Evolutionary Forces

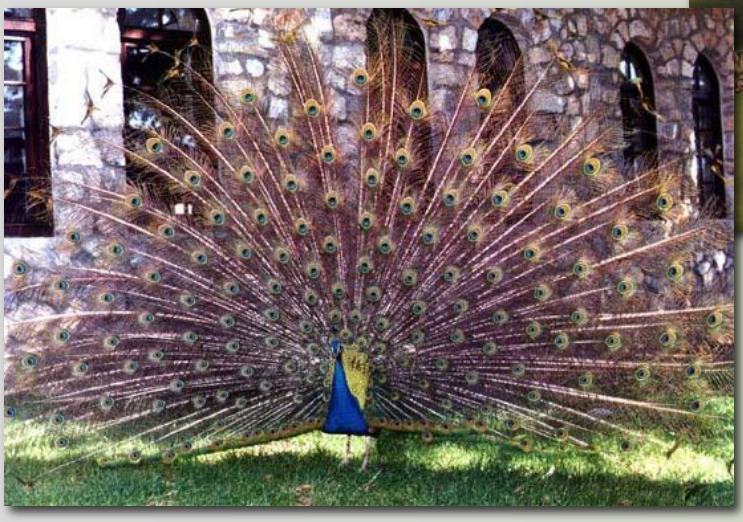
What changes populations?

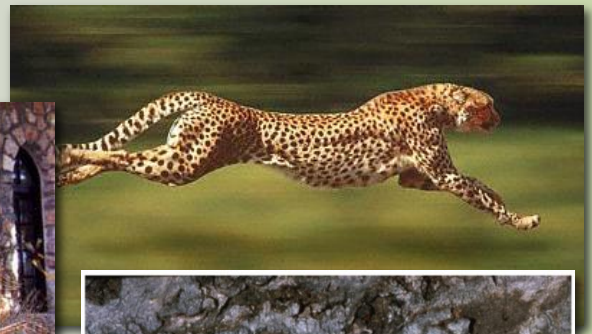
Forces of evolutionary change

- Natural selection
  - traits that improve survival or reproduction accumulate in the population
    - ADAPTIVE change
- Genetic drift
  - frequency of traits changes in a population due to chance events
    - RANDOM change

Natural Selection

- Selection acts on any trait that affects survival or reproduction
  - predation selection
  - physiological selection
  - sexual selection





Predation Selection

- Predation selection
  - act on both predator & prey
    - behaviors
    - camouflage & mimicry
    - speed
    - defenses (physical & chemical)

Physiological Selection

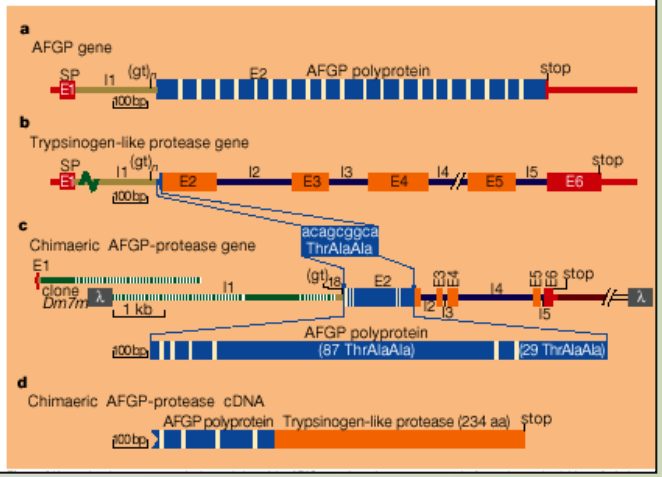
- Acting on body functions
  - disease resistance
  - physiology efficiency (using oxygen, food, water)
  - biochemical versatility
  - protection from injury

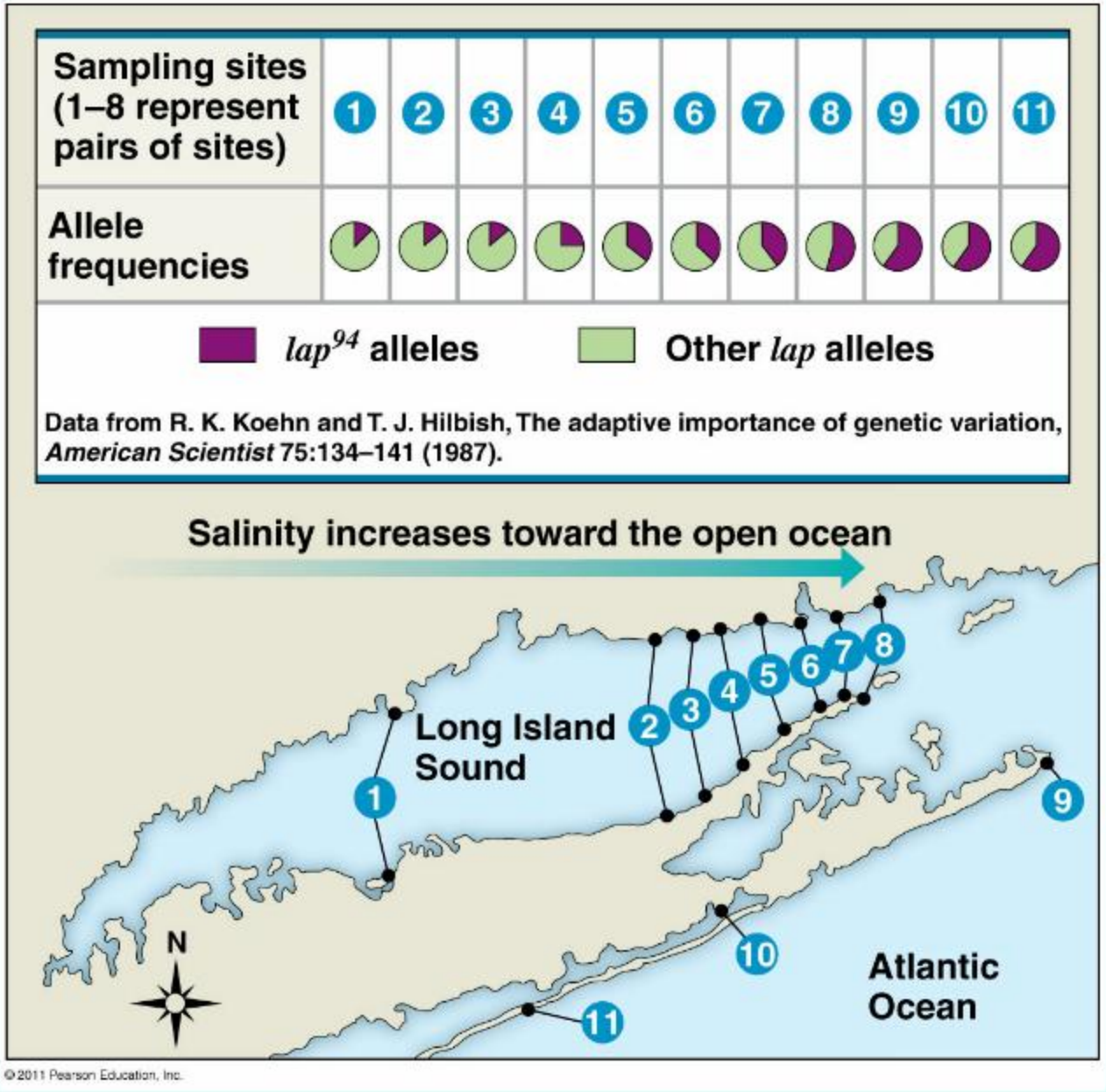
Evolution of an antifreeze glycoprotein

A blood protein that keeps Antarctic fish from freezing arose from a digestive enzyme.

The ice-binding antifreeze glycoprotein (AFGP) that circulates in the blood of Antarctic notothenioid fishes enables them to avoid freezing in their perpetually icy environment[1]. This crucial survival protein probably arose from a functionally unrelated pancreatic trypsinogen-like protease[2]. We have now discovered an important intermediate in this evolutionary process — transcriptionally active chimaeric genes that encode both an AFGP polyprotein and the protease, confirming the protease origin of AFGP and indicating how it was created.

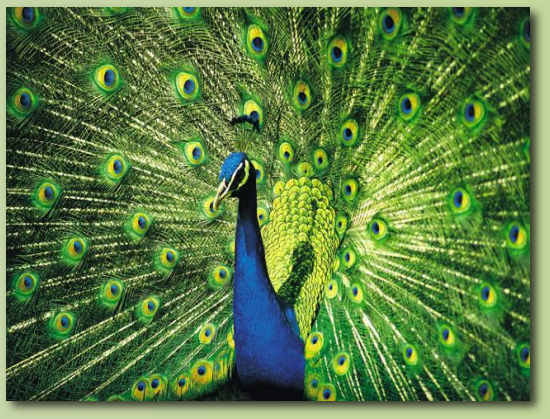
AFGP binds to and arrests the growth of ice crystals that enter the fish, thereby preventing the fish from freezing. There are at least eight forms of the protein of different sizes (AFGP 1–8), all composed of repeats of a simple glycotripeptide monomer (Thr-Ala/Pro-Ala-) with a disaccharide attached to each threonine





Variation in the lap94 gene as a function of habitat salinity in a mussel species

Sexual Selection – "the traits that get you the mates"



- Acting on reproductive success
  - attractiveness to potential mate
  - fertility of gametes
  - successful rearing of offspring

Sexual selection – sexual dimorphism

The lion's mane…

Science magazine

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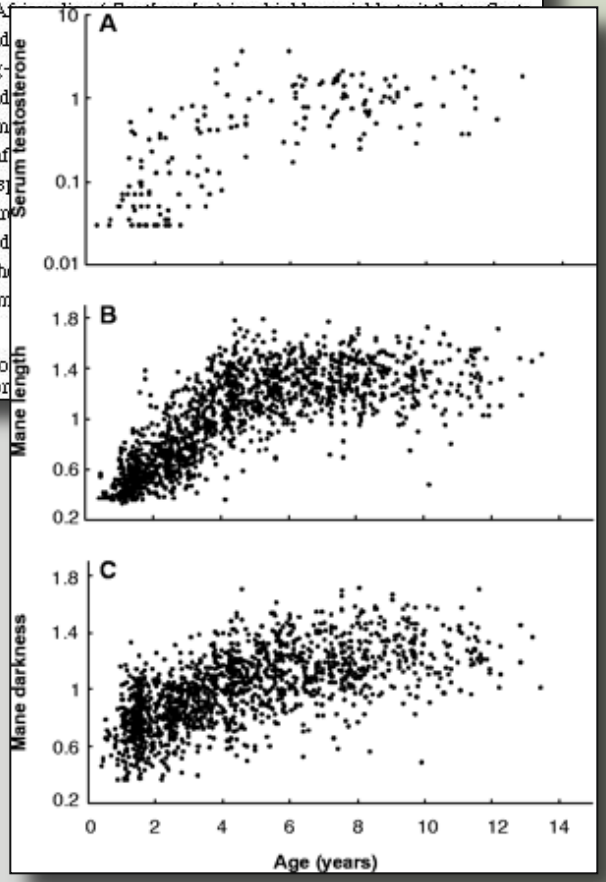
Sexual Selection, Temperature, and the Lion's Mane

Peyton M. West* and Craig Packer

The mane of the A… male condition and… variation in a long-… Mane darkness ind… choice and male-m… only appears to inf… reproductive life-s… surface temperatur… of the year. Maned… shorter manes in h… suggests that the m… temperature.

Department of Eco… 1987 Upper Bufor…



- Females are attracted to males with larger, dark manes
- Correlation with higher testosterone levels
  - Better health
  - more muscle and aggression
  - Better fertility
  - longer life
  - More successful young
- But imposes a cost to male
  - *HOT!* Is it worth it??

Sexual dimorphism and sexual selection

Why does this happen?

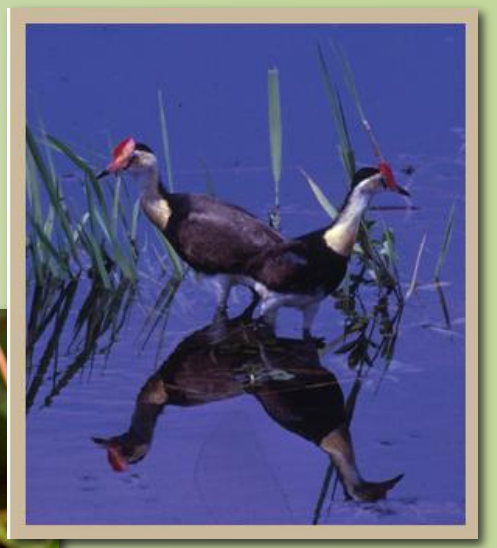
Sexually selected traits serve as fitness markers for mating.

You know what they say about crabs with big claws...

Sexual dimorphism:

Sexual selection

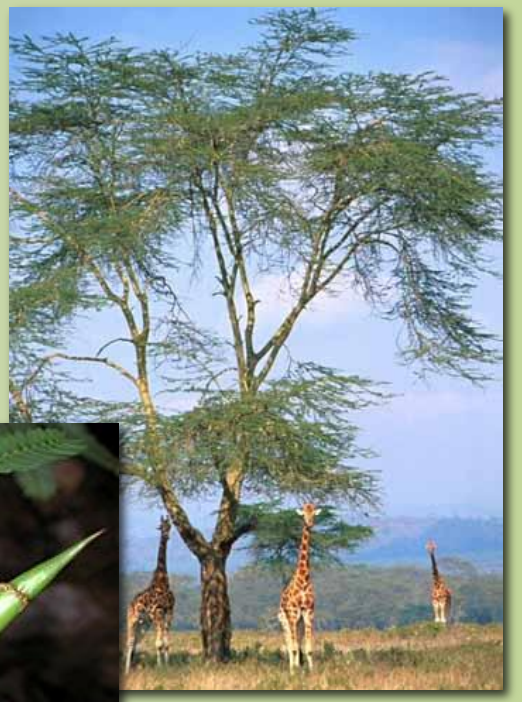
- Acts in all sexually reproducing species
  - the traits that get you mates
  - influences both morphology & behavior
  - Can seem maladaptive



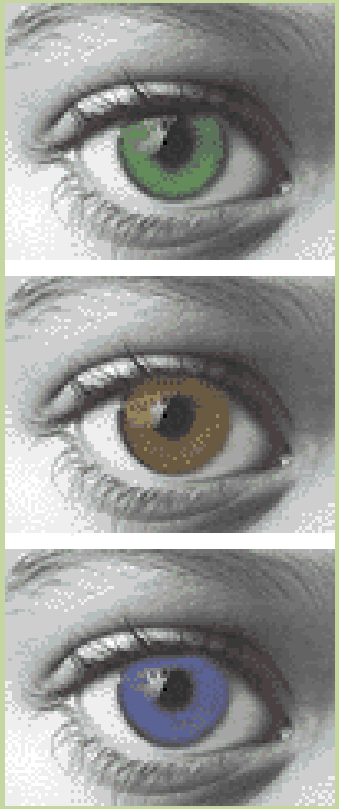
Jacanas

Coevolution

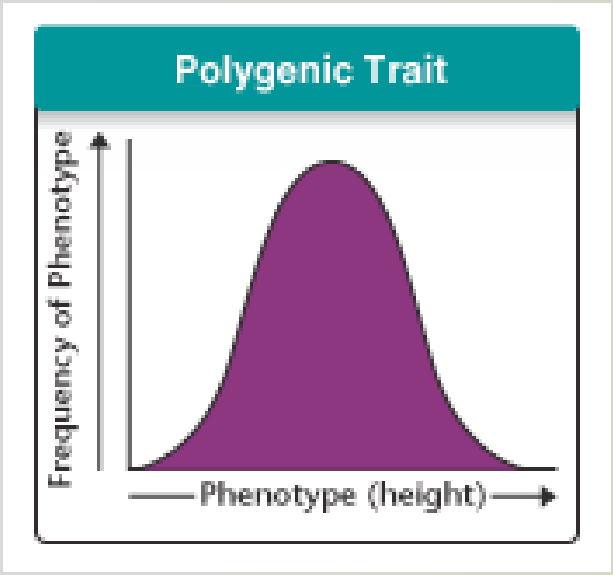
- Two or more species reciprocally affect each other's evolution
  - predator-prey
  - competitive species
  - Mutualism
  - "The Flower and The Fly"



POLYGENIC traits are controlled by two or more genes.



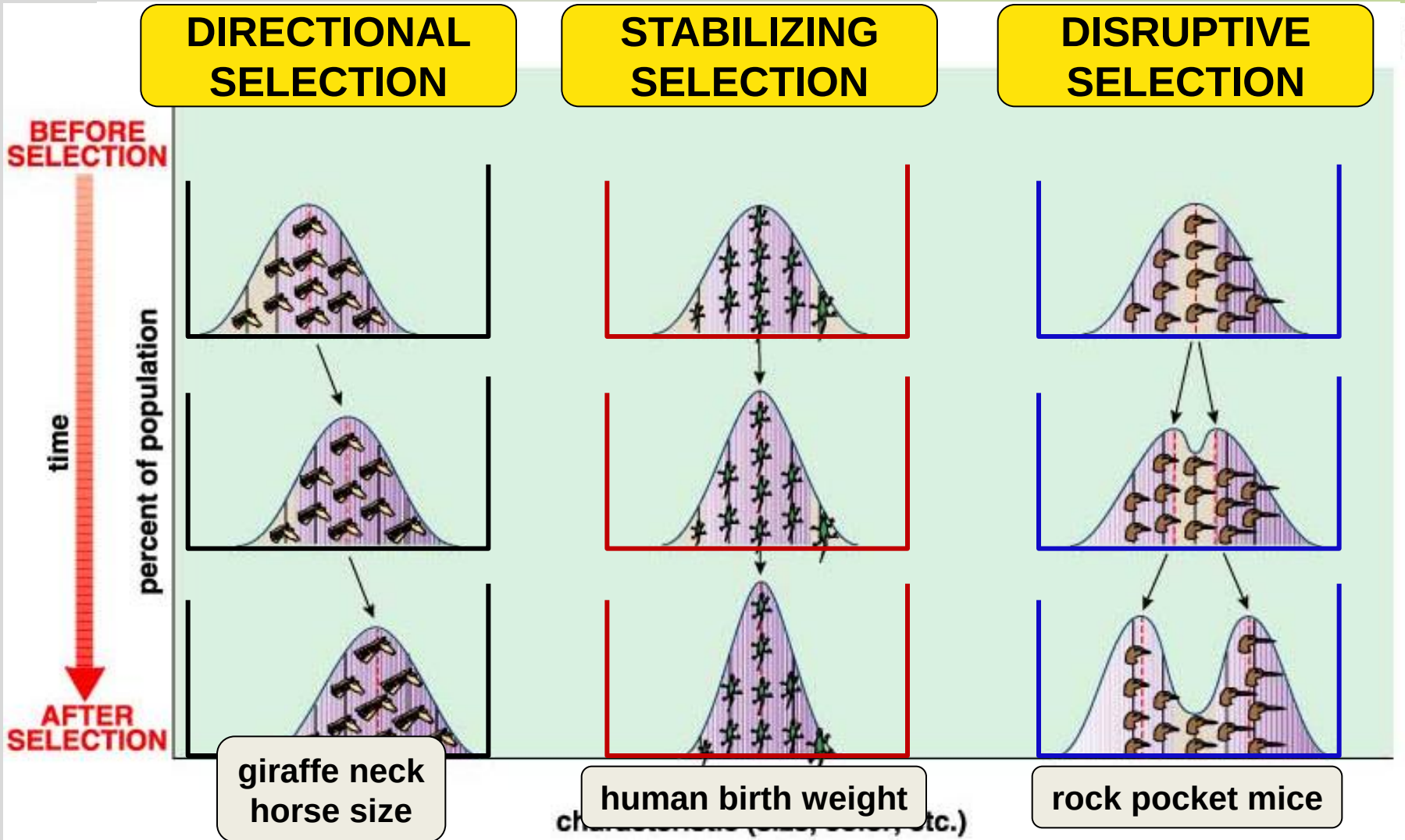
A bell shaped curve is typical of polygenic traits



Graph from BIOLOGY by Miller and Levine; Prentice Hall Publshing©2006

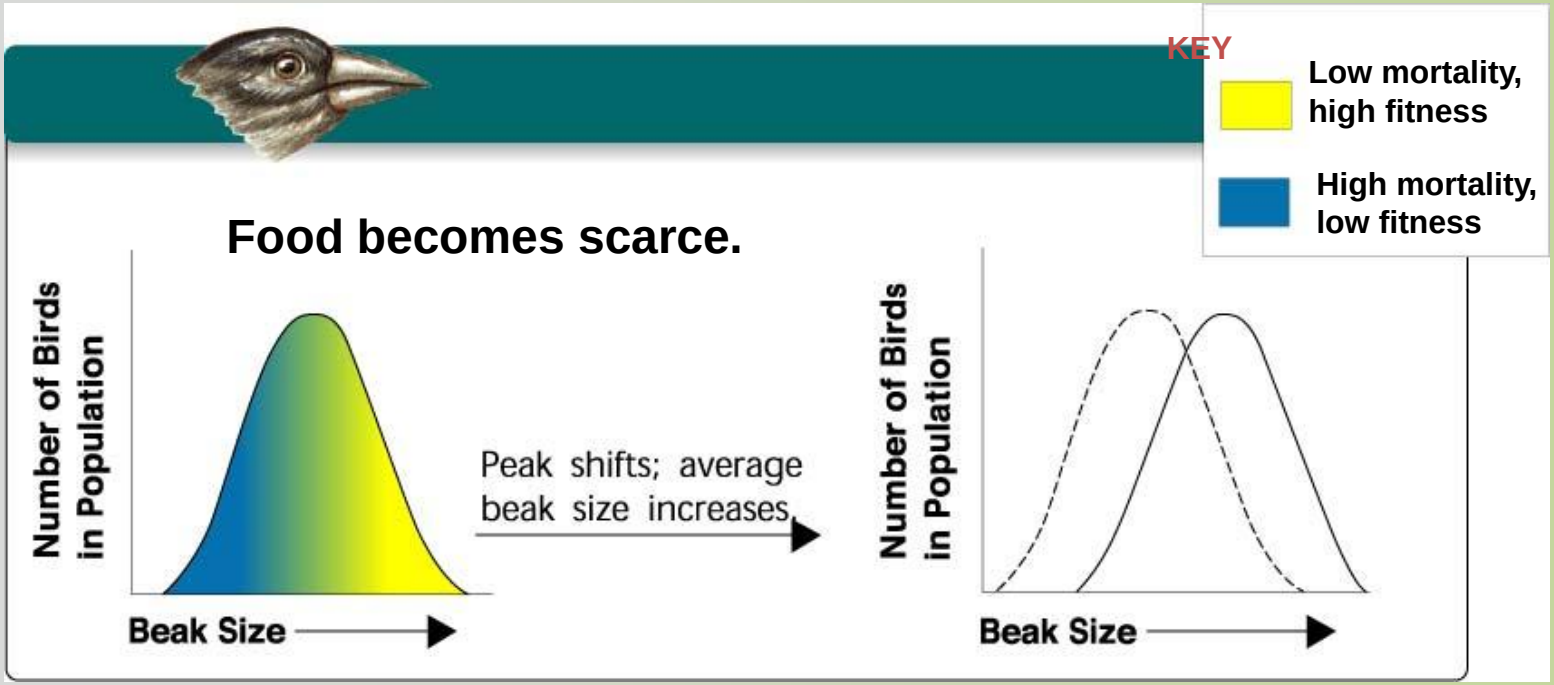
Effects of Selection

- Changes in the average trait of a population



Graph from BIOLOGY by Miller and Levine; Prentice Hall Publishing©2006

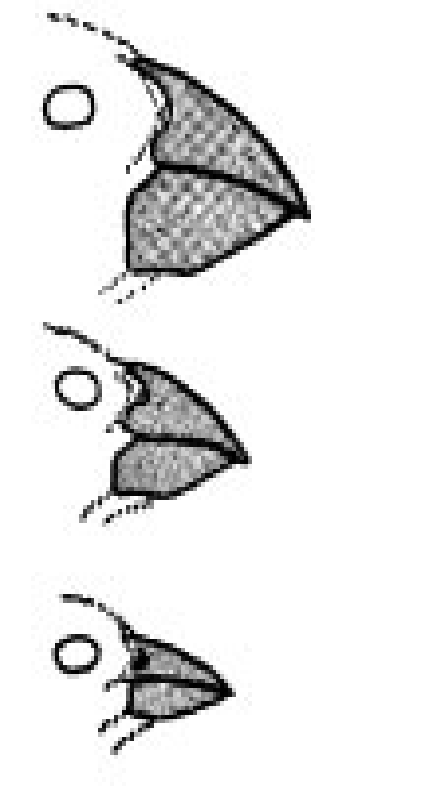
DIRECTIONAL SELECTION



Individuals at one end of the curve have higher fitness than individuals in middle or at other end.

Graph shifts as some individuals fail to survive at one end and succeed and reproduce at other

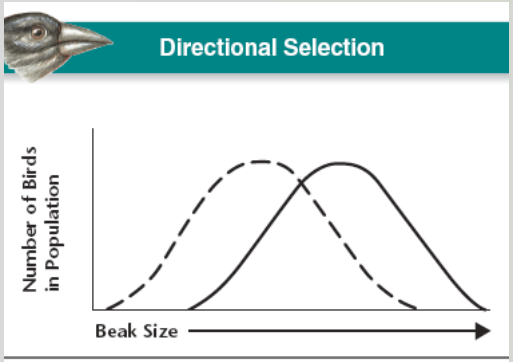
EXAMPLE OF DIRECTIONAL SELECTION



Beak size varies in a population

Birds with bigger beaks can feed more easily on harder, thicker shelled seeds.

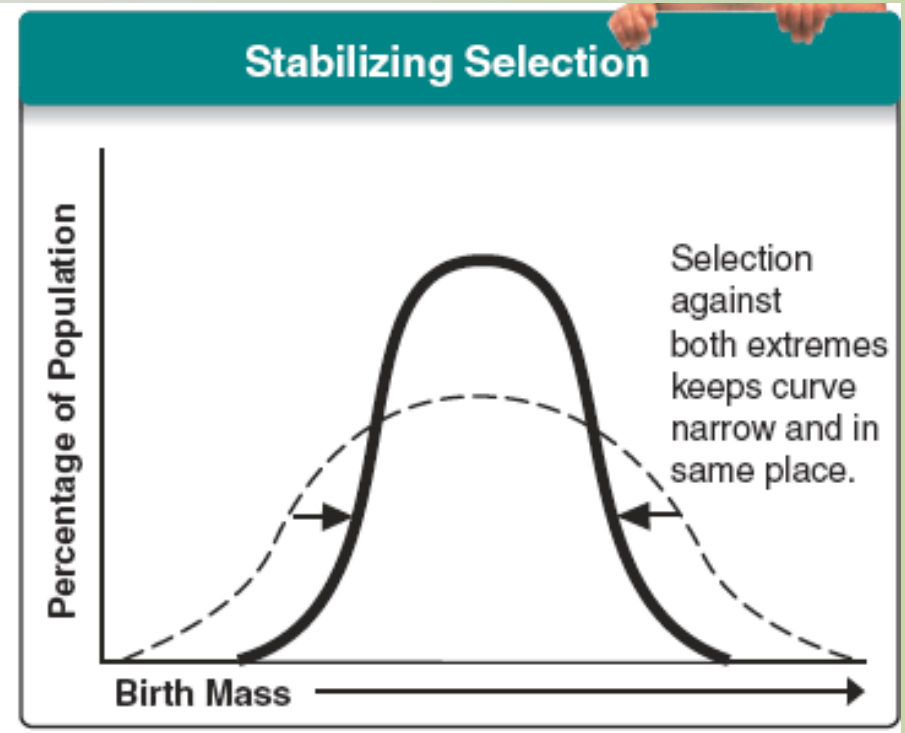
A food shortage causes small and medium size seeds to run low.



Birds with bigger beaks would be selected for and increase in numbers in population.

http://www.animalbehavior.org/ABS/Stars/ONI/Podos_-_finch_graphic.jpg

STABILIZING SELECTION



Individuals in center of the curve have higher fitness than individuals at either end

Graph stays in same place but narrows as more organisms in middle are produced.

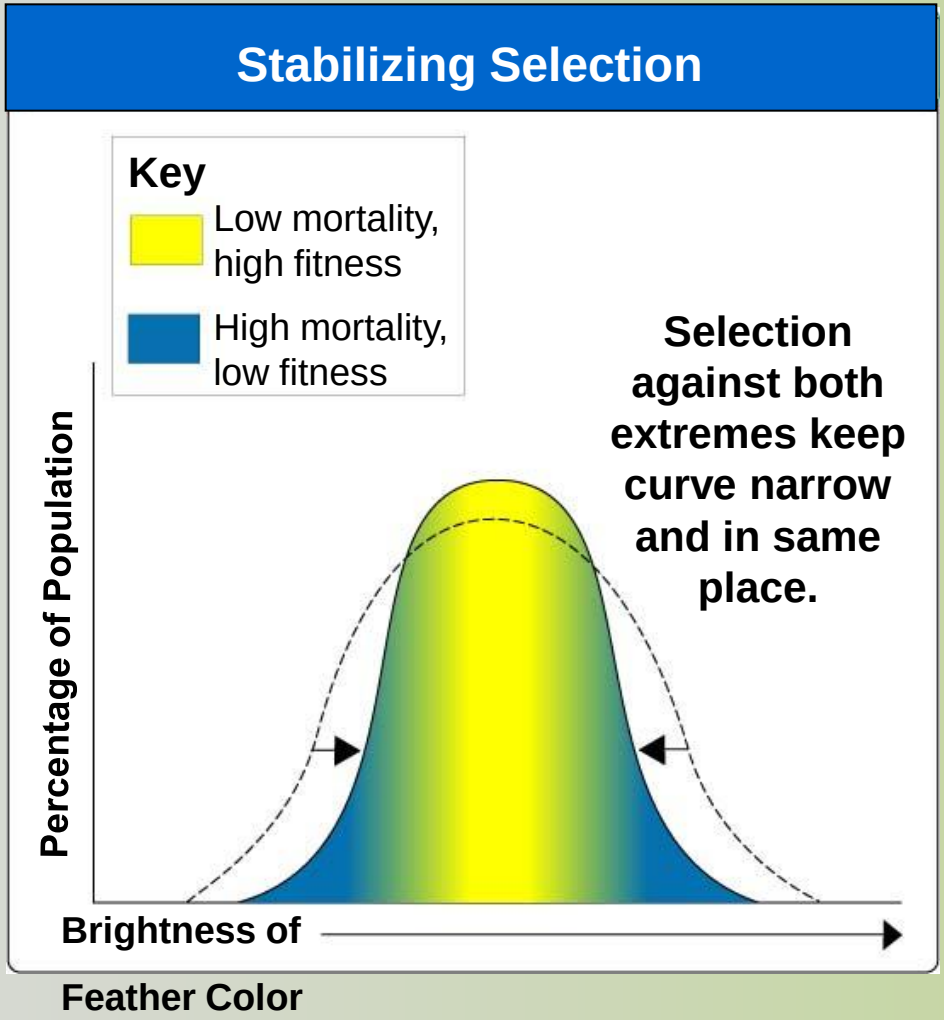
STABILIZING SELECTION

Section 16-2

Male birds use their plumage to attract mates.

Male birds with less brilliant and showy plumage are less likely to attract a mate

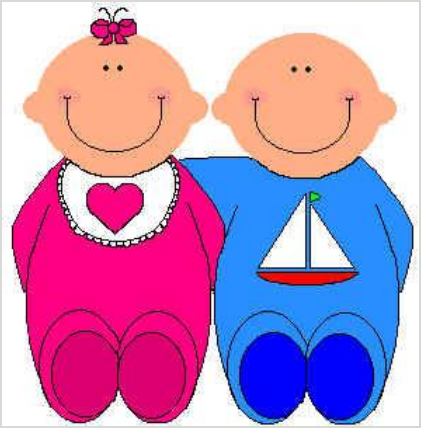
Male birds with showy plumage are more likely to attract a mate.



Male birds with showier, brightly colored plumage also attract predators, and are less likely to live long enough to find a mate.

The most fit is male bird in the middle-- showy, but not too showy.

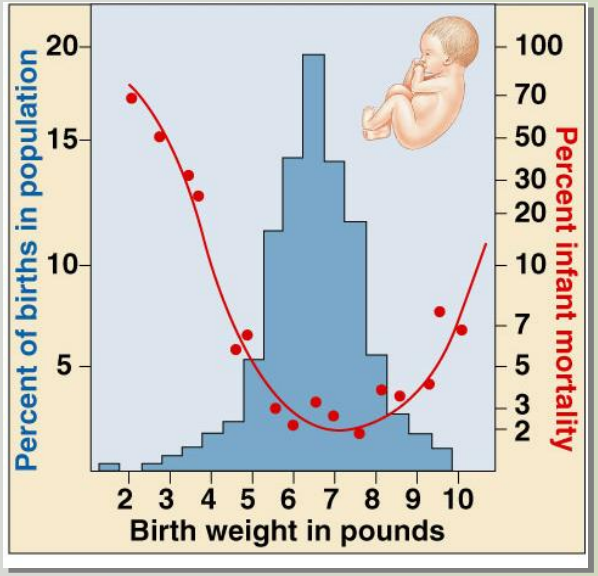
EXAMPLE OF STABILIZING SELECTION

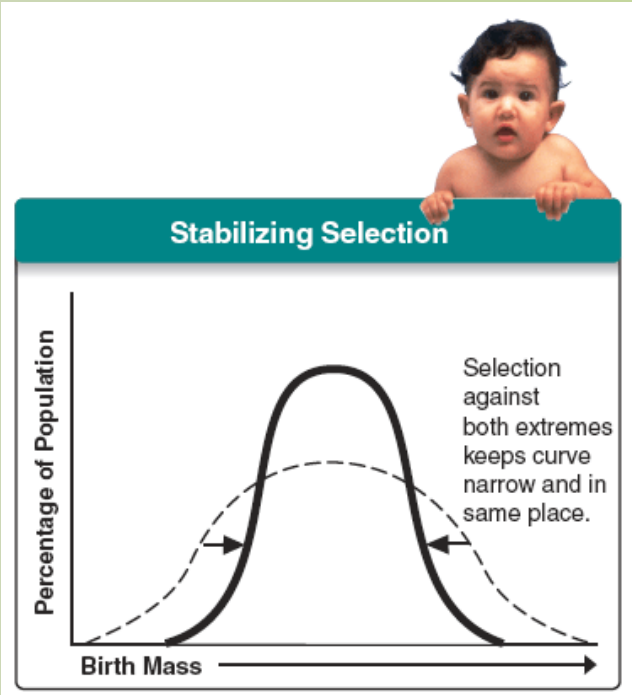


Human babies born with low birth weight are less likely to survive.

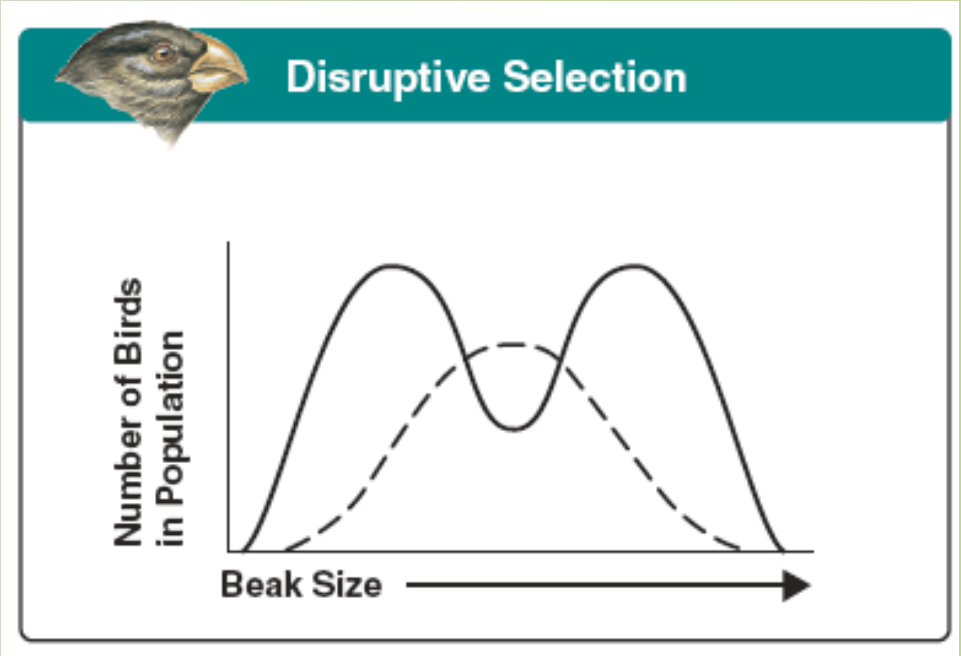
Babies born too large have difficulty being born.

Average size babies are selected for.





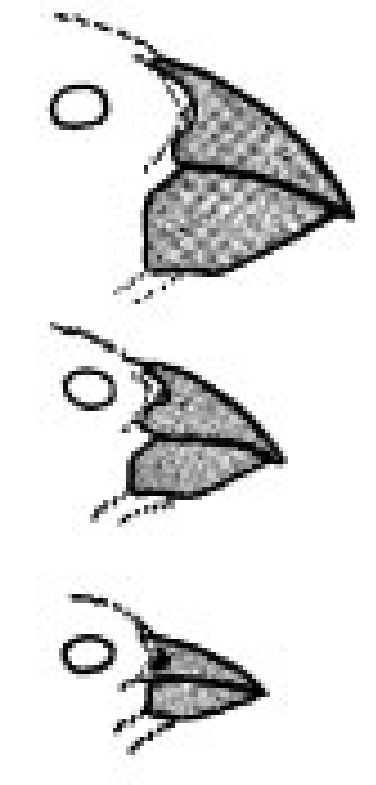
DISRUPTIVE SELECTION

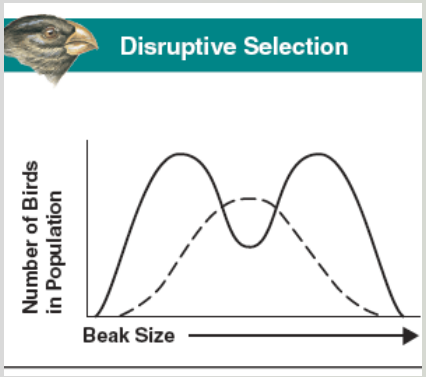


Individuals at extremes of the curve have higher fitness than individuals in middle.

Can cause graph to split into two.
Selection creates two DIFFERENT PHENOTYPES

EXAMPLE OF DISRUPTIVE SELECTION





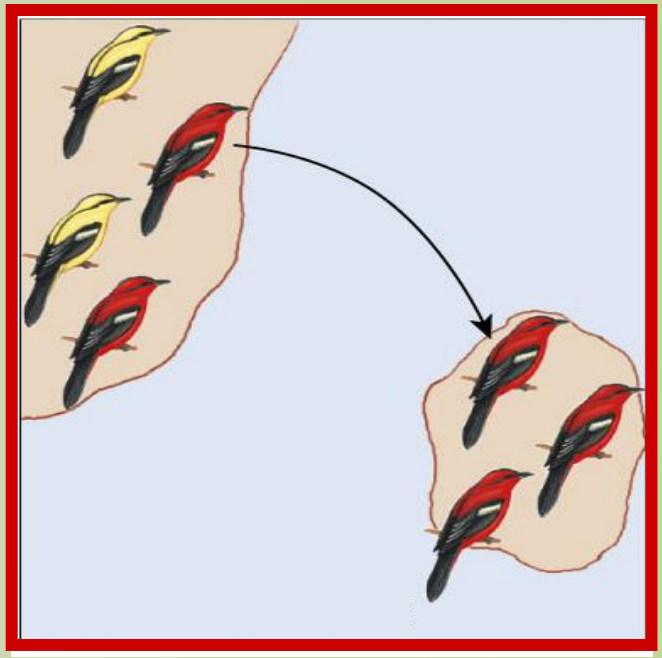
A bird population lives in area where climate change causes medium size seeds become scarce while large and small seeds are still plentiful.

Birds with bigger or smaller beaks would have greater fitness and the population may split into TWO GROUPS. One that eats small seeds and one that eats large seeds.

http://www.animalbehavior.org/ABS/Stars/ONI/Podos_-_finch_graphic.jpg

Genetic Drift – Random, Not selective, Not adaptive

- Chance events changing frequency of traits in a population
  - *not* adaptation to environmental conditions
    - Not selection
  - founder effect
    - Small group splinters off and starts a new colony
    - It is random who joins the group
  - Bottleneck (who survives is random)
    - A disaster reduces the population to small number & then population recovers & expands again but from a limited gene pool



Founder Effect

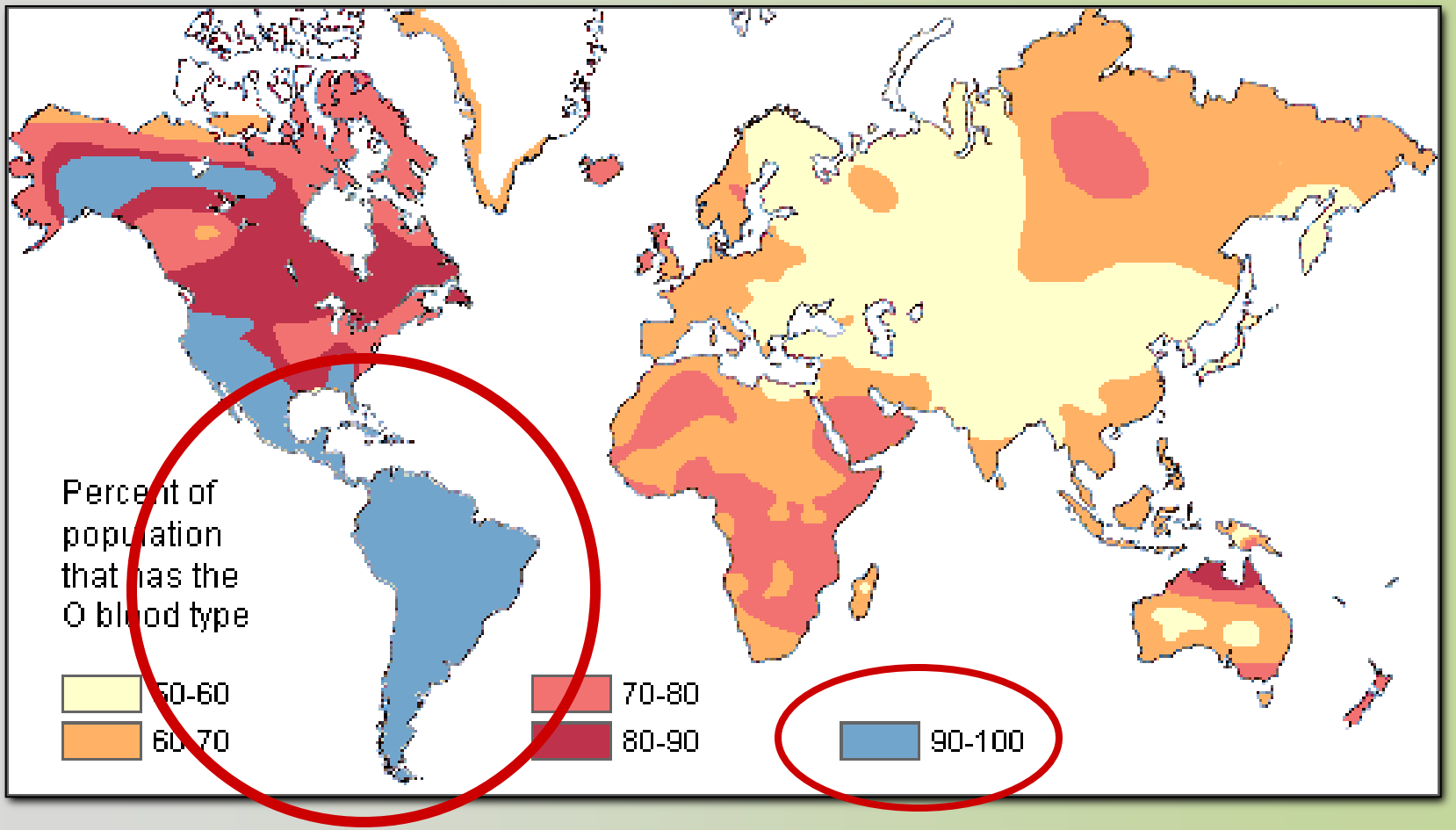
- A new population is started by a small group of individuals
  - just by chance some rare traits or alleles may be at high frequency; others may be missing
  - skews the gene pool of new population
    - example: colonization of New World
    - ISLANDS!!!

Polydactyl – Amish in Pennsylvania

Albino deer

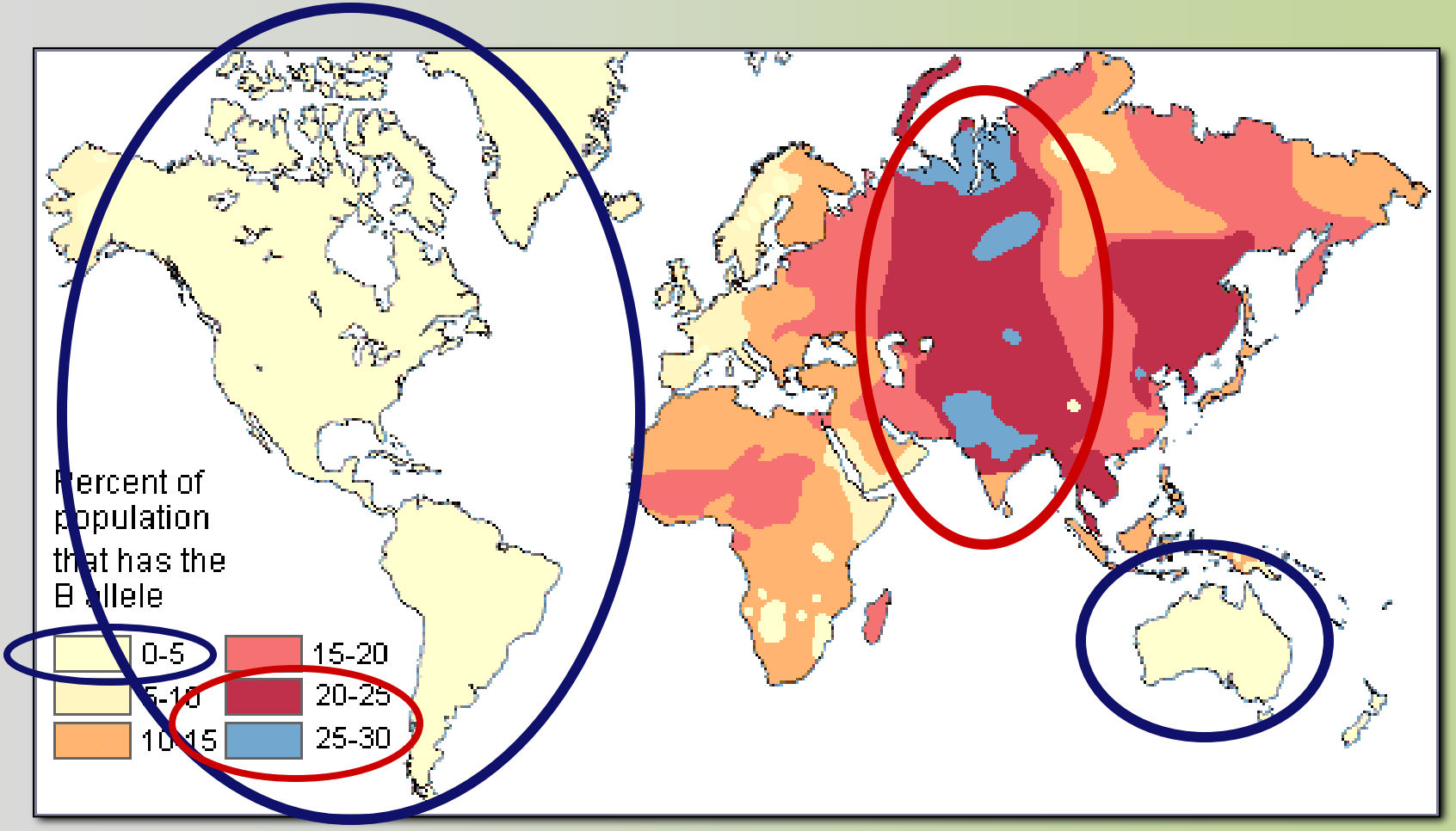
Distribution of blood types

- Distribution of the O type blood allele in *native* populations of the world reflects original settlement



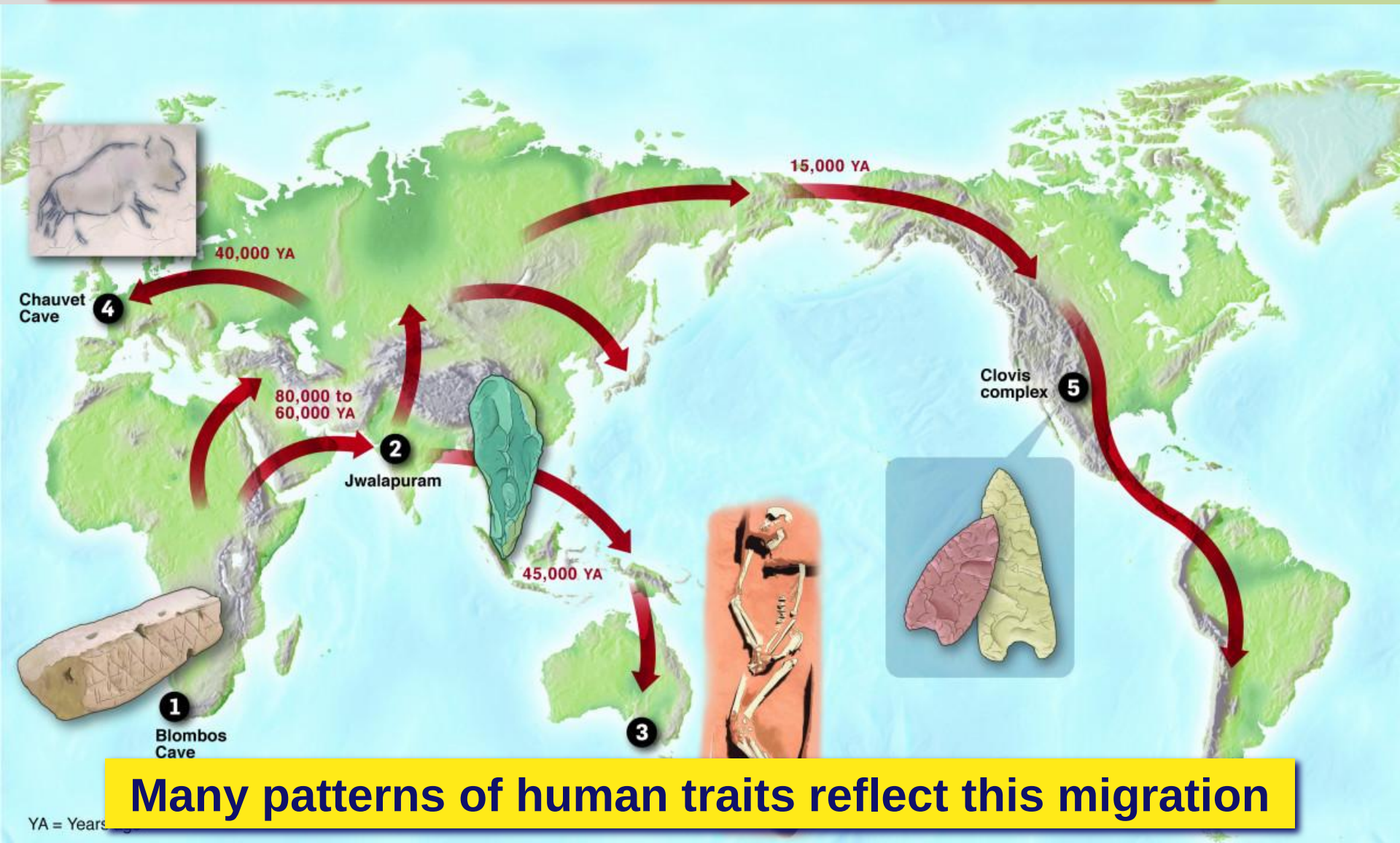
Distribution of blood types

- Distribution of the B type blood allele in *native* populations of the world reflects original migration



Out of Africa

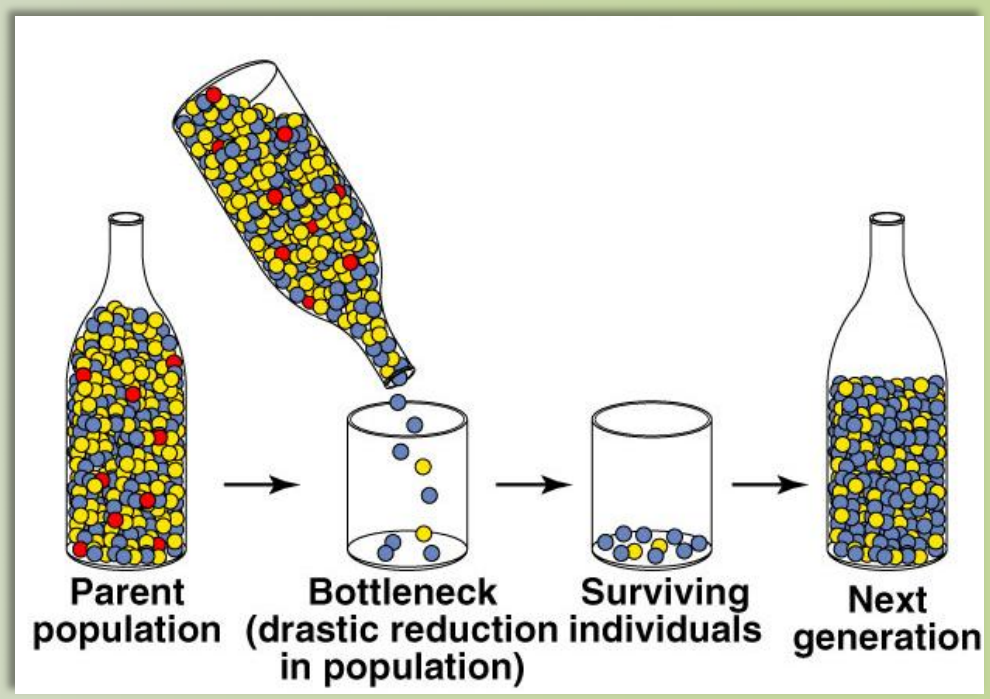
Likely migration paths of humans out of Africa



Many patterns of human traits reflect this migration

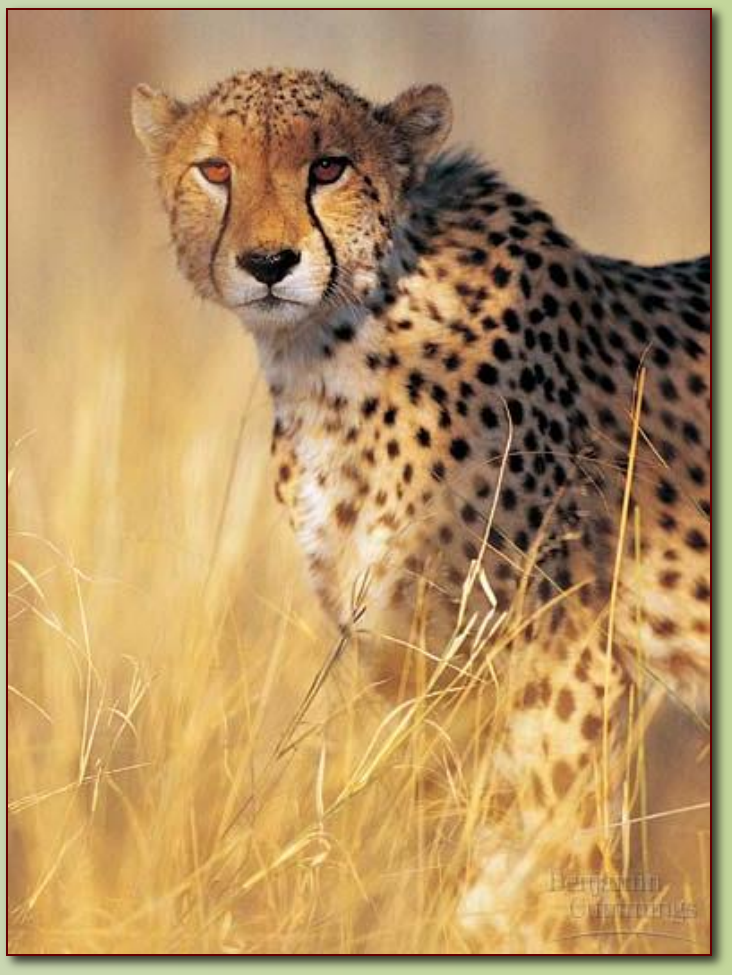
Bottleneck effect

- When large population is drastically reduced by a non-selective disaster
  - famine, natural disaster, loss of habitat…
  - loss of variation by chance event
    - narrows the gene pool



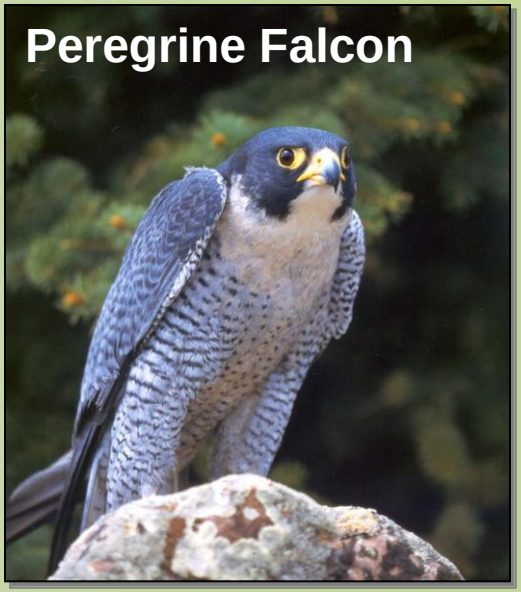
Cheetahs

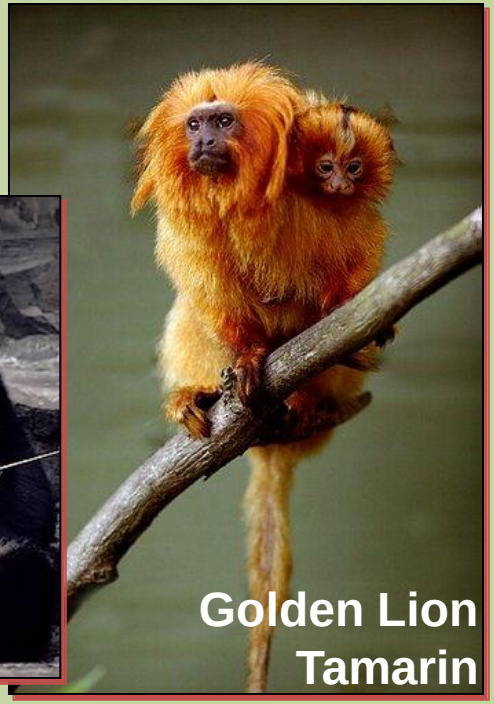
- All cheetahs share a small number of alleles
  - less than 1% diversity
  - as if all cheetahs are identical twins
- 2 bottlenecks
  - 10,000 years ago
    - Ice Age
  - last 100 years
    - poaching & loss of habitat



Conservation issues

- Bottlenecking is an important concept in conservation biology of endangered species
  - loss of alleles from gene pool
  - reduces variation
  - reduces adaptability





Breeding programs must consciously outcross

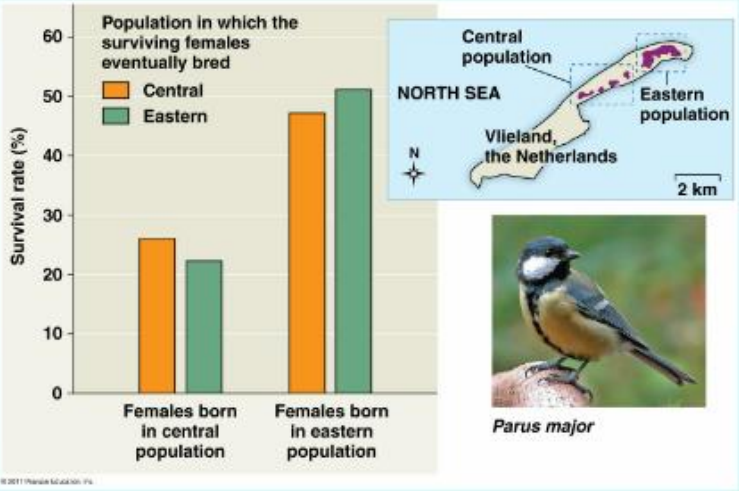
Gene Flow

What it is:

Change in the frequency of traits in a population due to immigration/emmigration

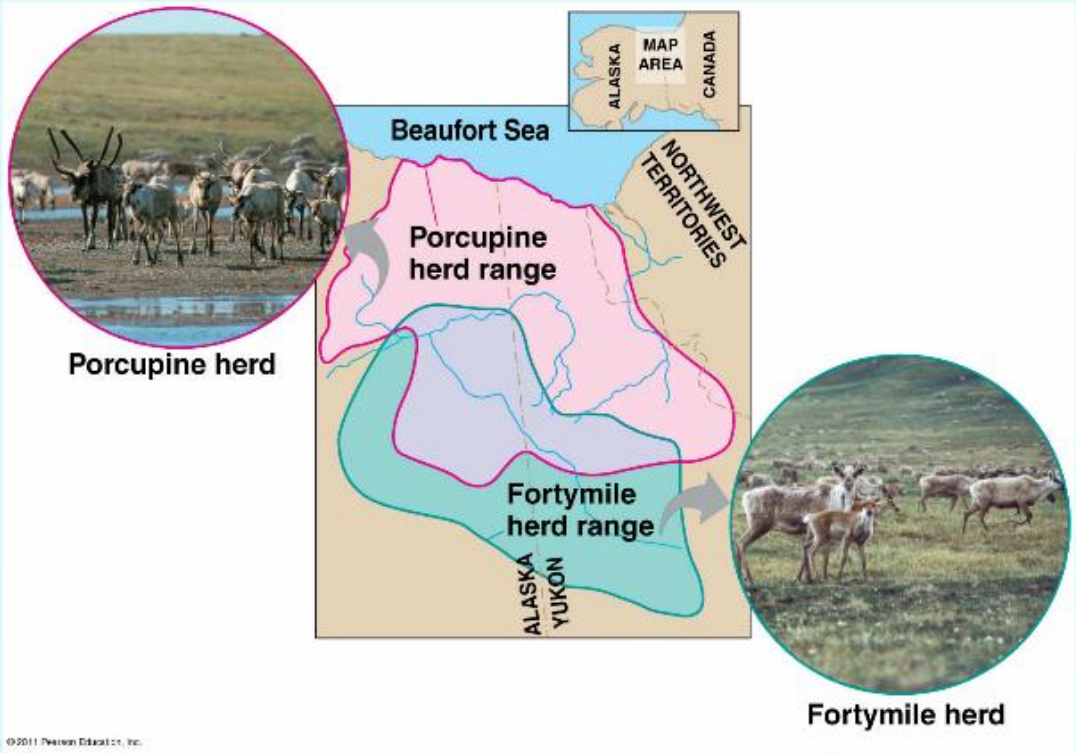
EQUALIZING CHANGE.

Hard to predict the effects



Two island populations of the Great Tit.

Gene flow from the mainland population to the central population may be contributing to the lower survival rate of the central population compared to the eastern population



The overlap of these two populations of Carribou allows for gene flow between them

Effects of Evolution

How does evolution work?

Evolution is a population level phenomenon.

It emerges from the selection of individuals by the environment.

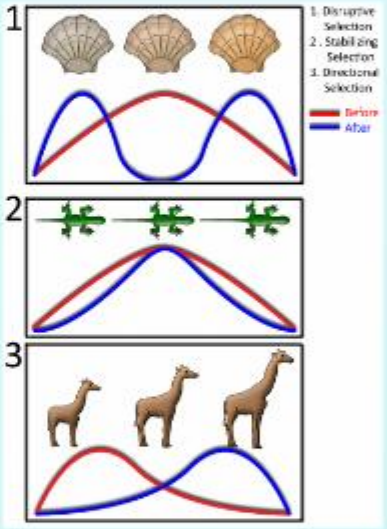
Modes of selection:

How selection affects a population.

Disruptive
Against the mean, towards both extremes

Stabilizing
Towards the mean, against extremes

Directional
Towards one extreme



Traits must be inherited!

The different morphologies of Nemoria arizonaria caterpillars is due entirely to chemicals in their diet, NOT genetic differences

Traits can be physiological OR behavioral

Review Questions

The following question refers to this information*:*

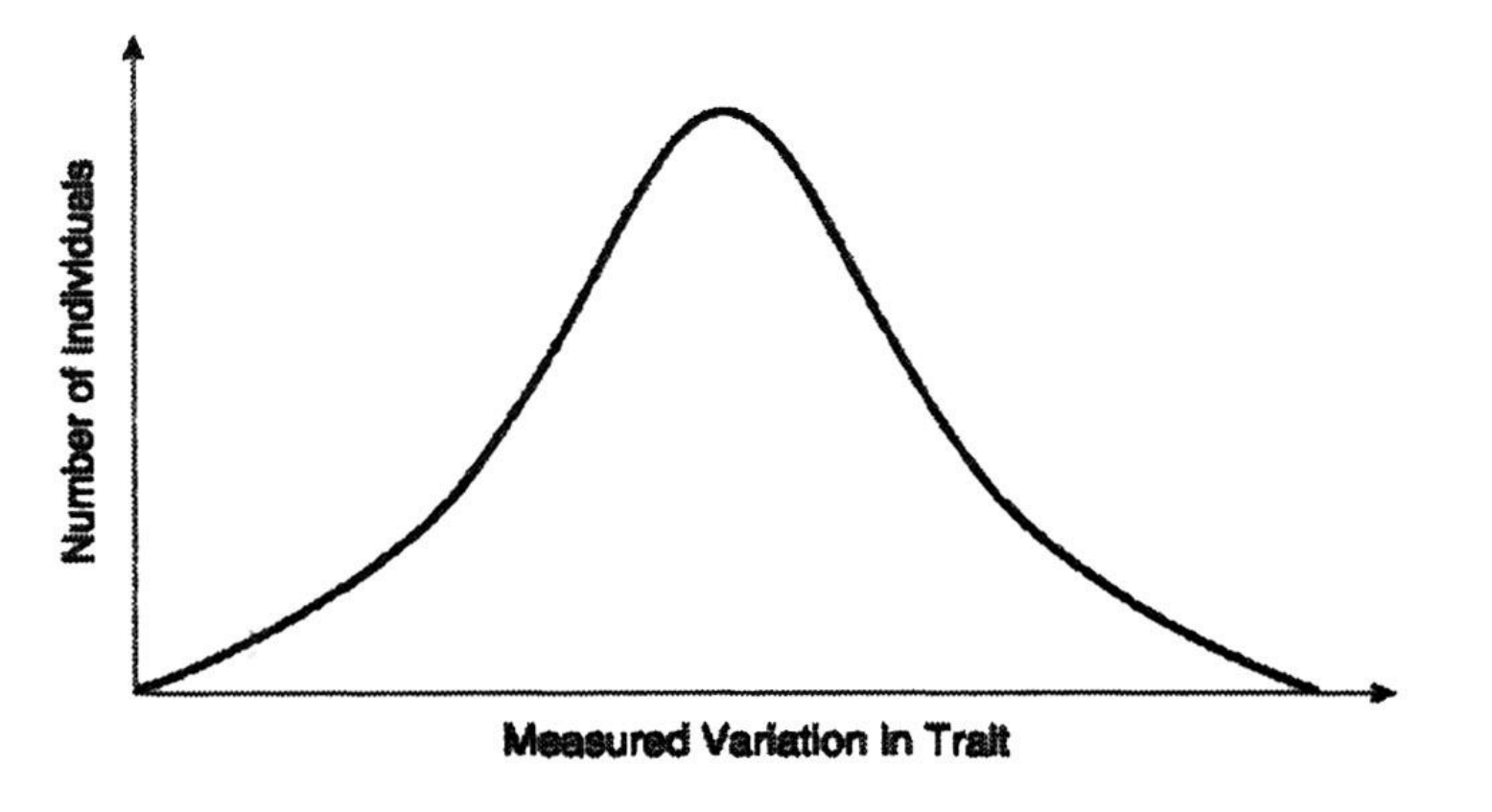
In the year 2500, five male space colonists and five female space colonists from Earth settle on an uninhabited Earthlike planet in the Andromeda galaxy. The colonists and their offspring randomly mate for generations

1. After many generations, the population on this planet has an unusually high frequency for the incidence of retinitis pigmentosa, relative to Earth's population. This is most likely due to
   A. the founder effect.
   B. sexual selection.
   C. the inheritance of acquired characteristics.
   D. mutations.
   E. the bottleneck effect.

2. A balanced polymorphism exists through diversifying selection in seedcracker finches from Cameroon in which small- and large-billed birds specialize in cracking soft and hard seeds, respectively. If long-term climatic change resulted in all seeds becoming hard, what type of selection would then operate on the finch population?

A. diversifying selection.
B. directional selection
C. stabilizing selection
D. sexual selection
E. No selection would operate because the population is in Hardy-Weinberg equilibrium.

In a very large population, a quantitative trait has the following distribution pattern:



3. What is true of the trait whose frequency distribution in a large population appears above? It is undergoing *

A. directional selection.
B. stabilizing selection.
C. diversifying selection.
D. sexual selection.
E. It is not possible to say, solely from the information above.

4. The bottleneck effect

   A. Eliminates traits whether they are beneficial or not.
   B. Increases the overall variability in the population.
   C. Amplifies the presence of traits that will eventually lead to extinction
   D. Increases the adaptability of a population
   E. Decreases the number weak organisms in the population.

5. Which of the following statements accurately describes genetic drift?

   A. It occurs when individuals in a population drift out due to emmigration
   B. It occurs when individuals drift in to a population due to immigration
   C. It refers to random changes in the gene frequencies in a population due to a drop in population size
   D. Mutations are the cause of genetic drift
   E. Natural selection is the cause of genetic drift.