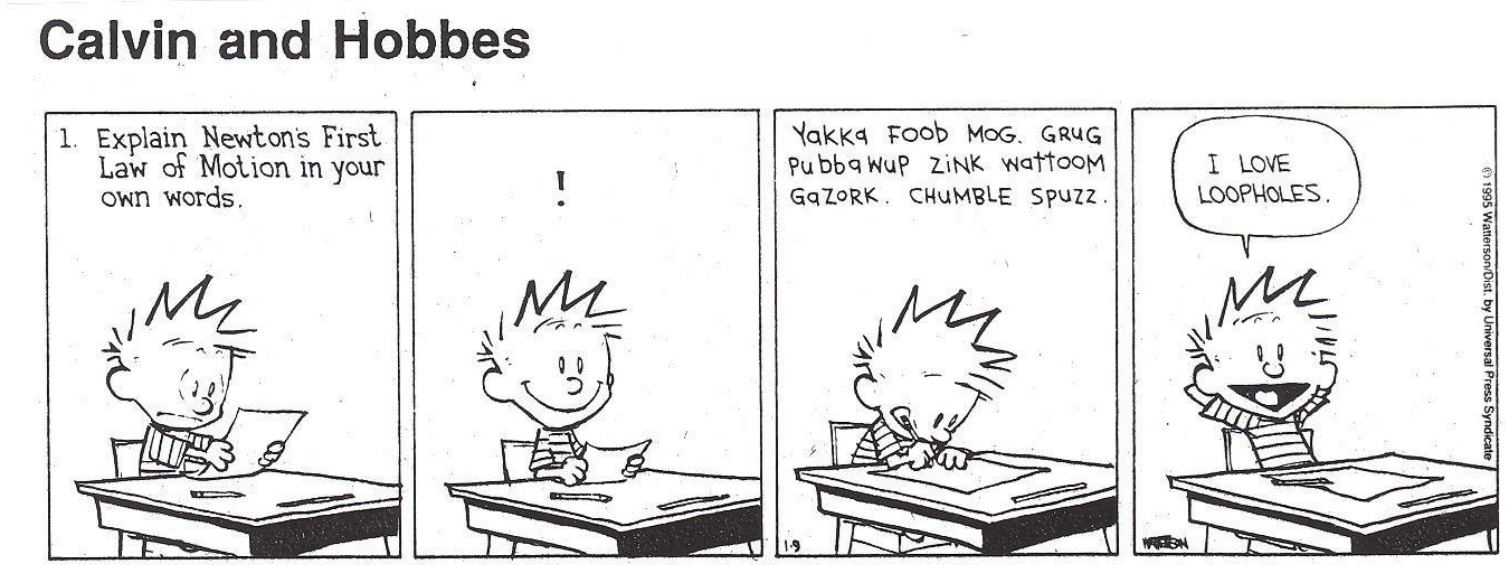
Biology 121 Review Session



Outline of today's review session

Time for questions for Rory

Order: Ecology, Genetics, Evolution

Breakdown of time (~75 minutes total):

- Ecology ~ 30 minutes ; short break
- Genetics ~25 minutes; short break
- Evolution ~20 minutes

No update on details about the exam yet. We haven't started. But, our deadline for completion is next Wednesday. So, I will update you by then.

Learning objectives

- There is not enough time in the review session to go through all of the learning objectives for this class.
- There is a complete list of learning objectives on the Canvas Home Page, near the top.

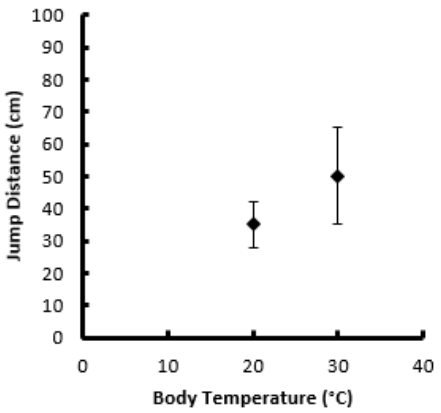
I will post all questions (and the answers) on Canvas on Friday on the Homepage, and in the Final Exam module.

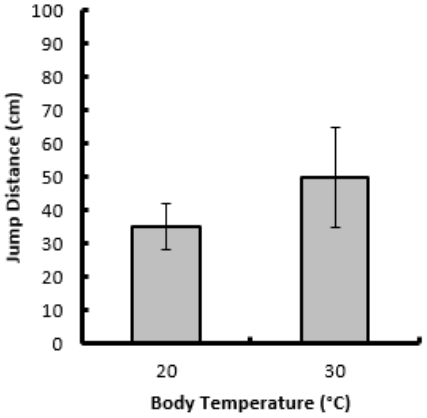
Reading a figure

These researchers were looking at the effect of body temperature (°C) on the jump distance (cm) of frogs.

Both figures show the same data; just in different formats

Error bars beyond scope of 121; often a measure of variation in data





Independent variable on x-axis

Dependent variable on y-axis

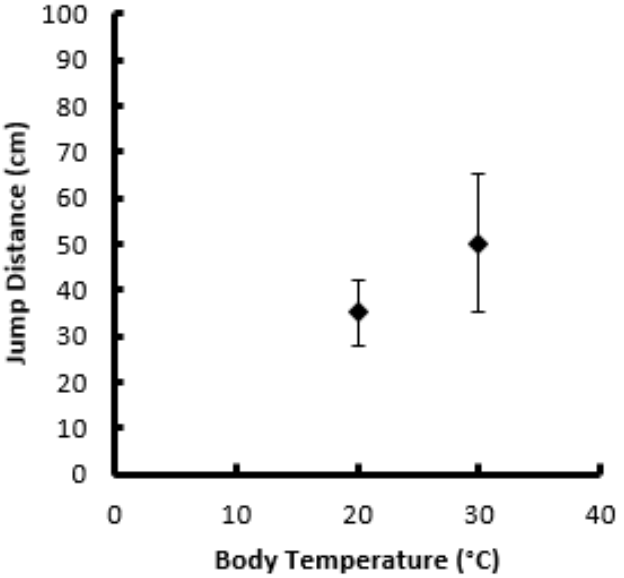
Describing results

For BIOL121:

1. Pattern or trend (if 3 or more points)

2. Quantification of values (do not simply list numbers – describe; recommend including direction, and some measure of difference, if appropriate)

3. Significant difference or not (if possible); need a p-value or an *.



Describing results

For BIOL121:

1. Pattern or trend (if 3 or more points)

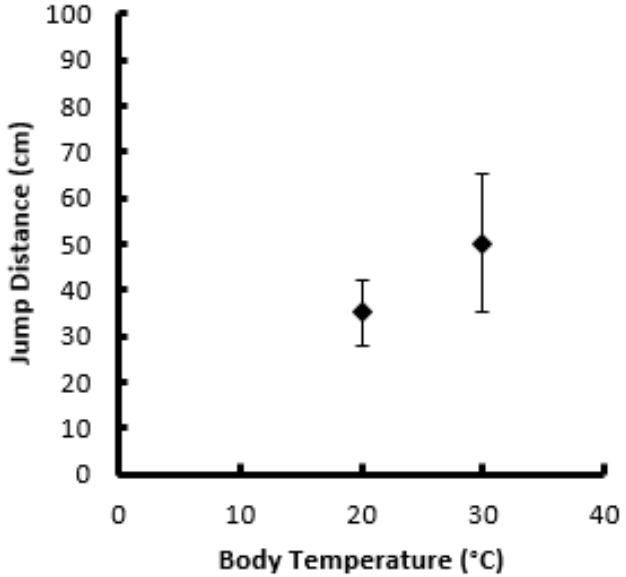
- The frogs jumped farther at warmer body temperatures (30°C vs 20°C)

2. Quantification of values (not listed)

- Frogs tested at 30°C jumped an average of 53 cm, which is approximately 20 cm farther than individuals tested at 20°C (mean=~35 cm)

3. Significant difference or not

- can't say anything; no p-value given
- nor, an asterix *



Describing results….

1. Pattern or trend (if 3 or more points)

2. Quantification of values

3. Significant difference or not.

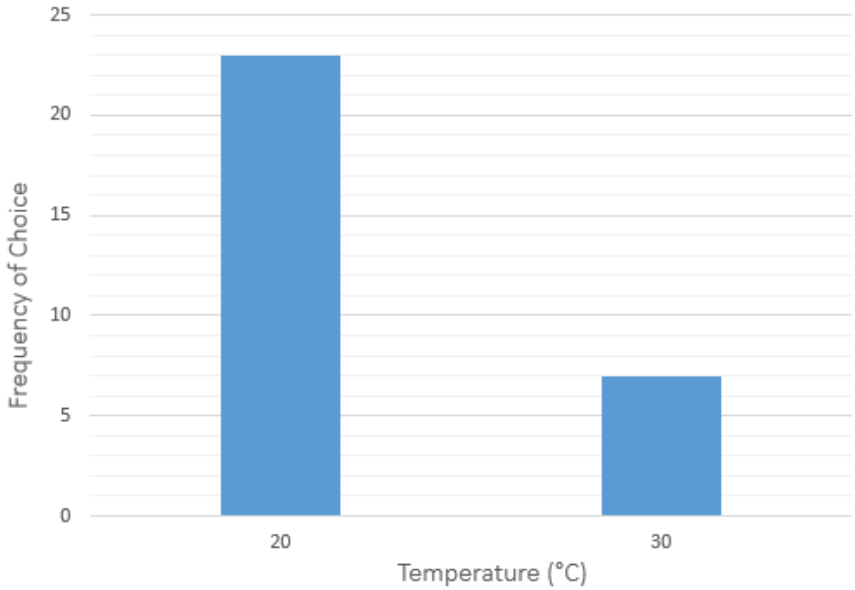


Figure 1. Trial 1. Number of *Bufo marinus* choosing sites when offered a choice of sites at 20°C and 30°C (n=30). $\chi 2 = 8.533$, p=0.0035

Describing results….

In Trial 1, more toads chose the cooler (20°C) site than the warmer (30°C) site. (pattern) Specifically, 23 toads chose the 20°C site, which was 3 times greater than the number of toads that chose the 30°C site (n=7). (results described) The results were statistically significant ($\chi 2 = 8.533$, p=0.0035).

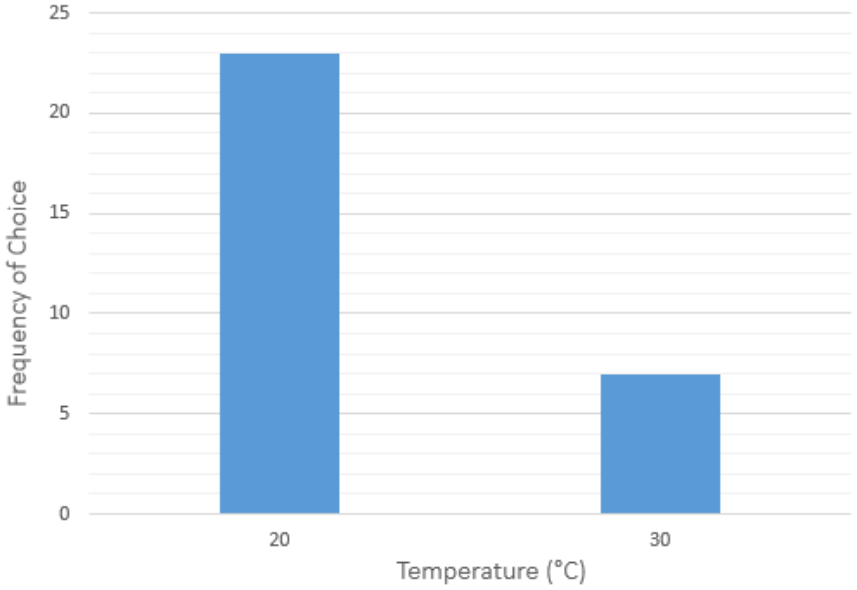


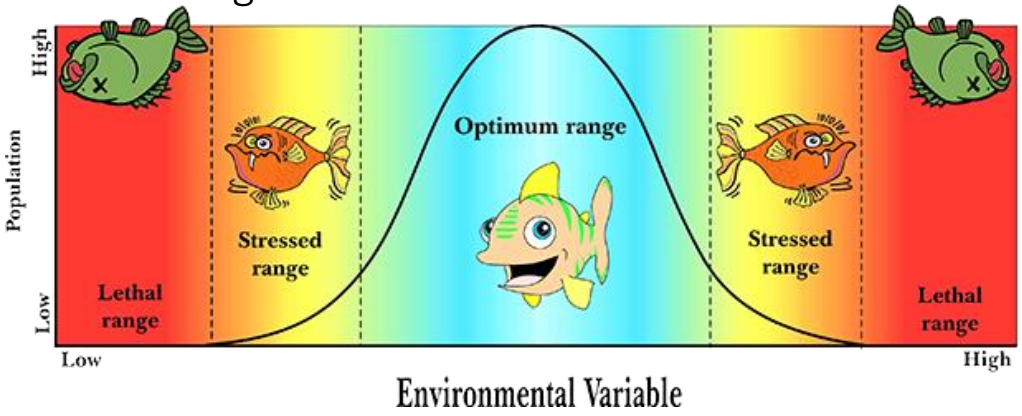
Figure 1. Trial 1. Number of *Bufo marinus* choosing sites when offered a choice of sites at 20°C and 30°C (n=30). $\chi 2 = 8.533$, p=0.0035

QUESTIONS?

Ecological Terms		
○ Abiotic Factor	○ Biotic Factor	○ Range of Tolerance
○ Abundance	○ Distribution	○ Dispersal
○ Population Size	○ Population Density	○ Lincoln-Petersen Index
○ Population growth (absolute)	○ per capita growth rate (*r*)	○ per capita birth rate
○ per capita death rate	○ Exponential Growth	○ Logistic Growth
○ Carrying capacity	○ Density independent growth / lfactor	○ Density dependent growth / factor
○ Life history traits	○ Survivorship curves / survivorship	○ Fitness trade-offs
○ r-selected life histories	○ K-selected life histories	○ Species interactions
○ Amensalism	○ Commensalism	○ Mutualism
○ Consumption (predation, parasitism, herbivory)	○ Competition	○ Niche – Fundamental and Realized
○ Limited resources	○ Competitive Exclusion	○ Niche partitioning
○ Community disturbance	○ Succession (1° and 2°)	Pioneering, early successional species
○ Mid successional species	○ Late succession species	○ Climax community
○ Ecosystem	○ Food web	○ Trophic Levels
○ Producers	○ Consumers	○ Detritivore/Decomposer
○ Detritus	○ Biomasss	○ Energy Flow/Energy Loss
○ Carbon cycle	○ Nitrogen Cycle	○ Fixation
○ Limiting Factors	○	○

Abiotic, biotic factors and range of tolerance

- Understand how abiotic and biotic factor can influence patterns of distribution and the abundance of a species
- Understand the concept of Range of Tolerance
    - organisms are most abundant when conditions are optimal
    - less abundant when conditions are suboptimal
    - absent (except perhaps for a short period of time) if factor is beyond range of tolerance.



http://aisyaturrobia.blogspot.com/2017/05/tolerance-range.html

Question

The Great Basin Spadefoot Toad is a medium-sized frog that inhabits the grassland ecosystem in British Columbia's Okanagan Valley. It is at risk in British Columbia because the Spadefoots depend upon temporary pools of water created by heavy Spring rainfall for breeding. However, much of this habitat has been lost because of urban and agricultural development.

The B.C. Ministry of Environment has hired you and a friend to determine if Spadefoot tadpoles are present at 2 sites. After reviewing the characteristics of the two sites (see below), your friend predicts that it is more likely that the spadefoot tadpoles will be present at site A than at site B.

Factor	Larval spadefoot's range of tolerance	Site A	Site B
Water temperature	10.2°C to 24.1°C	16.5°C to 20.7°C	17.5°C to 22.3°C
pH	7.2 to 10.4	7.5-8.2	10.3 – 10.8
Dissolved oxygen (mg/L)	8.3 mg/L to 9.1 mg/L	8.4 mg/L – 8.8 mg/L	7.9 mg/L – 8.4 mg/L

Question: Do you agree with your friend's claim? Use the claim, evidence, and reasoning model.

Example Answer

I agree with my friend's claim that Spadefoot tadpoles are more likely be present at site A than Site B. *(claim, note comparison).*

Abiotic conditions at site A are suitable for tadpole survival at site A but not at site B. *(reason, my writing style)*

The water temperatures are within the tadpoles' range of tolerance (10.2°C - 24.1°C) at both sites (site A =16.5°C-20.7°C; and site B=17.5°C-22.3°C).

However, pH levels are within the tadpoles' range of tolerance (7.2 - 10.4) at only site A (7.5-8.2). At site B, the pH levels (10.3-10.8) can exceed the tadpoles' upper range of tolerance (10.4)

Similarly, the dissolved oxygen levels (8.3 mg/L – 9.1 mg/L) are within the tadpoles' range of tolerance only at site A (8.4 mg/L – 8.8 mg/L). At site B, the dissolved oxygen levels (7.9 mg/L – 8.5 mg/L) can fall below the tadpoles' lower limit of tolerance (8.4 mg/L).

Therefore (*in conclusion*), the Spadefoot tadpoles are more likely to be present at site A than site B because they are able to tolerate the abiotic conditions at site A. In contrast, the larval Spadefoots will likely not be present at site B because the high pH and low dissolved oxygen levels can exceed the tadpoles' range of tolerance; so, the tadpoles would likely be not able to survive at this location.

(note – sandwich method, i.e. evidence/reasoning, evidence/reasoning; directional (e.g. too low), plus concluding sentence linking evidence back to claim; also use of descriptive comparative terms, e.g. "in contrast")

QUESTIONS?

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○ Carbon cycle	○ Nitrogen Cycle	○ Fixation
○ Limiting Factors	○	○

Population Ecology

- Be able to use the Lincoln-Petersen Index to estimate population size
- Know the assumptions of the Lincoln-Petersen Index

Question

- You and your friend conduct a mark-recapture study of the adult Great Basin Spadefoot toads at Site 1.
- In your first visit, you capture and mark 10 adult toads by placing a bright yellow mark on their back that is easy to see.
- In your second visit two months later you capture 5 adult toads.
- 2 of these toads were marked.
- What is the estimated population size?

$$\hat{N} = \frac{M*n}{m}$$

Question

- You and your friend conduct a mark-recapture study of the adult Great Basin Spadefoot toads at Site 1.
- In your first visit, you capture and mark 10 adult toads.
- In your second visit you capture 5 adult toads.
- 2 of these toads was marked.
- What is the estimated population size?

N = (10*5)/2 = **25**

$$\hat{N} = \frac{M*n}{m}$$

iClicker Question - Do you have confidence in your population estimate?

A. Yes
B. No
C. Not sure

Why?

Answer

A. Yes
B. No
C. Not sure

Why? The assumption that marking does not affect catchability is likely violated (e.g. marked frogs likely easy to detect by predators)

Other assumptions of Lincoln-Petersen Index?

Some other assumptions of Lincoln-Petersen Index?

- Population is closed (no births, no deaths, no immigration no emigration).
- Marks are not lost between sampling times
- Marked individuals mix randomly into population
- Proportion of marked individuals in the second sample represents the proportion of marked individuals overall.

Estimating population size in the future

$$N_{t+1} = N_t(1 + r)$$

In 2000 if the population size of gray squirrels on campus was 50 individuals, and the per capita growth rate was constant at 0.10 for the next 3 years, what would the estimated population size of gray squirrels be in 2003?

Year	Population Size	*r*	Calculation
2000	50	0.10	
2001		0.10	
2002		0.10	
2003	?		

Answer

$$N_{t+1} = N_t(1 + r)$$

For example, in 2000 if the population size of gray squirrels on campus was 50 individuals, and the per capita growth rate was constant at 0.10, what would the estimated population size be in 2003?

Year	Population Size	*r*	Calculation
2000	50	0.10	=50(1+0.10)
2001	55	0.10	=55(1+0.10)
2002	61	0.10	=61(1+0.10)
2003	67		

Population Ecology

- Understand the concept of population density.

Question

Spotted (Kliluk) Lake – is an isolated lake in the Okanagan Valley that is home to some extremophile organisms like *Artemia*, which can tolerate the high salinity levels. During the summer, most of the water in the lake evaporates, leaving small pools.

What would happen to the density of the *Artemia* during the summer months, assuming their population size did not change?

A. Increased
B. Decreased
C. No change

Answer

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What would happen to the density of the *Artemia* during the summer months, assuming their population size did not change?

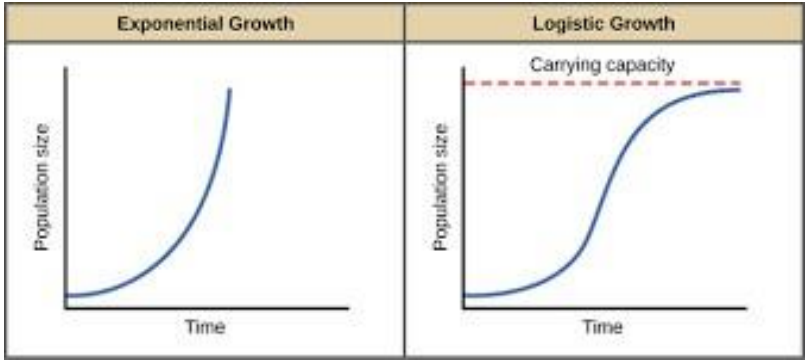
A. Increased
B. Decreased
C. No change

Population Ecology

- Be able to identify logistic and exponential growth
- Understand how the per capita growth rate (*r*) changes or does not change with population size in both logistic and exponential growth

Population growth models

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



$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

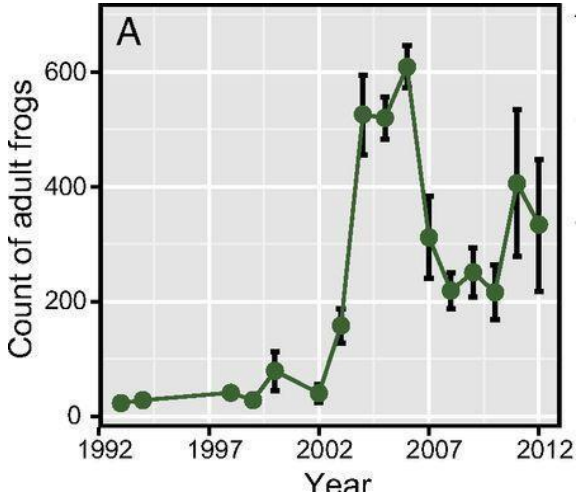
- Exponential growth – J shaped curve (*r* constant)
- Logistic growth – S-shaped curve (*r* not constant, *r* gets smaller as N increases)
  - as population size increases, resources become more limited and intraspecific competition increases.
  - Either *b* starts to decline and/or *d* starts to increase due to density-dependent factors; which decreases "*r*". *r=b-d (be able to calculate r)*

Questions

Frog abundance in Yellowstone National Park (1992-2012)

Is this graph showing exponential or logistic growth?

Where is r>0? r<0?



Knapp et al. 2016

Answer

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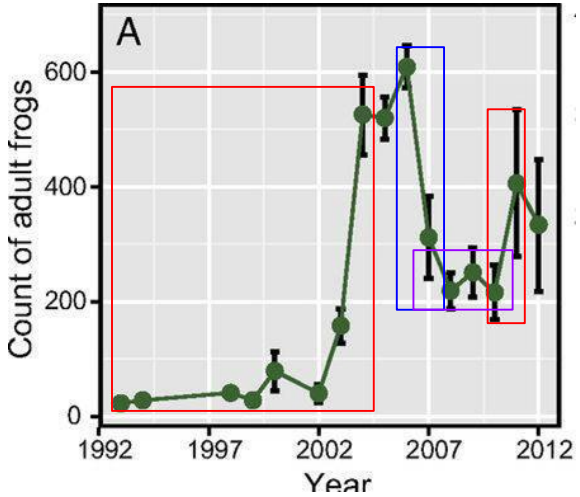

Knapp et al. 2016

Population Ecology

- Be able to identify when a population has reached carrying capacity.

Question

1. What is the carrying capacity for beavers in this environment?

2. Where is the per capita growth rate greatest on the figure?

3. In what year (~) was the greatest absolute growth of the beaver population?

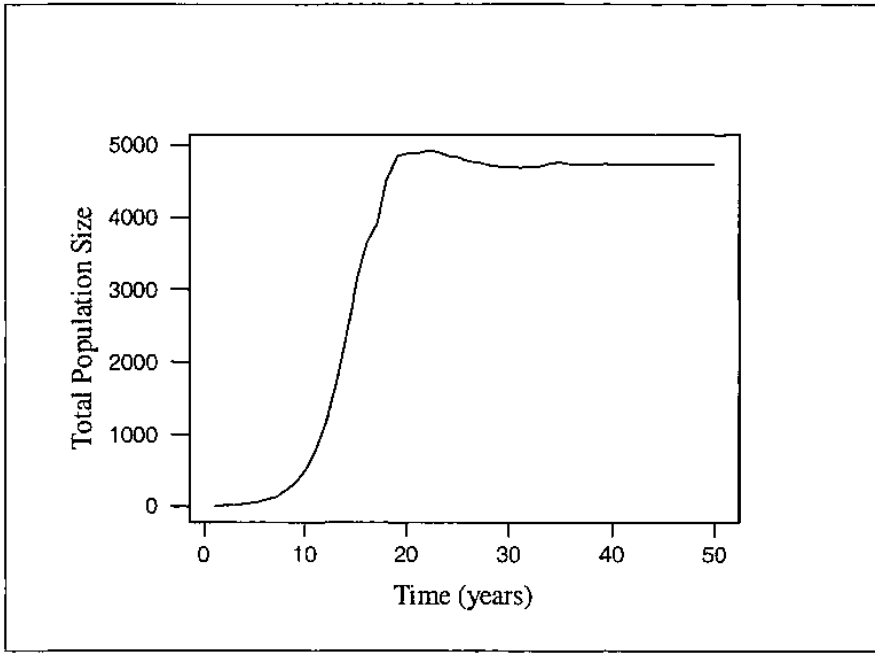

Figure 7. Growth of a nonexploited beaver population over time.

Runge 1999

Question

1. What is the carrying capacity for beavers in this environment? ~4800 beavers

2. Where is the per capita growth rate greatest on the figure? (early – e.g. 1 – 10 years)

3. In what year (~) was the greatest absolute growth of the beaver population? ~15 years (inflection point of curve).

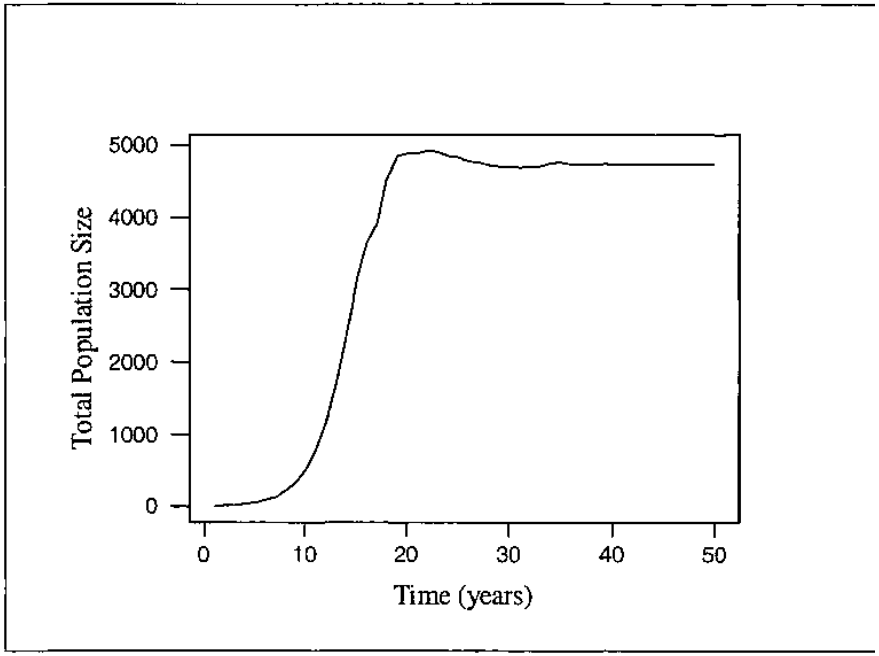

Figure 7. Growth of a nonexploited beaver population over time.

Runge 1999

Population Ecology

- Be able to explain how density-dependent and density-independent (limiting) factors can affect population growth/per capita growth rate.

Density-dependent and –independent limiting factors

Limiting factors are factors that can limit the growth, abundance, and distribution of a population.

Ask yourself:

Is the factor more likely to happen if the population is growing (or larger)?

- if the answer is no, then likely a density-independent factor (abiotic)
- if the answer is yes, then likely a density-dependent factor (biotic)

Density-dependent and density-independent factors

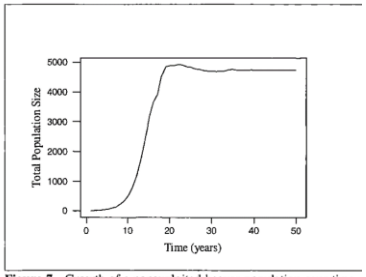

Figure 7. Growth of a nonexploited beaver population over time.

Name two density-independent factors that could potentially affect the population size (or growth rate) of this beaver population.

Name two density-dependent factors that could potentially affect the population size (or growth rate) of this beaver population.

Density-dependent and density-independent factors

Name two density-independent factors that could potentially affect the population size (or growth rate) of this beaver population.

- Drought, natural catastrophe (e.g. fire), global warming.

Name two density-dependent factors that could affect the population size (or growth rate) of this beaver population.

- Competition for food and/or for space, predation, disease

Can you explain how one of these factors could affect the per capita growth rate?

- You would need to explicitly refer to the effects on the per capita birth rates and/or per capita death rates (and how that would affect the value of *r*).

Population Ecology

Be able to draw or identify survivorship curves for a species or population

Be able to describe life history traits associated with different types of survivorship curves.

Question

Dall sheep display what type of survivorship curve?

A. Type I
B. Type II
C. Type III

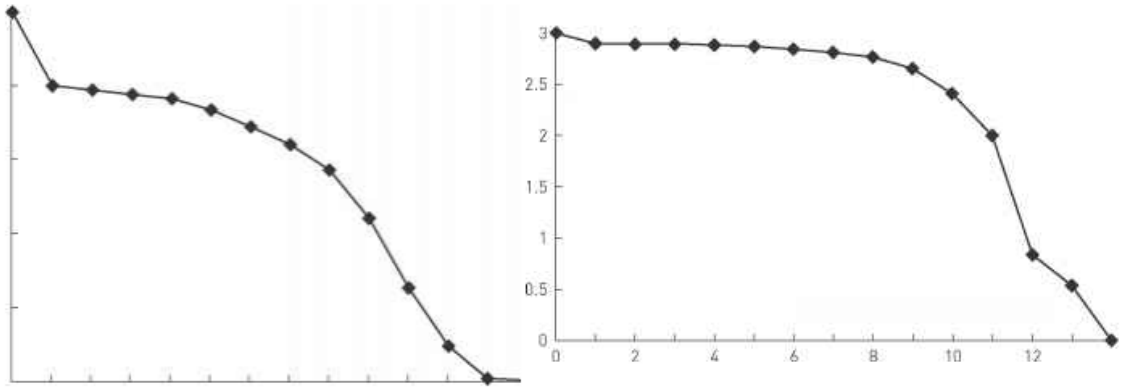

Figure 4.2 DaLL sheep (Ovis dalli) in Denali National Park, Alaska. (a) Survivorship (/J; (b) log of survivorship (Sj. After Deevy (1947).

https://www.ecologycenter.us/population-growth/survivorship.html

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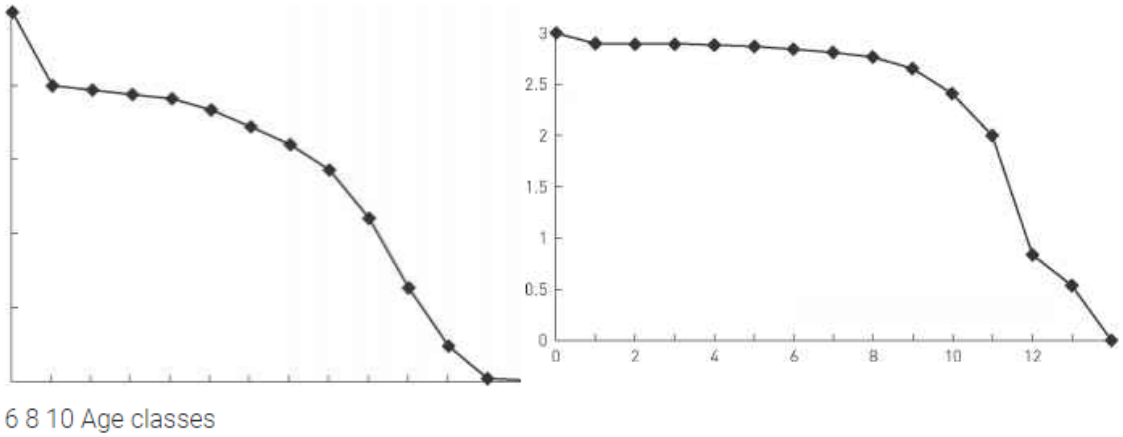

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Gray squirrels display what type of survivorship curve?

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B. Type II
C. Type III

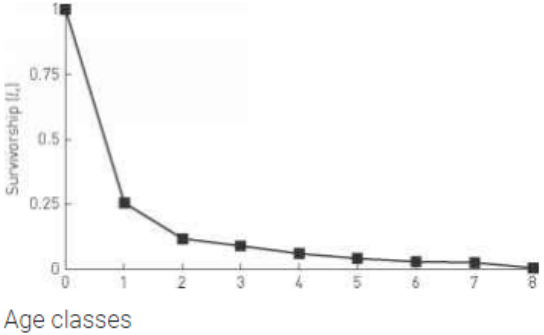

Figure 4.5 Survivorship curve for a gray squirrel (Sciurus carolinensis) population in North Carolina. Based on Barkalow et al. (1970).

https://www.ecologycenter.us/population-growth/survivorship.html

Question

Gray squirrels display what type of survivorship curve?

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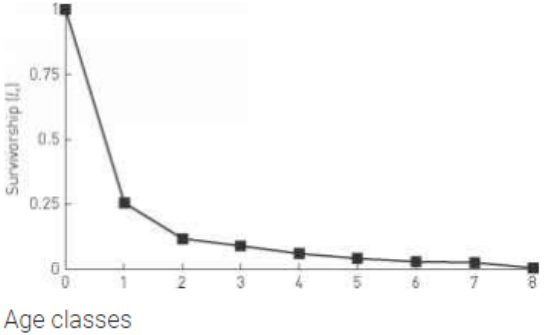


Figure 4.5 Survivorship curve for a gray squirrel (Sciurus carolinensis) population in North Carolina. Based on Barkalow et al. (1970).

https://www.ecologycenter.us/population-growth/survivorship.html

Question

White-crowned sparrow display what type of survivorship curve?

A. Type I
B. Type II
C. Type III

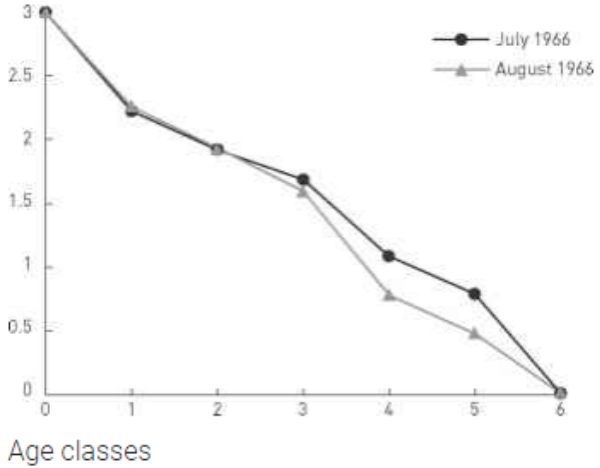
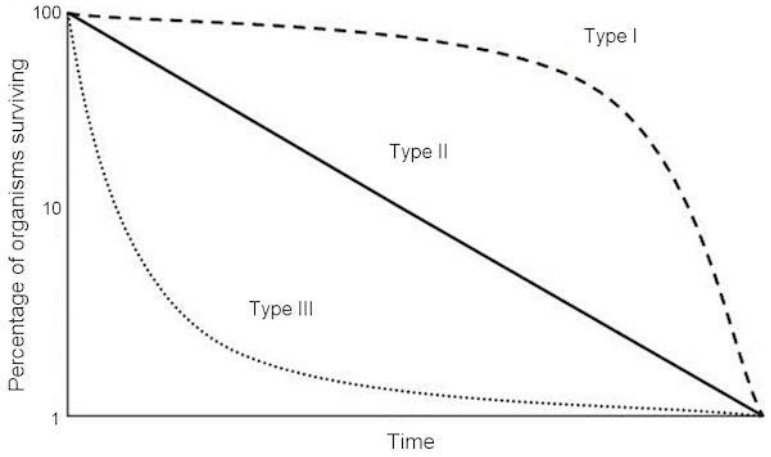


Figure 4.4 Log survivorship for two cohorts of white-crowned sparrows (Zonotrichia leucophrys). Based on Baker et al. (1981).

https://www.ecologycenter.us/population-growth/survivorship.html

Population Ecology - Life history traits

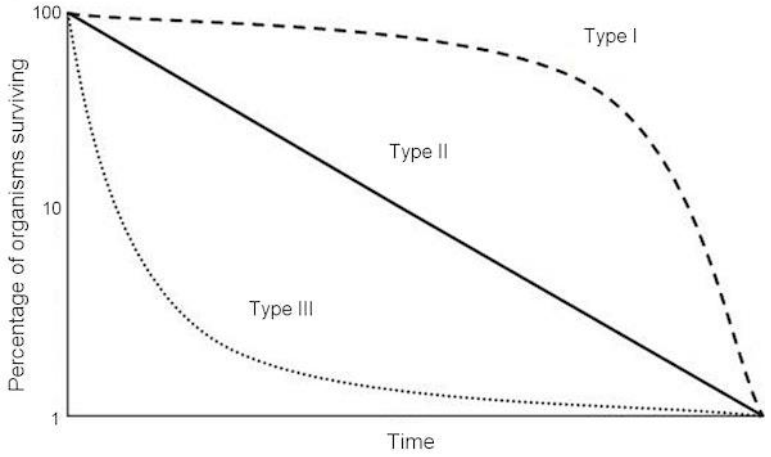
Be able to describe life history traits associated with different survivorship curves



Is a population with a Type III survivorship curve more likely to have *r*-selected life history traits or K-selected life history traits? What about individuals with a Type I survivorship curve?

Population Ecology - Life history traits

Be able to describe life history traits associated with different survivorship curves



Is a population with a Type III survivorship curve more likely to have *r*-selected life history traits or K-selected life history traits? (r-selected) What about individuals with a Type I survivorship curve? (K-selected)

Population Ecology - Life history traits

r-selected life history traits

K-selected life history traits

Population Ecology - Life history traits

r-selected life history traits

- small body size
- short-lived
- density-independent mortality
- poor competitors
- single reproductive event at a young age.
- little or no parental care
- high numbers of offspring

r-selected species tend to inhabit rapidly changing or unpredictable environments

K-selected life history traits

- large body size
- long-lived
- density-dependent mortality
- good competitors
- multiple reproductive events beginning later in life
- prolonged parental care
- relatively few offspring

K-selected species tend to live in predictable, stable environments

QUESTIONS?

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○ Carbon cycle	○ Nitrogen Cycle	○ Fixation
○ Limiting Factors	○	○

Community Ecology

Be able to predict the type of interactions among species and the **fitness** effects for each species justifying with evidence and clear reasoning.

Amensalism (- / 0)
Commensalism (+ / 0)
Mutualism (+ / +)
Competition (- / -)
Consumption (+ / -)
- Parasitism (+ / -)
- Predation (+ / -)
- Herbivory (+ / - 0)

Fitness refers to?

Question

Sacculina carcini, also called the crab hacker barnacle, is a type of barnacle that looks a bit like a slug. In the juvenile stage it seeks out crabs. Once a crab is found, it attaches to the crab's antenna and enters the crab's body, moving to just below the crab's heart. The *Sacculina* then extends tendrils throughout the crab's body that allow it to absorb nutrients from the crab's tissues.

The *Sacculina* forms a massive reproductive mass that produces hundreds of eggs per day. It is positioned in the same position as where the female crab's eggs would be; so the crab cares for the barnacles offspring.

If the *Sacculina* enters a male crab, it releases hormones that castrate the male crab and makes it act like a female

This interaction is:

A. Amensalism (- / 0)
B. Commensalism (+ / 0)
C. Mutualism (+ / +)
D. Competition (- / -)
E. Consumption (+ / -)
   Parasitism (+ / -)
   Predation (+ / -)
   Herbivory (+ / - 0)

Answer

Sacculina carcini, also called the crab hacker barnacle, is a type of barnacle that looks a bit like a slug. In the juvenile stage it seeks out crabs. Once a crab is found, it attaches to the crab's antenna moves to just below the crab's heart. The *Sacculina* then extends tendrils that allow it to absorb nutrients from the crab's tissues.

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This interaction is:

A. Amensalism (- / 0)
B. Commensalism (+ / 0)
C. Mutualism (+ / +)
D. Competition (- / -)
E. Consumption (+ / -)

Parasitism (+ / -)

Predation (+ / -)

Herbivory (+ / - 0)

Question

Could you explain to me:

A. Why the relationship between the crab hacker barnacle and the crab has a positive fitness effect for the crab hacker barnacle?

B. Why this relationship has a negative fitness effect for a crab that is parasitized?

A few key points

A. Why this relationship between the crab hacker barnacle and the crab has a positive fitness effect for the crab hacker barnacle?

- The c.h. barnacle is receiving nutrients from that crab; these nutrients can be used to increase the reproductive success of the c.h. barnacle, e.g. More nutrients could potentially mean more offspring and/or healthier offspring
- The crab is also taking care of the c.h. barnacle's offspring, potentially increasing the survivorship of the offspring, and the c.h. barnacle's fitness.

B. Why this relationship has a negative fitness effect for the crab that is parasitized?

- For both male and female crabs, they may have insufficient nutrients to maximize reproduction, and potentially use their limited energy caring for the young of the c.h. barnacle; this could potentially mean lower reproductive success (and fitness for the crabs)
- If the crab is a male crab, they will be castrated; and therefore unable to produce children, which would have a very negative effect on reproductive success, and fitness.
- If the crab is a female crab

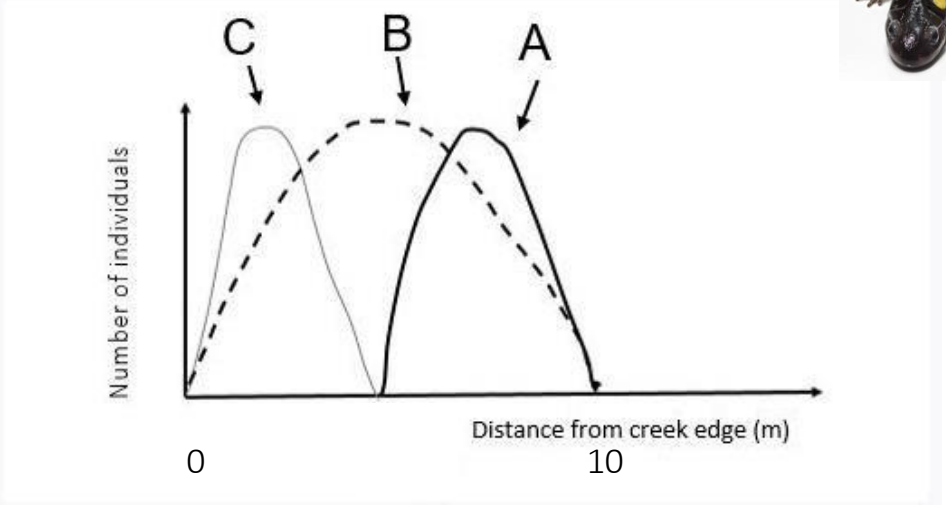
Interspecific competition: fundamental versus realized niches - Question

Orange newts and spotted salamanders live close to creek edges.

If the orange newts are alone, they can be found from 0 to 10 m from the edge of the creek.

If the spotted salamanders are also present, orange newts are only found from 5 to 10 m from the edge of the creek.

Spotted salamanders are found from 0 to 5 m from the edge of the creek whether orange newts are present or not.



What do letters A-C represent?

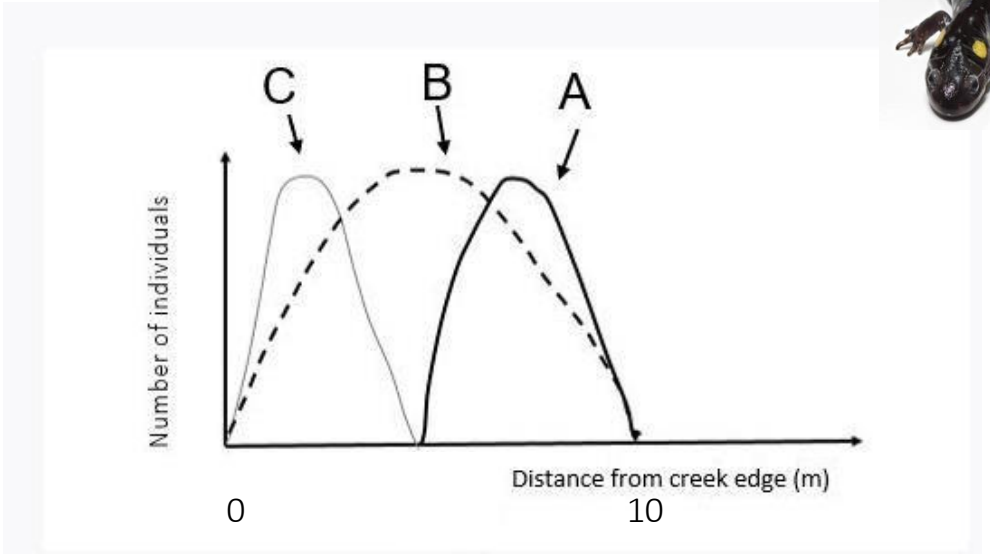
Answer

What do letters A-C represent?

A: Realized niche of orange newts

B: Fundamental niche of orange newts

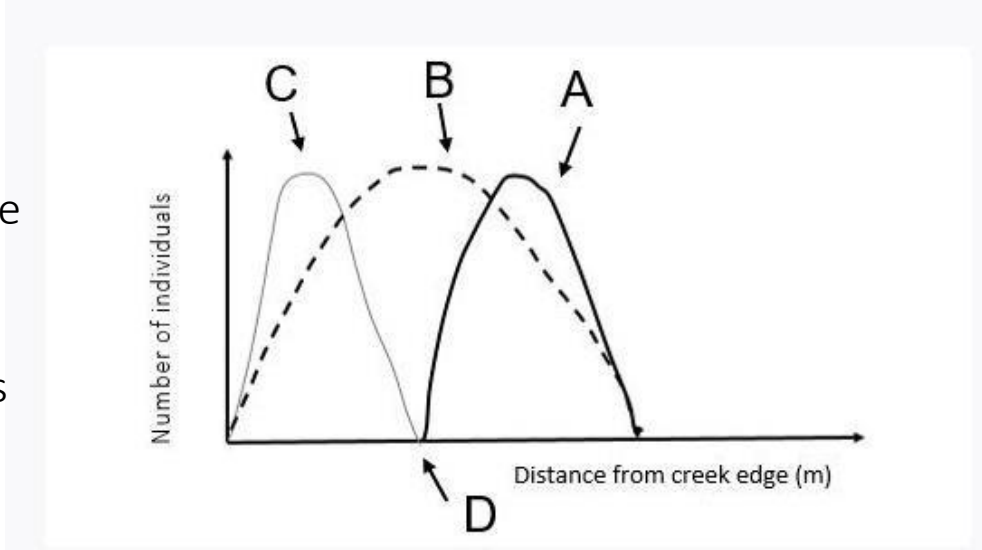
C: Fundamental and realized niche of spotted salamanders



iClicker Question

What is the ecological outcome of the interaction between newts and the spotted salamanders?

A. Niche partitioning
B. Competitive exclusion of the orange newts by the spotted newts
C. Competitive exclusion of the spotted newts by the orange newts
D. Not sure



Answer

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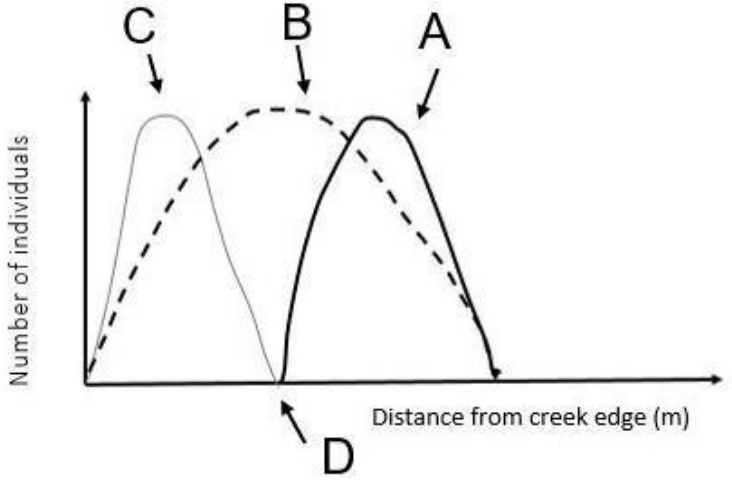


Community Ecology - Succession

- Describe different types of disturbances.
- Given a scenario, identify the type of succession (primary or secondary).
- Describe general characteristics of species found at different successional stage in a forest biome (e.g., dispersal ability, tolerance of abiotic conditions, competitive ability, including life history characteristics).
- Explain how abiotic and biotic factors change with succession.

Community Ecology: Disturbances

Examples of a disturbance that results in primary succession?

Example of a disturbance that results in secondary succession?

Community Ecology: Disturbances

Examples of a disturbance that results in primary succession?

Volcano, severe landslide, mining

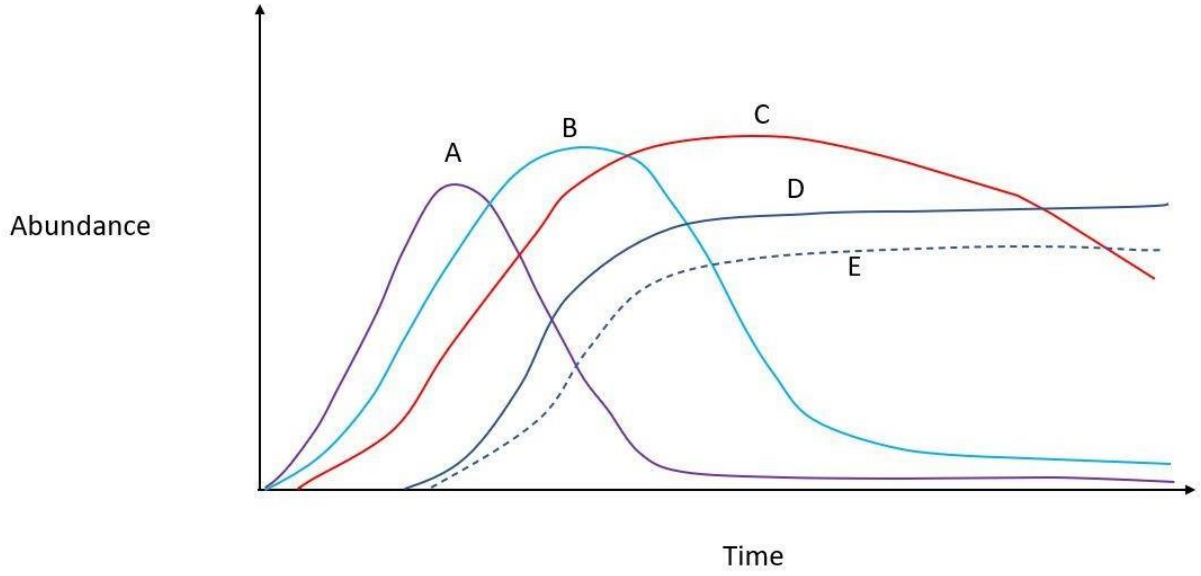
Example of a disturbance that results in secondary succession?

Logging, tornado, flooding, wind storm

Succession – life history traits

Which of the 5 plant species is strongly r-selected?

Which plant species are likely good competitors?



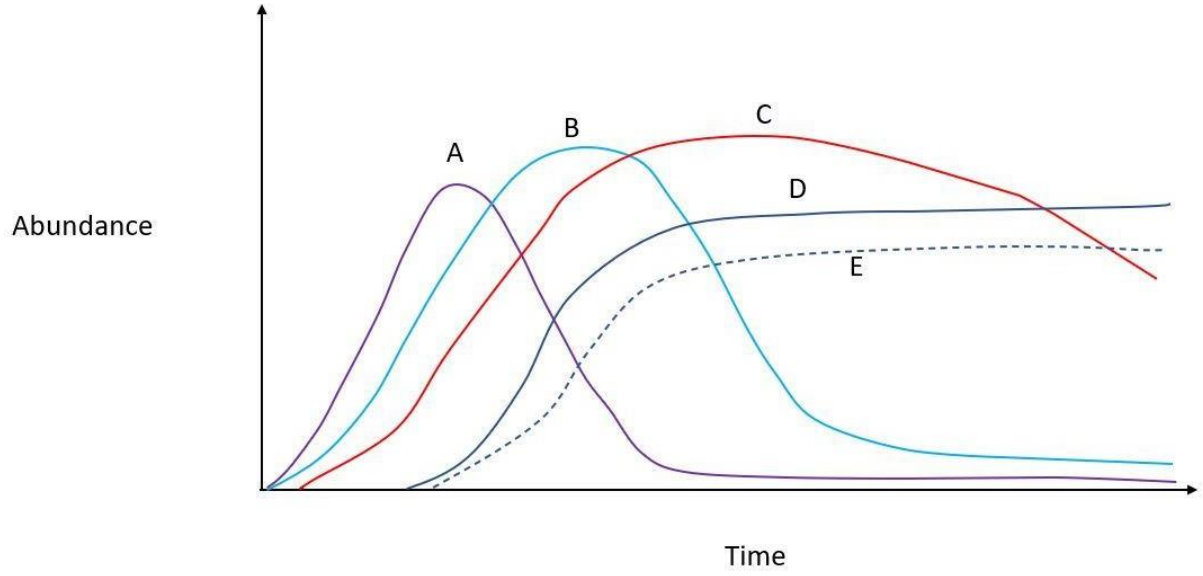
Succession

Which of the 5 plant species is strongly r-selected?

A, B

Which plant species are likely good competitors?

D, E, likely C



Rank these 4 plant species in the order from earliest to latest successional species.

Species	Characteristics	Picture	Rank
Crowberry	Low growing shrub (15-30 cm) that can form mats. Woody tissue. Produces berries that are transported by birds and small mammals. Tolerant of low light. Competitive. Tolerant of harsh abiotic conditions. Can live more than 20 years.		
Sitka Spruce	Grows up to 100m tall. Long-lived > 800 years. Deep roots (200 cm). High shade tolerance. Low tolerance of high temperatures and wind Absent from sites with low nutrient availability. Reproduces via seeds.		
Clustered rock moss	Herbaceous (no woody tissue). Can grow directly on ice or rock, tolerant of harsh abiotic conditions. Have no “true roots”, can absorb water and nutrients from the air. Forms low (<10 cm) clumps or mats. Reproductive via spores. Spores can travel 100 of km via wind. Grow slowly.		
Thyme-leaved sandmat	Form mats. Rare for it to grow over 1 cm in height. Short-lived. Cannot grow in the shade. Prefers drier, exposed soils. Have a taproot up to 0.5m long. Killed by frost. Reproduces via seeds. Can produce thousands of seeds. Seeds are sticky – dispersed by wind, water, and/or transported by animals.		

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QUESTIONS?

Ecological Terms		
○ Abiotic Factor	○ Biotic Factor	○ Range of Tolerance
○ Abundance	○ Distribution	○ Dispersal
○ Population Size	○ Population Density	○ Lincoln-Petersen Index
○ Population growth (absolute)	○ per capita growth rate (*r*)	○ per capita birth rate
○ per capita death rate	○ Exponential Growth	○ Logistic Growth
○ Carrying capacity	○ Density independent growth / lfactor	○ Density dependent growth / factor
○ Life history traits	○ Survivorship curves / survivorship	○ Fitness trade-offs
○ r-selected life histories	○ K-selected life histories	○ Species interactions
○ Amensalism	○ Commensalism	○ Mutualism
○ Consumption (predation, parasitism, herbivory)	○ Competition	○ Niche – Fundamental and Realized
○ Limited resources	○ Competitive Exclusion	○ Niche partitioning
○ Community disturbance	○ Succession (1° and 2°)	Pioneering, early successional species
○ Mid successional species	○ Late succession species	○ Climax community
○ Ecosystem	○ Food web	○ Trophic Levels
○ Producers	○ Consumers	○ Detritivore/Decomposer
○ Detritus	○ Biomasss	○ Energy Flow/Energy Loss
○ Carbon cycle	○ Nitrogen Cycle	○ Fixation
○ Limiting Factors	○	○

Ecosystem Ecology – Food web

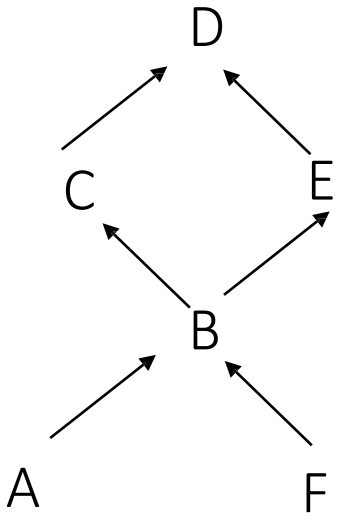
Be able to:

- Identify trophic levels and energy sources of organisms
- Describe the flow of energy through an ecosystem (e.g. draw a food web)
- Explain why there is less biomass at higher trophic levels
- Predict consequences of changes to these systems

Activity

Use the information in the table
- assign taxa to trophic levels
- draw a food web
- okay to annotate this slide

Pond Ecosystem		
Organism	Biomass present (g)	Trophic level
A	6100	
B	900	
C	50	
D	6	
E	40	
F	5900	



Pond Ecosystem		
Organism	Biomass present (g)	Trophic level
A	6100	Producer
B	900	1° consumer
C	50	2° consumer
D	6	3° consumer
E	40	2° consumer
F	5900	Producer

Why is only ~ 10% of the biomass (or energy) available at one trophic level available at the next tropic level?

Pond Ecosystem		
Organism	Biomass present (g)	Trophic level
A	6100	Producer
B	900	1° consumer
C	50	2° consumer
D	6	3° consumer
E	40	2° consumer
F	5900	Producer

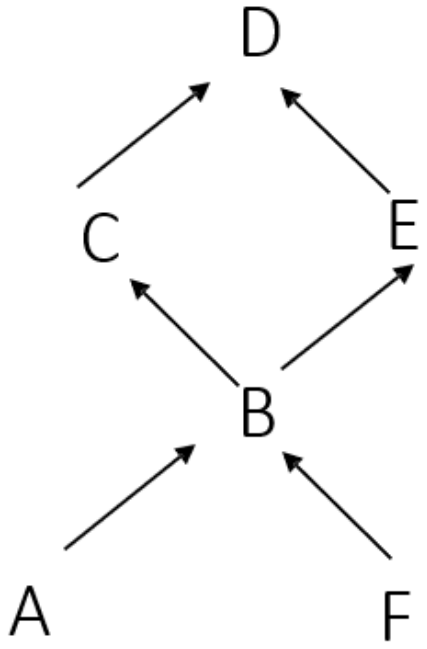
Why is only ~ 10% of the biomass (or energy) available at one trophic level available at the next tropic level?

Examples:
- energy lost as heat due to metabolism
-inefficient digestion
-energy used for hunting/prey handling
- some of the biomass goes directly to detritivores/decomposers

Pond Ecosystem		
Organism	Biomass present (g)	Trophic level
A	6100	Producer
B	900	1° consumer
C	50	2° consumer
D	6	3° consumer
E	40	2° consumer
F	5900	Producer

Ecosystem Ecology - Question

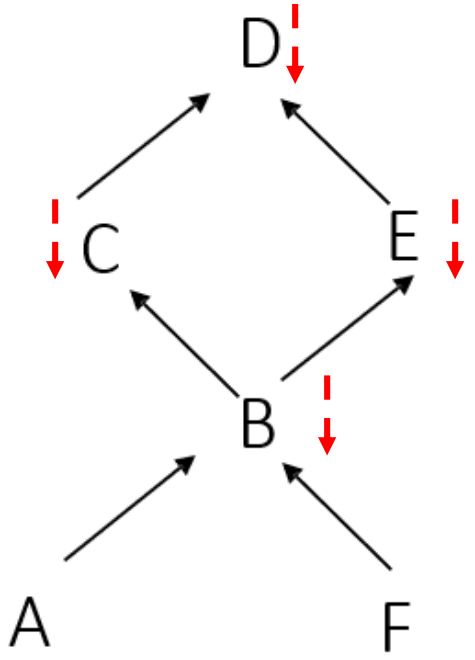
What would happen to the biomass of D if a predator of B was introduced into the ecosystem?



Ecosystem Ecology - Question

What would happen to the biomass of D if a predator of B was introduced into the ecosystem?

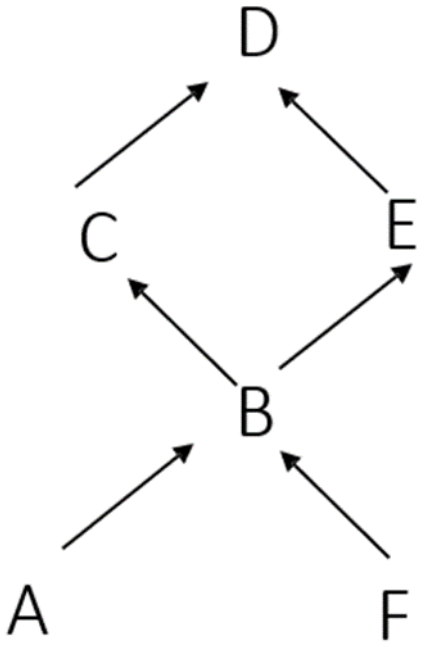
Biomass of D would decline? Could you explain why?



Activity

A detritivore (G) has been added to the food web.

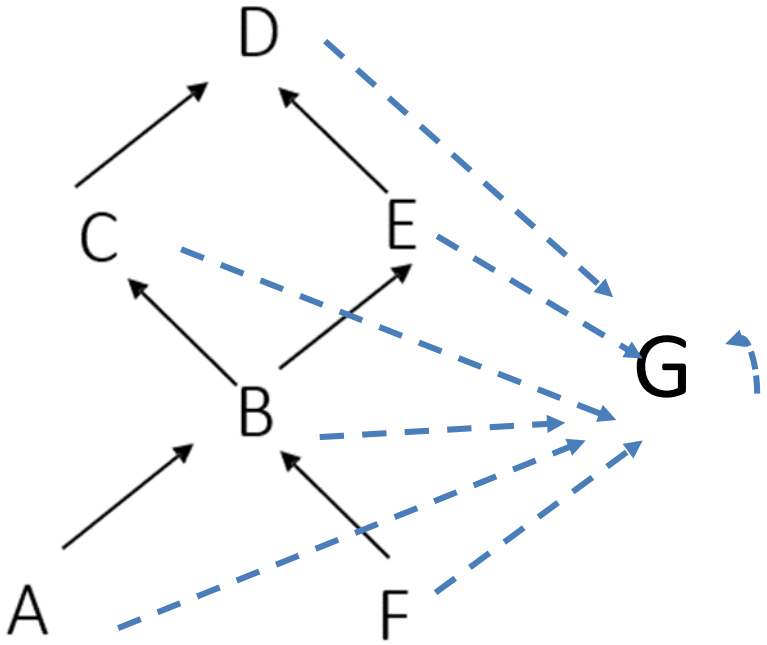
Where would you add arrows?



G

Activity

A detritivore (G) has been added to the food web.



Ecosystem Ecology – Nutrient Cycling

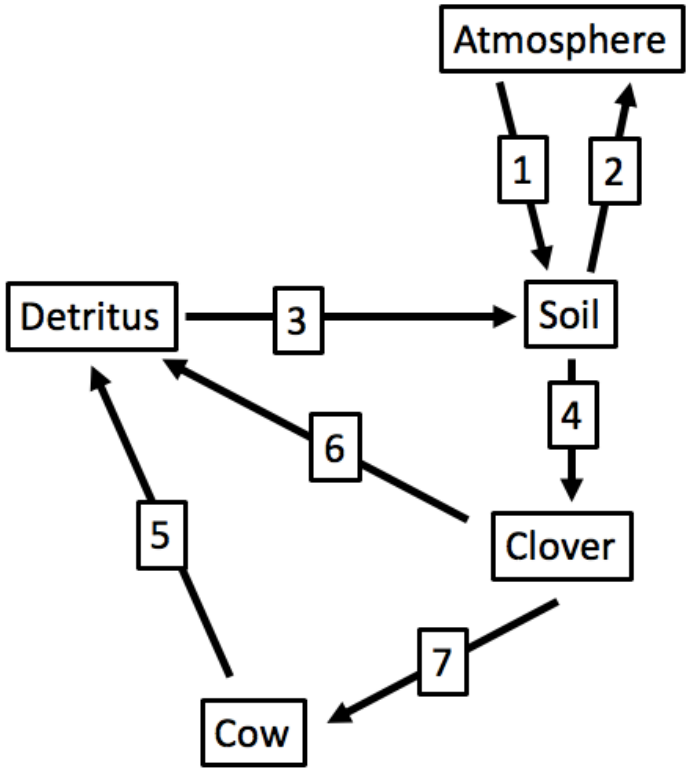
Be able to:

- Describe how nutrients cycle through a food web and/or ecosystem
- Predict the consequences of changes to this system

Question

What step of the **nitrogen cycle** is being shown by arrow 1?

A. Release of N_2 gas by denitrifying bacteria
B. Decomposition of dead organic material by decomposers (bacteria and fungi) and detritivores
C. Uptake of ammonium, nitrates and nitrates by producers
D. Nitrogen-fixing bacteria and nitrifying bacteria convert N_2 to ammonium, nitrates and nitrites.
E. Not sure



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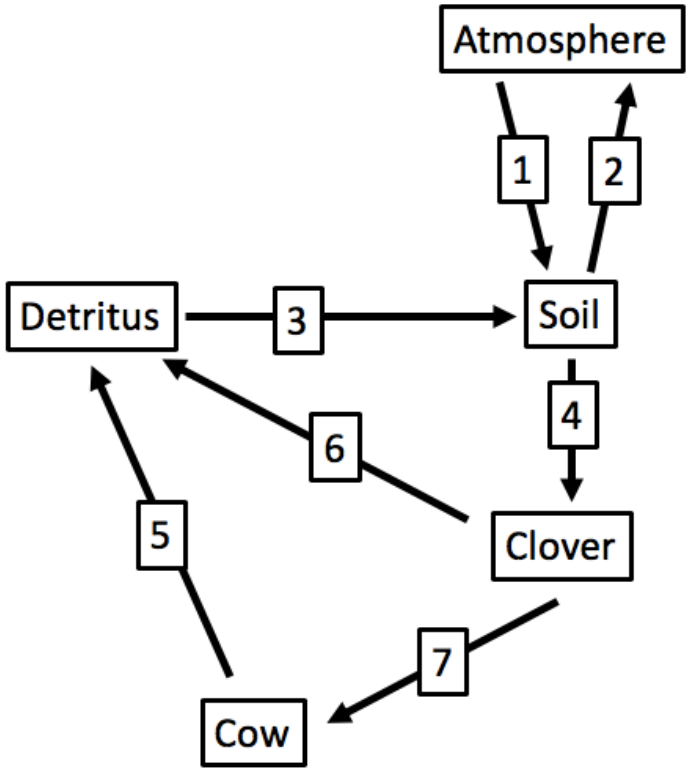


Atmospheric N_2

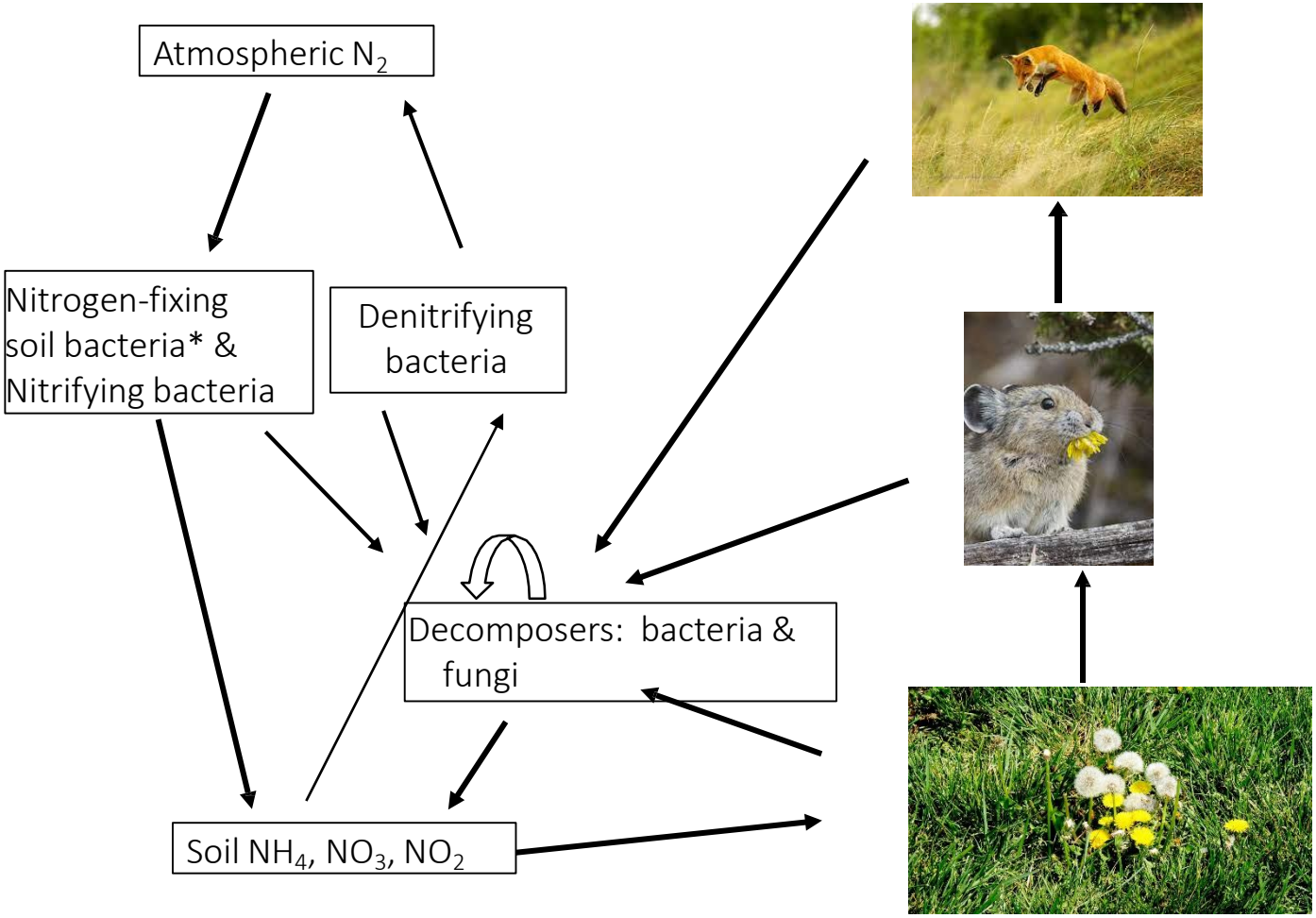
Add in arrows to show the flow of nitrogen

Nitrogen-fixing soil bacteria* & Nitrifying bacteria

Denitrifying bacteria

Decomposers: bacteria & fungi

Soil NH_4, NO_3, NO_2


Atmospheric N_2
Nitrogen-fixing soil bacteria* & Nitrifying bacteria
Denitrifying bacteria
Decomposers: bacteria & fungi
Soil NH_4, NO_3, NO_2

Activity: Draw the movement of carbon through this ecosystem
- annotate this slide

Atmospheric CO_2

Activity: Draw the movement of carbon through this ecosystem
- annotate this slide

Atmospheric CO_2

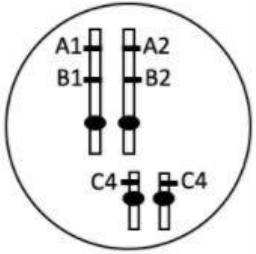
- Key points
- Carbon moves from source (in this example the atmosphere) to plants, then consumers.
- Carbon in all living organisms moves to detritivore/decomposer trophic level when organism dies.
- Detritivores and decomposers also decomposed.
- All organisms release C (CO2) to atmosphere including plants.
- For plants – net movement of carbon into plants.

End of ecology portion of review

Questions?

In the Genetics Unit, we talked about…

Terms to describe chromosomes:
- cell ploidy
- chromosomes (homologous, non-homologous)
  - -chromatids (sister, non-sister)
  - - genes and alleles



iClicker Question

What is the ploidy of this cell?

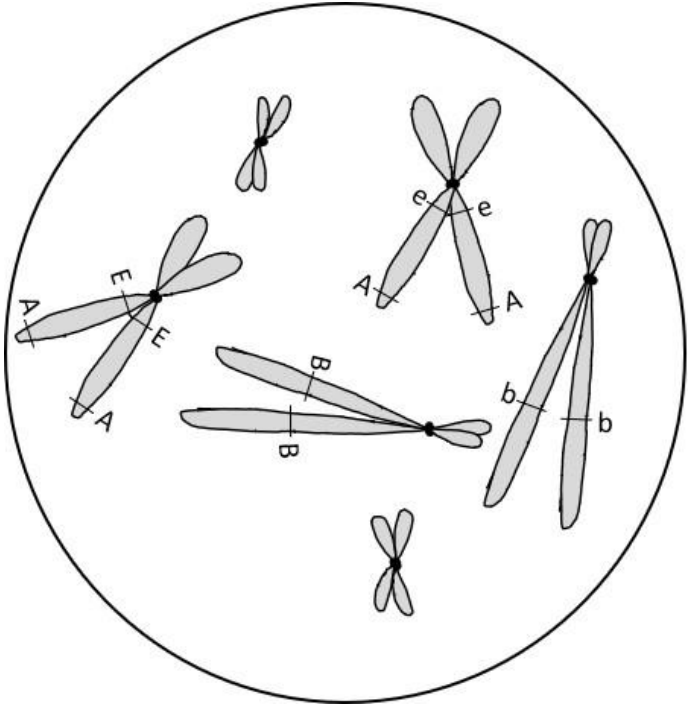
A. Haploid

B. Diploid

C. Polyploid

D. Godzillaploid

E. Not sure



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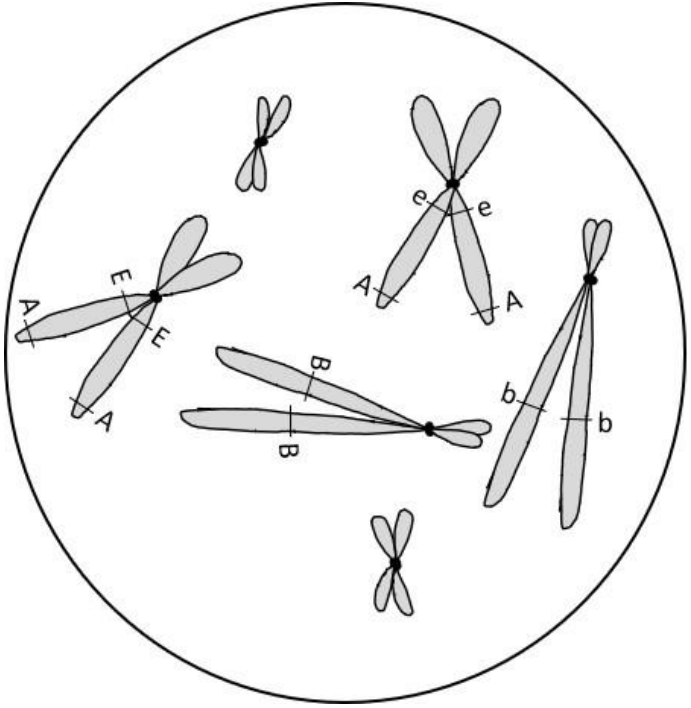


In the Genetics Unit, we also talked about…

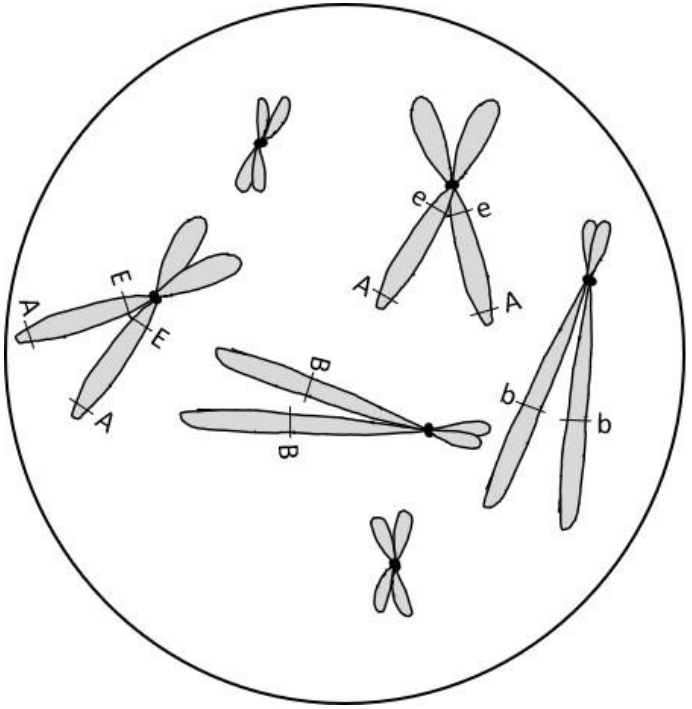
- how to draw, and/or interpret drawings of cells in different stages of interphase, mitosis and meiosis.

- how to make predictions about the genotypes of gametes and/or the genotypes and phenotypes of offspring (and their frequencies) if:
    - genes are on autosome or X-chromosome
    - if the genes are not physically linked
    - If they are physically linked and crossing-over and recombination can or cannot occur.

- The mechanisms that result in genetic variation in gametes and offspring.

What stage/stages of the cell cycle could this cell be in if the cell is a somatic cell?

G1	
S	
G2	
Prophase	
Metaphase	
Anaphase	
Telophase	
Cytokinesis	
Not sure	



Answer

G1	
S	
G2	
Prophase	
Metaphase	
Anaphase	
Telophase	
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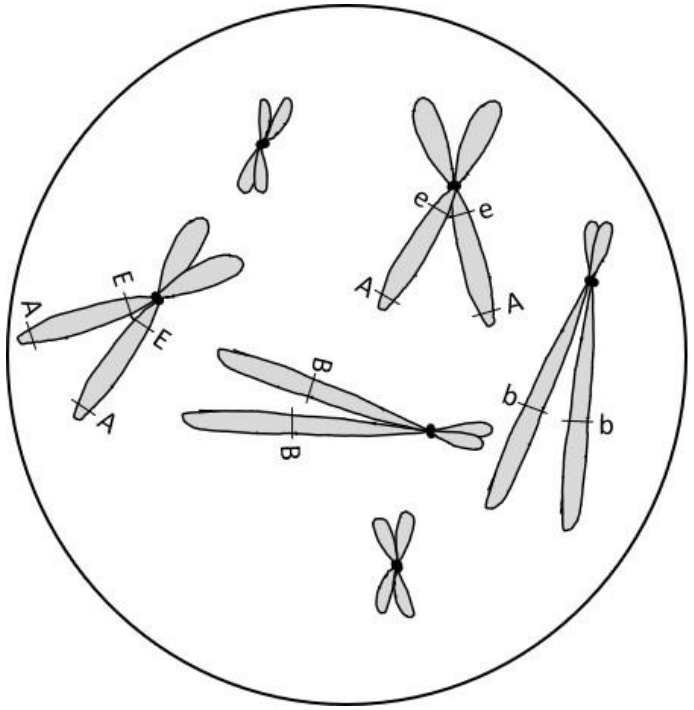
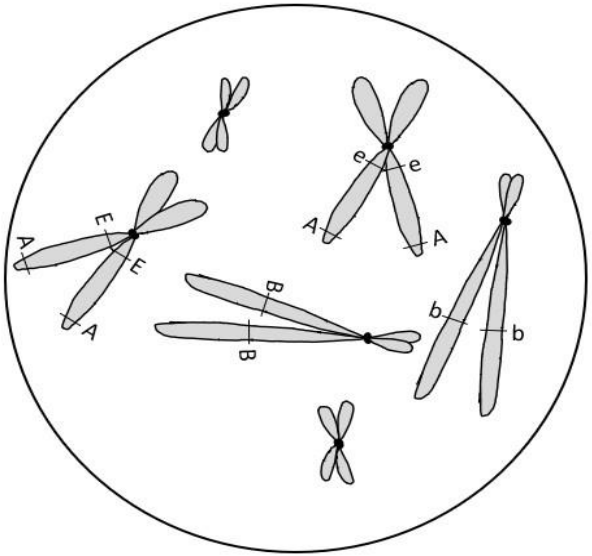
Not sure	



iClicker Question

If this cell was undergoing meiosis, how many gamete genotypes could be produced?

assume crossing-over can occur.



Answer

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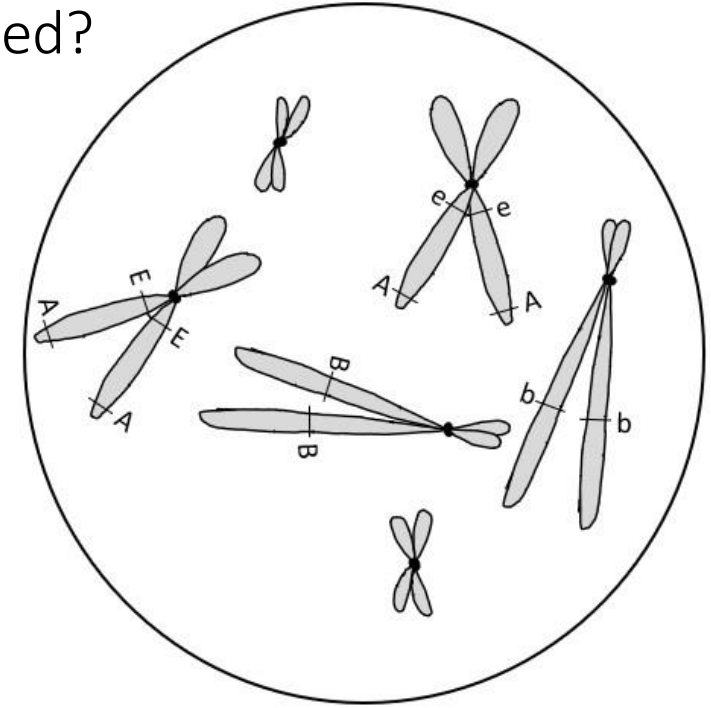
4



What would those gamete genotypes be?

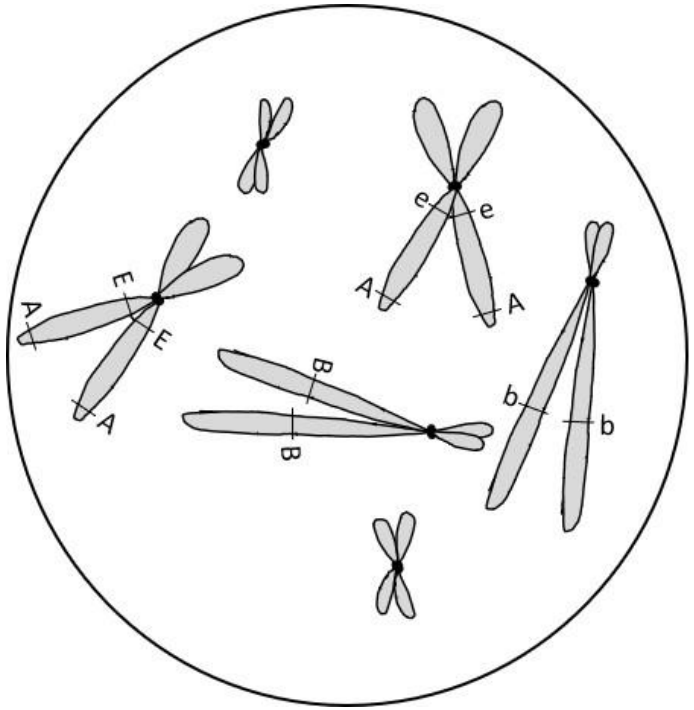
assuming crossing-over can occur.

ABE

ABe

Abe

AbE



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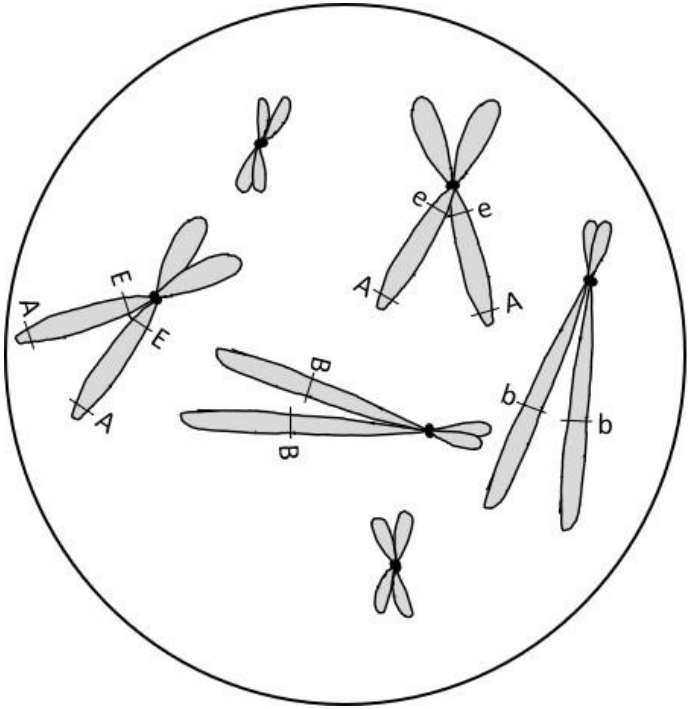
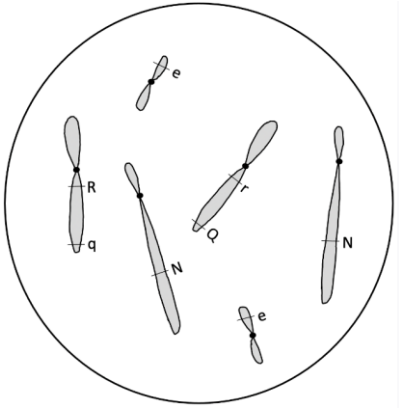
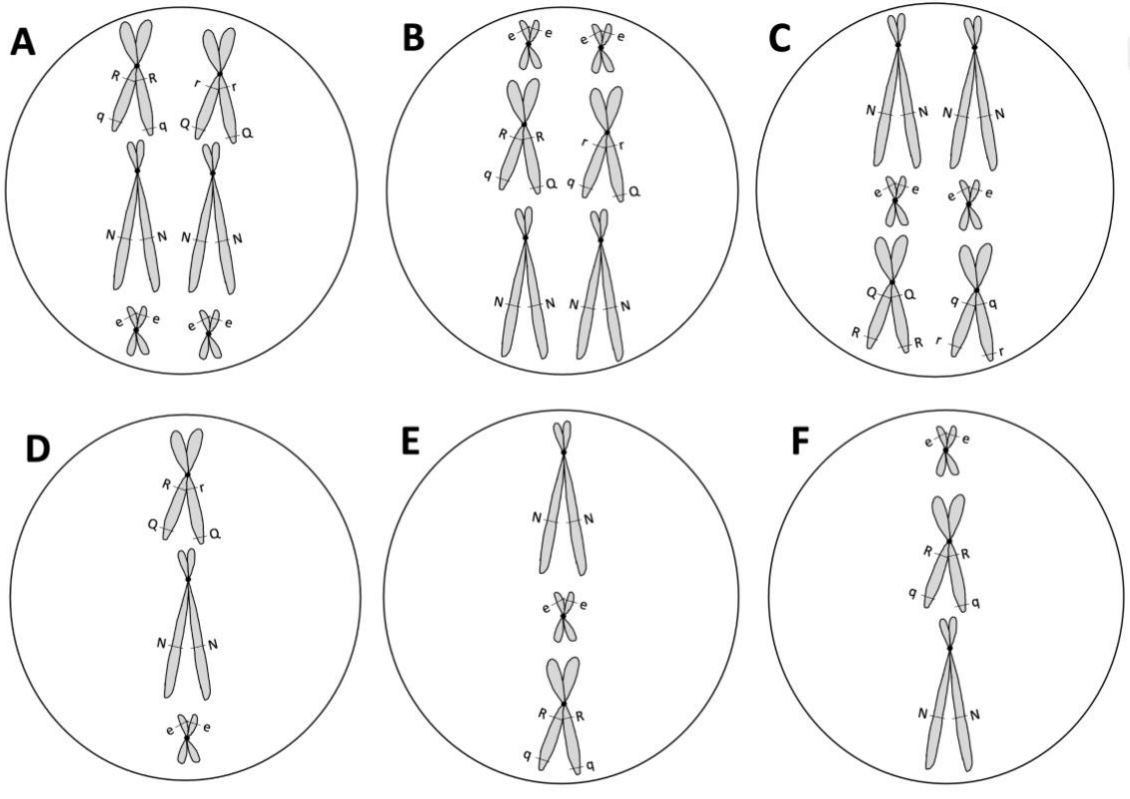


Given the parent cell on the left, which of the 6 cell diagrams on the right (A-F) could be a cell a Metaphase I?





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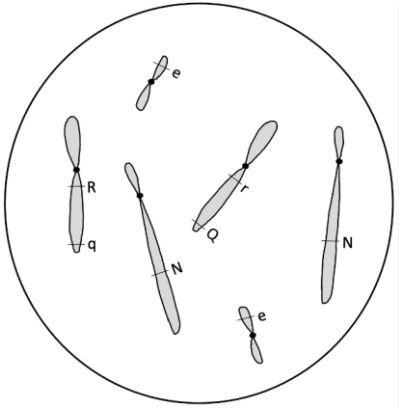

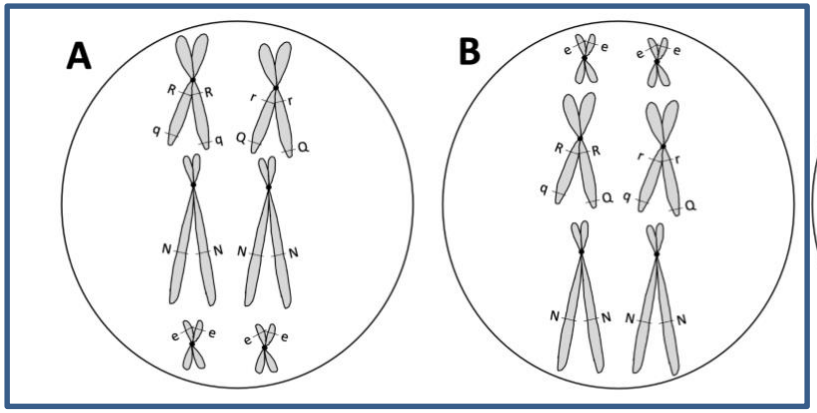

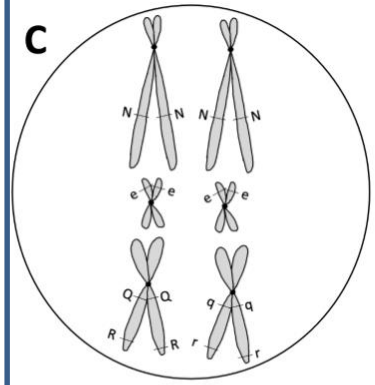

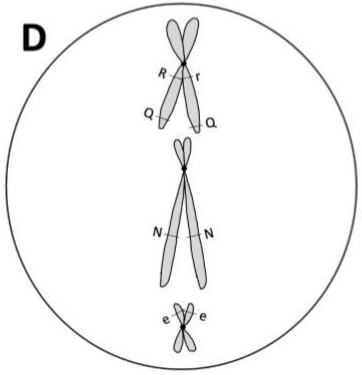

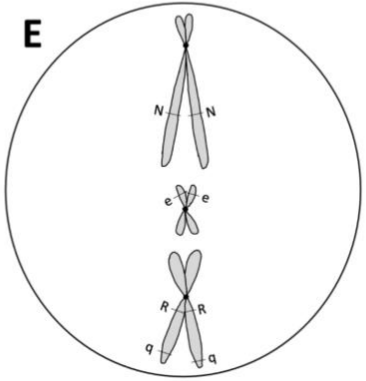

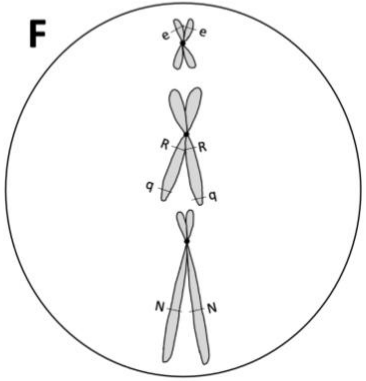

Genetic Crosses Question

Ladybugs (or lady beetles) are small insects with dome-shaped bodies. Red body colour (R) is dominant to black body colour (r), and the allele for two spots (T) is dominant to the allele for 20 spots (t).
True breeding ladybugs with red bodies and twenty spots were crossed with ladybugs with black bodies and two spots. The F1 ladybugs all had red bodies and two black spots.

If the two genes (for body colour and spot number) assort independently (i.e. **the genes are not linked**), what are the **genotypes** of the parents and the F1 offspring?

Answer

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True breeding ladybugs with red bodies and twenty spots were crossed with ladybugs with black bodies and two spots. The F1 ladybugs all had red bodies and two black spots.

If the two genes (for body colour and spot number) assort independently (i.e. **the genes are not linked**), what are the **genotypes** of the parents and the F1 offspring?

Parent #1: RRtt
Parent #2: rrTT

F1s: RrTt

Ladybug Question

The F1 ladybugs are then crossed with ladybugs with black bodies and twenty spots (test cross).

Remember: Red is dominant to black; and two spots is dominant to 20 spots.

What **genotypes** and **phenotypes** do you expect to observe in the F2 generation and in **what ratio** do you expect these phenotypes to occur?

Answer

The F1 ladybugs are then crossed with ladybugs with black bodies and twenty spots (test cross).

Remember: Red is dominant to black; and two spots is dominant to 20 spots. Genes are not linked

What **genotypes** and **phenotypes** do you expect to observe in the F2 generation and in **what ratio** do you expect these phenotypes to occur?

RrTt, x rrtt (test cross)

	rt	Phenotype
RT	RrTt	Red, 2 spots
Rt	Rrtt	Red, 20 spots
.rT	rrTt	Black, 2 spots
.rt	rrtt	Black, 20 spots

1:1:1:1 phenotypic ratio

Ladybug Question

If you perform the same test cross as in the previous question (F1s x test cross), if the genes for colour and spot number are physically linked with no crossing over, what genotypes and phenotypes do you expect and in what ratio do you expect these phenotypes to occur?

Reminder: Original Parents = True breeding ladybugs with red bodies and twenty spots were crossed with ladybugs with black bodies and two spots.

Answer

If you perform the same test cross as in the previous question (F1s x test cross), if the genes for colour and spot number are physically linked with no crossing over, what genotypes and phenotypes do you expect and in what ratio do you expect these phenotypes to occur?

Reminder: Original Parents = True breeding ladybugs with red bodies and twenty spots were crossed with ladybugs with black bodies and two spots.

RrTt x rrtt

	Rt	Phenotype
Rt	Rrtt	Red, 20 spots
rT	rrTt	Black, 2 spots

iClicker Question

What results do you expect from this same test cross as in the previous questions (F1s x test cross), if the genes are linked (close together on the same chromosome) but there is crossing over? Choose all that apply.

A. Majority of the ladybugs will have recombinant phenotypes: red bodies and two spots, and black bodies and twenty spots.
B. Minority of the ladybugs will have parental phenotypes: red bodies and twenty spots, and black bodies and two spots.
C. Majority of the ladybugs will have parental phenotypes: red bodies and twenty spots, and black bodies and two spots.
D. Minority of the ladybugs will have recombinant phenotypes: red bodies and two spots and black bodies and twenty spots.
E. C & D

Answer

What results do you expect from this same test cross as in the previous questions (F1s x test cross), if the genes are linked (close together on the same chromosome) but there is crossing over? Choose all that apply.

A. Majority of the ladybugs will have recombinant phenotypes: red bodies and two spots, and black bodies and twenty spots.
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C. Majority of the ladybugs will have parental phenotypes: red bodies and twenty spots, and black bodies and two spots.
D. Minority of the ladybugs will have recombinant phenotypes: red bodies and two spots and black bodies and twenty spots.
E. C & D

iClicker Question – Ladybug scenario

Which statement(s) related to genetic variation in ladybugs is/are correct?

A. Mutations are the ultimate source of genetic variation in ladybugs.

B. In the P-generation, crossing-over between sister chromatids during meiosis I will increase genetic variation in gametes.

C. If the genes for body colour and spot number were not linked, then genetic variation could NOT be increased by independent assortment of chromosomes when an F1 cell is undergoing meiosis.

D. The fusion of gametes from two different ladybugs during sexual reproduction will result in offspring that are genetically distinct from either parent.

E. A and D.

Answer

Which statement(s) related to genetic variation in ladybugs is/are correct?

A. Mutations are the ultimate source of genetic variation in ladybugs.
B. In the P-generation, crossing-over between sister chromatids during meiosis I will increase genetic variation in gametes.
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D. The fusion of gametes from two different ladybugs during sexual reproduction will result in offspring that are genetically distinct from either parent.
E. A and D.

In the Genetics Unit, we also talked about

- How to use the result of genetic crosses to determine the modes of inheritance for a trait:
- And how to test a hypothesized mode of inheritance for a trait (if provided).

Mode of Inheritance Question

Numerous species of amphibians are at risk of extinction.

The chytrid fungus is believed to be one of the main causes of this decline.

There is some evidence that there is a gene that may confer some resistance to the chytrid fungus (Q gene).

However, it is unclear how resistance is inherited.

Some researchers conducted the following crosses to determine the mode of inheritance for resistance to the chytrid fungus in the Spadefoot toads

iClicker Question

What is the mode of inheritance of resistance to the chytrid fungus?

A. autosomal dominant
B. autosomal recessive
C. X-linked dominant
D. X-linked recessive
E. Non-dominant.

	Parent Phenotypes		Offspring Phenotypes (F1s)	
Cross	Male	Female	Males	Female
1	susceptible	resistant	48 susceptible	51 susceptible
2	resistant	susceptible	39 susceptible	40 susceptible
3	resistant	resistant	42 resistant	38 resistant
4	susceptible	susceptible	20 resistant 59 susceptible	18 resistant 57 susceptible

Answer

Step 1: Quickly review the data from the crosses

	Parent Phenotypes		Offspring Phenotypes (F1s)	
Cross	Male	Female	Males	Female
1	susceptible	resistant	48 susceptible	51 susceptible
2	resistant	susceptible	39 susceptible	40 susceptible
3	resistant	resistant	42 resistant	38 resistant
4	susceptible	susceptible	20 resistant 59 susceptible	18 resistant 57 susceptible

Cross 1 & Cross 2 = reciprocal crosses; but no difference in phenotype, indicating resistance is an autosomal trait.

Cross 1 and Cross 2:
S x R – produces offspring that are susceptible (99 from cross 1 and 79 from cross 2)

Cross 4:
S x S – 3:1 phenotypic ratio of susceptible to resistant for both males and females. (59:20 males and 57:18 females).

A. autosomal dominant
B. autosomal recessive
C. X-linked dominant
D. X-linked recessive
E. Non-dominant.

These observed phenotype frequencies are what you would predict to see if resistance to the chytrid fungus is an autosomal recessive trait

Step 2. Define alleles and genotypes

B = susceptible
b = resistant

BB = susceptible
Bb = susceptible
bb = resistant

	Parent Phenotypes		Offspring Phenotypes (F1s)	
Cross	Male	Female	Males	Female
1	susceptible	resistant	48 susceptible	51 susceptible
2	resistant	susceptible	39 susceptible	40 suspectiple
3	resistant	resistant	42 resistant	38 resistant
4	susceptible	susceptible	20 resistant 59 susceptible	18 resistant 57 susceptible

Step 3. What genotypic/phenotypic ratios would you EXPECT to see if your mode of inheritance was correct?

Cross 1		
	B	B
b	Bb	Bb
b	Bb	Bb

Genotype: All Bb (heterozygotes)
Phenotypes: All susceptible

Cross 4		
	B	b
B	BB	Bb
b	Bb	bb

Phenotypes: 3 susceptible, 1 resistant

Step 4. Compare OBSERVED phenotypic frequencies with PREDICTED/EXPECTED values. Quantify values.

Expected F1 phenotype frequencies from a susceptible x resistant cross = 100% susceptible
Observed F1 phenotype frequencies = 99/99 susceptible or 100% (48 males and 51 females)

REPEAT FOR CROSS 4.

Expected F1 phenotype frequencies from a cross between two heterozygotes = 3:1 (susceptible to resistant)
Observed F1 phenotype frequencies from the cross = 59 susceptible, 20 resistant males (3:1) and 57 susceptible and 18 resistant females (3:1)

Step 5. Do the data support your hypothesis? Yes, the observed data are consistent with the predicted data, supporting the hypothesis that resistance is an autosomal recessive trait.

	Parent Phenotypes		Offspring Phenotypes (F1s)	
Cross	Male	Female	Males	Female
1	susceptible	resistant	48 susceptible	51 susceptible
2	resistant	susceptible	39 susceptible	40 suspectiple
3	resistant	resistant	42 resistant	38 resistant
4	susceptible	susceptible	20 resistant 59 susceptible	18 resistant 57 susceptible

Incorporating an evolution question

Could resistance to the chytrid fungus be considered an adaptation? Justify your claim.

Answer

Could resistance to the chytrid fungus be considered an adaptation? Justify your claim.

Yes

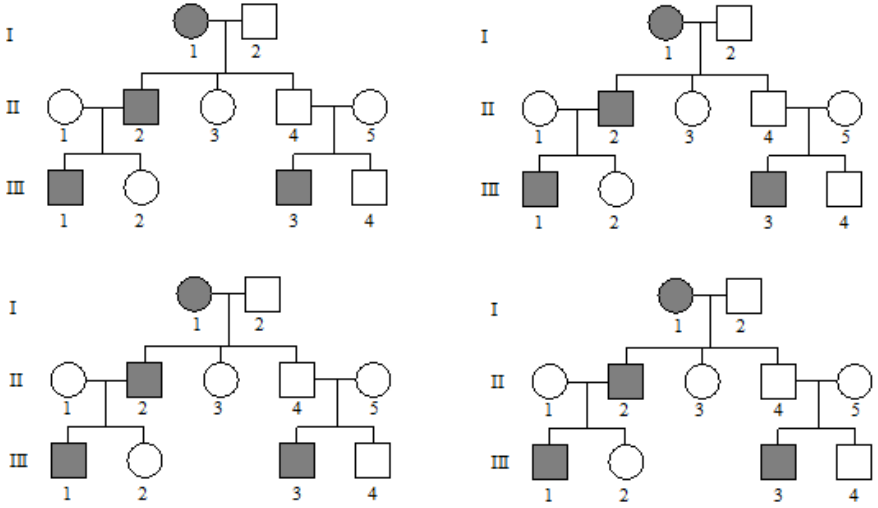
- The trait is heritable (Q gene).
- The trait is functional (i.e. reduces risk of death due to chytrid fungus)
- Positive fitness effect. It helps the frog to survive, potentially leading to more mating opportunities and greater reproductive success (compared to frogs without this trait). Thus, resistance to the chyrid fungus increases relative fitness.

In the Genetics Unit we also discussed

- How to determine possible/impossible modes of inheritance for a trait using a pedigree
  - calculating probabilities of offspring with a certain genotype/phenotype

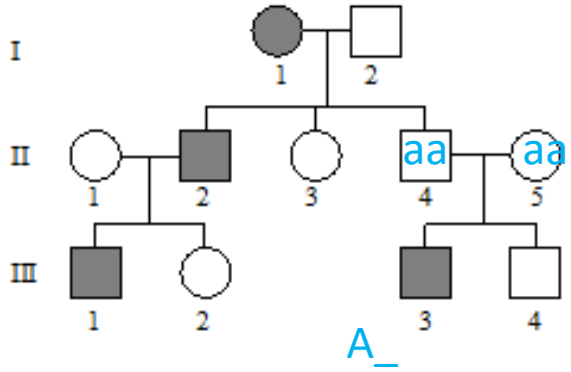
Question

Osteopetrosis, also called stone bone disease, is an inherited disorder that results in denser, harder bones. The following pedigree shows the inheritance of Osteopetrosis in one family.



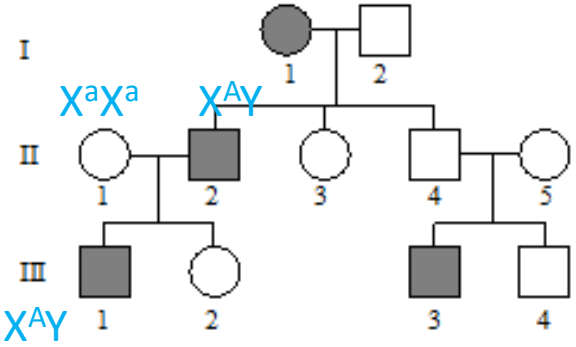
Name one **impossible** mode of inheritance for Osteopetrosis and provide support for your answer. Refer to specific individuals to support your argument. Use "A" and "a" or X^A and X^a for the dominant and recessive alleles, respectively.

Answer #1 – Impossible, Autosomal Dominant



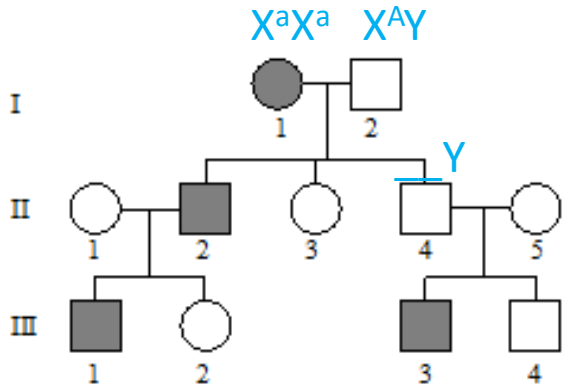
Autosomal dominance is an impossible mode of inheritance for Osteopetrosis.
For individual III-3 to have Osteopetrosis, they must be carrying at least one dominant allele (A_)
But both parents (II-4, and II-5) are unaffected, which means they must be homozygous recessive (aa), if the mode of inheritance was autosomal domianant. Therefore, they do not have a dominant allele to pass to their son.
Note – individuals identified by number, phenotype and predicted genotype.

Answer #2 – Impossible, X-linked Dominant



X-linked dominant is an impossible mode of inheritance for Osteopetrosis.
For individual III-1 to have Osteopetrosis, they must be carrying the dominant allele on their X chromosome (X^AY)
Individual III inherits their X chromosome from their female parent (II-1), but they are unaffected, which means their genotype must be (X^aX^a) if the mode of inheritance is X-linked dominant; and they would not have a dominant allele to pass to their son.
Again – not individuals identified by number, phenotype and predicted genotype.

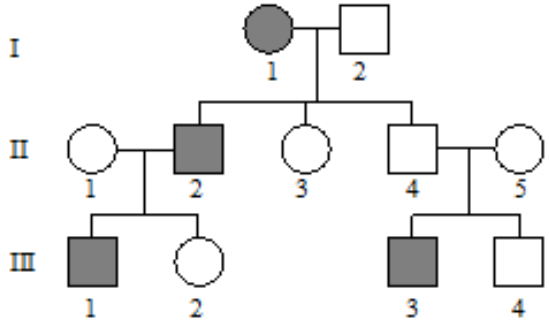
Answer #3 – Impossible, X-linked Recessive

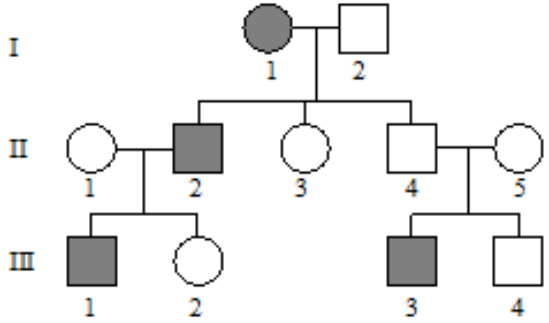


X-linked recessive is an impossible mode of inheritance for Osteopetrosis.
For individual II-4 to be unaffected, i.e. not have Osteopetrosis, they must be carrying the dominant allele on their X chromosome (X^AY)
Individual II-4 inherits their X chromosome from their female parent (I-1), but they are affected, which means if the mode of inheritance is X-linked recessive, their genotype must be (X^aX^a); and they would not have a dominant allele to pass to their son.
Again – not individuals identified by number, phenotype and predicted genotype.

Question

Osteopetrosis, also called stone bone disease, is an inherited disorder that results in denser, harder bones. The following pedigree shows the inheritance of Osteopetrosis in one family.

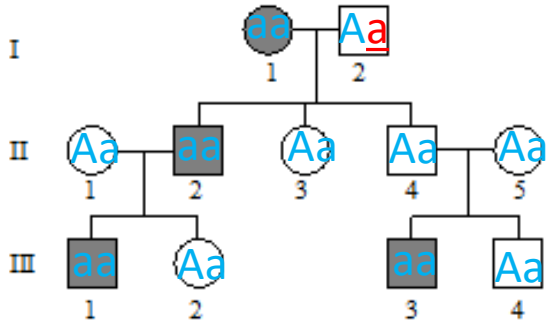




Which modes of inheritance are possible?

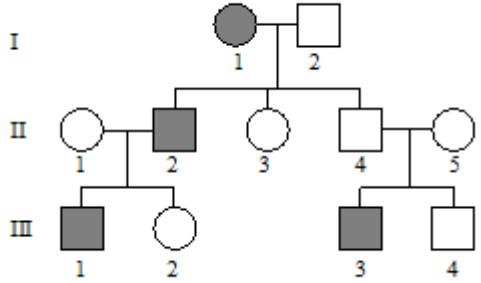
Answer

Osteopetrosis, also called stone bone disease, is an inherited disorder that results in denser, harder bones. The following pedigree shows the inheritance of Osteopetrosis in one family.



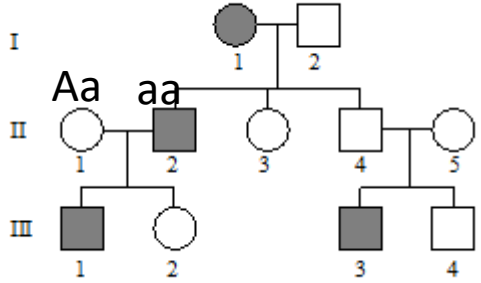
Which mode(s) of inheritance are possible? Autosomal recessive

Question



Assume individuals II-1 and II-2 had another child, and the mode of inheritance was autosomal recessive, what is the probability that their child would be an affected male? Show your work.

Answer



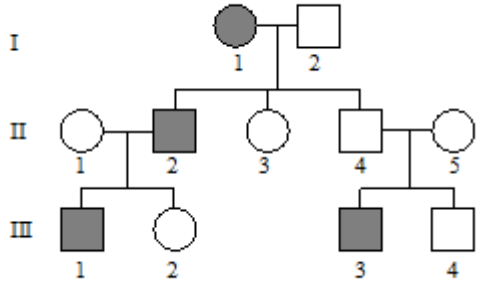
Assume individuals II-1 and II-2 had another child, and the mode of inheritance was autosomal recessive, what is the probability that their child would be an affected male? Show your work.

	A	a
a	Aa	aa

50% chance affected and 50% of being a boy:

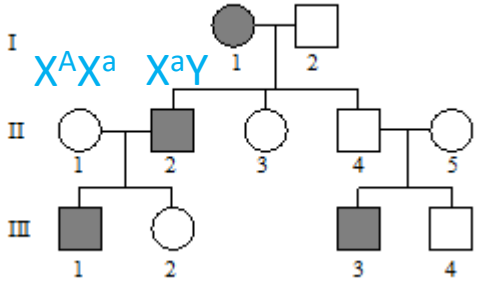
½ * ½ = ¼ or 25%

Question



Assume X-linked recessive was possible (even though it is not), if individuals II-1 and II-2 had another child, what is the probability that their child would be an affected male? Show your work.

Question



Assume individuals II-1 and II-2 had another child, and the mode of inheritance was X-linked recessive, what is the probability that their child would be an affected male? Show your work.

	X^A	X^a
X^a	X^AX^a	X^aX^a
Y	X^AY	X^aY

25%

Evolution Unit – we discussed

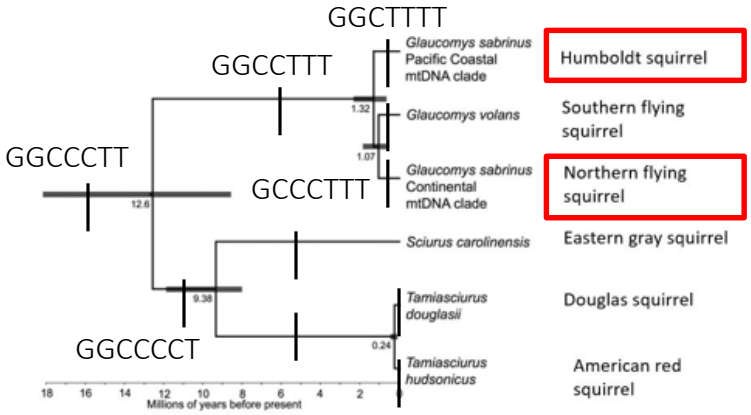
- Evidence for Evolution
- Mechanisms of evolution
  - mutation
  - natural selection (requirements / modes: directional, balancing, disruptive / adaptations)
  - genetic drift
  - gene flow
- Hardy-Weinberg equilibrium and assumptions (population genetics)
- Phylogenetic Trees
- Species Concepts
  - biological, morphological, ecological, phylogenetic
- Speciation
  - Allopatric speciation (via vicariance or dispersal)
  - Sympatric speciation
  - 3 steps to speciation – stop gene flow, genetic divergence, reproductive barriers

Species Concept Question

Flying squirrels are small mammals closely related to the squirrels that you see on campus. Until recently (2017), biologists believed that British Columbia was home to only one species of flying squirrel, the northern flying squirrel (*Glaucomys sabrinus*). However, very recent research has revealed that B.C. is home to two species of flying squirrel: the Northern flying squirrel and the Humboldt squirrel (*G. oregonensis*). Researchers estimate that the two species diverged from each other approximately 1 million years ago, during the Pleistocene glaciation period.

Species Concept Question

Characteristic	Northern Flying Squirrel	Humboldt Squirrel
Fur Colour	light brown	dark brown
Weight	110-230 g (adult)	Not quantified, but lighter
Length	25 to 37 cm (adult)	Not quantified, but smaller
Baculum (penis bone)	Robust and spiky	Unknown
Geographic Range	From the U.S-Canada border north to parts of Alaska, Yukon & Northwest Territories.	Pacific coastline from southern mainland British Columbia to southern California
Habitat	Coniferous forests, sleep in old tree holes	
Diet	Berries, nuts, fungi, eggs	Unknown
Predators	Owls, hawks, martens	
DNA	12.5% difference in mitochondrial DNA sequences (note: *G. sabrinus* Pacific Coastal Clade is now *G. oregonensis*, the Humboldt squirrel)	



Using only the information provided in the table which species concept (choose only one) would justify the classification of the two flying squirrels <u>as two different species</u>? Explain your answer.

Species Concept Question

Characteristic	Northern Flying Squirrel	Humboldt Squirrel
Fur Colour	light brown	dark brown
Weight	110-230 g (adult)	Not quantified, but lighter
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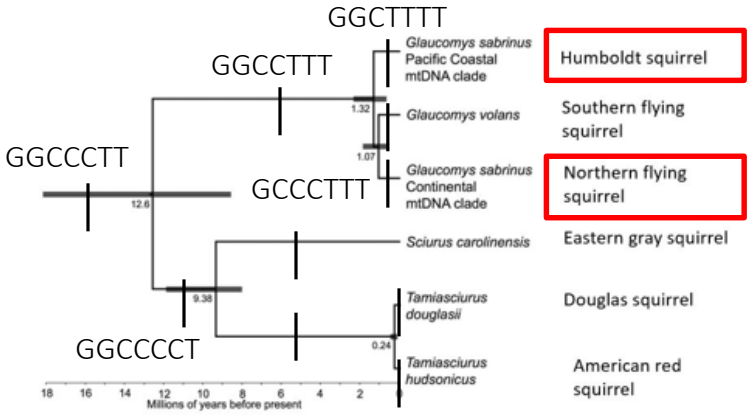

What species concept did you choose?

What are the requirements for the species concept that you chose?

Does the evidence meet this requirement?

If you can quantify the evidence have you done so?

Species Concept Question

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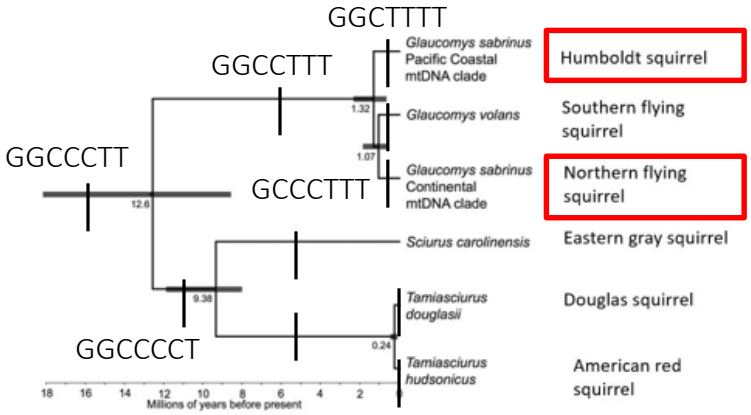

The phylogenetic species concept could be used to justify classifying the Humboldt Squirrel and the Northern Flying Squirrel as separate species. (Claim)

Both taxa represent the smallest, non-divisible clade/monophyletic groups on the available phylogenetic tree.

They have unique genetic synapomorphies that help to define their clade, i.e. the Humboldt squirrel has the DNA sequence GGCTTTT, whereas the Northern Flying Squirrel has the unique sequence GCCCTTT.

Question

Describe the evolutionary steps that would result in the Northern Flying Squirrel and Humboldt Squirrel becoming two distinct species. Explain what could have happened during each step that would ultimately result in speciation. Use the biological species concept and include references to appropriate evolutionary mechanisms in your answer. Be as specific as possible and use only the information given in the question/scenario.

Reminder: Researchers estimate that the two species diverged from each other approximately 1 million years ago, during the Pleistocene glaciation period.

What are the 3 steps to speciation?

Answer – Step 1

Step 1: Stop Gene Flow

Identify the fact that there would need to be a lack of gene flow between the two squirrel populations

e.g., 1,000,000 years ago the squirrel populations became physically isolated from one another due to the presence of a glacier, which prevent gene flow between populations

Answer – Step 2

Step 2: Genetic Divergence of BOTH populations (this is where the evolutionary mechanisms other than gene flow can act)
e.g., Allele frequencies in the two populations might diverge due to genetic drift, which is defined as changes in allele frequencies due to chance (or sampling error). If one (or both) of the squirrel populations was small, genetic drift could cause the allele frequencies to diverge between the two populations quickly.

If the environment inhabited by the two isolated squirrel populations differed in some way (e.g. type of predator present, substratum colour), natural selection may have acted on each population separately. For example, the environment inhabited by the Humboldt squirrel may have conferred higher fitness on squirrels with a darker coat colour, whereas the environment inhabited by the northern flying squirrel, may have conferred higher fitness on the squirrel with a lighter coat colour.

It is also possible that different mutations arose in each population, i.e. mutations that resulted in the unique DNA sequences: GGCTTTT and GCCCTTT

Answer – Step 3

Step 3 – A reproductive isolating mechanism (Prezygotic or postzygotic) that could evolve between the two squirrel populations.

- If mating does not occur – why?
- It mating can occur, why are the offspring not viable (i.e. can't survive) and/or not fertile (e.g. cannot reproduce themselves)

e.g., Behavioural differences between the Humbolt squirrels and Northern flying squirrels have arisen such that the two squirrels do not recognize each other as mates, or differences in the timing of mating, or differences in reproductive structures

e.g., Incompatibility between eggs and sperm due to mutations, differences in chromosomal numbers.

Geographic isolation is not acceptable as the squirrels are sympatric in parts of B.C.

iClicker Question – Evolutionary mechanisms

Mutation is the only evolutionary mechanism that:

A. does little to change allele frequencies on its own.
B. has no effect on genetic variation.
C. is not mentioned by the Hardy-Weinberg model.
D. always causes decreased fitness.

Answer

Mutation is the only evolutionary mechanism that:

A. does little to change allele frequencies on its own.
B. has no effect on genetic variation.
C. is not mentioned by the Hardy-Weinberg model.
D. always causes decreased fitness.

iClicker Question – Evolutionary mechanisms

Which of the following is the most predictable outcome of increased gene flow between two populations?

A. Lower average fitness in both populations
B. Increased genetic drift
C. Increased genetic differences between the two populations
D. Higher average fitness in both populations
E. Decreased genetic differences between the two populations

Answer

Which of the following is the most predictable outcome of increased gene flow between two populations?

A. Lower average fitness in both populations
B. Increased genetic drift
C. Increased genetic differences between the two populations
D. Higher average fitness in both populations
E. Decreased genetic differences between the two populations

iClicker Question – evolutionary mechanisms

Consider the following two scenarios:

1) A flash-flood sweeps through an area and random lemmings are killed, resulting in a change in lemming phenotype in subsequent generations.

2) A flash-flood sweeps through an area and some lemmings are able to survive because they are able to hold their breath longer than other lemmings, resulting in a change in lemming phenotype in subsequent generations.

What are the primary differences between the two scenarios?

A. Both scenarios represent natural selection because some individuals survived in each scenario.
B. Scenario 1 represents genetic drift because changes in the allele population were random (non-adaptive), while Scenario 2 represents natural selection because the individuals that survived were better adapted than other individuals.
C. Both scenarios represent genetic drift because the flash-flood is a random event.
D. Scenario 1 represents natural selection because changes in the population were adaptive, while Scenario 2 represents genetic drift because changes in the population were due to higher fitness of some individuals.

Answer

Consider the following two scenarios:

1) A flash-flood sweeps through an area and random lemmings are killed, resulting in a change in lemming phenotype in subsequent generations.

2) A flash-flood sweeps through an area and some lemmings are able to survive because they are able to hold their breath longer than other lemmings, resulting in a change in lemming phenotype in subsequent generations.

What are the primary differences between the two scenarios?

A. Both scenarios represent natural selection because some individuals survived in each scenario.
B. Scenario 1 represents genetic drift because changes in the allele population were random (non-adaptive), while Scenario 2 represents natural selection because the individuals that survived were better adapted than other individuals.
C. Both scenarios represent genetic drift because the flash-flood is a random event.
D. Scenario 1 represents natural selection because changes in the population were adaptive, while Scenario 2 represents genetic drift because changes in the population were due to higher fitness of some individuals.

QUESTIONS?

You did it!