Demography

Chapter 52 Population Ecology
p.1151-1156, 1158-1168
Chapter 53 Community Ecology
p.1176-1181

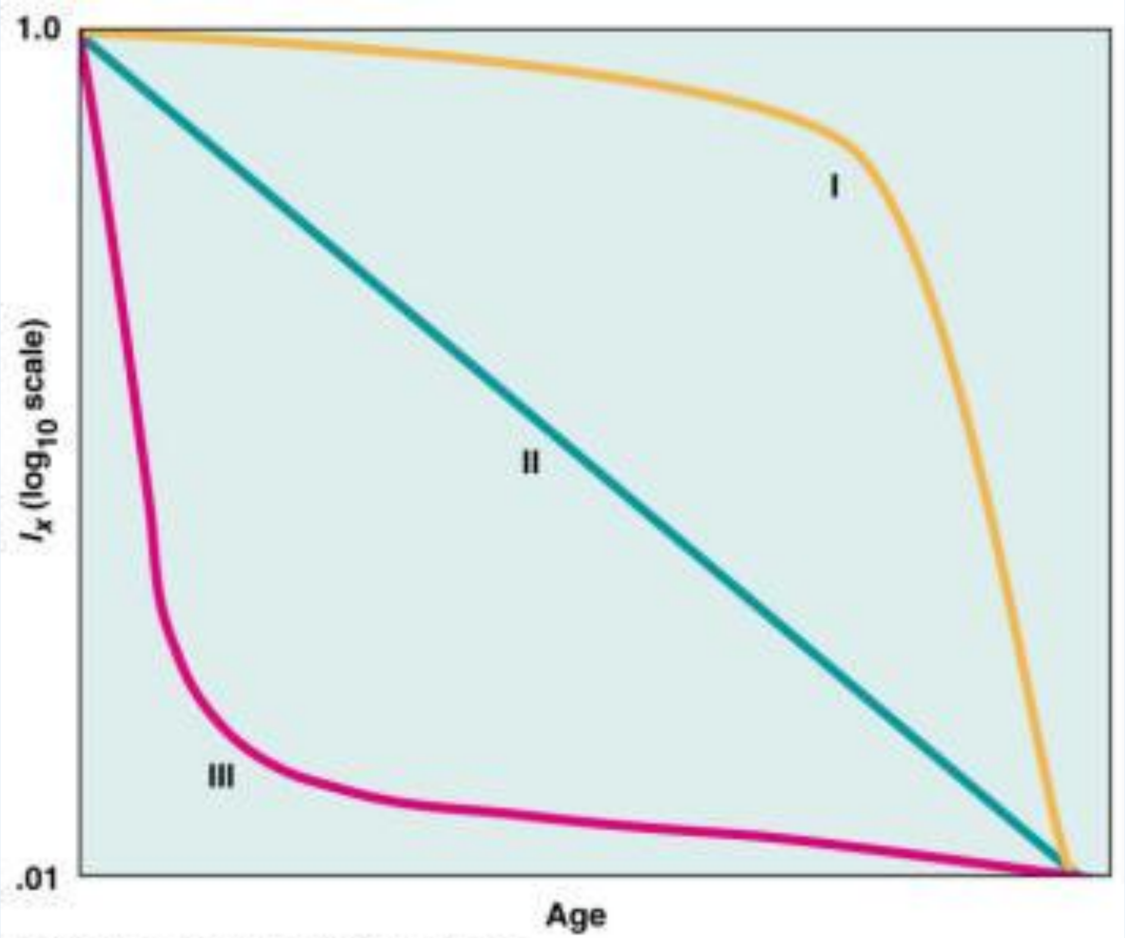
Demography

- Study of the changes in the characteristics of a population
- Life history: all the traits that affect an organism's reproduction and survival

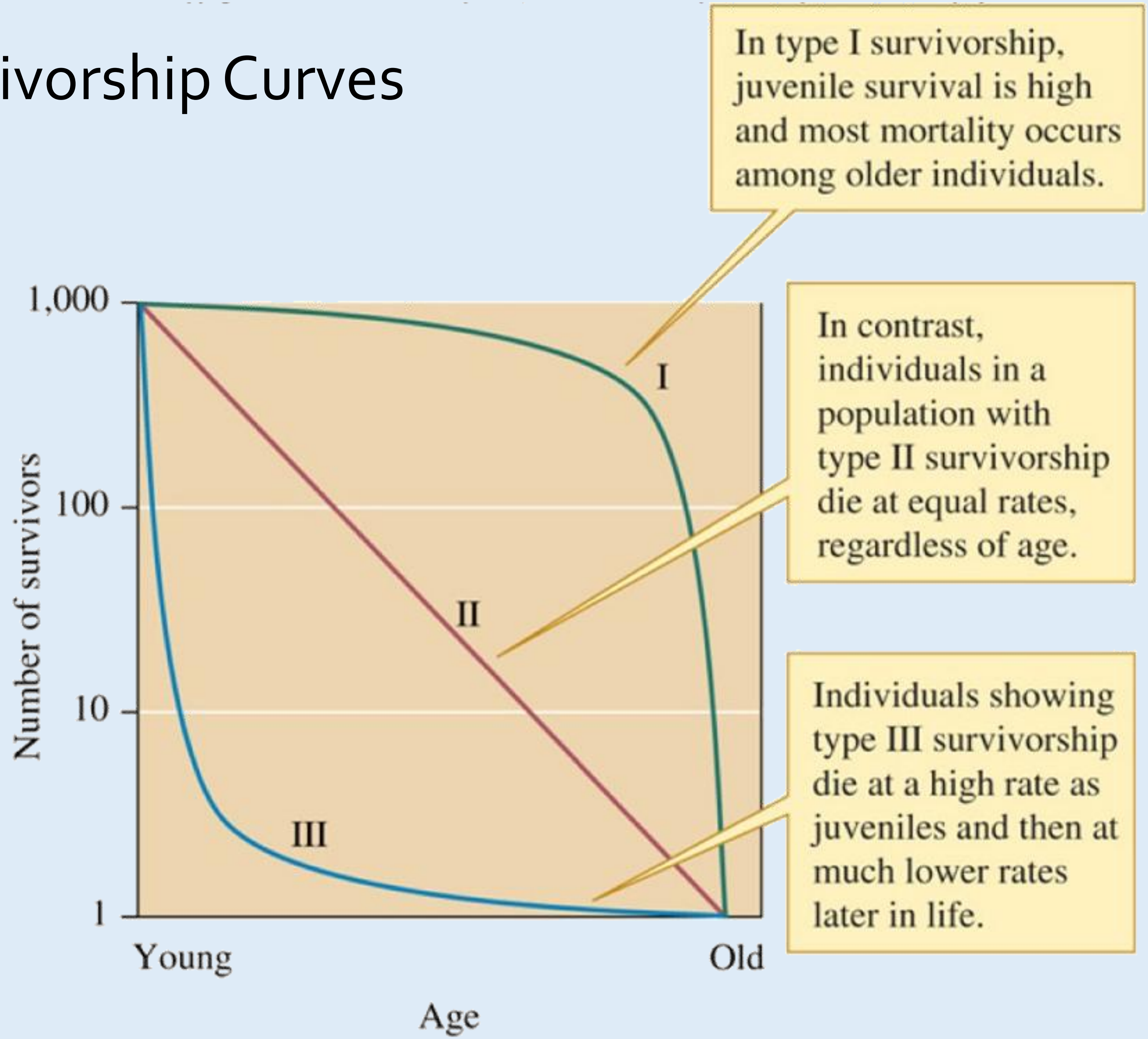
Life Table

- Summarizes demographic characteristics of a population
- Method: monitor a cohort until they die
- **Cohort**: a group of individuals of similar ages
- Originally developed by insurance companies to measure human mortality rates
- Adapted by ecologist

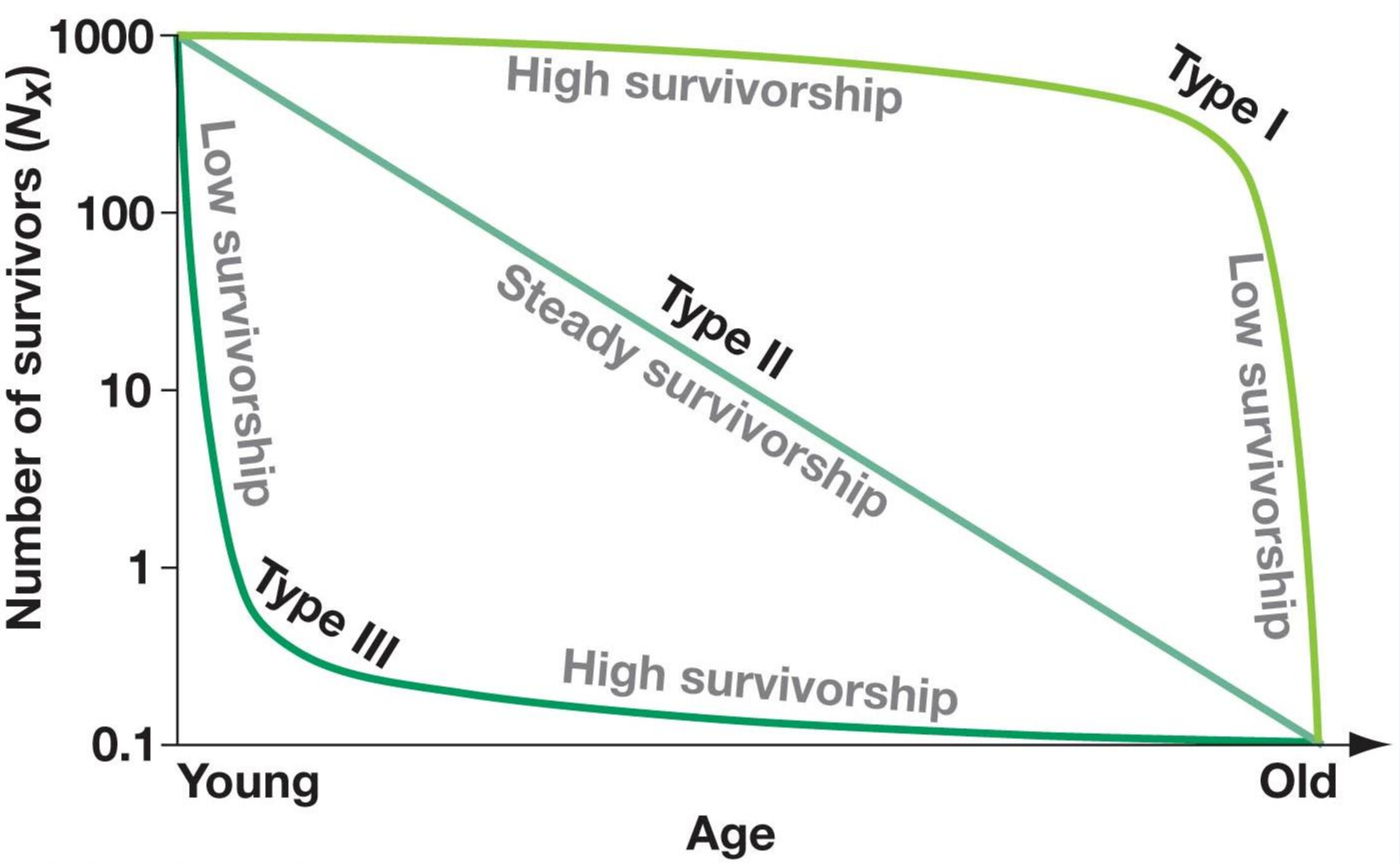
Survivorship Curves – a plot of the numbers in a cohort still alive at each age



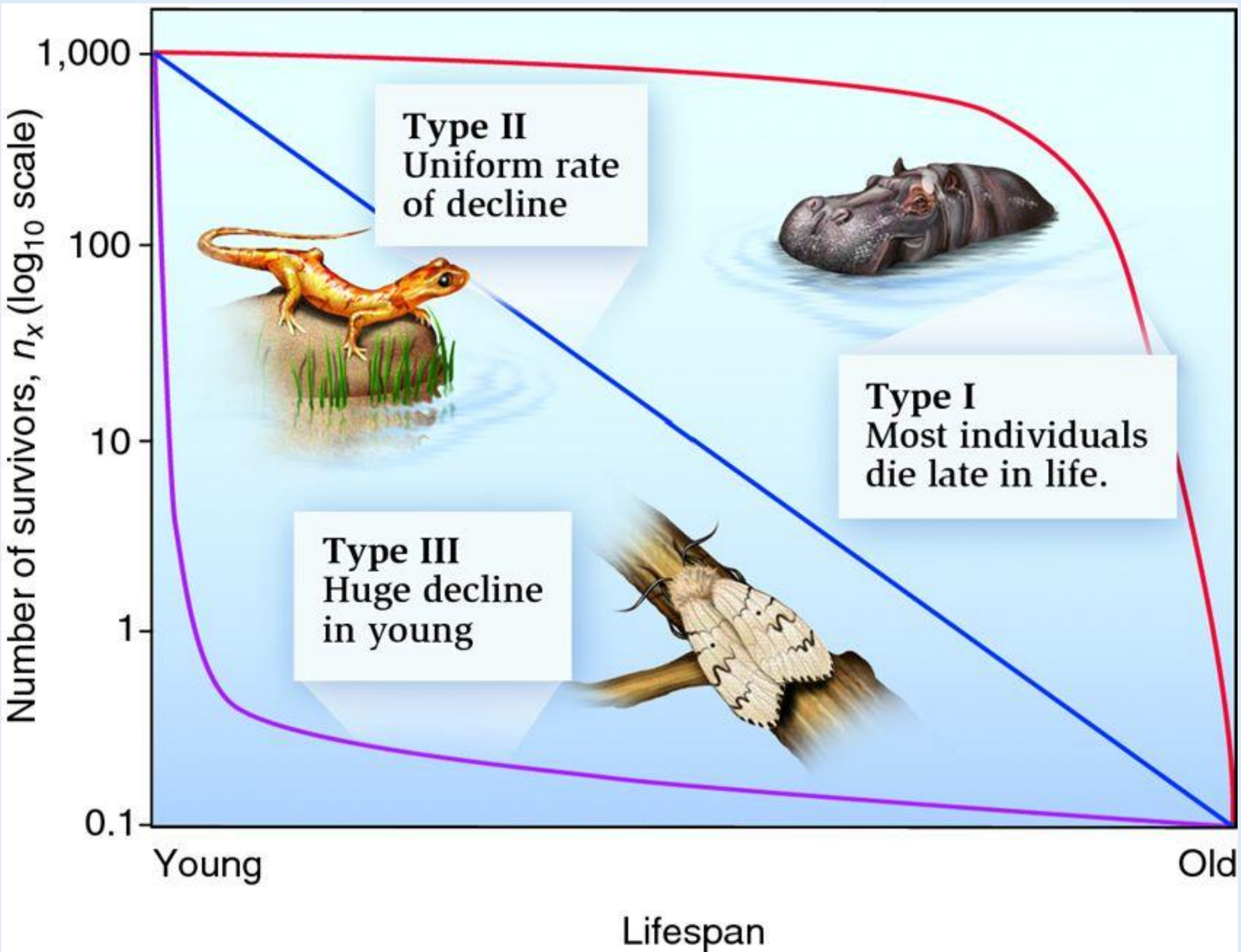
Survivorship Curves

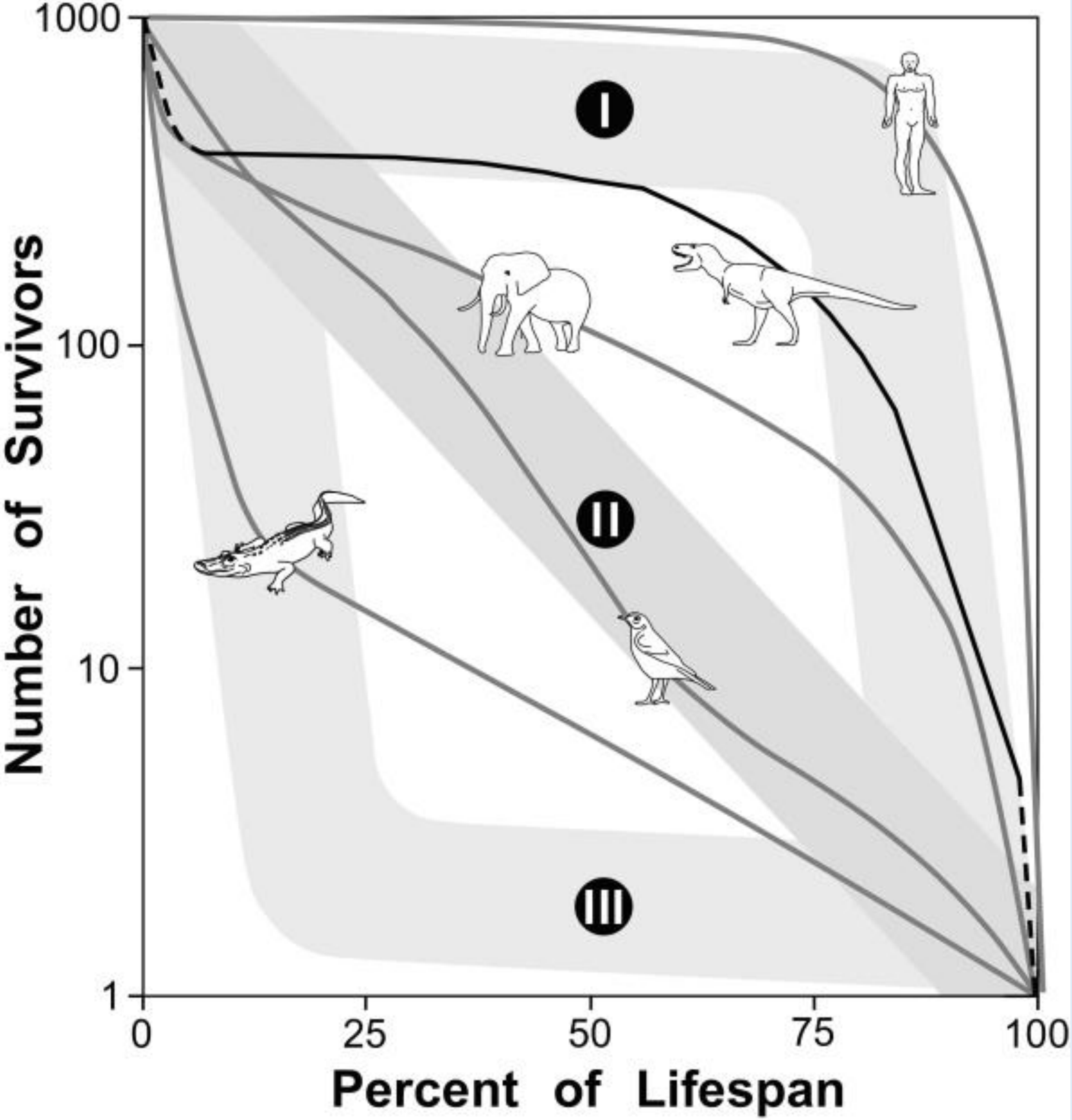


Survivorship Curves



Survivorship Curves





1000
100
10
1
0
25
50
75
100
Number of Survivors
Percent of Lifespan
I
II
III

Survivorship Characteristics

	Type I	Type II	Type III
Mortality	Low in early years and high at older	Constant over life span	High in early years and low in later life
Number of offspring	Few	Few	Many
Gestation period	Long	Average	Short
Parental care	Good	Short	Short
Organism size	Large	Small	Small
Examples	Human	Hydra	Fish

Fecundity

- Potential for a species to produce offspring

- Average number of offspring produced by a female over her lifetime

Activity

- In your groups, brainstorm factors that may affect fecundity.
- Determine whether the factors will increase or decrease fecundity.

Factors Affecting Fecundity

- Age of sexual maturity
- Maximum reproductive age
- Length of gestation period
- Number of offspring per gestation period
  Seahorse giving birth:
  http://www.youtube.com/watch?v=uKrkXXaRMUI&feature=player_embedded
- Amount of parental care
- Sex ratio (number males vs females)

Factors Affecting Fecundity

Factors	Effect on fecundity	Explanation
Age of sexual maturity		
Maximum reproductive age		
Length of gestation period		
Number of offspring per gestation period		
Amount of parental care		
Sex ratio		

Measuring Population Change

- Change in population size (ΔN)
- Growth rate (r)

Factors Affecting Change in population size

Factors	Symbol	Description (all assume a given period of time)	Effect on population size
Immigration	I	Number of individuals that moved into a population	Increase
Emigration	E	Number of individuals that moved away from the population	Decrease
Birth	B	Number of individuals born into the population	Increased
Death	D	Number of individuals that died in the population	Decrease

Change in population size

- $\Delta N = (B+I) - (D+E)$

- $\Delta N = N_2 - N_1$
  - N_1 = starting population size
  - N_2 = final population size

Sample Question: Change in Size

- 100 angry birds left asia. 50 moved in. 25 died. The change in population was -50 (a decrease of 50 angry birds). How many angry birds were born?
- 2 dogs gave birth to 101 puppies. 99 of them were stolen. 97 were found and returned. None of them died.
  - What is the change in population size?
  - What is the final population size?

Growth Rate (r)

- Measure of the change in population size

- Calculated relative to the starting population size:
  - $r = \Delta N / N_1 = (N_2 - N_1)/N_1$

- Usually written as a ratio or percentage
  - E.g. 0.5 or 50%
- Decreases in population size would result in a negative growth rate

Sample Question: Growth Rate

- 2 dogs gave birth to 101 puppies. 99 of them were stolen. 97 were found and returned. None of them died. What is the growth rate of the dog population (rate of change in population size)?
- The growth rate for a population of 90 field mice in 6 months is 500%. If the number of births was 342, the number of deaths was 43, and there was no emigration, calculate the number of mice that migrated into the area.

Sample Question: Growth Rate

- A population decreased by 2%. If the original population was 800 organisms, calculate:
  - change in population size
  - final population size
- Brad Pitt and Angelina Jolie gave birth to 3 children but also adopted a number of others. If the Pitt-Jolie growth rate is 300%, calculate:
  - number of adopted children (assume there are no deaths nor emigration) Hint: You need the size of the initial population.
  - final population size

Growth Rate (ignoring I and E)

Rates	Symbol	Equation
Natality (birth rate)	b	$b = B/N_1$ Birth rate must be positive
Mortality (death rate)	d	$d = D/N_1$ Death rate must be positive
Growth	r	$r = b - d$ $r = \Delta N/N_1 = (N_2 - N_1)/N_1$ If $r > 0$, population growth If $r < 0$, population decline If $r = 0$, **zero population growth (ZPG)**

Example: Birth & Death Rates

- A population 1000 individuals experience 34 births in the year. Calculate the birth rate.

- Calculate the number of deaths that would occur in a population with a size of 500 if the death rate is 2.5%.

Example: Growth Rate

- If a population of 10 grew by 2 individuals but the death rate was 5%, what is the birth rate?

- If a population of 10 grew by 2 individuals but the birth rate was 5%, what is the death rate? (Think logically: Is this possible?)

Intrinsic Rate of Increase (r_{max})

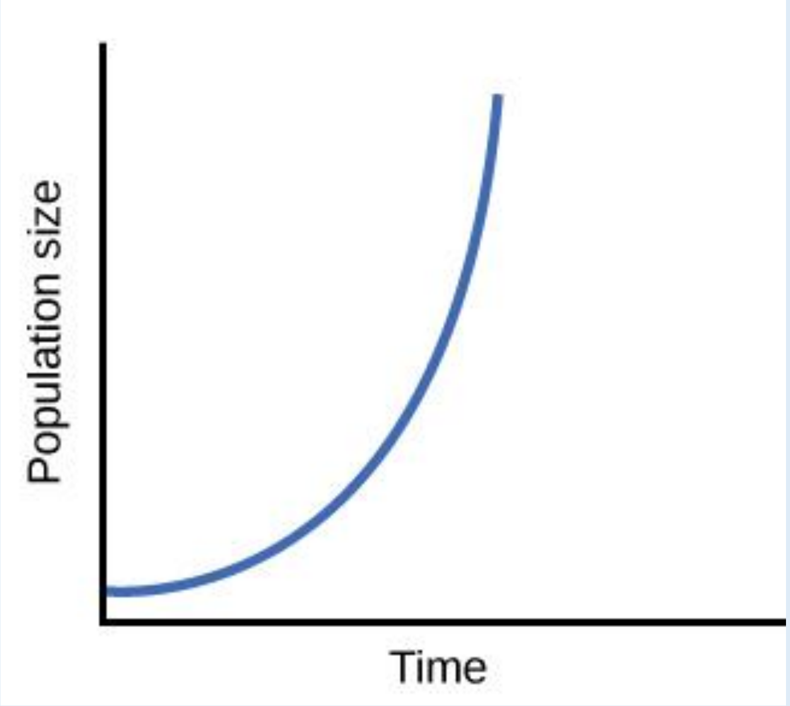
- If conditions are ideal (theoretical):
  - No predation, parasites, disease
  - Unlimited resources
  - Without environmental limits (i.e. no density-dependent factors, no immigration or emigration)

- Then $r = r_{max}$
  - High birth rate, low to no death rate
  - Highest possible growth rate for a population when no external factors are acting on it

Exponential Growth Model

- If you plot a graph of a population growing by r_{max}, it would look like an exponential curve

- Exponential Growth model: A growth pattern exhibited by organisms reproducing at a constant rate with unrestricted growth



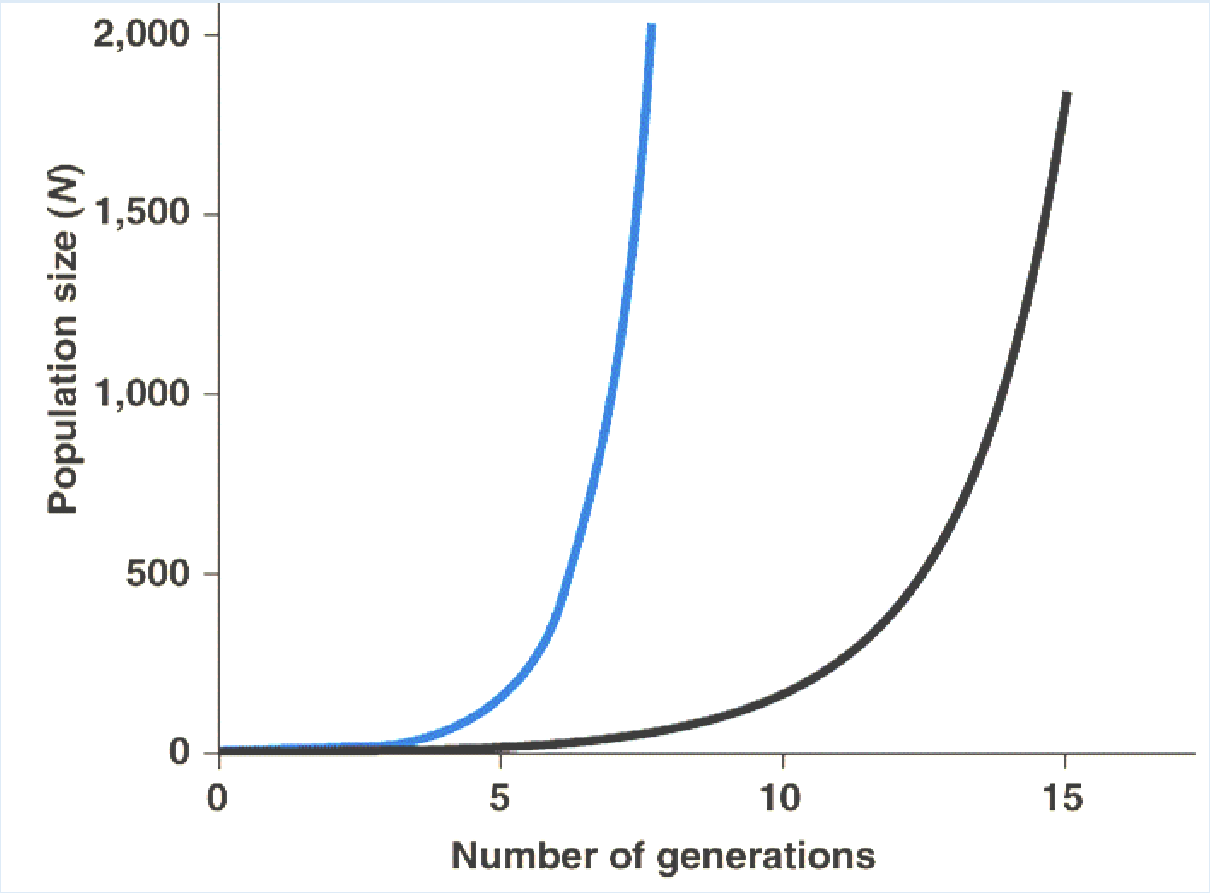
Comparing r_{max}

- Comparing r_{max} between different populations identifies which population will grow faster

- Example: Would a population with r_{max} of 0.5 grow faster, or a population with r_{max} of 1.0?

Example: Comparing r_{max}

- **Which line represents an r_{max} of 0.5 versus 1.0?**



Activity

- Brainstorm: What would affect a population's intrinsic rate of increase (r_{max}) if the conditions are ideal?

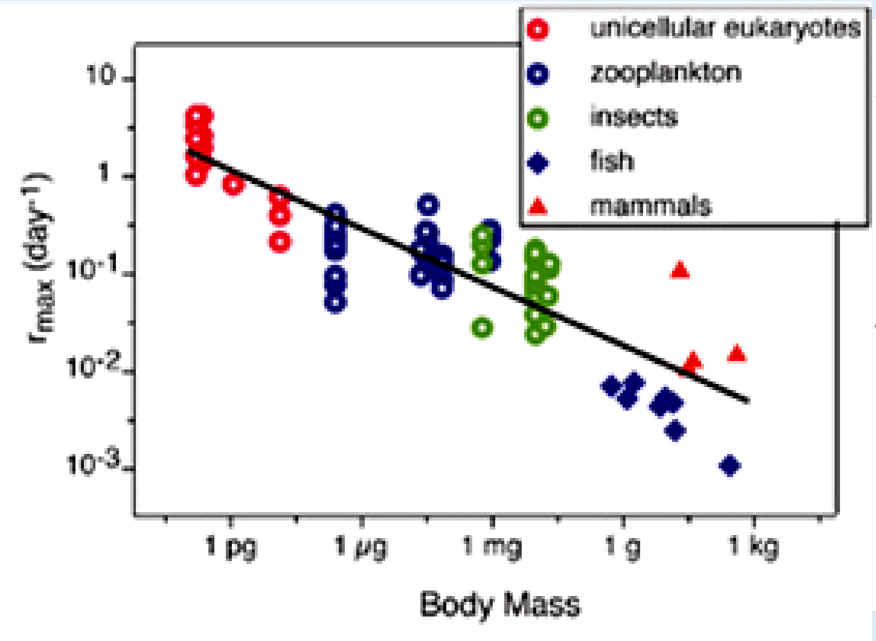
- Hint: it's in the name

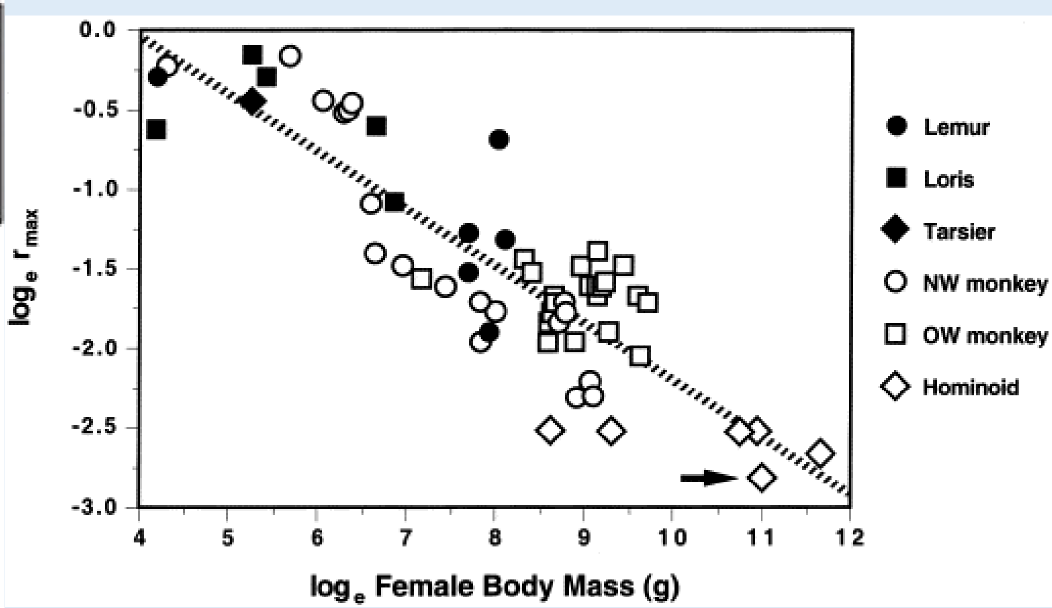
Factors Affecting Intrinsic Rate of Increase (r_{max})

Factors	Effect on r_{max}	Explanation
Age of sexual maturity		
Maximum reproductive age		
Length of gestation period		
Number of offspring per gestation period		
Amount of parental care		
Sex ratio		

Interesting Correlation

Intrinsic Rate of Increase (r_{max}) and body mass





Relationship between the maximum intrinsic rate of natural increase (r_{max}) and adult female body mass for a representative sample of 58 primate species. Humans (arrowed) have a relatively low, but not extreme, value relative to body size (data from Ross, 1988).

Factors Affecting Intrinsic Rate of Increase (r_{max})

- Under biological limitations

- Intrinsic factors affecting r_{max} are the same as those affecting fecundity

Intrinsic Rate of Increase (r_{max})

- Recall: $r = \Delta N/N1$ then $r_{max} = \Delta N/N1$
  - $\Delta N = r_{max}N1$

  - This shows that even though the change in population size is dependent on a population's intrinsic rate of growth, it is also dependent on the population's starting size

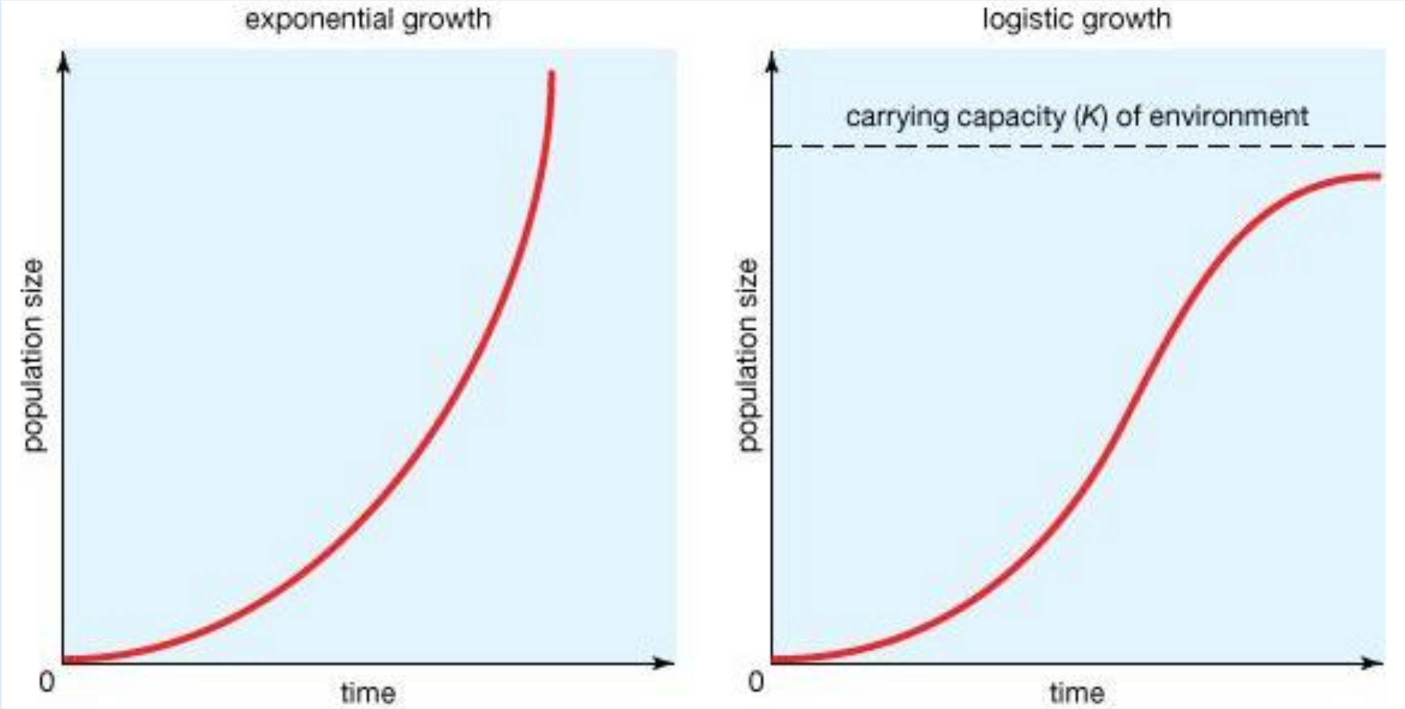
Example: $\Delta N = r_{max}N1$

- If a population of 200 individuals and a population of 500 individuals both had the same intrinsic rate of increase, which population would grow faster?

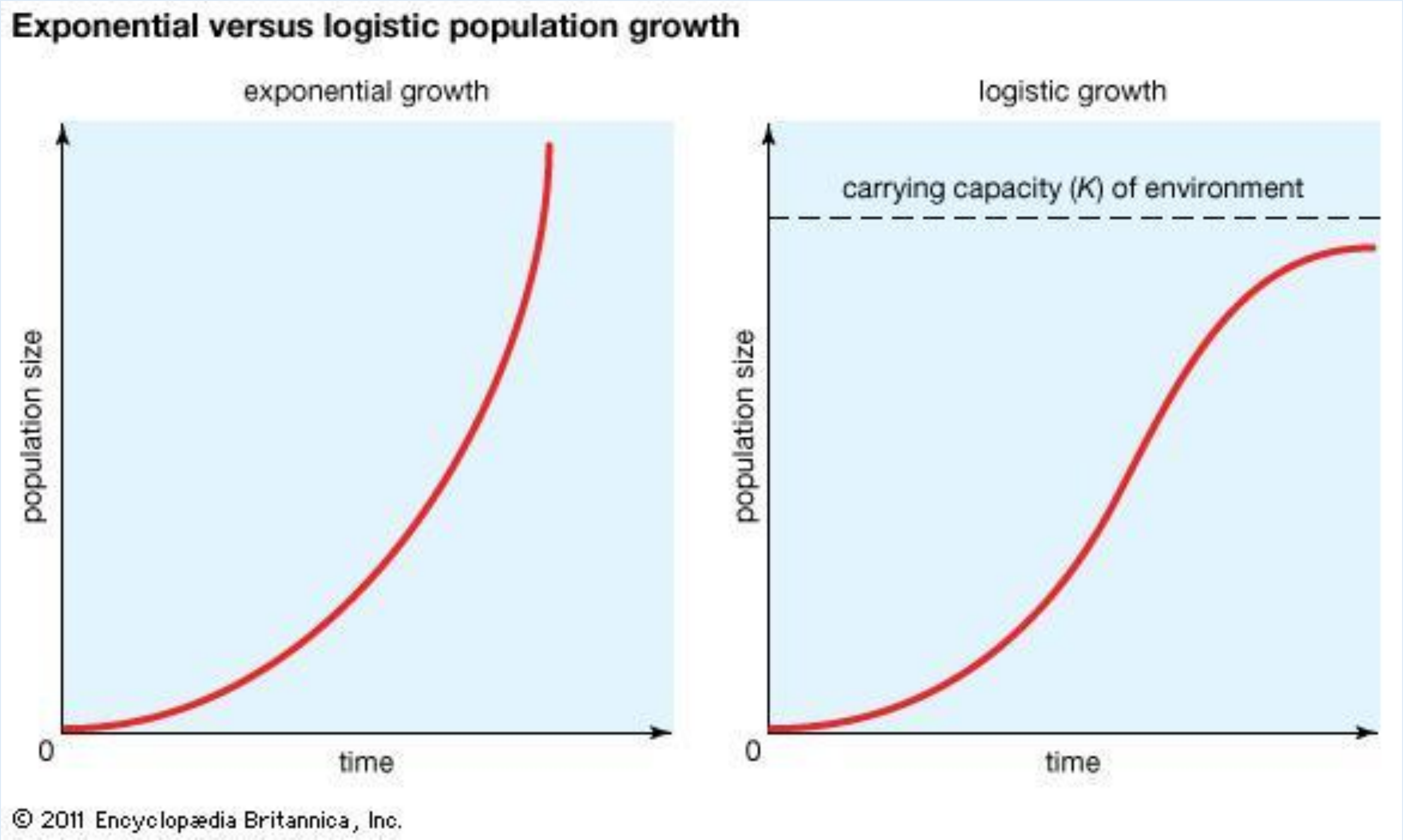
- Note: this question is asking for change in population size (ΔN), not growth rate since r_{max} is the same.

Population Growth Models

- Exponential – theoretical
- Logistic (sigmoid) – more realistic

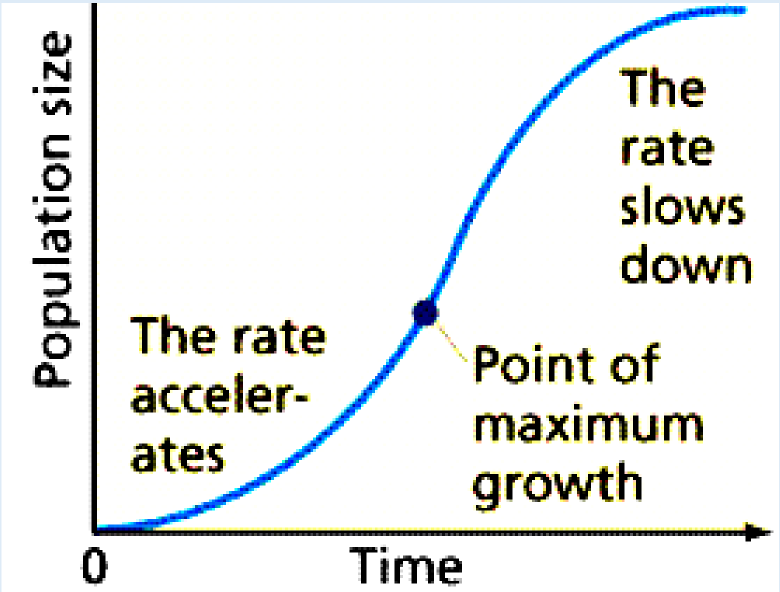


Comparing growth curves



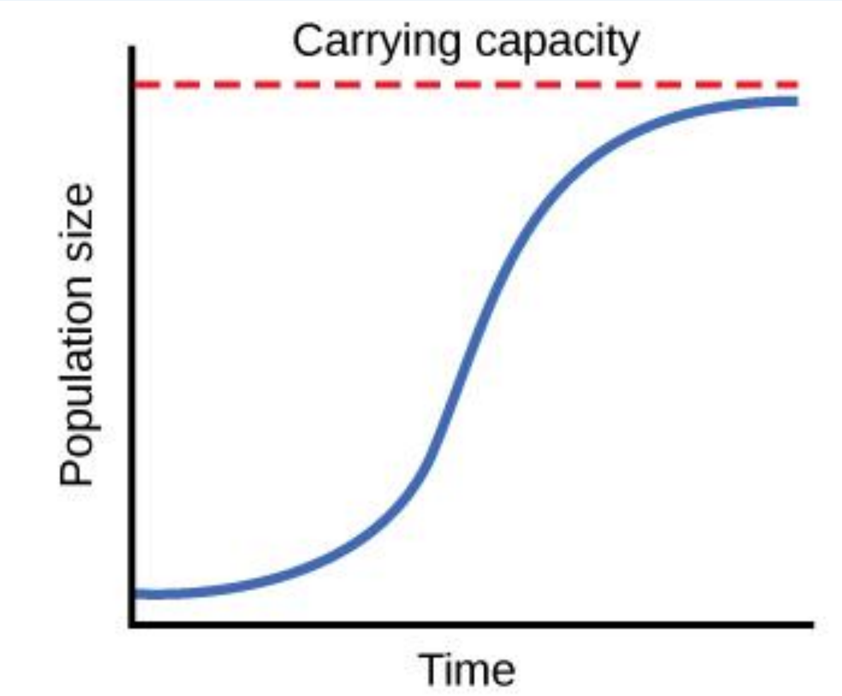
Logistic Growth Model

- A model that describes limited population growth, often due to limited resources or predation
- Incorporates change in growth rate due to the effect of **population density**
- Restricted growth due to **environmental resistance** resulting in leveling off of growth

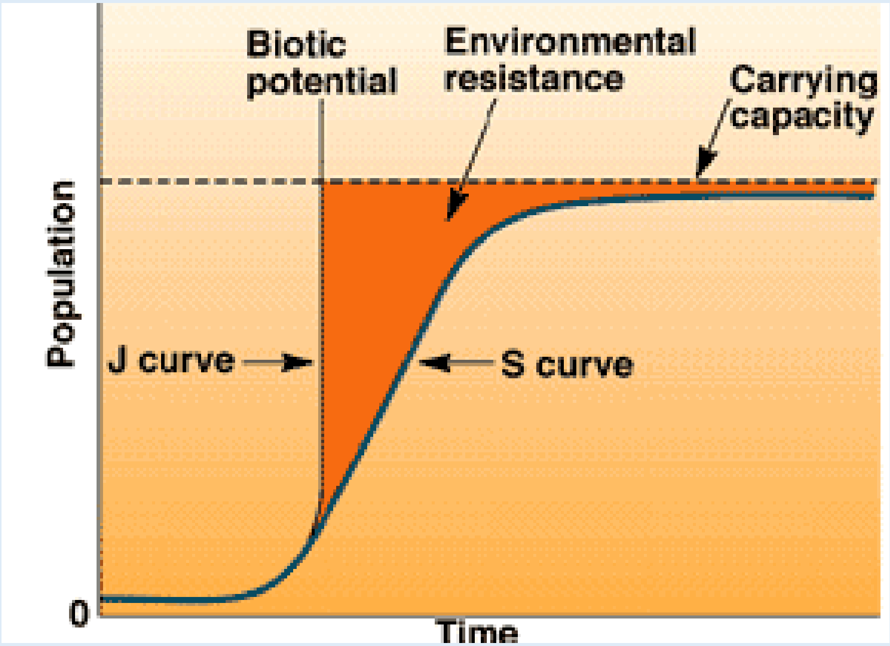


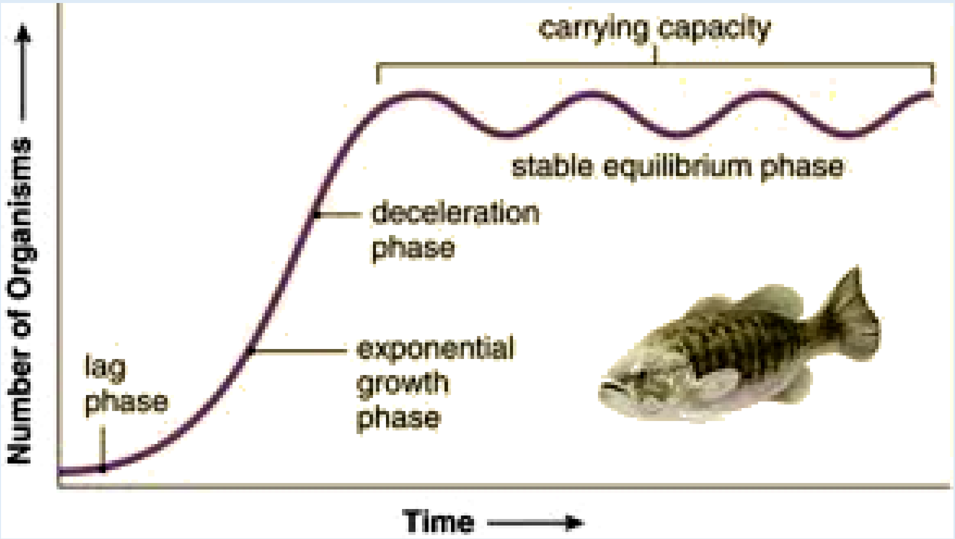
Carrying Capacity (K)

- number of individuals in a population that the environmental resources can support
- maximum population the environment can carry



Logistic Growth Curve





Factors affecting population growth

- 2 classes of factors:
  - Density-independent
  - Density-dependent

Density-Independent Factors

http://nupge.ca/sites/new.nupge.ca//files/images/2011/forest-fire_FL.jpg

Density-Independent Factors

http://therivermanagementblog.files.wordpress.com/2013/01/dsc03951.jpg

Density-Independent Factors

http://swpollutionproject.weebly.com/uploads/5/6/3/8/5638619/2339139_orig.jpg

Density-Independent Factors

- Natural disturbances: fire, flood, earthquake
- Climate change / temperature fluctuations
- Pollution

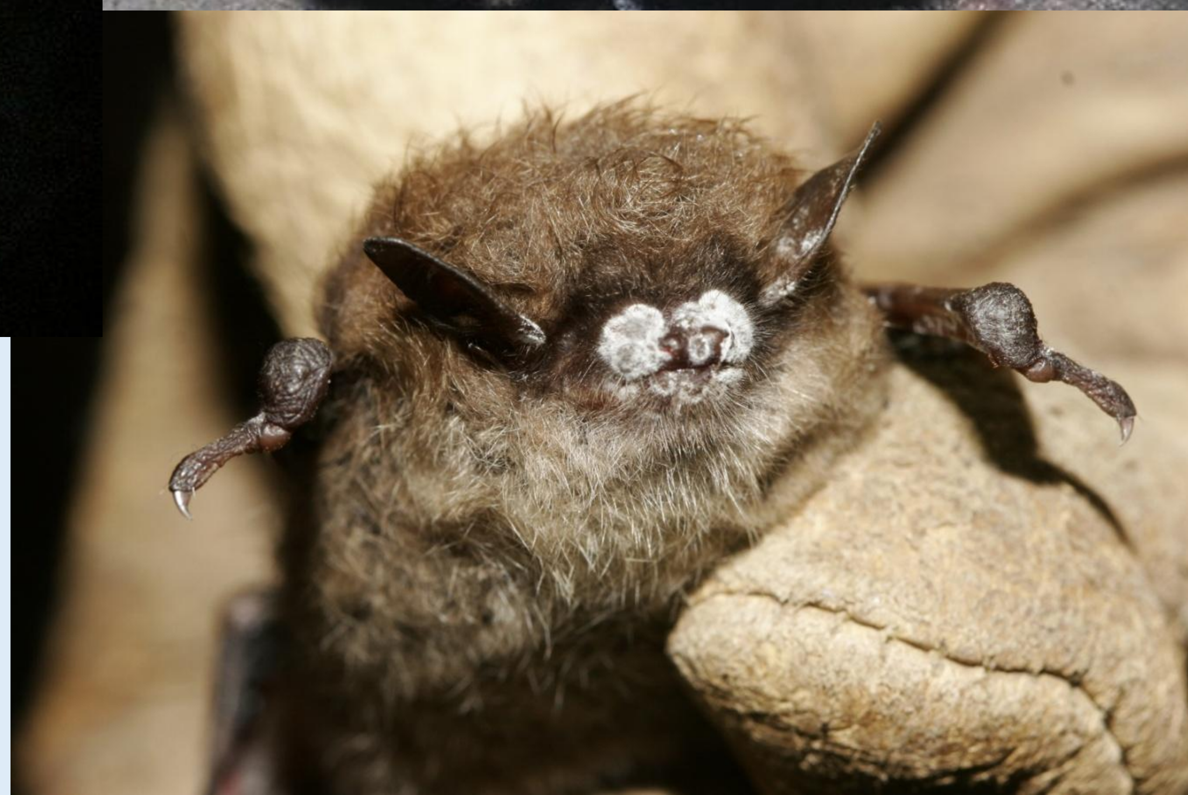
Density-Dependent Factors

- Factors that regulate high-density populations:
  - Disease
  - Predation & herbivory
  - Competition: food, space, mate
- Factor affecting low-density populations:
  - Allee effect

Disease

- Density increases spreading of disease
- Example: White-nose syndrome in hibernating little brown bats. White fungus appears around bat's snout and body. Resulting in high mortality and rapid decline in numbers.





Allee Effect

Warder Clyde Allee (1885–1955), University of Chicago, Zoologist & Animal Ecologist

- When the population **density (or size) is too low:**
  - a population cannot survive
  - fails to reproduce enough to offset mortality
  - increases the risk of extinction
    - Example: great auk, passenger pigeon
- **Undercrowding** (rather than competition) reduced population size or limited growth rate
  - “aggregation had positive effects on the survival of land isopods, which were subject to rapid desiccation when isolated” (Allee 1927)
- Contradicted the logistic model

http://www.nature.com/scitable/knowledge/library/allee-effects-19699394

Allee Effect is Counter Intuitive

- Why would having less individuals in a population reduce the growth rate of the population when there is less competition and more resources? Shouldn't the population size increase?

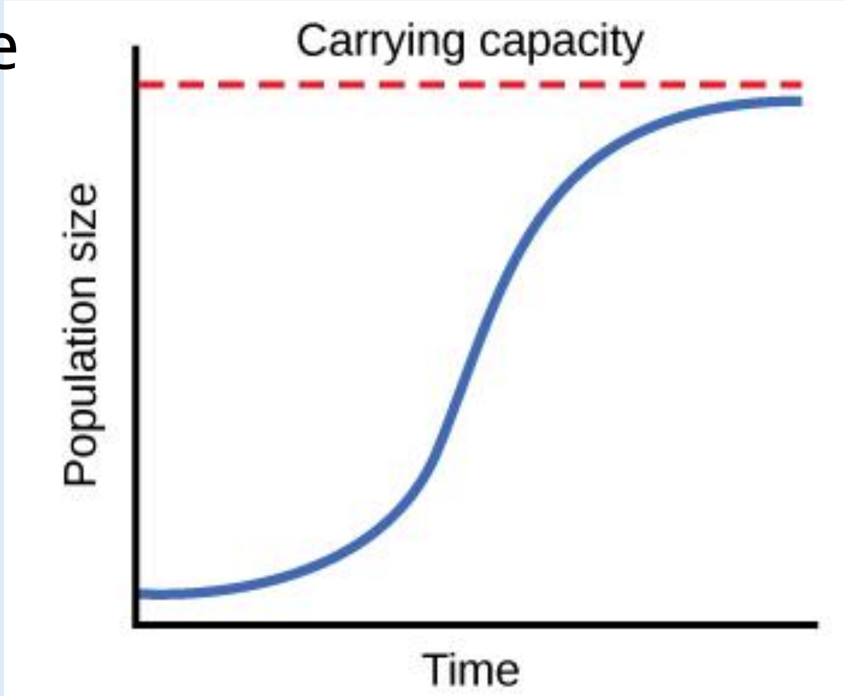
- Brainstorm: factors that would affect low density small-sized populations that reduces population growth/size.

Minimum Viable Population Size

- The smallest population size that is likely to survive
- A population with a size lower than the minimum viable population size will go extinct because the factors affecting low population become significant

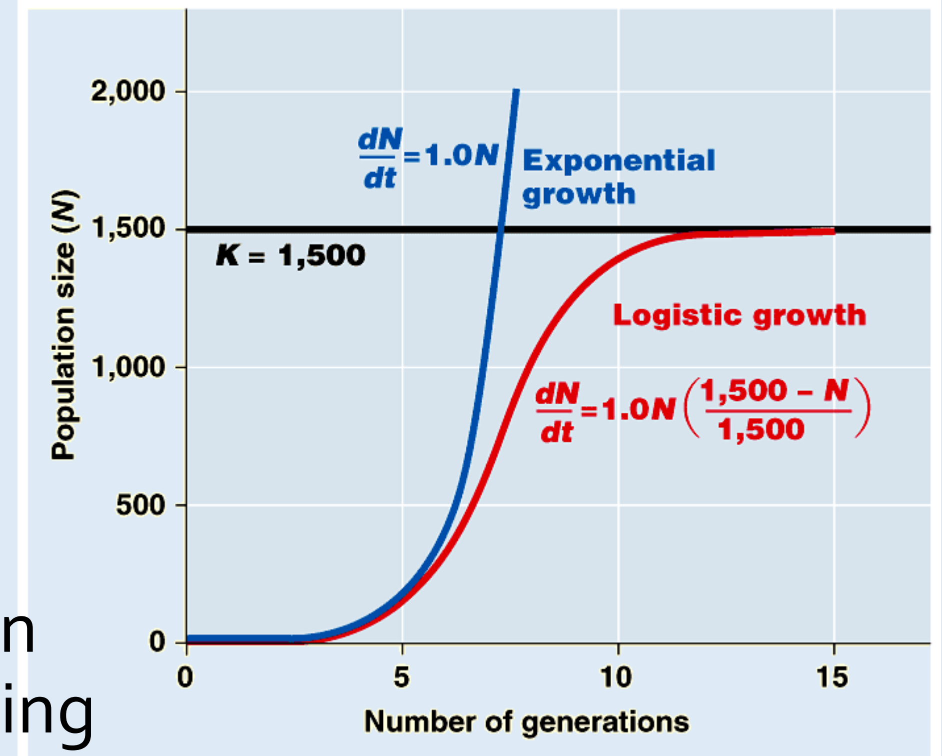
Logistic Growth Rate Equation

- When population reaches carrying capacity, growth rate is zero (N = K, r = 0)
- **Zero population growth (ZPG)**: when r = 0
- (K-N) = additional individuals the environment can still accommodate
- (K-N)/K = fraction of carrying capacity still available



Logistic Growth Rate Equation

- $\Delta N = r_{max}N_1(K-N_1)/K$
- $\Delta N = r_{max}N(K-N)/K$
- $\Delta N = r_{max}N \left(\frac{K-N}{K}\right)$
- Explanation: Change in population size depends on intrinsic growth rate, starting population and available capacity



Example: Logistic Growth Rate

- Calculate the change in population size of a microorganism with an intrinsic rate of increase of 2.5 and a carrying capacity of 8000 if the initial population size is 5000.
- A population of 1000 Mackenzie students increased by 100 after September's registration. Calculate the carrying capacity if the intrinsic rate of increase is 0.43.

Logistic Growth Rate Equation

- Relate growth rate (r) to intrinsic rate of growth (r_{max})
  - Recall: $\Delta N = r_{max} N1(K-N1)/K$
  - Rearrange: $\Delta N/N1 = r_{max}(K-N1)/K$
  - Recall: $r = \Delta N/N1$
  - Substitute: $r = r_{max}(K-N1)/K$ or $r = r_{max} \left(\frac{K-N}{K}\right)$
- Explanation: The rate of growth of a population is dependent on the intrinsic growth rate and the available capacity

Example: Logistic Growth Rate

- A deer population in a forest exhibits logistic growth. The carry capacity is 300 deer and the r_{max} is 0.23.
  - Determine the population growth rate based on population sizes of 100, 180, 200, 250, 280 and 300.
  - Explain the relationship between growth rate and population size.

- Calculate the intrinsic rate of increase of a population of 250 penguins whose growth rate is 0.38 with a carrying capacity of 600.