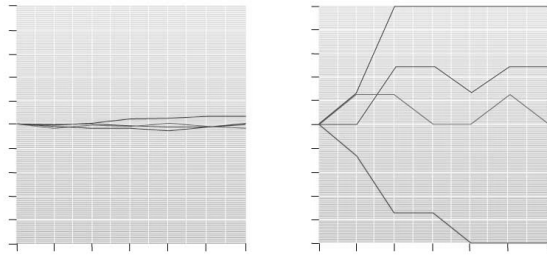


Chapter 15:
How Organisms Evolve

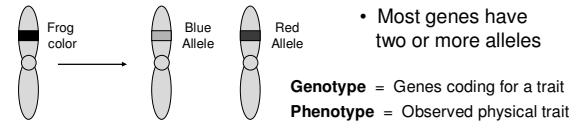


Natural selection works at the level of the individual, whereas evolution occurs at the level of the population

Individual Organism $\xrightarrow{\text{Inheritance}}$ Population Evolution

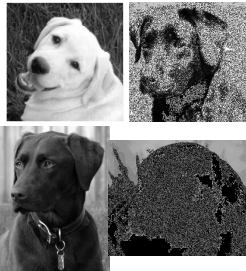
Principles of Inheritance:

- Genes determine the traits of an individual
 - Gene:** Section of DNA that codes for a particular structure
 - Alleles:** Slightly different codes for a structure



Genes vs Alleles

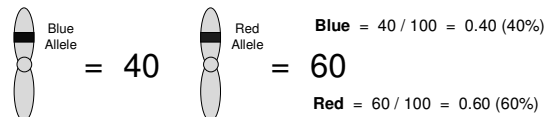
- Genes: code for a **TRAIT**
 - ❖ Hair color, eye color
- Alleles: code for variations of that trait
 - ❖ Black, brown, blonde, & red hair
 - ❖ Each hair color variation has a different **allele**.



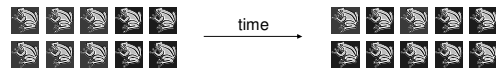
Coat color **GENE**
Different **alleles** give a different color dog

Principles of Inheritance:

- Gene Pool = Sum of all genes in a population
 - Allele Frequency:** Relative proportion of different alleles in a population



- Evolution is a change of gene frequencies within a population over time (but natural selection acts on phenotype...)



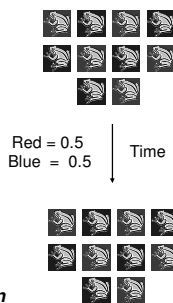
Equilibrium Population: A hypothetical population in which evolution does not occur

- Gene frequencies stay constant over time (genetic equilibrium)
 - Hardy-Weinberg Principle**

Conditions that Must Exist in Population:

- Mutations must not occur
- Gene flow must not occur
 - net migration of alleles between populations
- Population must be large
- Mating must be random
- Natural selection must not exist

Shift in Conditions = Causes of Evolution



Mutation: A change in the genetic structure of a gene

- Caused by radiation, chemical damage, or copying errors
- Occur rarely (1 per 500,000 genes)

BUT

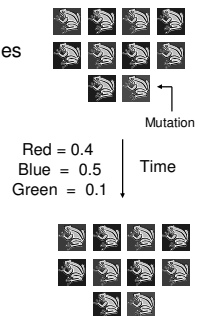
- Mutations are the source of new alleles

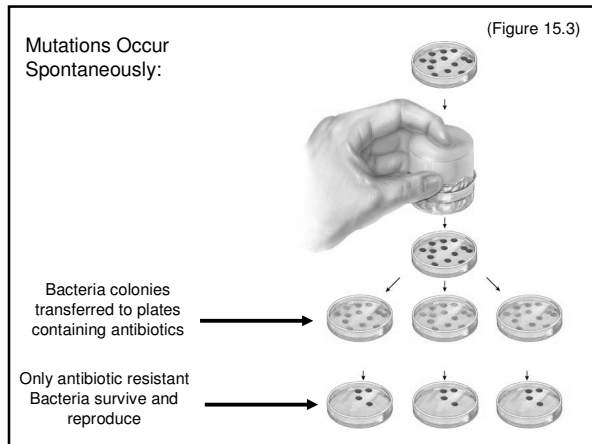
Foundation of Evolutionary Change

Without mutations, there would be no variation among individuals and thus no evolution

Remember (Important!):
Mutations are not goal-oriented but happen by chance

Environmental conditions then dictate its fate...





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Shift in Conditions = Causes of Evolution

Red = 0.5
Blue = 0.5

Gene Flow Changes Allele Frequencies:

Population 1

Population 2

Migration

Time

Significant Effects:

- 1) Gene flow spreads advantageous genes throughout species
- 2) Gene flow helps maintain all the organisms over a large area as one species

Red = 0.4
Blue = 0.5
Green = 0.1

Equilibrium Population: A hypothetical population in which evolution does not occur

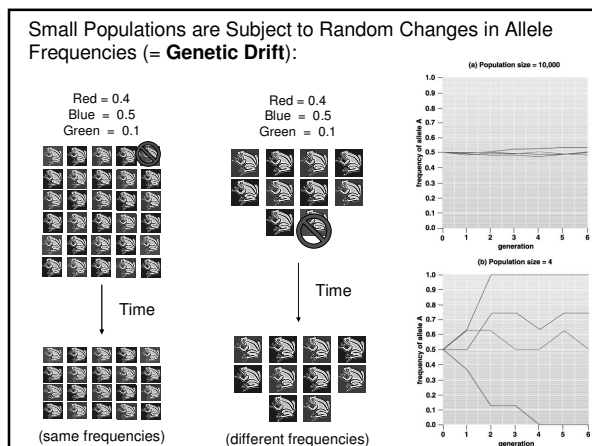
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Shift in Conditions = Causes of Evolution

Red = 0.5
Blue = 0.5



Outcomes of Genetic Drift:

- 1) Genetic drift tends to reduce genetic variability within a population (Red, Blue, Green → Red, Blue)
- 2) Genetic drift tends to increase genetic variability between populations (Red, Blue, Green → Red, Blue OR Red, Green OR etc...)

Special Cases of Genetic Drift:

- 1) Population Bottleneck: Population undergoes a dramatic reduction in size

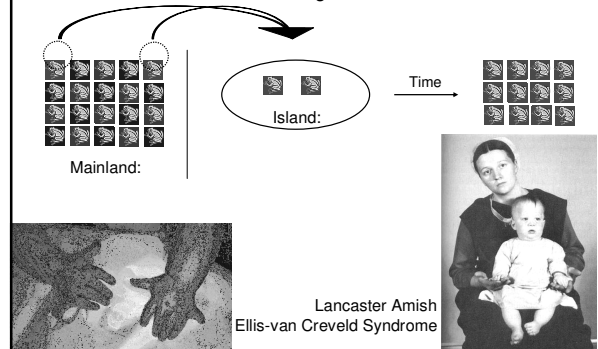
Examples of population bottleneck

- Florida panthers
 - ❖ Florida panthers was reduced to only 50 individuals.
 - ❖ Severe inbreeding resulted in mostly sterile males.
 - ❖ To save the Florida panther, researchers mated them to Texas panthers
 - Pure Florida panthers no longer exist.



Special Cases of Genetic Drift:

- 2) Founder Effect: Formation of isolated colonies by a small number of organisms



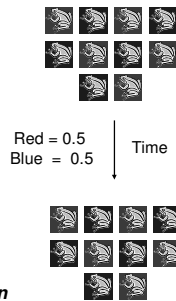
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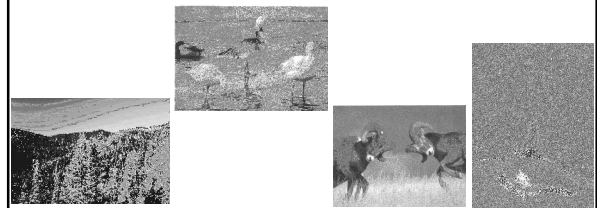
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Shift in Conditions = Causes of Evolution



Mating Within a Population is Almost Never Random:

- A) Lack of mobility = Mating with nearby neighbors
- B) **Assortative Mating**: Mating with individuals that closely resemble you
- C) **Male - Male Competition**: Males contest for access to mates
- D) **Female Choice**: Females choose among potential mates



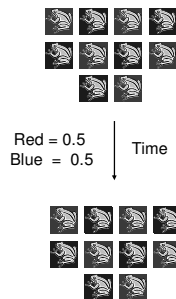
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Shift in Conditions = Causes of Evolution



All Genotypes are not Equally Adaptive:

- Natural selection will favor a beneficial trait via increased reproductive success (= evolution via natural selection)

Natural Selection:

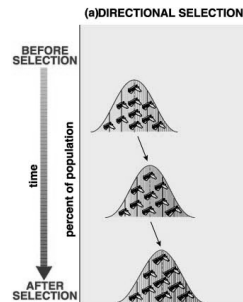
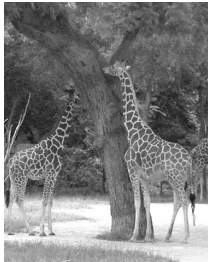
- Is a mindless, mechanical process...
 - ❖ Natural selection does not cause individual genetic change
- Concerns survival and reproduction...
 - Not just "survival of the fittest"
 - ❖ **Differential Reproduction**: Individuals with certain alleles leave more offspring than individuals with other alleles
- Acts on **phenotypes** (which reflects genotypes)...

Categories of Natural Selection:

1) Directional Selection

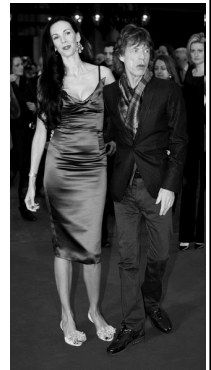
- Favors organisms at one end of a distribution, and selects against those at the average or far end of distribution

- Long / Thick fur
- Antibiotic resistance



Directional selection

- Example:
 - Human height
- Humans have become taller on average in the last 100 years.
 - Better nutrition (environmental effect)
 - Sexual selection (both male & female)



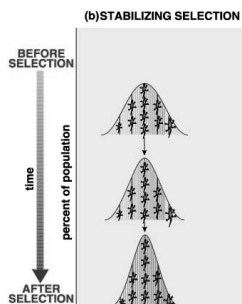
Categories of Natural Selection:

2) Stabilizing Selection

- Favors organisms that possess the average for a trait and select against individuals with extreme values

- Peacock's tail
- Lizard size

Compromise between opposing environmental pressures



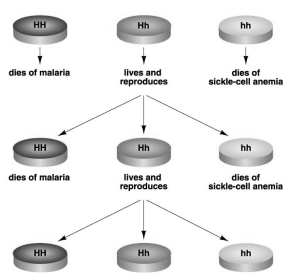
Stabilizing selection

- Swordtails
 - Females prefer long swords on male fish.
 - Males with long swords reproduce more than those with short.
 - Males with very long swords are easily caught by predators.
 - Males with long swords are eaten more than those with short.

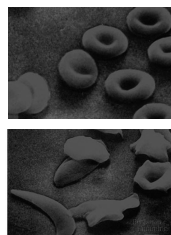


Opposing environmental pressure may give rise to **balanced polymorphism**:

- Multiple alleles of a gene are maintained in a population because each is favored by different environmental forces



Sickle-cell Anemia



Categories of Natural Selection:

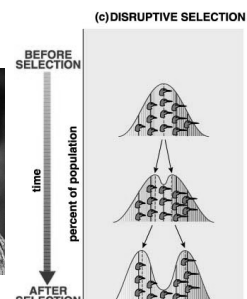
3) Disruptive Selection

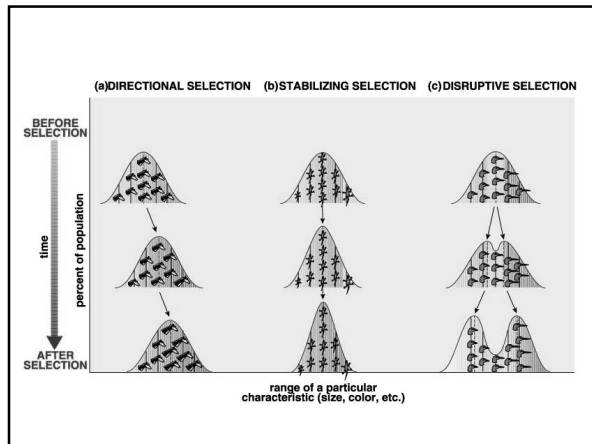
- Favors organisms with extreme values for a trait and selected against individuals with average values

Allows populations to utilize different types of resources in a given habitat



Black-bellied Seedcatcher





Processes Causing Natural Selection:

- Adaptations: Characteristics that help an individual survive and reproduce in a particular environment

1) Abiotic Conditions: Establish "bottom line" requirements

2) Biotic Conditions: Adaptations arising via interactions with living organisms

- Competition for scarce resources favors well-adapted individuals
- Both predator and prey act as agents of selection on each other (coevolution...)
- Symbiosis produces adaptations for living with other species
- Sexual selection favors traits that help an organism mate
 - ❖ Traits often at odds with survival

Females are choosy...



Sometimes males are choosy..



Males prefer heavy females



Males prefer more colorful females

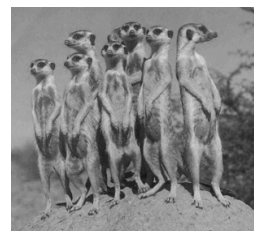
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 - Symbiosis produces adaptations for living with other species
 - Sexual selection favors traits that help an organism mate
 - Traits often at odds with survival
 - Kin selection favors altruistic behavior
 - Altruism: Behaviors that lower personal fitness but benefit others

Kin selection and altruism

• Kin selection

- ❖ Selection of kin over non-related kin in terms of food, protection, etc.



Meercats



Belding's ground squirrel