

PowerLecture:

Chapter 18

Microevolutionary Processes

Section 18.0: Weblinks and InfoTrac

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Impacts, Issues: **Rise of the Super Rats**

- Rats – one of the most notorious and successful mammalian pests
- In any given year, rats cause economic losses approaching 19 billion dollars

Impacts, Issues: **Rise of the Super Rats**

- Warfarin was an extremely effective rodenticide until the allele for resistance spread throughout rat population
- Latest worry is the evolution of super rats – which newer and even more potent rodenticides cannot seem to kill

Impacts, Issues Video

Section 18.1: Weblinks and InfoTrac

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Populations Evolve

- Biological evolution does not change individuals
- It changes a population
- Traits in a population vary among individuals
- Evolution is change in frequency of traits

The Gene Pool

- All of the genes in the population
- Genetic resource that is shared (in theory) by all members of population

Gene Mutations

- Infrequent but inevitable
- Each gene has own mutation rate
- Lethal mutations
- Neutral mutations
- Advantageous mutations

Variation in Phenotype

- Each kind of gene in gene pool may have two or more alleles
- Individuals inherit different allele combinations
- This leads to variation in phenotype
- Offspring inherit genes, not phenotypes

Variation in Phenotype

Variation in Phenotype

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Variation in Phenotype

What Determines Alleles in New Individual?

- Mutation
- Crossing over at meiosis I
- Independent assortment
- Fertilization
- Change in chromosome number or structure

Genetic Equilibrium

- Allele frequencies at a locus are not changing
- Population is not evolving

Microevolutionary Processes

- Drive a population away from genetic equilibrium
- Small-scale changes in allele frequencies brought about by:
 - Natural selection
 - Gene flow
 - Genetic drift

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Five Conditions

- No mutation
- Random mating
- Gene doesn't affect survival or reproduction
- Large population
- No immigration/emigration

Hardy-Weinberg Rule

At genetic equilibrium, proportions of genotypes at a locus with two alleles are given by the equation:

$$p^2 AA + 2pq Aa + q^2 aa = 1$$

Frequency of allele $A = p$

Frequency of allele $a = q$

Punnett Square

Frequencies in Gametes

No Change through Generations

No Change through Generations

Hardy-Weinberg Rule

How to find out if a population is evolving

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Natural Selection

- A difference in the survival and reproductive success of different phenotypes

- Acts directly on phenotypes and indirectly on genotypes

Reproductive Capacity

& Competition

- All populations have the capacity to increase in numbers
- No population can increase indefinitely
- Eventually the individuals of a population will end up competing for resources

Variation in Populations

- All individuals have the same genes that specify the same assortment of traits
- Most genes occur in different forms (alleles) that produce different phenotypes
- Some phenotypes compete better than others

Change over Time

- Over time, the alleles that produce the most successful phenotypes will increase in the population
- Less successful alleles will become less common
- Change leads to increased fitness
 - Increased adaptation to environment

Results of Natural Selection

Three possible outcomes:

- A shift in the range of values for a given trait in some direction
- Stabilization of an existing range of values
- Disruption of an existing range of values

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Directional Selection

- Allele frequencies shift in one direction

Directional Selection

Directional selection

Directional Selection

Directional Selection

Directional Selection

Directional Selection

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Peppered Moths

- Prior to industrial revolution, most common phenotype was light colored
- After industrial revolution, dark phenotype became more common

Moth Population

Change in moth population

Pesticide Resistance

- Pesticides kill susceptible insects
- Resistant insects survive and reproduce
- If resistance has heritable basis, it becomes more common with each generation

Antibiotic Resistance

- First came into use in the 1940s
- Overuse has led to increase in resistant forms
- Most susceptible cells died out and were replaced by resistant forms

Stabilizing Selection

- Intermediate forms are favored and extremes are eliminated

Stabilizing Selection

Stabilizing selection

Disruptive Selection

- Forms at both ends of the range of variation are favored
- Intermediate forms are selected against

Disruptive Selection

Disruptive selection

Selection for Gall Size

- Gall-making fly has two major predators
- Wasps prey on larvae in small galls
- Birds eat larvae in large galls
- Flies that cause intermediate-sized galls have the highest fitness

Selection for Gall Size

Disruptive selection among African finches

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Sexual Selection

- Selection favors certain secondary sexual characteristics
- Through nonrandom mating, alleles for preferred traits increase
- Leads to increased sexual dimorphism

Balanced Polymorphism

- Polymorphism - “having many forms”

- Occurs when two or more alleles are maintained at frequencies greater than 1 percent

Sickle-Cell Trait:

Heterozygote Advantage

- Allele Hb^S causes sickle-cell anemia when heterozygous
- Heterozygotes are more resistant to malaria than homozygotes

Sickle-Cell Trait

Distribution of sickle-cell trait

Malaria

Life cycle of *Plasmodium*

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Genetic Drift

- Random change in allele frequencies brought about by chance
- Effect is most pronounced in small populations
- Sampling error - Fewer times an event occurs, greater the variance in outcome

Genetic Drift in

Snail Populations

- Robert Selander studied *Helix aspersa*
- Collected snails from a two-block area
- Analyzed the allele frequencies for five genes

Genetic Drift

Simulation of genetic drift

Bottleneck

- A severe reduction in population size
- Causes pronounced drift
- Example
 - Elephant seal population hunted down to just 20 individuals
 - Population rebounded to 30,000
 - Electrophoresis revealed there is now no allele variation at 24 genes

Founder Effect

- Effect of drift when a small number of individuals starts a new population
- By chance, allele frequencies of founders may not be same as those in original population
- Effect is pronounced on isolated islands

Inbreeding

- Nonrandom mating between related individuals
- Leads to increased homozygosity
- Can lower fitness when deleterious recessive alleles are expressed
- Amish, cheetahs

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Gene Flow

- Physical flow of alleles into a population
- Tends to keep the gene pools of populations similar
- Counters the differences that result from mutation, natural selection, and genetic drift

Barriers to Gene Flow

- Whether or not a physical barrier deters gene flow depends upon:
 - Organism's mode of dispersal or locomotion
 - Duration of time organism can move

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Speciation & Natural Selection

- Natural selection *can* lead to speciation
- Speciation can also occur as a result of other microevolutionary processes
 - Genetic drift
 - Mutation

Adaptation to What?

- Relationship between adaptation and the environment isn't always direct
- Llamas of the Peruvian highlands have oxygen-efficient hemoglobin
- So do llamas close relative, the dromedary camel
- Trait was present in shared ancestor

Adaptation to What?

Adaptation to what?