Lecture 19 (and probably 20!)

Complete selection on bean bag traits

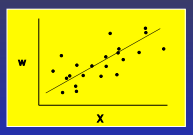
Origins of Species

Selection Model

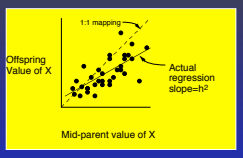
$$R = h^2 S$$

$$R = \frac{V_G}{V_P} S$$

Two graphs (from L18)



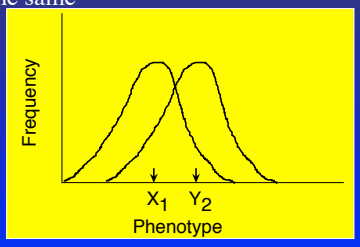
Quantifies phenotypic selection



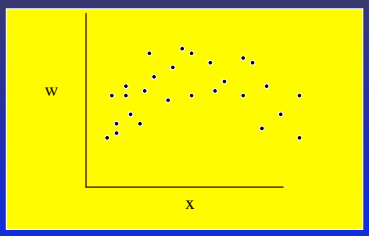
Quantifies heritability

Predictions of the Model

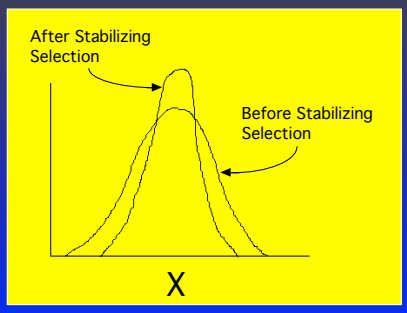
- Shift in phenotypic mean. Variance remains the same



Stabilizing selection

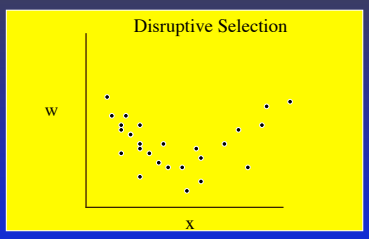


Stabilizing Selection

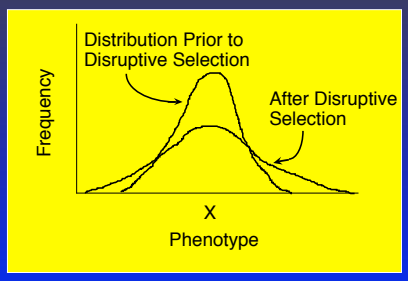


Mean stays the same. Variance decreases.

Disruptive selection



Consequences of Disruptive Selection



Mean stays the same, Variance increases

Cepaea nemoralis

- High level of variation maintained by disruptive selection: mechanism - predation by birds against varying backgrounds

More *Cepaea* pictures

Does Selection Lead to New Species?

- Darwin's arguments:
  - 1. Variation under domestication (i.e., artificial selection as an analogue of natural selection)
  - 2. Natural variation among varieties within species grades into species differences (i.e., ecotypes are common)
  - 3. Consistencies in the fossil record (i.e., primitive to advanced forms in progressively younger strata)
  - 4. Patterns of geographic variation among species on islands are consistent with evolution by natural selection (microevolution on islands is likely)

792,000 hits for 'pigeon breeding' on Google!

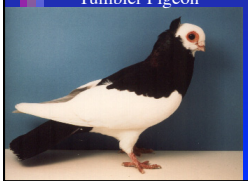
Argument 1: Variation Under Domestication

Butterfly Pigeon

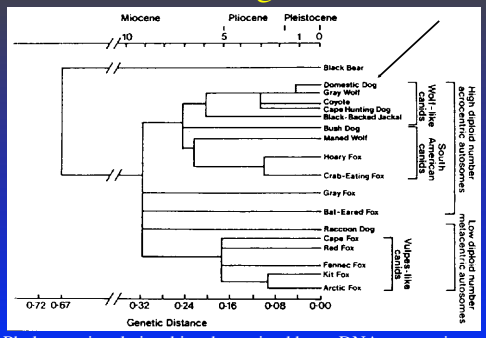
Owl Pigeon

Tumbler Pigeon

Polish Barb Pigeon



Domestic Dog Evolution



Phylogenetic relationships determined by mtDNA sequencing:
0.2% difference between gray wolf and domestic dogs

Wolves - Recent Ancestors of Domestic Dogs

Domestic Dogs

Newfoundland Wolf

Papillon

DNA? Nearly identical!!!

Wolf to Woof

The Evolution of Dogs

National Geographic. January, 2002.

Recent Westminster Dog Show Winners

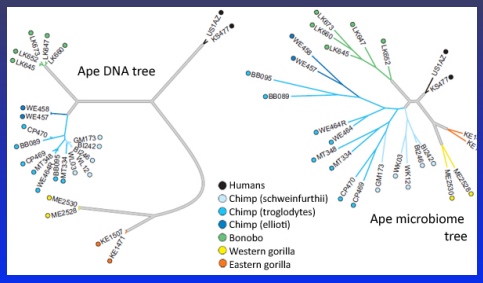
Miniature Australian Shepherds

1978. Doris Cordova from California began breeding a line of small Australian shepherds. Some don't recognize it as a separate breed from Australian shepherds, others do.

Bottom Line

- Human desires ('artificial' selection) can easily produce species-sized genetic changes in very short periods of time
- These genetic changes can be at a few key loci, and they will serve to isolate gene pools

Humans as apes



Separation of 'human' ancestor from chimpanzee/bonobos ancester ca. 5-6 million ybp

2. Natural variation within species

- Species - actually or potentially interbreeding populations
- Numerous 'gray areas' exist in nature about <u>what a species is!</u> e.g., when lions and tigers are crossed, what do you get? A liger, of course! (AND, lions consist of 8 subspecies, tigers 9 subspecies!)

2. Natural Variation Within Species

Are these two plants different species?
A. Yes
B. No

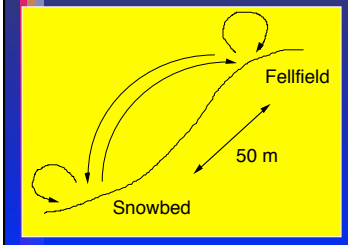
Dryas octopetala ssp. *octopetala*

Dryas octopetala ssp. *alaskensis*

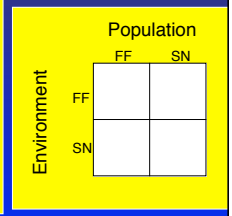
*note; these photos are to scale!

Partitioning Phenotypic Variance Between Populations

- Reciprocal transplant experiment:

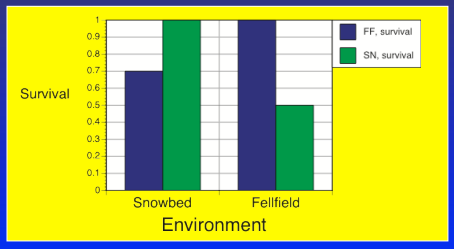


Physical Layout

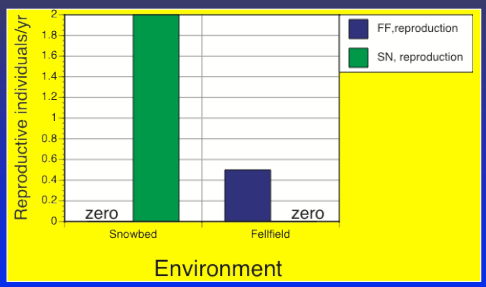


Statistical Layout

Population X Environment Interaction



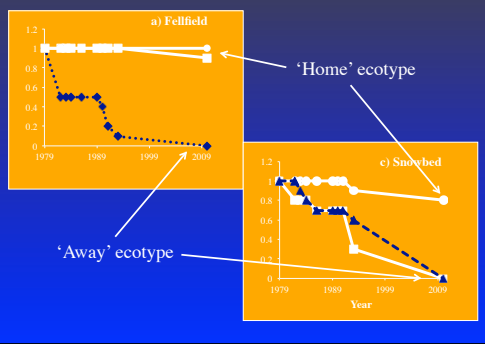
Population X Environment Interaction



Ecotypes

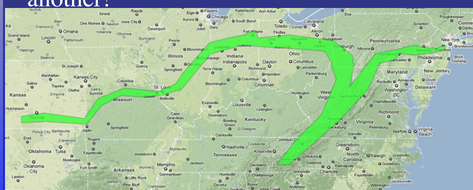
- Ecotypes - genetically distinct populations whose differences result in adaptation to local environments
- In plants, ecotypic differentiation is the norm
- Ecotypic variation is a process that may lead to speciation if reproductive isolation evolves

30 Years Later…



Black-capped Vs. Carolina Chickadees

- These are known 'species' – except here in Morgantown, where we can't tell one from another!



Black-capped Chickadee [illegible] just north of the current contact brighter and more contras[illegible] (especially in irruption years) well south sides, darker tertials, whi[illegible] extremely tricky and an observer back. It is also slightly la[illegible] have a difficult time proving the copyright David Sibley. claim.

Bottom Line

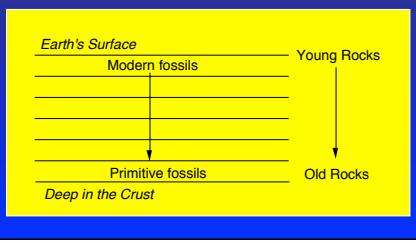
- Subspecies, varieties, ecotypes are transitional phases that are 'nearly species' (and some of these may be actual genetically isolated gene pools); some species may be better classified as varieties or ecotypes, and occasionally interbreed in nature!
- Ecotypes are locally-adapted populations that may be as different as products of artificial selection
- Large population-level differences evolve easily and frequently in nature under selection pressures

Bottom bottom line

- Evolution of species-level differences is easily accomplished by the same mechanisms we can readily show with simple mathematics (e.g., $R=h^2S$)

3. Consistencies in the Fossil Record

- "If a single, well-verified mammal skull were to turn up in 500 million year-old rocks, our whole modern theory of evolution would be utterly destroyed" -Richard Dawkins, The Blind Watchmaker



Stratigraphy

Where will the oldest fossils be found?

Bottom Line

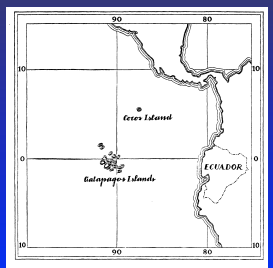
- We don't see inconsistencies in the fossil record

4. Speciation on Islands

- Speciation on islands is likely where:
  - Immigration is slow (S<equilibrium S for a long time), and
  - High diversity of niches exist on the island (high S)
- These conditions are met when islands are DISTANT and LARGE
- 2 examples: Galapagos, Hawaii

Galapagos Islands

- 600 mi. west of S. America, 3000 mi. east of Polynesia



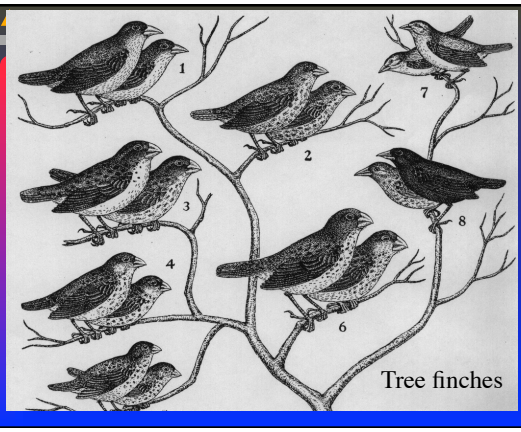
THE GALAPAGOS are shown some 600 miles west of Ecuador, above, and close up below. Cocos Island is not in the group, but it has developed one species of finch, presumed to have come originally from the mainland.

Original Immigrants of the Galapagos

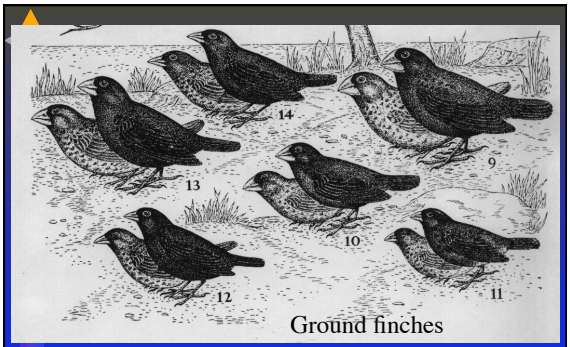
- 2 species of mammals
- 5 species of reptiles
- 6 species of songbirds; 1 was a finch
- 5 other types of land birds

Current Finch Fauna

- 14 species of finches are presently found in the Galapagos:
  - Ground finches - 6 species
    - seed eaters of arid/coastal habitat
  - Tree finches - 6 species
    - insect eaters of moist forests
  - Warbler finches - originally misclassified as a warbler!
    - narrow beak, flitting habit
  - Cocos Island Finch - different from all the others



Tree finches



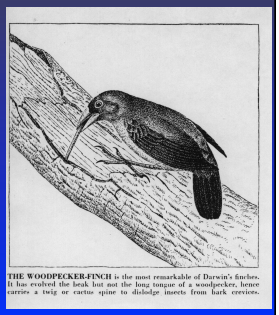
Ground finches

Origin of Darwin's Finches by Speciation

- Early in island history, 1 species of finch migrated from South America
- Immigration of other bird species was slow (empty niche space)
- Differences in selection pressure among islands led to different subspecies
- Eventually, isolating barriers arose that protected gene pools of subspecies from intrusion of maladapted genes from sister subspecies

Origin of Darwin's Finches by Speciation

- Migration between islands occurred with maintenance of species integrity (e.g., 4 ground finches regularly coexist, but differ in beak size and therefore seed size use).



THE WOODPECKER-FINCH is the most remarkable of Darwin's finches. It has evolved the beak but not the long tongue of a woodpecker, hence carries a twig or cactus spine to dislodge insects from bark crevices.

Update in the Darwin's Finch Story

- *Grant, P. R. and B. R. Grant. 2002. Adaptive radiation of Darwin's finches. American Scientist 90: 130 - 139.*
- *Grant, P. R. and B. R. Grant. 2011. How and Why Species Multiply: The Radiation of Darwin's Finches ($23.71 on Amazon.com. Free supersaver shipping ;)*
- (1) it was not necessary for speciation that two divergent groups re-establish contact
- (2) the islands were not static during the time of evolution (e.g., new islands appeared)
- (3) bird song divergence reinforces mating isolation

Islands and Endemism

- **Endemic species** - species found only in one location. Due to the prevalence of speciation on large, distant islands, places such as Hawaii and the Galapagos have very high numbers of endemics.
- Hawaii has:
  - 10,000 endemic species
  - >350 species in the genus *Drosophila* alone

Nene geese; Maui, Hawaii; evolved from Canada goose ca. 500,000 ybp

Homo floresiensis

Discovered on the Indonesian Island of Flores
~18,000 years old
New species previously unknown to science
Chimp-size brain; 3 feet tall!
Human tool-using and fire-using traits
First published; October 28, 2004, Nature.

Bottom Line

- Islands produce clear, repeated storylines of speciation that are consistent with Darwin's theory of natural selection as the primary means of speciation

Darwin's arguments

- Phenotypic variation, trait heritability, and phenotypic effects on fitness, yield adaptive evolution
- Evidence for this process giving rise to species:
  - Humans have produced 'species' (therefore nature can, easily, with time)
  - In nature, incipient 'almost' species are very common (and in fact, the line between species and varieties/ecotypes/subspecies is a matter of opinion
  - The fossil record is long, and consistent (though incomplete, it is getting better)
  - Islands have been a visible natural laboratory for evolution (and islands are everywhere!)