Rapid Evolution:

Ecological Change

Adaptation

Definitions

- What is a genotype?
  - The genetic make up of an organism
- What is a phenotype?
  - Observable traits that are the result of both the organism's genetics and environment (G X E)

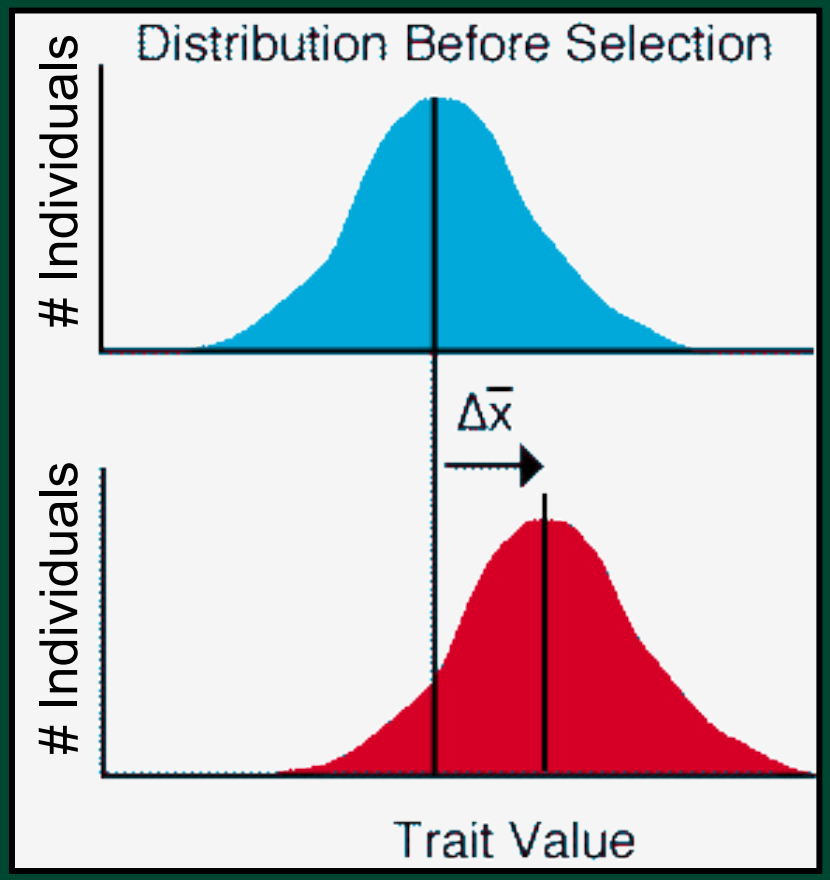
What is Rapid Evolution?

- Rapid Evolution: a genetically based change in phenotype that occurs rapidly enough to keep up with a quickly changing environment

- This type of evolution can happen over tens or hundreds of years

Directional Selection & Measuring Evolution

Directional selection moves the mean of a population in one direction or the other.



Beak size of medium ground finches on Daphne Major (Galapagos Islands) when seed size shifted around 1980.

Definitions

- How can a trait be heritable?
  - If the trait can be passed on from parent to offspring
- What is fitness?
  - When an organism survives and reproduces

Don’t Shell Yourself Short

- Break into four groups
  - Grades K-3
  - Grades 4-6
  - Grades 7-9
  - Grades 10-12

Blue Mussel *(Mytilus edulis)*

- Blue mussels present along entire Atlantic coast
- Asian shore crab (*Hemigrapsus sanguineus*) arrived in 1988.
- Current range: NC to midcoast of ME
- The Asian shore crab was a brand new predator of the blue mussel

- Freeman & Byers

Instructions:

1. Data collection: fill out the table below for your population.
2. Selection, generation 1: Everybody removes one nut, shells and eats it, and goes back for another shell. If you can't shell the nut, return it to the table and take another.
3. Reproduction, generation 1: Count the number of each type of nut left and add more nuts to double the number of each type.
4. Repeat Selection and Reproduction for generations 2 and 3.

	Number of peanuts (soft shells)	Number of almonds (hard shells)	Total number of individuals in population (sum peanuts + almonds)	Percent peanuts	Percent almonds
Starting population					
After generation 1					
After generation 2					
After generation 3					

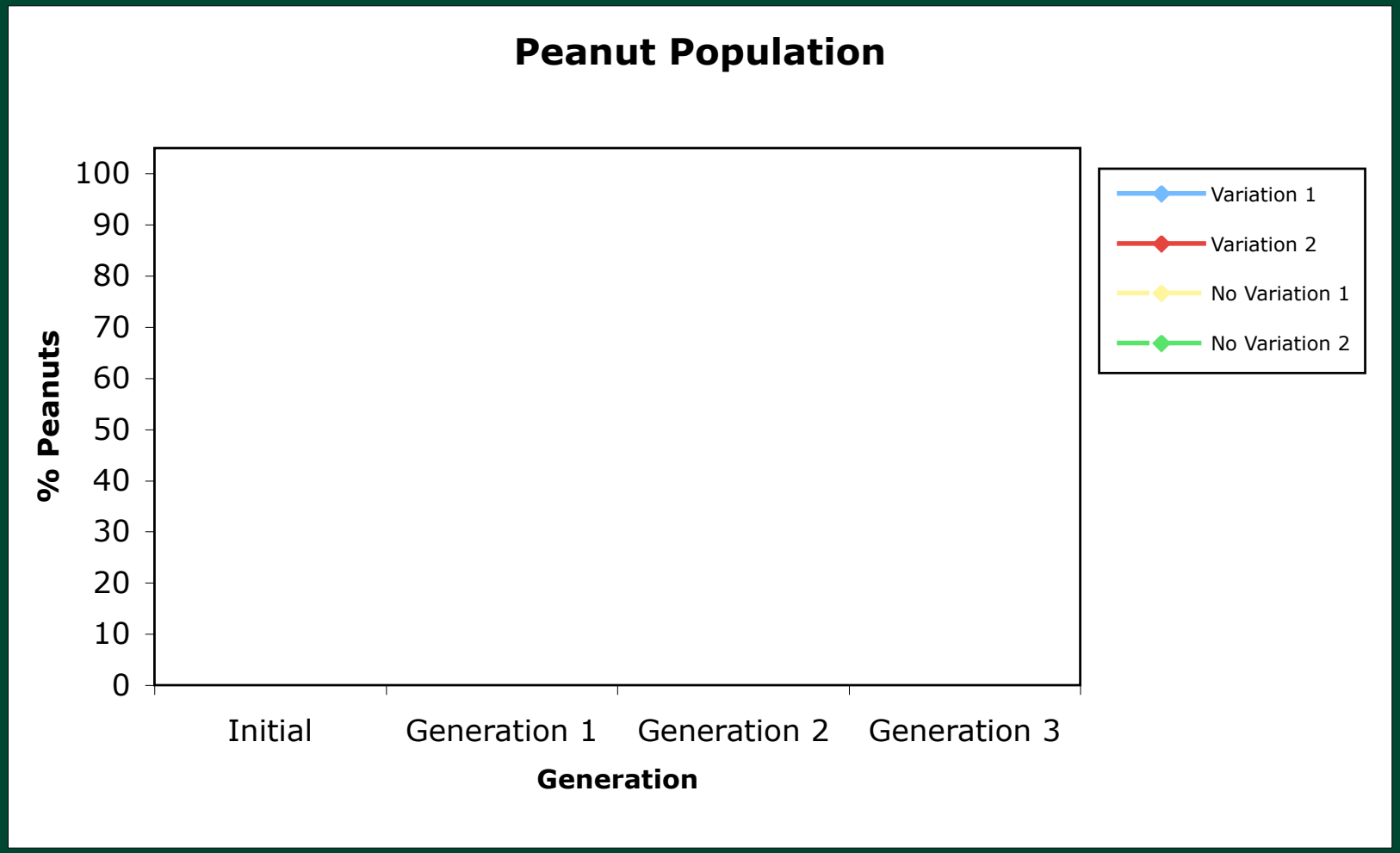
Results:

Compile all the groups' data after 3 generations

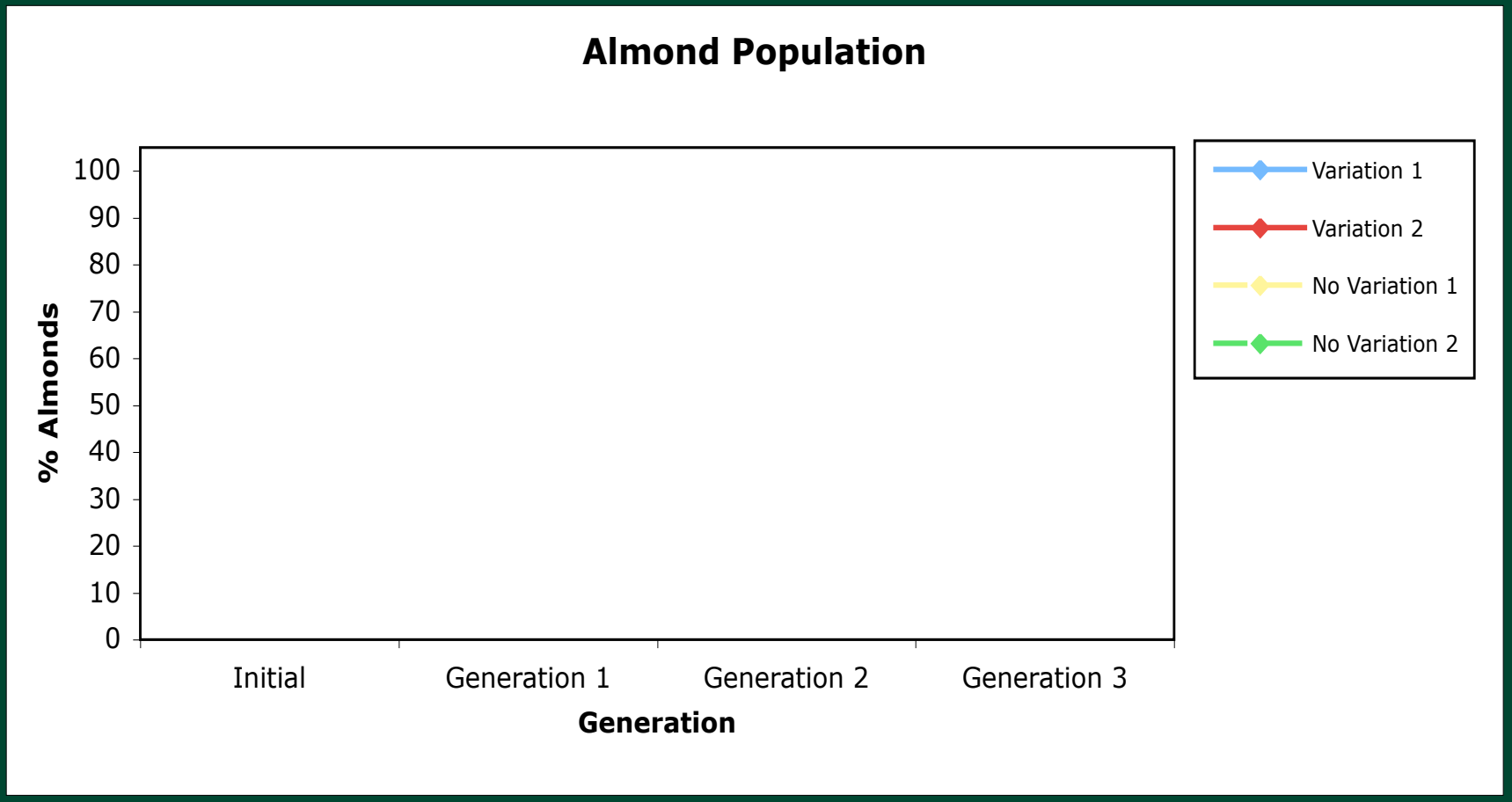
	Group 1 (Variation)	Group 2 (Variation)	Group 3 (No variation)	Group 4 (No variation)
Final % peanuts				
Final % almonds				
Final population size				

Now plot the data on the three graphs…

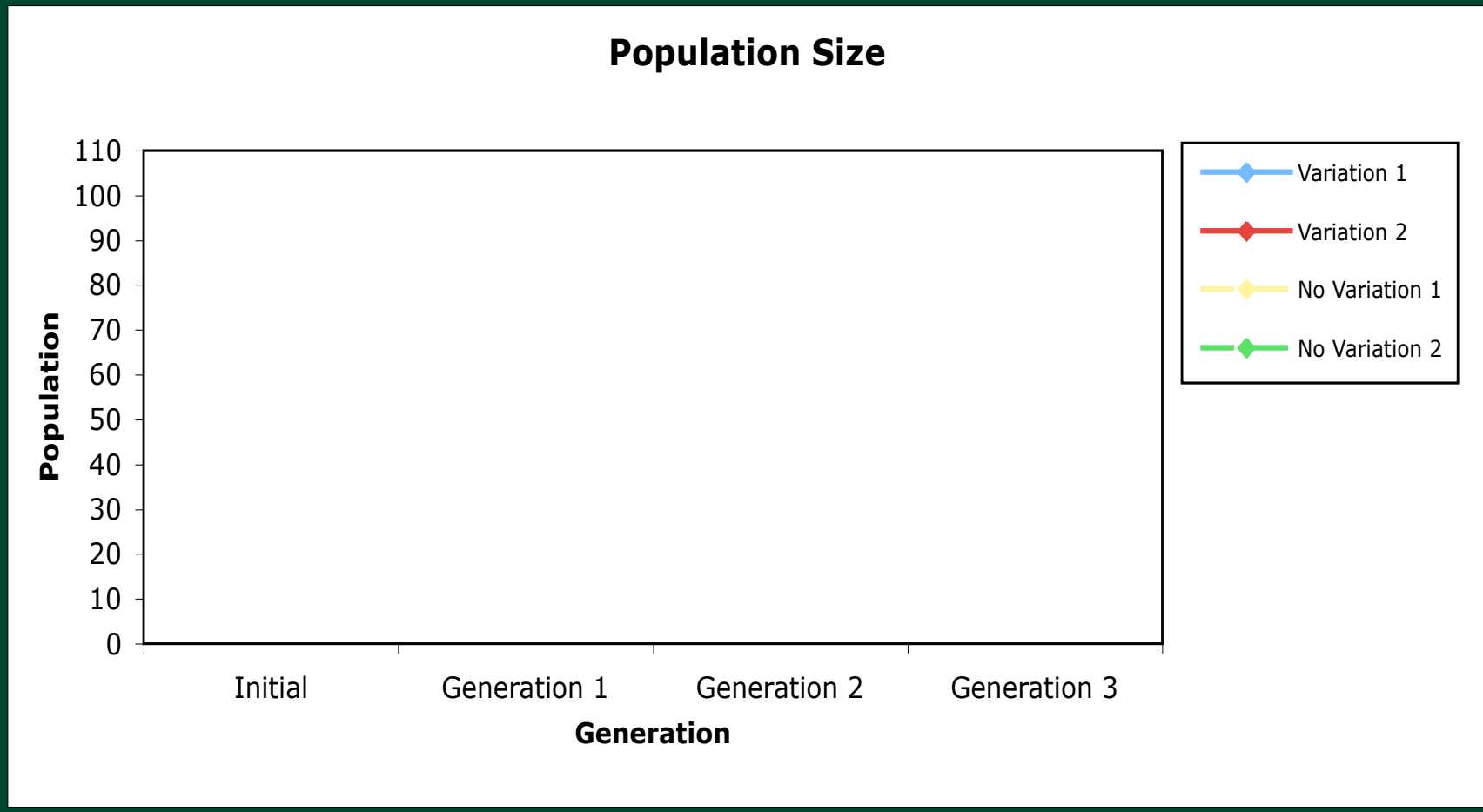
Peanut Population



Almond population



Population Size



Discussion

- Variation group: Did the percent peanuts (soft shells) change over time? Why?
- No variation group: Did the percent peanuts (soft shells) change over time? Why?

Discussion

- Did evolution occur? In which group(s)?

- What three things are necessary for evolution to occur?

Three Things for Evolution

Evolution needs:	**What in the game represents this?**
Phenotypic variation	Nutshells of different thicknesses
A heritable trait	Nuts have offspring of the same thickness
Relationship between a trait and fitness	Only the nuts that don’t get cracked live and reproduce

Discussion

- How quickly did evolution occur?
- Variation group: Did population sizes respond to predation by the crab?
- No Variation group: Did population sizes respond to predation by the crab?

Discussion

- The introduction of a new species (in this example, the crabs) can cause new selection pressures. What other factors could cause novel selection pressures? Give an example of each.

What Can Promote Rapid Evolution by Natural Selection?

- Ecological shift
  - New abiotic environment
    - Pollution
    - Pesticides
    - New habitat
    - Climate change
  - New biotic environment
    - Predator-Prey
    - Introduced species
    - New habitat

Peppered moth (*Biston betularia*)

- Peppered black and white
- They rest on trees trunks and branches
- Coloration helps it blend into lighter bark and lichens

Coloration

- During the Industrial Revolution in England, soot killed the lichens and covered the trees making them appear darker
- Predators could easily spot and eat the moths that were light colored
- Darker moths were selected for and there was a shift to darker coloration

Dark-eyed Junco
(Junco hyemalis)

- Novel environment (~1983)
  - Population established on the campus of UC-San Diego
- Nearest native breeding range ~70km away in the Laguna Mountains
- Coastal population has less white in their tail feathers than the mountain population.

- Pamela Yeh (2004)

Possible Explanations

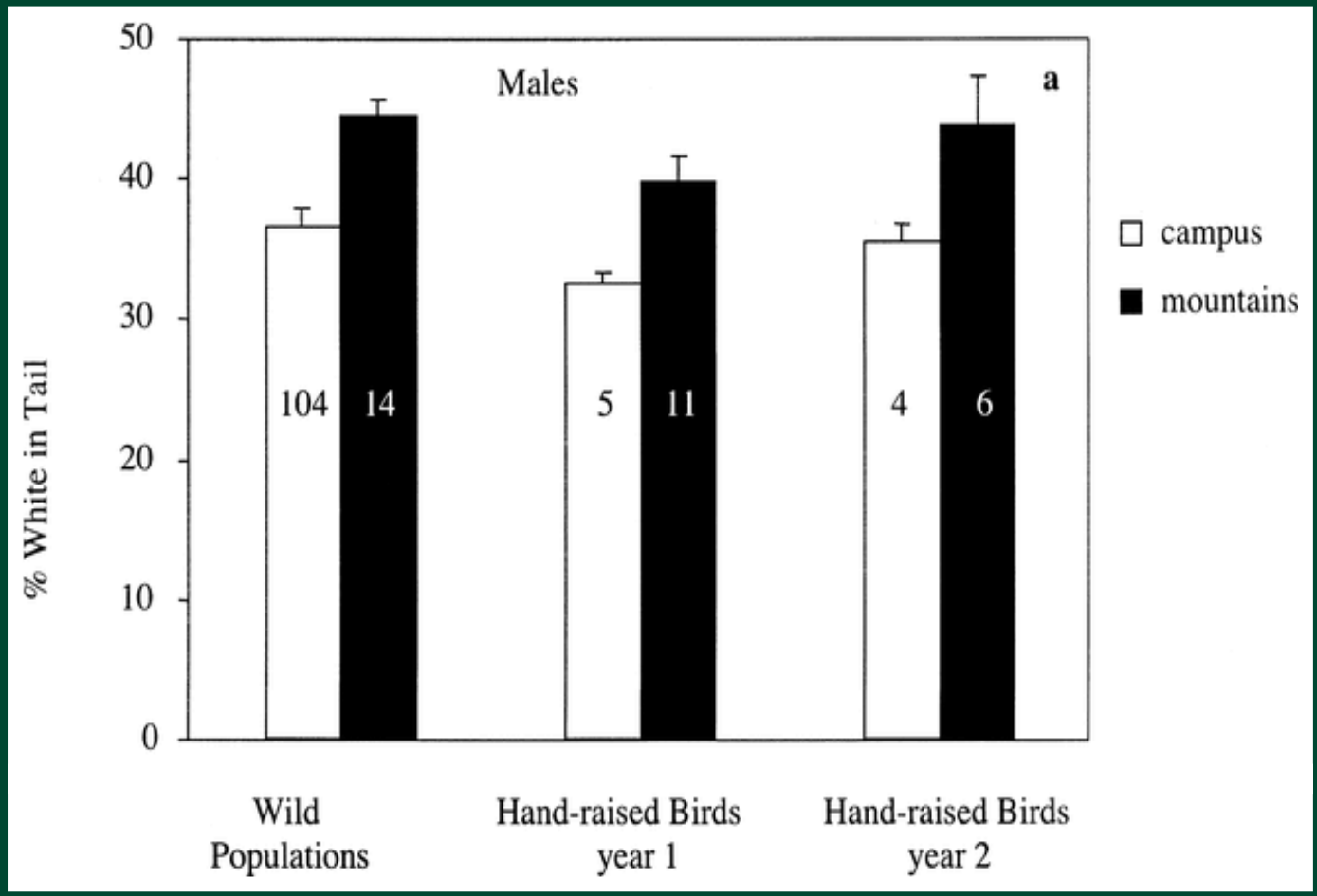
1) Phenotypic plasticity
   - Same genotype having a range of phenotypes

2) Evolution
   - Natural selection
   - Random genetic changes

Ruling out Phenotypic Plasticity
G X E

- Common “garden”
  - Collected baby birds from both the UCSD population and Laguna Mountains
  - Raise them under identical conditions
  - Compare phenotypes
    - Identical = phenotypic plasticity
    - Not Identical = some other reason

The Data


Males
a
% White in Tail
50
40
30
20
10
0
104
14
5
11
4
6
campus
mountains
Wild Populations
Hand-raised Birds year 1
Hand-raised Birds year 2

Soapberry Bug

Balloon vine (*Cardiospermum corindum*)

- Related to the boxelder bug
- Uses its beak to probe into the balloon-like fruits to suck out the contents of the seeds.

Change in Beak Length

- Introduction of the goldenrain tree
- The seeds are easier to reach
- Bugs with shorter beaks have higher fitness (they lay more eggs)
- There is selection for shorter beaks

introduced

- Carroll et al. 2001

Pink Salmon

- Born in freshwater streams
- Travel to the Pacific Ocean to mature
- Return to the freshwater stream to spawn
- Are captured with gill nets

Growth rate

- After two years at sea, the salmon return to spawn
- Those that grew quickly during that time are caught by fisherman
- Those that did not grow as quickly can pass through the net and reproduce
- Humans select for pink salmon with lower growth rates

Conclusions

- Rapid evolution by natural selection can result from:
  - Phenotypic variation within a trait
  - A relationship between that trait and fitness
  - That trait is heritable

- "Rapid" is relative to the organism being studied.
  - Because of the difference in generation time, "rapid" in bacteria could be several days, whereas "rapid" in a mammal could take hundreds of years.

The End