Mechanisms of Evolution

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Population Genetics

• Population genetics is…
  – the study of the complex behavior of genes in populations of plants and animals.

• Recall that Darwin’s theory was developed before we developed our understanding of genes and how traits are inherited.

• Many of today’s principles of evolution are rooted in this area.
We now know…

- We cannot (as individuals) develop traits in response to natural selection.
- **Populations** evolve over time, **not people**.
- **Gene pool**
  - All of the alleles of a population together in a large “pool” or collection
- **Allelic frequency**
  - Percentage of any specific allele in the gene pool
Genetic Equilibrium

- Genetic equilibrium is when the frequency of alleles remains the same over generations.
- A population in genetic equilibrium is not evolving:
  - Allelic frequencies remain the same.
  - Phenotypes remain the same.
  - Disrupting genetic equilibrium results in the process of evolution.
Ways Species Change

• When a species, and in some cases entire communities change in response to environmental pressures, it is called macroevolution
• There are 5 main ways in which a species can change over time
  – Mutations
  – Gene flow
  – Genetic drift
  – Non-random mating
  – Natural Selection
Mutations

- Changes caused by radiation, chemicals or chance
- “Good mutations” can occur that result in an organism becoming naturally selected for & these new (favorable) genes become part of the gene pool.
Gene Flow

• Process of genes moving from one population to another
  – Immigration: movement “in”
  – Emigration: movement “out”

*Example*: Baboons travel in troops. Females stay with group but males leave the troop to ensure gene flow.
Genetic Drift

- Allele frequencies change as a result of random events or chance.
- These changes can greatly affect small populations that include descendants of a small number of organisms.
Non-Random Mating

• Selection of a mate is not random.
• Females or males select mates with certain traits.
• Example: Female peacocks select males with extravagant feathers. Males with colorful feathers are more likely to mate and reproduce.
Natural Selection

• Natural selection operates on variations of traits within a population, such as body size or color.

• There are 3 patterns of natural selection.
  1) Stabilizing  
  2) Directional  
  3) Disruptive
Stabilizing Selection

• Most common type
• Favors **average** individuals
  (average=survival)
• Reduces variation
• **Example:**
  - Lizards that are too big are easily spotted by predators. Smaller ones don’t run fast enough to escape. Medium ones are successful
Directional Selection

- Favors **one of the extreme** variations
- Can lead to the rapid evolution of a population
- **Example**
  - Anteaters feed by sticking their tongues into anthills. Ones with longer tongues can catch ants in deeper nests.
Disruptive Selection

- Favors **both extreme variations** of a trait
- No intermediate forms of the trait
- Leads to the evolution of **two** new species
- **Example:**
  - Light colored limpets blend in with white barnacles & dark limpets blend in with dark rocks. In-between colored limpets stand out to predators & are eaten.
The Evolution of Species

• Speciation:
  – Evolution of a new species
  – Occurs when members of similar populations no longer interbreed to produce fertile offspring within their natural environment
  – Reminder:
    • the definition of **species** is a group of organisms that interbreed and produce fertile offspring
Causes of Speciation

- **Geographic isolation**
  - physical barrier divides a population
  - Example: Volcanic eruption divides a population where they can no longer interbreed.

- **Reproductive isolation**
  - Occurs when formerly interbreeding organisms are prevented from producing fertile offspring
  - Sometimes follows disruptive selection
  - **Changes in chromosome number**
    - Abnormal chromosome numbers occur as a result of an error during meiosis

- **Behavioral isolation**: rituals
- **Temporal isolation**: timing
Rates of Speciation

• Speciation sometimes takes millions of years or can occur more rapidly for some species.

• Speciation can occur by
  – Gradualism
  – Punctuated equilibrium
Speciation Rates

• **Gradualism**
  – Speciation happens at a regular, gradual rate
  – Some evidence from fossil record supports this

• **Punctuated Equilibrium**
  – Speciation occurs relatively quickly, in rapid bursts with long periods of genetic equilibrium in between.
  – Environmental changes (temp, introduction of competitive species) lead to rapid changes in a small populations gene pool
  – Also supported by fossil record
Speciation Rates

(a) Gradualism model

(b) Punctuated equilibrium model
Evolution in Action Today

- Evolution is a continuous process & is going on today in populations of living species and can be observed, recorded and tested.

- Patterns of Evolution
  - Divergent Evolution (A)
  - Convergent Evolution (B)
  - Co-evolution (C)
Divergent Evolution
(Adaptive Radiation)

- Descendents of a single ancestor diversify into species that fit different parts of the environment.
- Example:
  - Caribbean anoles
Divergent Evolution

Look at beaks and food resources.
Convergent Evolution

• Unrelated species live in similar environments in different parts of the world & because they have similar environmental pressures, they develop similar characteristics.
Koala and Sloth
Co-Evolution

• When two or more species have evolved adaptations to each other’s influence

• Examples: Bacteria & human antibiotic use; bees & flower pollination