Bio 1M: Primate evolution (complete)

1 Patterns of evolution

Humans as an example

- We are an example of a biological species that has evolved
  - Many of your friends are probably humans
- Humans seem unique:
  - How do they differ from other evolved organisms?
  - What do they share with other evolved organisms?

Similarities and differences

- What is different about people?
  - **Answer:** Complex thoughts
  - **Answer:** Culture
  - **Answer:** Language
  - **Answer:** Technology
- What is the same?
  - **Answer:** We're here because our ancestors reproduced
  - **Answer:** If reproductive success depends on heritable variation in traits ...
    - **Answer:** We're still evolving
    - **Answer:** In what direction or directions?

History

- There are a *lot* of steps (and a lot of divergences) between us and the last universal common ancestor of life
- More than 3 billion years ago!
- Some key steps:
  - **Eukaryotes**
  - **Animals**
  - **Vertebrates**
  - **Mammals**
  - **Primates**
  - **Apes**

Timeline

- Why not just say how long ago?
  - Periods may be punctuated by major events
    - Radiations, mass extinctions
  - People started talking about periods before they had good measures of how long ago things happened
  - Periods have cool names
    - **Answer:** Connections help people think clearly

1.1 Context for evolution

- Adaptations build on existing adaptations – often in unexpected ways
- Evolution does not know where it's going
- In a constant environment, species can only improve with gradual adaptations to the same environment
  - and will be in danger of getting "stuck", e.g. vertebrate eyes
- A changing environment provides opportunities to try new combinations and build in unexpected directions

Physical changes

- Physical changes often provide species with new adaptive challenges and opportunities:
- Global climate change
- Continental drift
- Geological changes
  - New environments can arise (e.g., mountain ranges, desert basins)
  - Geology may also change connections between two populations without a large effect on how they live
    - Rivers changing course
    - Mountain ranges separating valley species
    - **Answer:** Provides opportunities for allopatric speciation

Changing ecosystems

- Taxa can be dramatically affected by changes in other taxa
  - Due to evolution or to colonization
- Interactions with other organisms are key to most ecological niches
  - Who do I eat? Who is trying to eat me? How do I reproduce?
- Co-evolution is a key driver of diversity. For example:
  - Plants evolve new ways to use insects for sex, or vertebrates for dispersal
  - Animals evolve new ways to benefit from plant resources

Mammalian ancestors

- Our ancestors, the **therapsids**, radiated and dominated many terrestrial environments *before* dinosaurs did
- Therapsids were largely replaced by dinosaurs in the age of dinosaurs
  - But some survived, and one radiated after a mass extinction

Radiation and contraction

- Many clades seem to go through periods of radiation and contraction
  - Gain and then loss of species diversity
- Examples:
  - **Answer:**
  - Therapsids, apes, hominins (us)
- Radiation gives many chances for adaptation
  - Things that have had radiations may be more likely to persist
  - Even after periods of contraction

Reasons for contraction

- Why might a clade diversify and then suffer many extinctions?
  - **Answer:** Changing conditions (climate change, continents moving)
  - **Answer:** Competition from other clades (therapsids vs. dinosaurs)
  - **Answer:** Competition from a successful member (people vs. other hominins)

Observer bias

- One reason we see a lot of clades with a history of radiations may be that those clades are the ones we're looking at
  - **Answer:** More successful now
- Clades with a history of radiation may be more successful
  - They've explored more kinds of environments
  - They're found in more different specific places
    - e.g., marsupials in Australia
  - They've had more chances to adapt
    - May have a few very successful species (like us)

Mammals

- **Answer:** Produce milk
- **Answer:** Diaphragm enhances respiration
- **Answer:** Hair (fur) for insulation
- **Answer:** Hard palate to breathe efficiently while eating
- What might these have in common?
  - **Answer:** High metabolism (warm-blooded)

2 The evolution of primates

- Humans are **primates**, an "order" characterized by
  - Highly developed **stereroscopic** vision
    - Eyes are close together, face forward, and are used together
    - Allows 3-d visualization
  - Versatile limbs
    - Grasping hands and feet
    - Nails and fingertips (instead of claws)
  - Large brains

Traits

- What sort of traits do biologists use to characterize a group?
  - **Answer:** Derived traits
- How would you interpret the fact that humans don't have grasping feet?
  - **Answer:** Our ancestors lost the trait
  - **Answer:** It takes many traits to make an accurate phylogeny

The angiosperm explosion

- Flowering plants diversified very rapidly around 100 **mya** – million years ago
- This radically changed the ecology of the world, and opened up many new niches, apparently including space for primates

Primate adaptations

- There are a variety of theories for how characteristic primate adaptations evolved
- Each step was likely favored adaptively
- Likely something to do with processing and handling angiosperm fruit and flowers
  - Or else the insects that fed on these fruit and flowers

Adaptive theories

- There are many theories for why primate traits might have been adaptively favored in our ancestors
  - Leaping from branch to branch
  - Climbing and balancing on trees
  - Exploiting new plant resources
  - Catching insects
  - **Adaptive foraging**: the ability to switch between types of food, and to learn to use new types of food

Patterns of adaptation

- These strategies may have evolved sequentially
  - Maybe exploiting tree resources came first, but similar traits helped some species later catch insects
  - Maybe traits which evolved for one specific purpose later became useful for adaptive foraging

Anthropoids

- Anthropoids is the sub-group of primates including apes and monkeys
  - **Answer:** Monkeys are not a clade!
  - **Answer:** Old-world primates (book) is not a good name for the clade containing Old-world monkeys
  - **Answer:** Another good name for anthropoids might be simians

3 Apes

Ape adaptations

- Apes are more adapted for swinging through trees, whereas monkeys are more adapted for climbing and leaping
- More upright
- Better at hanging, and worse at sitting
- Lots of missing pieces of the puzzle
  - There may be a lot of convergent evolution and secondary loss going on

Patterns of replacement

- Apes "radiated" into many habitats before monkeys did
  - Many ape species were apparently later replaced by monkeys
- Why might apes have diversified, and later been replaced by monkeys?
  - **Answer:** Changing climactic conditions
  - **Answer:** Changes in plants or insects
  - **Answer:** Unpredictable adaptive innovations
- What if the ape radiation had never happened?
  - **Answer:** Less diversity between surviving apes
  - **Answer:** Probably no people

4 Learning about the past

Getting fed

- A major factor in adaptation is food source.
- The most important strategies for early primates were:
  - **Frugivory**: eating fruits (and sometimes flowers)
  - **Folivory**: eating leaves
  - **Insectivory**: eating insects

Teeth

- Teeth are very important for processing food
- Why do we have wisdom teeth?
  - **Answer:** An adaptation to make it more likely we will have functional teeth in middle age
  - **Answer:** This is probably also why we have two sets of teeth
- Teeth help scientists understand what extinct animals ate
  - Well preserved, highly adapted

Eyes

- Eye **orbits** are the skeletal cavities where eyes are
- Orbits tell us size, shape and position of eyes from fossil animals
- What are the advantages and disadvantages of more forward-facing eyes?
  - **Answer:** Better for precise tasks, three-dimensional visualization
  - **Answer:** Not as good for looking around, being alert
- What are the advantages and disadvantages of larger eyes?
  - **Answer:** Better for night vision
  - **Answer:** More costly? Harder to protect?
  - **Answer:** Are small (or deep) eyes better for day vision?

Sexual dimorphism

- Information about differences between males and females has implications about social structure and mating patterns
  - In species where there is more variation in male success (less bonding in pairs), we expect:
    - **Answer:** More sexual dimorphism
    - **Answer:** More competition between males for females

Dimorphism and sexual strategies

- Gorillas live in male-centered groups (one adult male, several adult females)
- Chimpanzees live in large, well-mixed groups with lots of interactions between males and females
- Which species should have more sexual dimorphism overall?
  - **Answer:** Gorillas. Males are huge and strong and compete for females by displaying and fighting. A dominant male has exclusive access to a group of females
- Which species should have larger male genitals?
  - **Answer:** Chimpanzees have much larger genitals.
  - **Answer:** Gorillas don't use genitals as part of sexual competition
- What about humans?

Learning about evolution

- Understanding the course of evolution is an important part of understanding how things work now
  - How organisms work, and how ecosystems work
- There are many challenges:
  - Timelines, identification, convergent evolution

Summary

- People have important differences from other organisms
- We got here using the same rules of natural selection as everyone else
  - Things may be different *now*, but even that is not so clear
- Adaptation does not move in a straight line
  - Changing conditions lead to opportunities for new adaptations
  - New adaptations *themselves* can be an important cause of changing conditions
    - Innovations, or co-evolution with other taxa