Lecture 1: Evolutionary Theory: The Basics

Some Basic Concepts
Genotype = An organism's genetic make-up   **Phenotype** = Organism's physical/behavioral characteristics
- Most phenotypic traits are **polygenetic** = involve multiple genes to code
    - e.g. Even eye color requires 6 genes, so how silly is it to discuss/seek "*the* language gene"
- Altho occasionally even minor genetic differences can have huge phenotypic effects
    - e.g. One change in a **"control" gene** (Operator, Suppressor) can alter timing, order of processes
        - e.g. During brain development, cells first duplicate, then differentiate
        - By suppressing onset of differentiation, duplication goes on for longer, triples brain size!
- Because genetic material not available in fossil record (except recent Neanderthal discovery!),
        we will mainly be using phenotypic traits as basis for our evolutionary scenarios
    - Note that this will presume that those traits are heretiable
- "Heritability" generally genetic, but see later discussion of "memes" passed to next generation
        Memes - cultural units of selection, e.g. religious practices, writing, democracy, etc.

Evolution by Natural Selection requires…
   1) Variability in a heritable trait across a population
       - Some sources of genetic variance:
            Cross-over (Recombination)
                - e.g. Eye color a product of combination of dominant vs. recessive genes from parents
            Mutation (Insertion, Translocation, etc)
                - Note: Most genetic mutations are deleterious >> produce non-viable offspring!
   2) Selective environment
       - Unchanged context selects new trait, or change in context makes one old variant more successful
   3) Leads to differential reproduction
       - Genome represented, in the next generation, in a larger proportion of population
       - "Fitness" not primarily about survival, but about assuring that your genome is better represented
- e.g. **Peppered Moth** – coloration a heritable trait
    - Original range of variation: Most were light w/dark spots ranging to rare all dark
        - Light moths camouflaged against light birch bark; Dark ones stand out, eaten by predators
    - Industrial pollution => smoke blackened trees; Now dark moths camouflaged, light eaten
        - Selection favored dark moths = more survive to reproduce, population becomes mostly dark
            - So, we would say that dark coloration is adaptive in this context
    - When factories closed, trees become light again => evolution reversed, light moths now favored

ISSUES in composing an Evolutionary Scenario…

Teleology Error – Traits do **not** evolve because they are needed, or in order to convey an advantage
   - That is, evolution is NOT a goal-oriented process!
       - So, you may NOT say "humans evolved speech *in order to* better communicate"
   - It is, instead, a random process by which traits are better enabled by current environment
       - So, you MAY say "since those who could speak reaped the advantages of better communication,
            they were more reproductively successful, and thus passed on the genes for speech"

"Tinkering" – evolution generally occurs via **small changes** to existing traits
   - Large (and even most small) genetic changes tend to be non-viable
   - Some small changes are advantageous, enable indiv to leave more offspring/copies of that change
   - **Exaptation-** A trait, originally selected for one function, then becomes adaptive for a different one
       - e.g. Dinosaur fins originally adaptive for cooling, then exapted for flight (feathers)
       - e.g. Primate tongue dexterity adaptive for shelling seeds, then exapted for language

Convergence
   - Similar traits may appear in separate lineages, usually in response to similar selective pressures
   - These can be Homologues (derived from same initial structure – like bird wing & arm)
        or they can be Analogues, where similar solution arises in different ways (bird wing, insect wing)
   - e.g. Broca's Area is a homologue of primate pre-motor cortex for mouth/hand

Other Relevant Issues

Individual vs. Group Selection
 - The default "<u>unit of selection</u>" is the individual, NOT the species, and (usually) NOT the group
   - That is, evolution occurs through the differential reproduction of individuals
     - So you would NEVER say "this trait evolved because it was *good for the species*"
 - However, sometimes the argument is made for selection at the level of the group (esp with humans)
   - Where competition between groups, based on <u>group traits</u> not individual traits,
              determines which group is the most reproductively successful
   - BUT often even this can be reduced to Individual Selection
     - e.g. One innovative individual and many imitative individuals >> group adopts innovation

Sexual Selection
 - A variant of Natural Selection in which selective environment is <u>sexual competition &/or choice</u>
     - In mammals most typical for males to compete, females choose (tho can be reverse!)
   - e.g. Male deer compete, females choose largest antlers, next generation has more large antlers
     - This is an example of **Handicap Principal**: Having large antlers is costly, requires strength
       - Male that can bear that cost likely to sire offspring that will also be strong, successful
   - Sexual dimorphism (gender body diffs), Spatial abilities in men, may be examples in humans
     - e.g. Exaggerated female form may be result of female:female competition in early hominids

Kin Selection
     - "<u>Inclusive Fitness</u>" Not just an individual's own fitness, but the fitness of its kin matters
 - **Altruism** – Individual incurs a <u>cost</u>, to confer a <u>benefit</u> on kin with whom it <u>shares many genes</u>
   - Thus, may even sacrifice itself to assure that its genome gets represented in next generation
   - e.g. <u>Ground Squirrel alarm calls</u>, makes it more vulnerable to predator (cost), but since lives in
         extended family groups, increases likelihood of survival and reproduction (benefits) for kin
 - Common in many species, including humans

Reciprocal Altruism - Special case (rare) that may apply to humans
 - Altruism can emerge (become an "<u>Evolutionarily Stable Strategy</u>") between **<u>nonkin</u>** as long as…
   - Participants are long-lived, in coherent group with repeated encounters
   - Cost incurred by X to benefit Y later is <u>reciprocated</u> by Y incurring cost that benefits X
   - Sufficient cognitive ability to track who owes who & "currency" relations (e.g. groom for aid)
   - **Cheaters** (take benefit, do not reciprocate) are <u>detected and punished</u>
     - We will discuss "checking for cheaters", sanctioning, etc. in humans

Co-Evolution
  - Evolution of one trait helps select for another
   - Can occur within a species or across species
           - e.g. Bat emits high frequency chirps to echolocate prey moth,
                 Moth hears only those freqs & when does, wings desynchronized >> erratic flight
 - **Arms Race** – "Runaway" evolution, selection for a trait exerts further selective pressure for that trait
   - e.g. Peacock tail, increasingly exaggerated (see also Handicap Principal, above)
   - e.g. In hominids, deception may select for counter-deception which selects for deception, etc. etc.
   - e.g. Dependence on learning selects for individual diffs which demands greater dep on learning