Chapter 16: pp. 283 - 298

How Populations Evolve

10% of population

natural disaster kills five green frogs

20% of population
Outline

- Population genetics
  - Variations in terms of allele differences.

- Microevolution
  - Hardy-Weinberg
  - Causes of Microevolution

- Natural Selection
  - Types of Selection

- Macroevolution
Population Genetics

- Population
  - All members of a single species
  - Occupying a particular area at the same time.
HapMap Project

- People inherit patterns of sequence differences, called haplotypes
  - If one haplotype of a person has an A rather than a G at a particular location in a chromosome, there are probably other particular base differences near the A
  - Genetic data from African, Asian, and European populations will be analyzed

- A HapMap is a catalog common sequence differences that occur in a species
  - The goal of the project is to link haplotypes to risk for specific illnesses
  - May lead to new methods of preventing, diagnosing, and treating disease
HapMap Project

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Microevolution

- In 1930s population geneticists described variations in a population in terms of alleles.

**Microevolution** pertains to evolutionary changes within a population.

- Various alleles at all the gene loci in all individuals make up the **gene pool** of the population.
- Gene pool of a population:
  - Genotype
  - Allele frequencies
Frequency of Gametes Calculation

From genotype frequencies, the allele and gamete frequencies can be calculated.

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>DD</th>
<th>Dd</th>
<th>dd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of genotypes in the population</td>
<td>0.04</td>
<td>0.32</td>
<td>0.64</td>
</tr>
<tr>
<td>Frequency of alleles and gametes in the population</td>
<td>0.04 + 0.16</td>
<td>0.16 + 0.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.20 D</td>
<td>0.80 d</td>
<td></td>
</tr>
</tbody>
</table>

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The Hardy-Weinberg principle:

- Allele frequencies in a population will remain constant assuming:
  - No Mutations
  - No Gene Flow
  - Random Mating
  - No Genetic Drift
  - No Selection
Hardy-Weinberg Equilibrium

**F₁ generation**

Genotypes:
- DD
- Dd
- dd

Genotype frequencies:
- DD: 0.04
- Dd: 0.32
- dd: 0.64

Allele and gamete frequencies:
- D = 0.20
- d = 0.80

**F₂ generation**

<table>
<thead>
<tr>
<th>Eggs</th>
<th>D</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.20 D</td>
<td>0.80 d</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sperm</th>
<th>0.20 D</th>
<th>0.80 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.20 D</td>
<td>0.04 DD</td>
<td>0.16 Dd</td>
</tr>
<tr>
<td>0.80 d</td>
<td>0.16 Dd</td>
<td>0.64 dd</td>
</tr>
</tbody>
</table>

Offspring

Genotype frequencies:
- DD: 0.04
- Dd: 0.32
- dd: 0.64

\[ p^2 + 2pq + q^2 = 1 \]

- \( p^2 \) = frequency of DD genotype (dark-colored) = \((0.20)^2\) = 0.04
- \( 2pq \) = frequency of Dd genotype (dark-colored) = \(2(0.20)(0.80)\) = 0.32
- \( q^2 \) = frequency of dd genotype (light-colored) = \((0.80)^2\) = 0.64

= 1.00
Industrial Melanism and Microevolution

Early observation

Later observation

36% dark-colored phenotype

64% dark-colored phenotype
Hardy-Weinberg

- Required conditions are rarely (if ever) met
  - Changes in gene pool frequencies are likely
  - When gene pool frequencies change, microevolution has occurred

- Deviations from a Hardy-Weinberg equilibrium indicate that evolution has taken place
Causes of Microevolution

- Genetic Mutations
  - The raw material for evolutionary change
  - Provides new combinations of alleles
  - Some might be more adaptive than others
Causes of Microevolution

- **Gene Flow**
  - Movement of alleles between populations when:
    - Gametes or seeds (in plants) are carried into another population
    - Breeding individuals migrate into or out of population
  - Continual gene flow reduces genetic divergence between populations
Gene Flow

Pisum sativum

self-pollination

stigma

stamen
Causes of Microevolution

Nonrandom Mating

- When individuals do not choose mates randomly
  - Assortative mating:
    - Individuals select mates with their phenotype
    - Individuals reject mates with differing phenotype
  - Sexual selection:
    - Males compete for the right to reproduce
    - Females choose with males possessing a particular phenotype
- Both of these cause an increase in homozygotes
Causes of Microevolution

- Genetic Drift
  - Occurs by disproportionate random sampling from population
    - Can cause the gene pools of two isolated populations to become dissimilar
    - Some alleles are lost and others become fixed (unopposed)
  - Likely to occur:
    - After a bottleneck
    - When severe inbreeding occurs, or
    - When founders start a new population
  - Stronger effect in small populations
Genetic Drift

10% of population

natural disaster kills five green frogs

20% of population
Genetic Drift

- **Bottleneck Effect**
  - A random event prevents a majority of individuals from entering the next generation
  - Next generation composed of alleles that just happened to make it
Genetic Drift

- Founder Effect
  - When a new population is started from just a few individuals
  - The alleles carried by population founders are dictated by chance
  - Formerly rare alleles will either:
    - Occur at a higher frequency in the new population, or
    - Be absent in new population
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Even this larger population is not immune to ultimate fixation of an allele by genetic drift. However, in most cases a very large number of generations will pass before fixation occurs.
Founder Effect
Natural Selection

- Adaptation of a population to the biotic and abiotic environment
  - Requires:
    - Variation - The members of a population differ from one another
    - Inheritance - Many differences are heritable genetic differences
    - Differential Adaptiveness - Some differences affect survivability
    - Differential Reproduction – Some differences affect likelihood of successful reproduction
Natural Selection

- Results in:
  - A change in allele frequencies of the gene pool
  - Improved fitness of the population

- Major cause of microevolution
Types of Selection

- Most traits are polygenic - variations in the trait result in a bell-shaped curve

- Three types of selection occur:
  
  (1) Directional Selection
  
  - The curve shifts in one direction
    
    - Bacteria become resistant to antibiotics
    
    - Guppies become more colorful in the absence of predation
Three Type of Natural Selection

Phenotype Range

1. Stabilizing selection
   - Peak narrows.
   - Number of Individuals

2. Directional selection
   - Peak shifts.
   - Number of Individuals

3. Disruptive selection
   - Two peaks result.
   - Number of Individuals

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Directional Selection

All guppies are drab and small

Experimental site

above waterfall

below waterfall

Result

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Three types of selection occur (cont):

(2) Stabilizing Selection
- The peak of the curve increases and tails decrease
- Ex - when human babies with low or high birth weight are less likely to survive

(3) Disruptive
- The curve has two peaks
- Ex – When *Cepaea* snails vary because a wide geographic range causes selection to vary
Due to stabilizing selection, the average human birth weight stays steady.
Disruptive Selection

Forested areas

Low-lying vegetation

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Sexual Selection

● Female Choice
  ● Choice of a mate is serious consideration
    ● Good genes hypothesis: Females choose mates on the basis of traits that improve the chance of survival.
    ● Runaway hypothesis: Females choose mates on the basis of traits that improve male appearance.

● Male Competition
  ● Can father many offspring because they continuously produce sperm in great quantity.
  ● Compete to inseminate as many females as possible.
Sexual Selection

- **Sexual selection** adaptive changes in males and females to increase ability to secure a mate.
  - Males - ability to compete
  - Females choose to select a male with the best **fitness** (ability to produce surviving offspring).
The drab females tend to choose flamboyant males as mates.
Sexual Selection: Competition

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Sexual Selection: Competition

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Study shows that female choice and male competition apply to humans too

- Women must invest more in having a child than men.
- Men, need only contribute sperm
  - Generally more available for mating than are women.
- More men = competition
- Men Also Have a Choice
  - Prefer women who are most likely to present them with children.
King Husain and Family

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Maintenance of Variations

● Genetic variability

  ● Populations with limited variation may not be able to adapt to new conditions

  ● Maintenance of variability is advantageous to population

● Only exposed alleles are subject to natural selection
Maintenance of Variations

- Recessive alleles:
  - Heterozygotes shelter recessive alleles from selection
  - Allows even lethal alleles to remain in population at low frequencies virtually forever
  - Lethal recessive alleles may confer advantage to heterozygotes
    - Sickle cell anemia is detrimental in homozygote
    - However, heterozygotes more likely to survive malaria
    - Sickle cell allele occurs at higher than expected frequency in malaria prone areas
Species Definitions

- **Species Definitions**
  - **Morphological**
    - Can be distinguished anatomically
    - Specialist decides what criteria probably represent reproductively isolated populations
    - Most species described this way
Species Definitions

- Biological
  - Populations of the same species breed only among themselves
  - Are reproductively isolated from other such populations
  - Very few actually tested for reproductive isolation
Heterozygote Advantage

- Assists the maintenance of genetic, and therefore phenotypic, variations in future generations.
- In sickle cell disease heterozygous individuals don’t die from sickle-cell disease, and they don’t die from malaria.
Sickle Cell Disease
Review

- Microevolution
  - Hardy-Weinberg
  - Causes of Microevolution

- Natural Selection
  - Types of Selection

- Macroevolution
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