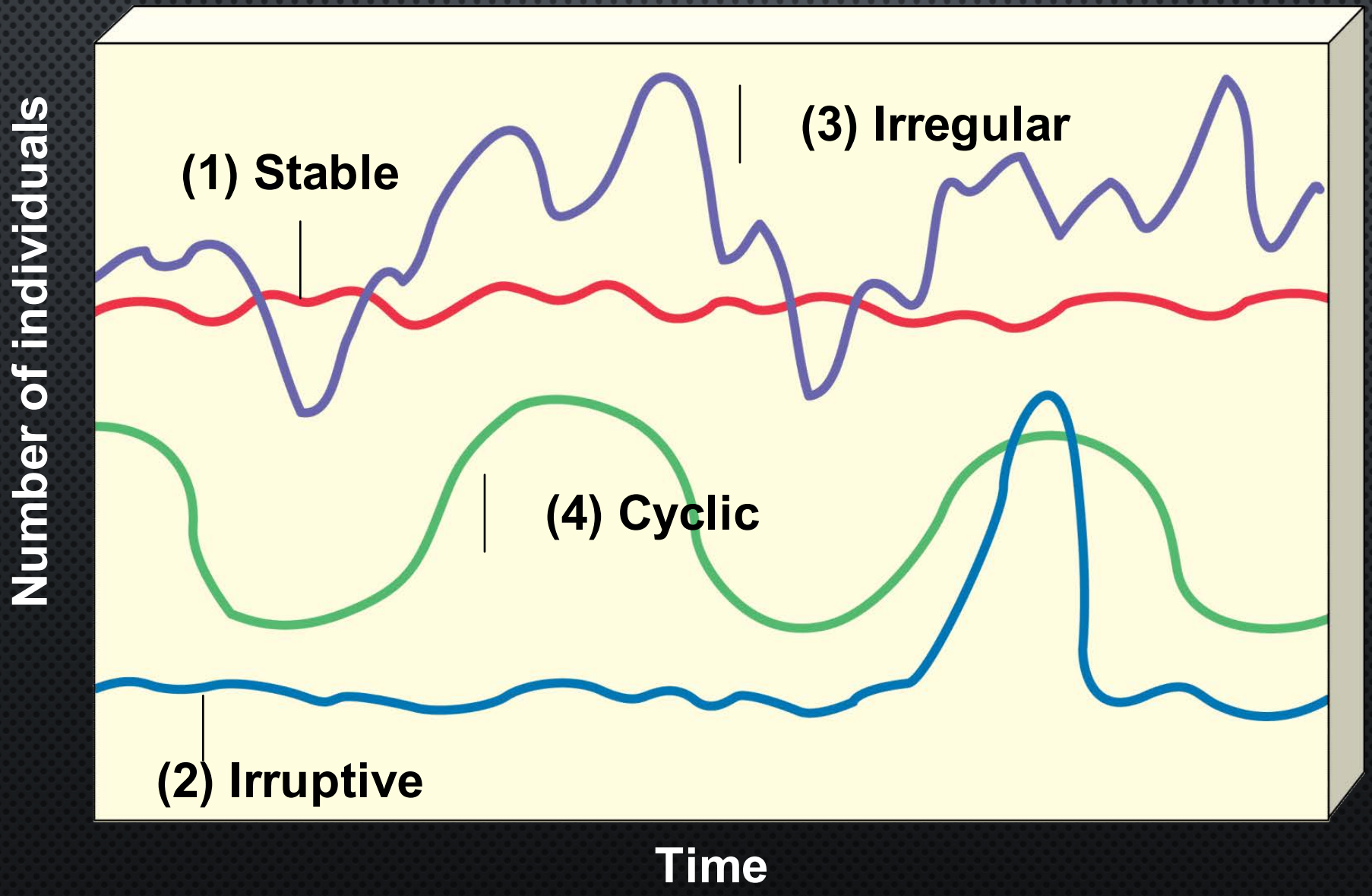
World Population Growth
Billions of people
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
?
?
?
Black Death–the Plague
2-5 Mil years
8000
6000
4000
2000
B.C.
A.D.
2000
2100
Time
Hunting and gathering
Agricultural revolution
Industrial revolution

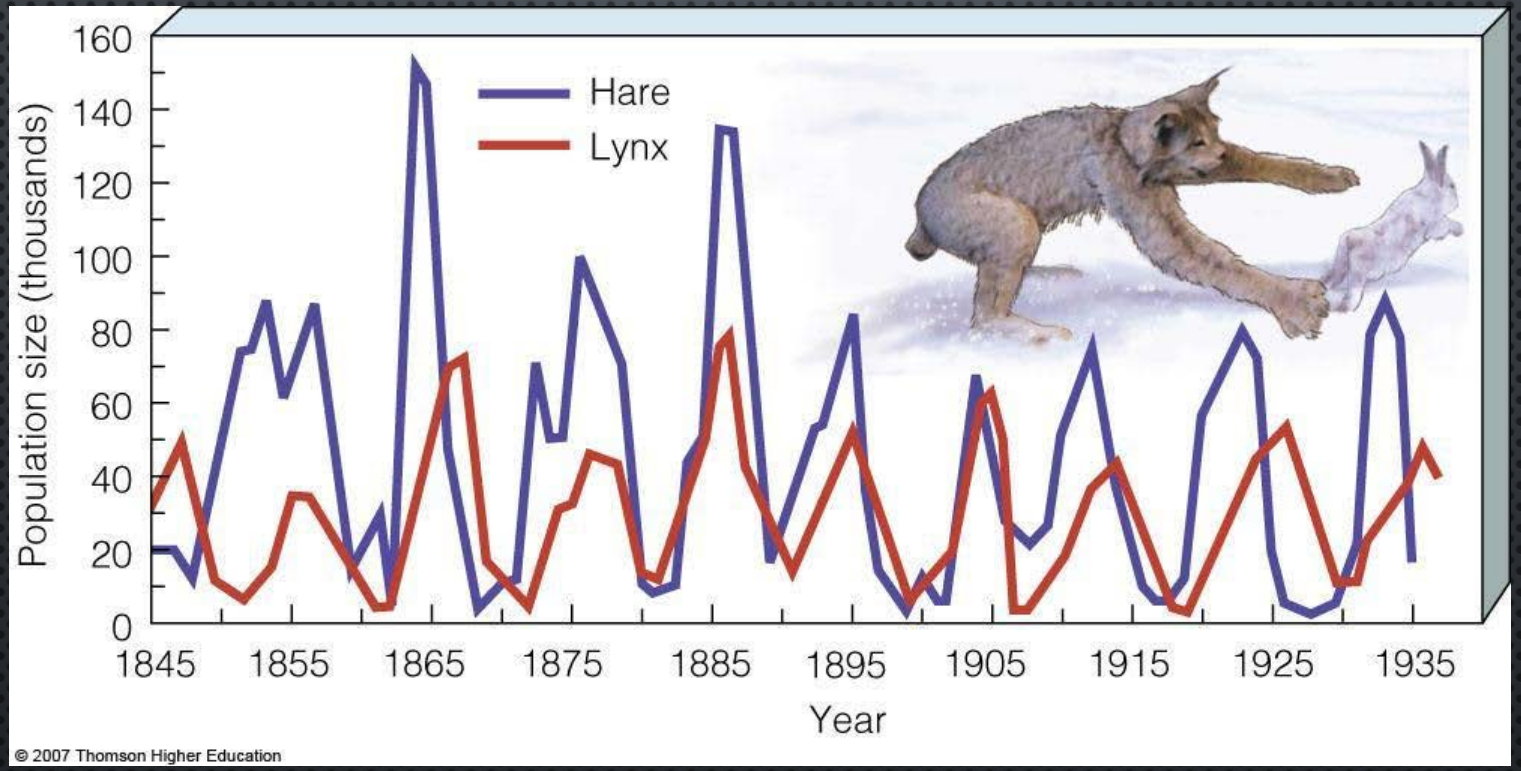
Types of Population Change Curves in Nature

- Population sizes may stay the same, increase, decrease, vary in regular cycles, or change erratically.
  - *Stable*: fluctuates slightly above and below carrying capacity.
  - *Irruptive*: populations explode and then crash to a more stable level.
  - *Cyclic*: populations fluctuate and regular cyclic or boom-and-bust cycles.
  - *Irregular*: erratic changes possibly due to chaos or drastic change.

Simplified Population Change Curves



Types of Population Change Curves in Nature



- Population sizes often vary in regular cycles when the predator and prey populations are controlled by the scarcity of resources. (predator-prey oscillation)

Reproductive Patterns and Survival

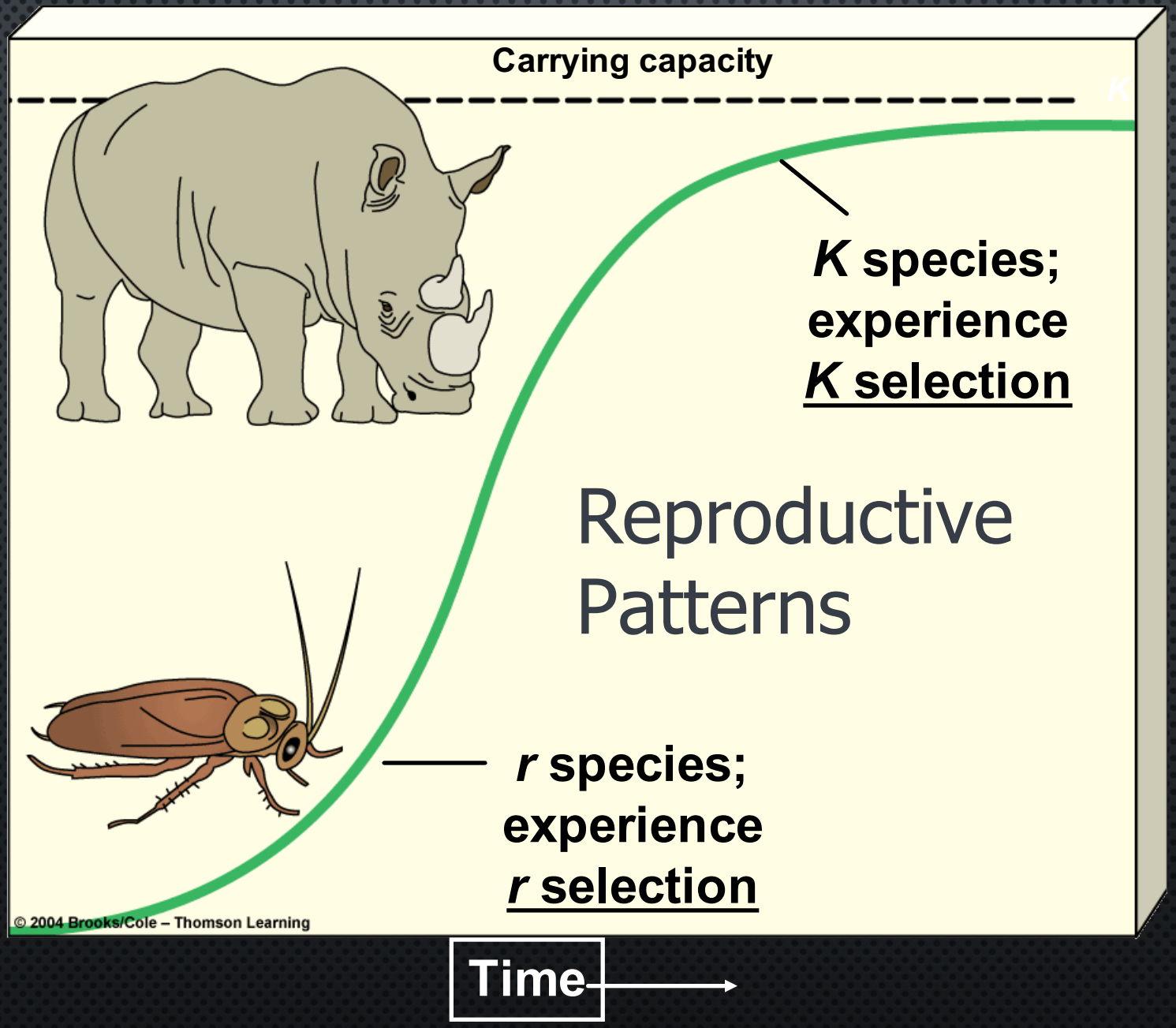
- Asexual reproduction
  - Offspring are exact copies of a single parent
- Sexual reproduction
  - Organisms produce offspring by combining the gametes or sex cells from both parent

  Disadvantages
  - Females must produce twice as many offspring
  - Chance of genetic errors increases
  - Mating entails costs

  Advantages
  - Provides greater genetic diversity
  - Division of labor – males gather food and protect females and young

Reproductive Strategies

- Goal of every species is to produce as many offspring as possible
- Each individual has a limited amount of energy to put towards life and reproduction
- This leads to a trade-off of long life or high reproductive rate
- Natural Selection has lead to two strategies for species: r - strategists and K - strategists


Carrying capacity
K
Number of individuals
K species;
experience
K selection
Reproductive
Patterns
r species;
experience
r selection
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Time

r-Selected Species
Opportunists

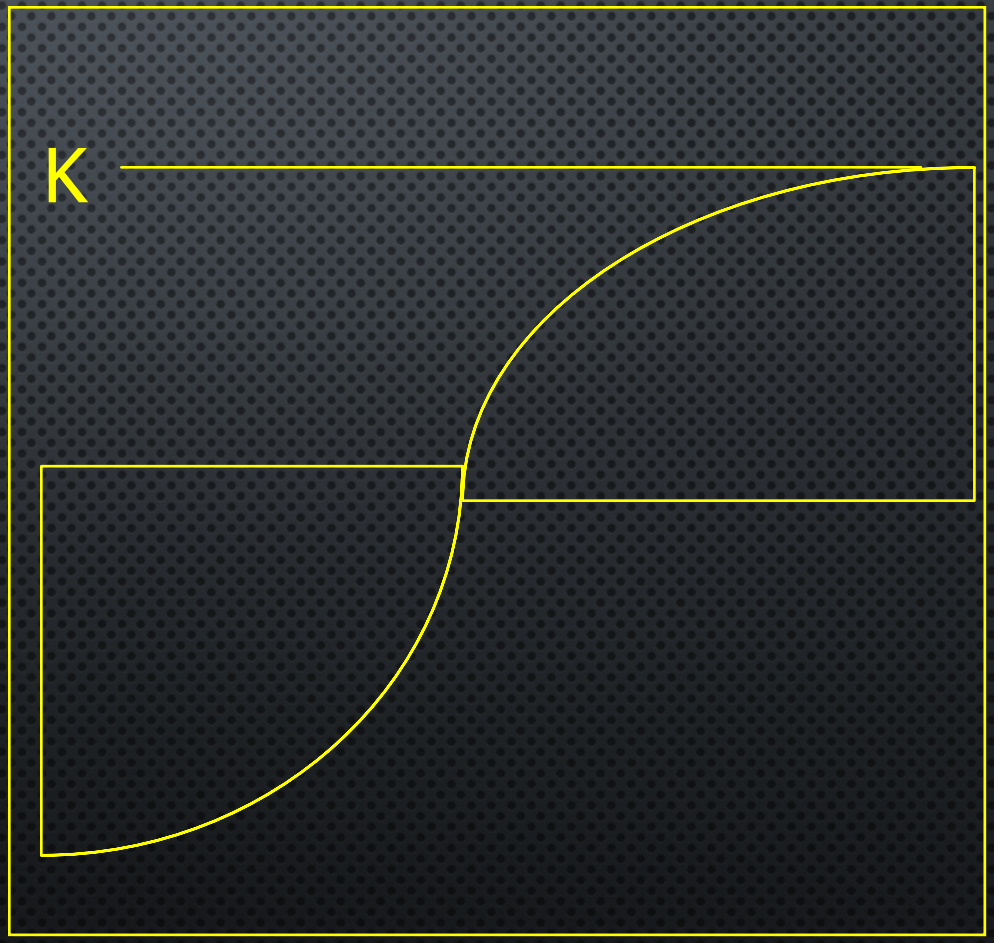
cockroach

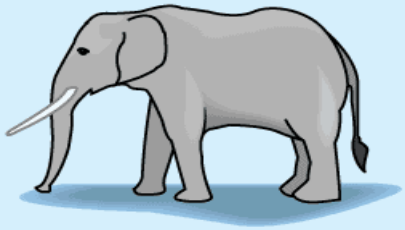
dandelion

1. Many small offspring
2. Little or no parental care and protection of offspring
3. Early reproductive age
4. Most offspring die before reaching reproductive age
5. Small adults
6. Adapted to unstable climate and environmental conditions
7. High population growth rate (r)
8. Population size fluctuates wildly above and below carrying capacity (K)
9. Generalist niche
10. Low ability to compete
11. Early successional species

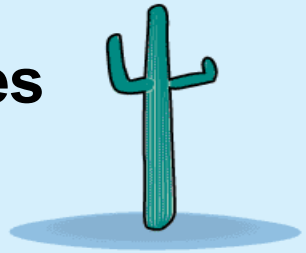
K - Strategists

- Maintain population at carrying capacity (K)





K-Selected Species
Competitors



elephant

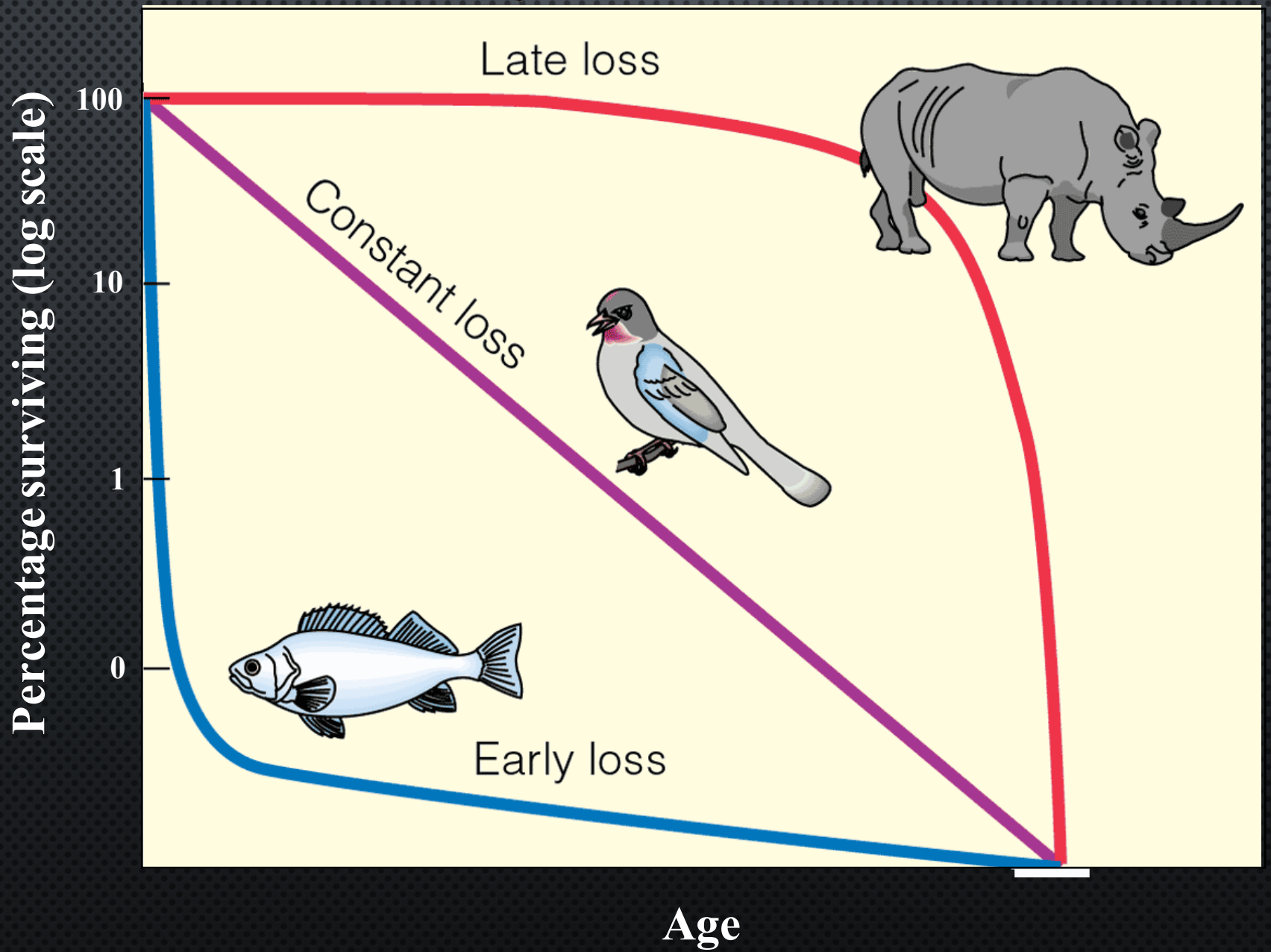
saguaro

1. Fewer, larger offspring
2. High parental care and protection of offspring
3. Later reproductive age
4. Most offspring survive to reproductive age
5. Larger adults
6. Adapted to stable climate and environmental conditions
7. Lower population growth rate (r)
8. Population size fairly stable and usually close to carrying capacity (K)
9. Specialist niche
10. High ability to compete
11. Late successional species

Survivorship Curves

- Late Loss: K-strategists that produce few young and care for them until they reach reproductive age thus reducing juvenile mortality

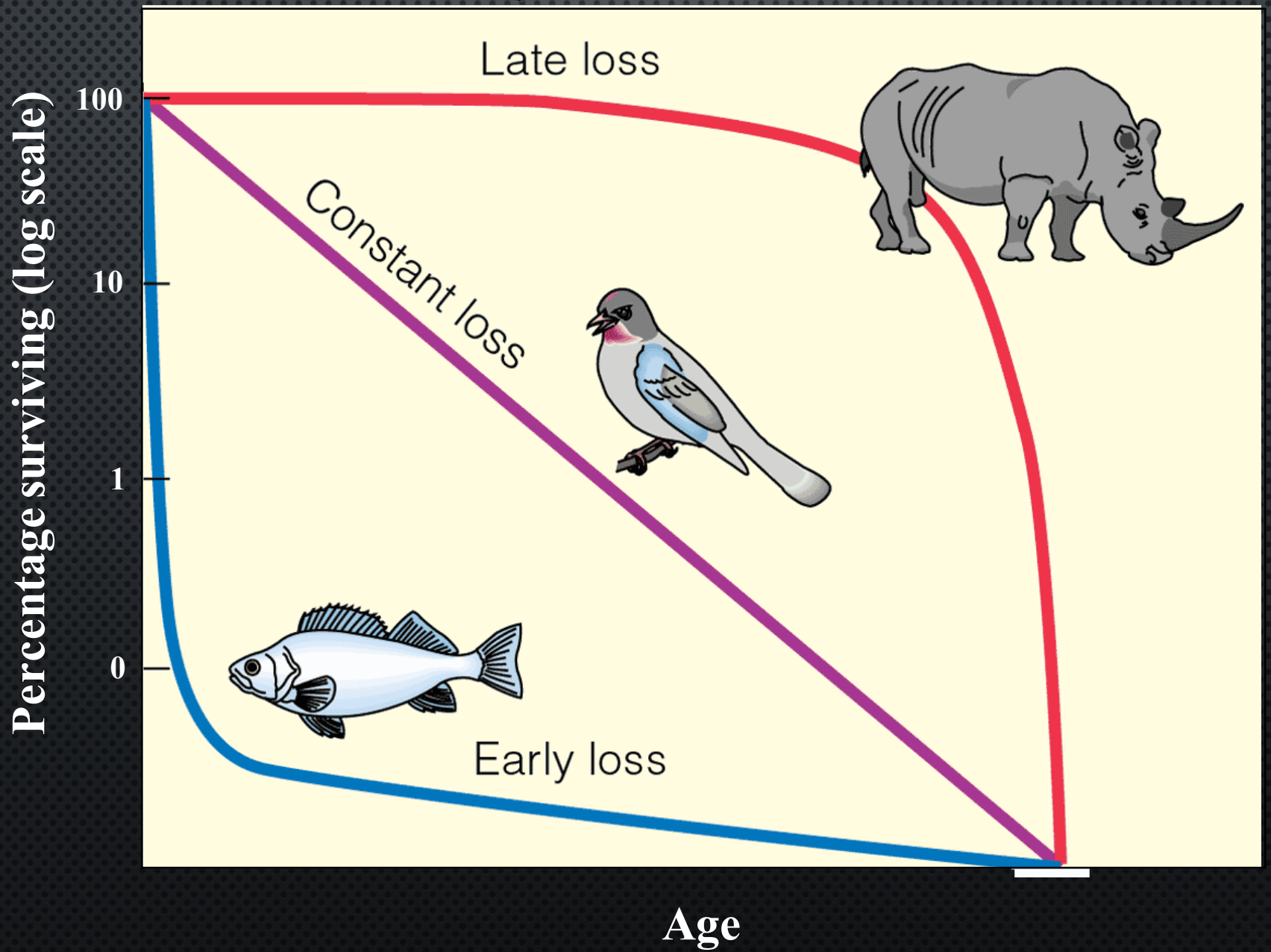
Survivorship Curves



Survivorship Curves

- Constant Loss: typically intermediate reproductive strategies with fairly constant mortality throughout all age classes

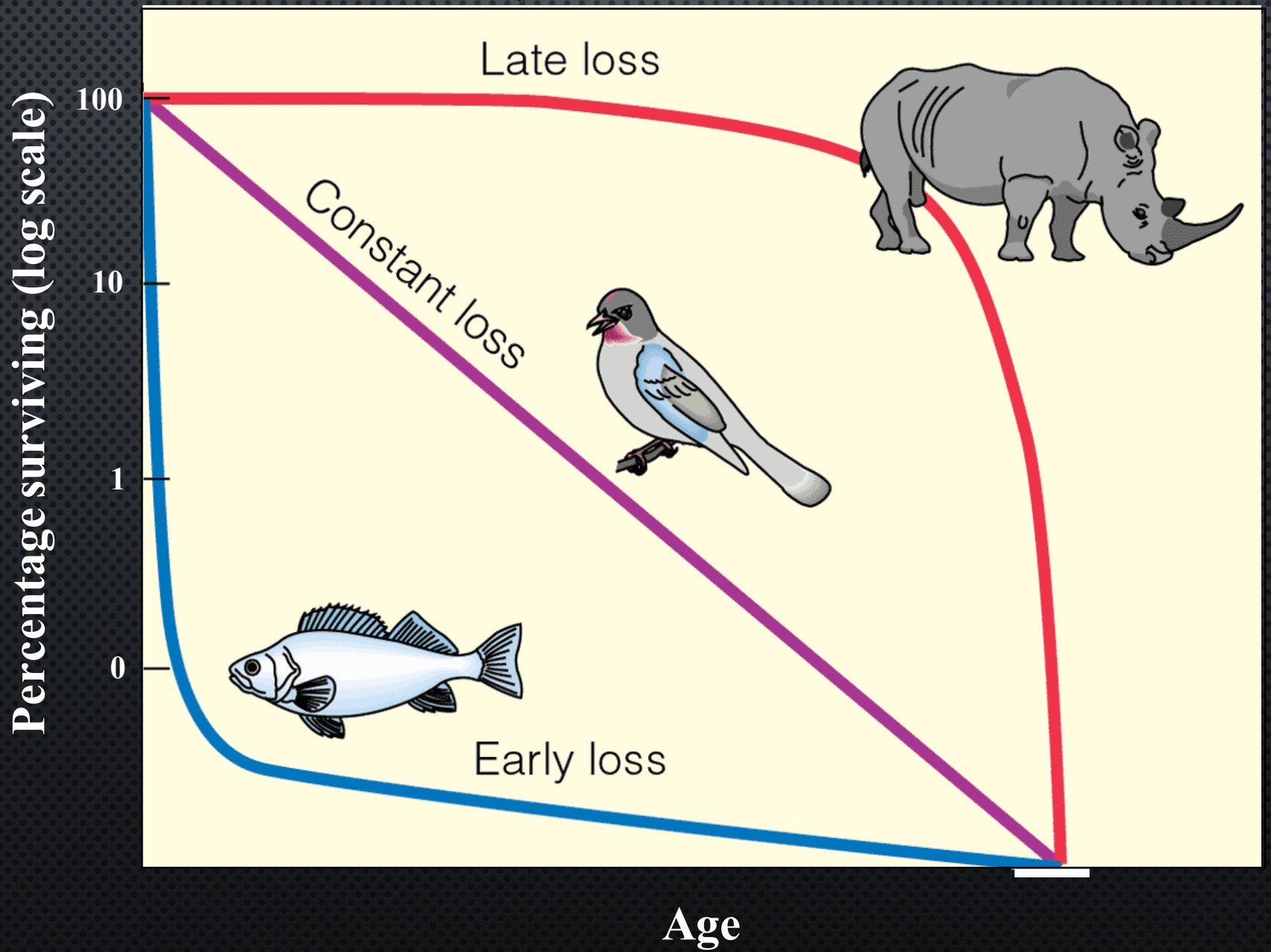
Survivorship Curves



Survivorship Curves

- Early Loss: r-strategists with many offspring, high infant mortality and high survivorship once a certain size and age

Survivorship Curves



Survivorship Curves: Summary

- ***Late loss population*** live to an old age.
- ***Constant loss population*** die at all ages.
- Most members of ***early loss population***, die at young ages.