From then ‘till now… the Cenozoic
Not just a steady increase in diversity over time...

Earth’s history helped shape the evolution of vertebrates, especially mammals.

Positions of the continents affected climate, formation of habitat types, and the ability of organisms to disperse among regions.
Continental drift played a key role in mammalian evolution

Permian, Triassic, Jurassic: continuity of Pangaea allowed tetrapods to move freely across land areas

By late Mesozoic, Pangaea breaking up, shallow seas across centers of many continents, southern continents separating both from northern continents and each other

Cretaceous: Gondwana split up, but retains some southern connections

Visit Paleomap Project
Eocene: S Am and Antarctica still have some connection, Ant. moving over pole, ice sheets form late Eocene-Oligocene

Miocene: cooling and drying, Arctic ice sheets forming by late Miocene

(Read pp 607-618 in text)
Paleotemperatures (see handout)

First half of Cenozoic fairly warm, modern climate cooler
Brief summary of ecosystem changes in Cenozoic:

1. Early Cenozoic (Paleocene, Eocene) was warm world with tropical-like forests even at high latitudes. Exceptionally broad-leaved forests above arctic circle and in Patagonia...tolerate long periods of low light in “winter” but no frost?

2. Global cooling in Oligocene. Temperate forests and woodlands replace tropical-like forests at higher latitudes. Tropical forests now more equatorial.

3. Miocene: Extensive grasslands and savannas form in N Am and Asia (earlier in S Am)...new kind of major habitat. Mountain ranges building in Miocene and Pliocene contribute to formation of arid regions (grasslands, steppes, deserts).

4. Pleistocene ice ages
Paleocene forest

- **Diatryma**
- **Ptilodus** - multituberculate
- **Phenacodus** – sheep-sized herbivore/omnivore
- **Chriacus** – small climber
Andrewsarchus – largest terrestrial predator

Prorastomus – early sirenian

Paleotherium – primitive perissodactyl

Eobasilus - uintathere

Moeritherium – elephant ancestor
Indricotherium  
Arsinoitherium  
Arsinoitherium - entelodon  
Archeotherium  
chalicotheres  
Oligocene... some big stuff  
Brontotherium  
Mesohippus
Epigaulus – horned rodent

Views of the Miocene

Some still like Oligocene
Pleistocene megafauna
Marsupials and Australia (pp 86-91 in text)

1. Marsupials: odd modern distribution (Australian region, neotropics) baffled biogeographers until discovery of continental drift

2. Oldest fossils from early Cretaceous in central Asia (*Sinodelphys*), but oldest ancestor of modern marsupials probably from N Am (Texas, *Kokopellia*) where diverse and common in late Cretaceous

3. Spread to S Am by late Cretaceous, southern dispersal through Antarctica to Australia by Eocene (fossils in Antarctica); southern continents major center of diversification

4. By Miocene, extinct in N Am, Europe, Asia (Oligocene in Asia)

5. Southern continents separate by late Eocene, Antarctica become polar, polar current develops, ice sheets

6. Australia basically an island continent from Oligocene to Recent, only monotremes and marsupials... a few placental rodents and bats appear in Miocene as nears SE Asia

7. But neat diversification of marsupials in Australia! (see HO)
Fossil marsupials in Antarctica (and fossil monotreme in southern South America); one S Am order more closely related to Australian marsupials than other S Am marsupials
Procoptodon
Thylacoleo
Diprotodon
Some examples of convergence between placentals and marsupials
South America – also an “island” (pp 618-623 in text)

1. At time of isolation from Africa and N Am, early Paleocene fossils included:
   - primitive marsupials (opossum-like)
   - xenarthrans: unique to S Am, now anteaters, sloths, armadillos
   - variety of primitive condylarths (ungulate types)
   - NO early placental carnivores like creodonts (group that became carnivores in Laurasia at this time)

2. Archaic mammals radiated in isolation in S Am
   - xenarthrans basically omnivores and folivores (giant ground sloths, glyptodonts)
   - herbivore niches mostly filled by primitive condylarths (horse-like Litopterns, bulky Notoungulates)
   - carnivore niches filled by marsupials (Thylacosmilids = sabretooth “cats”, Borhyaenids = dog and bear-like groups)
   - plus some unique S Am forms of marsupials (bipedal Argyrolagids, burrowing Necrolestids)
Megatherium and 2 Glyptodons

Thylacosmilus

Borhyaena

Miocene, horse-like litopterns

Macrauchenia
giant ground sloth = 12 ft tall

scale for glyptodont

Argyrolagus
1. Radiation in isolation (Paleocene, Eocene)

2. Early “island hoppers”: monkeys and histrigognath rodents arrive from Africa (late Eocene - Oligocene)

3. Early dispersers from the north: “newer” murid rodents and raccoons (late Miocene – Pliocene)

4. Great American Interchange after connection via Panamanian isthmus

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Great American Interchange

Figure 20-19: Mammalian taxa involved in the Great American Interchange. A dagger (†) indicates taxa now totally extinct; an asterisk (*) indicates taxa now extinct in that area.
What about the rest of the world?

1. Oldest split among eutherians (placental mammals) is a group that diversified in Africa: now called Afrotherians (elephants, hyraxes, aardvark, sirenians, golden moles, tenrecs, elephant shrews)

2. Next split was xenarthrans, only found in S Am: sloths, anteaters, armadillos

3. Remaining eutherian mammals all have northern origins in Laurasia, called Boreoeutherians

4. Boreoeutherians split into several clades, leading to most modern mammals (see handout); 2 major clades are Laurasiatheria and Euarchontoglires
1. Oldest split: marsupials and placentals (black)
2. Oldest split in placentals: **Afrotheria** (African origins; red text)
3. Next oldest: **Xenarthra** (South American origins; orange text)
4. Most modern mammal orders originated in the northern continents: **Boreoeutheria** (green and purple text)
5. Boreoeutherians also have a very old major division
Modern biogeography will be covered later...

1. N Am and Eurasia maintained high levels of dispersal, especially across Beringia, and share much of their northern mammal faunas (filter bridge... northern species did the most dispersing across northern land bridges, called the “Holarctic” fauna)

2. India didn’t have much by the time it became an island, was colonized only after colliding with Asia

3. Africa was mostly separated from Laurasia by the Tethys Sea by the late Cretaceous, and become more or less isolated like the other Gondwanan fragments. Afrotheria became distinct in Africa after this time.

4. By late Eocene or early Oligocene, Africa became “inoculated” with other types of mammals from the northern continents, as proximity to Laurasia (esp. Arabian area) developed. In Oligocene, Miocene, and Pliocene, lots of mixing with Laurasia, but through another filter bridge (narrow routes, often desertified). Thus, many modern African mammals bear close affinities with Laurasian taxa, but with high endemism at the genus and species levels. Africa gave the northern continents elephants!
Study questions:
1. Explain the modern distribution of marsupials in terms of their early history and continental drift. Note the timing and location of their origin, major dispersal events and extinctions, radiation in isolation, etc.
2. Discuss the “island” history of South America, what kinds of mammals occurred there during isolation, and what occurred during the Great American Interchange.
3. Why are the mammal faunas of northern North America and Eurasia so similar?
4. What unique mammal groups diversified in Africa and South America after a very early divergence from the rest of the placentals?