Lecture 21

- Exam: Wednesday, 8 - 10 AM, May 8, G15 LSB
- Final: 60 questions total; 36% of course grade
  - half = comprehensive (30 questions, ~equally from all 4 quarters of course; 15 from Dr. PJ, 15 from Dr. McG)
  - half = midterm 4 (30 questions; all from Dr. McG)
- Memorize: Exp. Growth, Hardy-Weinberg, $p$ or $q = (F_{11}, F_{12}, F_{22})$ equations

Today

- Finish: Darwin’s 4 Arguments
- The Grand Sweep of Selection - Sex, Sexual selection, the Eye...

Does Selection Lead to New Species?

- Darwin’s arguments:
  1. Variation under domestication (i.e., artificial selection as an analogue of natural selection)
  2. Natural variation among varieties within species grades into species differences (i.e., ecotypes are common)
  3. Consistencies in the fossil record (i.e., primitive to advanced forms in progressively younger strata)
  4. Patterns of geographic variation among species on islands are consistent with evolution by natural selection (microevolution on islands is likely)
3. Consistencies in the Fossil Record

If a single, well-verified mammal skull were to turn up in 500 million year-old rocks, our whole modern theory of evolution would be utterly destroyed. —Richard Dawkins, The Blind Watchmaker

---

Stratigraphy

---

Bottom Line

- We don’t see inconsistencies in the fossil record
- The fossil record and other geological evidence irrefutably points to an earth > 4 billion years old, with large amounts of time for evolution to act.
- More complex organisms evolved over hundreds of millions of years; clearly they did not appear ‘all at once’

IMHO; humans inherently have a difficult time comprehending such time scales; our brains are not wired to naturally comprehend what is possible over such expanses of time
4. Speciation on Islands

Speciation on islands is likely where:
- Immigration is slow ($S_{equilibrium} < S$ for a long time),
- High diversity of niches exist on the island ($S$ large)

These conditions are met when islands are DISTANT and LARGE

2 examples: Galapagos, Hawaii

Galapagos Islands
- 600 mi. west of S. America, 3000 mi. east of Polynesia

Original Immigrants of the Galapagos
- 2 species of mammals
- 5 species of reptiles
- 6 species of songbirds; 1 was a finch
- 5 other types of land birds
Current Finch Fauna

14 species of finches are presently found in the Galapagos:

- Ground finches - 6 species
  - seed eaters of arid/coastal habitat
- Tree finches - 6 species
  - insect eaters of moist forests
- Warbler finches - originally misclassified as a warbler!
  - narrow beak, flitting habit
- Cocos Island Finch - different from all the others
Ground finches

Origin of Darwin’s Finches by Speciation

- Early in island history, 1 species of finch migrated from South America
- Immigration of other bird species was slow (empty niche space)
- Differences in selection pressure among islands led to different subspecies
- Eventually, isolating barriers arose that protected gene pools of subspecies from intrusion of maladapted genes from sister subspecies

Origin of Darwin’s Finches by Speciation

- Migration between islands occurred with maintenance of species integrity (e.g., 4 ground finches regularly coexist, but differ in beak size and therefore seed size use).
Update in the Darwin’s Finch Story


- (1) it was not necessary for speciation that two divergent groups re-establish contact
- (2) the islands were not static during the time of evolution (e.g., new islands appeared)
- (3) bird song divergence reinforces mating isolation

Islands and Endemism

- **Endemic species** - species found only in one location. Due to the prevalence of speciation on large, distant islands, places such as Hawaii and the Galapagos have very high numbers of endemics.

- Hawaii has:
  - 10,000 endemic species
  - >350 species in the genus *Drosophila* alone
**Homo floresiensis**

Discovered on the Indonesian Island of Flores ~18,000 years old
New species previously unknown to science
Chimp-size brain; 3 feet tall!
Human tool-using and fire-using traits

---

**Evolution of Sex**

What do I think about sex?
Oh, I think it’s here to stay.

- There are advantages and disadvantages of sexual reproduction.
- For sexual reproduction to have evolved, presumably the advantages must outweigh the disadvantages!

---

**Disadvantages of Sex**

- 1. Two-fold cost of males: Compare population growth rate of asexual and sexual populations:
  - Asexual population
  - Sexual population
Disadvantages of Sex

2. Genetic Dilution:

- Asexual:
  - Meiosis
  - Egg

- Sexual:
  - Meiosis
  - Sperm

Disadvantages of Sex

3. The intimate contact between individuals required for sex promotes disease transmission! [and not just in humans!]

Anther-smut fungus in Silene; a plant STD.

Of course, in humans; HIV, syphilis, gonorrhea, Chlamydia, and trichomoniasis (>340 million new cases annually). Read more: Sexually Transmitted Diseases – Bacterial Stds, Viral Stds, Another Important Std, Global Distribution And Epidemiology Of Stds, Conclusion - history http://family.jrank.org/pages/1548/Sexually-Transmitted-Diseases.html#ixzz0mPMHBTDP

Advantages of Sex

1. Advantageous combinations of genes appear faster
2. Faster elimination of deleterious mutations
Advantages of Sex

- Advantages 1 + 2 are advantages of shuffling alleles each generation via recombination.

Note: Advantages 1 and 2 are advantages to the 'species' or 'population' with sex, not individual advantage.

Advantage 3
Advantage 3

Offspring that are variable due to recombination survive an identical environmental fluctuation.

Advantages of Sex

- In response to environmental change,
- Sexually reproducing species will track the environment better.
- Offspring of parents with sexual reproduction will succeed better, on average, because they are more variable.

\[ R = h^2 S \]

\[ \frac{dw_{pop}}{dt} = V_G \]

Fisher's Fundamental Theorem of Natural Selection

Sexual Selection - A Variant of Natural Selection

- Once sexual reproduction and sexes exist, a new kind of selection is possible.
- Sexual selection:____________________
Two Classes of Sexual Selection

1. Male Dominance -

2. Female Choice -

Results of Selection via Male Dominance

Female Choice

Showy males competing for female ‘attention’
Wild turkeys

Sexual Selection vs. Other Selective Forces

- Optimum Phenotype in the Absence of Sexual Selection
- Current Male Phenotype
- Male phenotype Preferred by Females

Mountain bluebirds

Other ‘Miraculous’ Products of Natural Selection

- Evolution of the organs of extreme perfection (Darwin 1859), e.g., the eye
Evolution of the Eye

How could a slow, inefficient process such as natural selection produce an organ showing qualities of extremely perfect design?

How indeed?

The evolutionary biologist’s simple response:

1. Time
2. Short steps
3. Hundreds of mutations
4. Who says eyes are perfect?

Here is a more detailed description:

Here’s how some scientists think some eyes may have evolved: The simple light-sensitive spot on the skin of an ancient ancestral creature gave it some very crude means of perceiving light. In the early stages, any movement of the light-sensitive patch might have been enough to trigger a response. Over time, the patch might have evolved into a more complex structure, allowing the creature to detect more subtle changes in its environment. The further evolution of this structure could have led to the development of a more sophisticated eye, capable of processing more complex visual information.

Every change had to confer a survival advantage, no matter how slight. The light-sensitive spot evolved into a more sensitive area, allowing the creature to react more quickly to changes in its surroundings. Over time, this area could have developed into a more complex structure, capable of synthesizing information from multiple sensory inputs. This led to the development of a more sophisticated eye, capable of processing more complex visual information. The evolution of this eye could have led to the development of a more sophisticated creature, capable of more complex behavior.

What Makes Species ‘Special’

From unselfish to selfish reasons
Why Conserve Biodiversity?

- Intrinsic value argument
- Ethics - moral imperative
- Legal – rights of nonhuman species
- Philosophical – Stewardship
- Religious – Dominion
- Biophilia
- Homo sapiens-centric reasons (economic, ecosystem ‘services’, recreation, indicator species, cultural, inspirational)

Conservation Biology

- “precaution of the intelligent tinkerer”
- The philosophy of the intelligent tinkerer.
  Aldo Leopold, 1949, A Sand County Almanac

Wolves of Yellowstone, Feb. 2006

- ‘Thinking Like A Mountain’ - Aldo Leopold

  “In wildness is the preservation of the world.”
  - Thoreau
Conservation Biology

**Mission Statement:** The application of ecological and genetic principles to the goal of preservation of biodiversity for future generations.

Some fundamental concepts:
- MVP: minimum viable population size - that population size required to ensure the existence of a population with X% probability for Y years.
- MDA: minimum dynamic area - the land area required to maintain an MVP.
- PVA: population viability analysis - the suite of demographic and genetic studies required to determine quantities such as MVP and MDA.

---

Sample Questions Conservation Biologists Ask

What is the smallest population that will be viable (e.g., 95% probability of existence) after 100 years (or 1000 years, or...)? Determine MVP - minimum viable population size.

---

Sample Questions Conservation Biologists Ask

How much land area is needed to ensure population viability for a long period of time? (e.g., 100 y) - Minimum Dynamic Area.
Sample Questions Conservation
Biologists Ask

How genetically diverse does a population have to be to ensure long-term viability?

Can populations survive through adaptation, acclimation or migration in the face of a directionally-changing climate?