Anthro 101:
Human Biological Evolution

Lecture 12: The Fossil Record

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The Fossil Record

- The Geological Time Scale
- Dating Techniques
- The Fossil Record
- Early Primate Ancestors
Our goal is to trace our lineage back in time

- unbroken chain of ancestors back in time to
  - a creature much like a modern chimpanzee
  - a creature like an Old World monkey
  - a creature like one of the prosimians
  - a creature like a tree shrew
How do you define an extinct species?

- Can’t see if fossil organisms reproduced
- Track phenotypic traits - skeletons

- **Paleospecies** - a group of similar fossils that vary from each other within the range of variation observed in a closely related living species

- Can be tricky to determine similarity
  - Age, sex
  - Intraspecific variation
  - Variation over time & location
  - Limited number of fossils to compare

- Typological viewpoint vs. Populationist viewpoint
Fossil evidence helps to trace our ancestry

- **Fossils**: any remains, impressions or traces of plants or animals from a previous geological age
  - Bones replaced by minerals

- **Paleoanthropology**: the study of fossil hominin species & related
  - Understand early primate-like & human-like creatures
  - Figure out the lives they led
The Fossil Record

• Knowing dates is only part of the story
• We are interested in evolutionary patterns
  • phylogenetic relationships
• Our ability to infer these is imperfect

• Still lot of interesting questions
  • Selective pressures
  • Adaptation
Finding fossils is a playing the lottery

- Fossils are very, very old
- Africa and Asia are very, very large
- Ancient habitats & poor preservation
- Difficult conditions in modern habitats
- Surface materials easily destroyed
- Much material is buried
Reconstructing the phylogeny is prone to errors

- Imagine the “real” diversity of extinct species
Reconstructing the phylogeny is prone to errors

- Start with the “real” diversity of extinct species
- Suppose known fossils are randomly drawn from extinct species
  - Only about 3% of fossil species are likely ever found
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- Start with the “real” diversity of extinct species
- Suppose known fossils are randomly drawn from extinct species
  - Only about 3% of fossil species are likely ever found
- Draw phylogenetic tree from *known* fossils
- *Falsely simplifies actual phylogenetic relationships*
Missing data can also mislead us about the date of origin and the lifespan of a species

- Extinct species
  - Many individuals lived
  - Very few become fossils

- Small chance of finding very earliest or very latest fossils
  - **Under-estimate both age and lifespan of species**
Determining the age of fossils pg 245 - 254

Relative Dating Techniques
- Stratigraphy
- Faunal Correlation
- Fluorine Dating
- Paleomagnetism

Chronometric Dating Techniques
- Radiometric Techniques
  - Carbon-14
  - Potassium-Argon

Between 3 & 4 my old
Radiometric Dating techniques

• Assign an absolute date to a layer of rock and fossils in it

• Radioactive isotopes are unstable
  • Isotope = variant of an element

• Decay into stable isotope

• Takes place at constant rate

• Measure decay rate by half-life
  • Amount of time it takes for half of remaining amount to decay

• Measure ratio of radioactive isotope to its decayed form = age
Radiometric Dating Techniques

potassium/argon (K/Ar) dating:
• Volcanic eruptions releases Ar gas
• Rock cools
• $^{40}\text{K}$ decays into $^{40}\text{Ar}$
• $^{40}\text{Ar}$ is trapped in the rock
• half-life of 1.3 billion yrs
• ratio of K/Ar tells you how long ago the volcanic rock was formed
  • age of any fossils within that rock

Carbon-14
• Animals eat carbon 14 during lifetime
• Carbon 14 decays to carbon 12 when an animal dies
• Measure the ratio of carbon 14 to carbon 12 in bones or organic material
• Best for fossils younger than 40,000
Reminders

- Exam tomorrow
- 6 CLASSES LEFT
  - HOLY SH*%
  - Last quiz Monday
  - Final project handout today
  - Homework tonight watch video and answer questions
- Lets finish strong!!!
Geologic Time Scale

- Measures history of Earth – 4.5 billion years
- Organizes history of Earth into various units
- Eon > Era > Period > Epoch
- Important to understand the scale and pace of evolution
The Earth forms 3.5 Billion years ago. Life appears on Earth during the Paleozoic era. The Phanerozoic eon includes the Paleozoic, Mesozoic, and Cenozoic eras.
Animal life diversifies starting in the Paleozoic Era. The following events occurred:

- **Cambrian**: 570 mya, Marine invertebrates appeared.
- **Ordovician**: 500 mya, First vertebrates emerged.
- **Silurian**: 430 mya, Arthropods diversified.
- **Devonian**: 395 mya, Age of Fishes, 1st amphibians & insects.
- **Carboniferous**: 355 mya, Decline of amphibians, expansion of reptiles.
- **Permian**: 280 mya, 1st reptiles, 1st great insect radiation.
- **Triassic**: 225 mya, Expansion of reptiles, decline of amphibians.
- **Jurassic & Cretaceous**: 190 mya, Age of dinosaurs.

The Mesozoic Era followed, with the rise of the dinosaurs and other significant evolutionary events.
Recognizable fauna of the Mesozoic

- **Triassic Period**: 225
  - 1st Mammals (Monotremes) & dinosaurs

- **Jurassic Period**: 1
  - Age of dinosaurs
  - 1st birds

- **Cretaceous Period**: 6
  - Mammals, birds, insects flourish

- **Cenozoic Era**: 65
  - 1st flowering trees (angiosperms)
  - 1st Marsupials, Placental mammals
  - Dinosaurs vanish @ 65mya
  - Continent(s) breaking apart
Starting in the Mesozoic the earth rearranged itself (200 mya – present)
The Mesozoic: Triassic (225 mya)

- Pangea was a single continent
- Dinosaurs & small mammals evolve
- Pangea HUGE land mass
  - Hot, arid, seasonal, some coastal areas more humid

Transition from Triassic to Jurassic
The Mesozoic: Jurassic (190 mya)

- 200 mya Pangea starts breaking up
  - Laurasia & Gondawana
- Oceans are barriers to gene flow = new species form
- World gets warmer, climate stable when continent splits
- Dinosaurs and mammals evolve in this warmer world
The Mesozoic: Cretaceous (136 mya)

- Rise of **angiosperms** = fruits bearing trees = new foods
- Placental mammals evolve
- Adaptive Radiation

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Gymnosperms

Angiosperms
The Mesozoic: Cretaceous (136 mya)

Life’s great until mass extinction of dinosaurs 65 mya

Continents & Climate @ 94 mya
Primates finally start to enter the scene, 65 mya

Cenozoic Era: 65 my - present: 7 Epochs

- Paleocene Epoch
  - Plesiadapiforms
    - First Primates Evolve
      - 25%
  - First Primates Evolve

- Eocene
  - Prosimians thrive
    - 1st Anthropoids Evolve
      - 50%
  - Monkeys & 1st primates in South America

- Oligocene
  - Hominoids
  - Hominins
    - 75%

- Miocene
  - Humans
    - 10 kya

- Pliocene
  - Pleistocene
    - 1.8 mya

- Holocene
  - 10 kya
Continental drift is an important part of human history because it changed global climates.

Temperatures have declined steeply from Eocene to present. Huge fluctuations in the last 5 million years.

\[25^\circ C = 77^\circ F\]
\[10^\circ C = 50^\circ F\]
The Cenozoic: Paleocene

- **Paleocene** wet & warm
  - Radiation of mammal taxa with some primate-like traits
  - **Plesiadapiforms** – not quite yet primates thrive
    - Europe & North America
    - Primate-like molars
    - Ankles for climbing trees
The Cenozoic: Eocene

• **Eocene** \(\uparrow\) wetter & warmer
  - Tropical forests
  - SA isolated from NA & Europe = new species
  - First true primates
  - Prosimian-like traits
  - Two families in North America & Europe
    - *Adapidae*
      - Lemur-like prosimians
    - *Omomyidae*
      - Tarsier-like prosimians
  - Mass extinction at end of Eocene
  - First Anthropoids evolve

*Smilodectes*
The Cenozoic: Oligocene

- **Oligocene** getting colder & drier
  - more seasonal variation
  - Mostly modern continent positions
    - South America still separate
  - Cold water currents cooling earth
    - Africa & SA tropical forests remain
    - Tropics receding in other areas
  - **Age of the Anthropoid (monkeys)**
    - Parapithecidae (*Apidium*)
    - Proliopithecidae (*Aegypotopithicus*)
  - First platyrrhines in South America!
  - **First Hominoids (apes) evolve**
The Cenozoic: Miocene

- **Miocene** warm & moist at beginning
  - Got colder & drier
  - Forests retreating = open woodland habitat
  - Himalayas form = block warm $\rightarrow$ cold air currents
  - Rift valley forms = rain shadow & dry savannah
The Cenozoic: Miocene

- **Miocene** warm & moist at beginning
  - Golden age of the Hominoids (apes) (early Miocene)
    - Great diversity of species
    - Fruit diet specialization
    - Some arboreal quadrupeds, some terrestrial quadrupeds, suspensory adaptations later

- **Late Miocene** getting drier & colder
  - Ape shift to knuckle-walking adaptations
  - Ape species retreat to remaining tropics
  - Mass extinction of apes at end of Miocene
  - First hominins evolved (late Miocene)
The distribution of primate species shifted during Miocene

- Monkeys are more r-selected than apes
- reproduce faster
- respond quickly to environmental changes
- apes didn’t adapt to changes, stayed in tropical forest niches
The Cenozoic: Age of the Hominins

- **Pliocene** begins frequent temperature fluctuations
  - Hominins diversify
  - *Australopithecines & Paranthropines*

- **Pleistocene**: extreme temperature fluctuations
  - Genus *Homo* appears 1.8 mya
Paleoanthropology is full of controversies:

We used to believe that the hominid lineage was fairly simple
As new species are unearthed, the phylogeny is less certain.
Don’t be too worried about the phylogenetic relationships

- Know a lot about how life has evolved
  - Recognize our understanding changes
  - Recognize that *improving ≠ disproving*

- More interested in the selective pressures & adaptations that occur along the way