Origin of Species & Microevolution
(a ridiculously cursory overview)

1. Origin of Species:
    A. Ways of classifying organisms
    B. Kinds of similarity
    C. Rules summary for macroevolution
    D. Speciation
2. Microevolution
    A. Four mechanisms
    B. Describing populations
    C. Types of selection
    D. Historical constraint
3. An important aside

1. Origin of species: the related disciplines of systematics & taxonomy

A set of scientific disciplines that aim to organize biological diversity into a "tree of life". Components include:

- **Systematics, aka phylogeny and classification** (the formation of hypotheses about the evolutionary relationships among taxa, and ranking of organisms according to those relationships).
    "Who is it related to?" -or- "What is its history?"
- **Taxonomy** (the identification and naming of organisms).
    "What is its name?"

1a. Classifying organisms with evolutionary trees

Evolutionary trees are branching diagrams that describe relationships of organisms.
Species that share a common ancestor are more closely related than species that do not.

1b. Kinds of similarity: How do organisms come to look the same?

1c. Systematics: rules summary

Basic assumptions:

1. Groups of organisms are related by descent from a common ancestor.
2. There is a bifurcating pattern of species evolution (lineages split into two)
3. Change in characteristics occurs in lineages over time.

1d. How does speciation happen? Two primary kinds of explanation:

Allopatry

Sympatry

Speciation in process: Beak depths in finches of the Galapagos

Effectively allopatric: why sympatric populations don't always mate

Two closely-related species can live in sympatry while effectively being isolated from one another. What are some of the conditions that cause such isolation?

2a. Mechanisms of microevolution

Populations change over time for a variety of reasons, including as a response to changing environmental conditions, both biotic and abiotic. Those changes have cascading effects that can affect entire ecosystems.

What are the mechanisms that change gene frequencies (or frequencies of anatomical traits, or behaviors) in populations?

Mutation

- Genetic changes that occur spontaneously in the genome.
- The only force in evolution that introduces new genetic variants into a species.
- Mutation is also the only mechanism of microevolution that is generated internally. The vast majority of mutations that code for some phenotypic trait are deleterious, and most do not survive.
- Mutation acts ***between*** generations.
- **Example**: A deer in a population of entirely brown deer has a dominant mutation for agouti fur. All of its offspring have agouti fur. (What on earth is agouti fur?)

Genetic Drift

- The random element in evolution. The effect that extrinsic factors (such as unpredictable or irregular abiotic forces) have on populations.
- Genetic drift acts ***within*** generations.
- **Example:** a population of deer are grazing at the base of Mt. St. Helens when it erupts. By chance, all the deer in the herd that had plain brown fur were among the deer closest to the volcano, all of whom were killed. Thus, all deer that remain in this population have agouti fur. Some agouti deer were also killed, but because all of the brown-furred deer were killed, genetic drift has caused the population to suddenly be entirely agouti-furred.

Gene flow

- Changes the make-up of populations by the movement of individuals into (***immigration***) and out of (***emigration***) those populations.
- Gene flow acts ***within*** generations.

- **Example**: A few individuals in a population of deer living out near Mt. Rainier wanted to be closer to the action, so migrated towards St. Helens. By their migration, they altered both the populations they left, and the ones that they joined. If some smarter deer in the Rainier population decided to head North instead, they, too, would have effects on both the population they left, and the one they joined.

Natural Selection

- The process by which variation in a population, introduced by mutation, gene flow, or genetic drift, is refined.
- Individuals with phenotypes that are not appropriate for their environment (e.g. that preclude them from hunting well, or from obtaining mates) will not pass their genes on to the next generation.
- **Selection produces adaptations.**
- **Example:** Another population of deer, also with mixed agouti- and brown-furred individuals, lives in a habitat with a lot of tall grasses and shadows, and having agouti fur makes them more cryptic. Brown fur was more obvious to predators, and brown-furred individuals were thus more likely to get eaten. In this situation, agouti-furred individuals would have gradually, due to selection, become the dominant, if not the only, morph, simply because they were better adapted to their environment. Same result; different process.

Your turn

In groups of three or four, take 10-15 minutes to think of creative, compelling, and clear examples of each of the four mechanisms of microevolution. Each group should come up with at least one example of each mechanism.

2b. Describing populations with statistics

- **normal distribution:** continuous distribution that is bell-shaped, symmetrical about its mean, and extends indefinitely in both directions from the mean.
- **standard deviation (SD):** a measure of variation within the data. For a normally distributed population, 68% of the data fall within 1 SD, 95% fall within 2 SD.
- **mean**: the average
- **median**: the data point that has an equal number of data points above and below it in the measured population (the 50th percentile of the distribution).
    - In normal distributions, the mean = the median.
- **mode:** most commonly observed value.

Take the dataset: 29, 29, 29, 30, 31, 32, 40, 44, 47, 49, 52.
What are the mean, median and mode?

Freaking out? Help is here: http://www.le.ac.uk/biology/gat/virtualfc/Stats/normal.htm

2c. Types of selection

1. **Stabilizing selection**: constant environment & modal phenotype.
2. **Directional selection**: changing environment → shifts the modal phenotype.

3. **Disruptive selection**: patchy environment → creates two or more modal phenotypes.

For each of these types, what is the effect of selection on the standard deviation of the population?

Why do I sometimes refer to it as *selection*, instead of *natural selection*?

How important / powerful are each of these four mechanisms?

What suggests that something is an adaptation?

3b. Historical constraint: you can't get there from here

- Also called *phylogenetic constraint*.
- In addition to the four mechanisms of microevolution, the phenotypes of individuals, and therefore of entire lineages, are determined by ***historical constraint***: Because of the long evolutionary history of a lineage, an organism's current form may not immediately (or possibly ever) be transferable into a different form.
- There may be a "better" (more efficient) way to do something, but no way for selection to act on it to get it there.
- Examples: inversion of the vertebrate eye; vestigial wings in flightless birds in places without terrestrial predators (e.g. New Zealand, Antarctica).

Some questions that evolutionary ecology may be able to help us answer

Communities and ecosystems comprise suites of organisms that have evolved in concert with one another. Some of the questions that we can pose about these systems include:

- What mechanisms determine species coexistence?
- What mechanisms determine species diversity?
- Is existing diversity required to maintain ecosystem processes?
- If not, how much diversity must be maintained?
- Which species are most "critical" to ecosystem functioning?
- Are we fooling ourselves if we think we can answer these questions?
- Are there risks in attempting to answer such questions?

3. An important aside re: the predictions of evolutionary ecology

- That which is natural is not necessarily good (moral, beneficial, desirable, etc). To understand what nature has made is not the same as endorsing it. To believe so is to fall prey to the "**naturalistic fallacy.**"
- Furthermore, "natural" tendencies are neither necessarily hard-wired (genetic), nor immutable.