Ed’s Simplified History of the Mammals

Note progression from Pelycosaurs (1) to Therapsids and Cynodonts (2) in Triassic.

Stem mammals appeared in Late Triassic and Early Jurassic (3).

Relationships among the Middle Jurassic forms (4) are controversial (see handout).

Therian clade, identified by the tribosphenic molar (5), emerged at the end of the Jurassic, Early Cretaceous.
A slightly more detailed version… in case you like something that looks more slick

Pelycosaurs
Dominated the late Permian, gave rise to therapsids
Therapsids

Rapid radiation in late Permian, around 270 MYA

Still “mammal-like reptiles”
The mass extinction at the end of the Permian was the greatest loss of diversity ever with >80% of all known genera and about 90% of all species going extinct, both terrestrial and marine.
Cynodonts

Last remaining group of therapsids, survived mass extinction at the end of the Permian. Persisted well into Triassic and developed many features associated with mammals.

Only 1 lineage of cynodonts survived through the late Triassic, and this group became ancestors of mammals.

Late Permian to mid Triassic
Mesozoic: the Dark Age for Mammals!

*Morganucodon*, one of the earliest mammals

(What else was happening in the Late Triassic and Jurassic that may have contributed to mammals becoming small and nocturnal?)

Most were very small with conservative morphology

Hadrocodium

multituberculate
...but new fossil finds indicate more diversity than we thought.

Still, largest known mammal during Mesozic is no larger than a woodchuck.

Most were shrew to mouse sized, for 125 million years!

Repenomanus
Some Mesozoic events and mammals you should know

1. Oldest known fossil classified as “mammal” = *Adelobasileus*, 225 MYA, from upper Triassic deposits in Texas

2. Other old fossils from lower Jurassic include *Sinoconodon* (China), *Morganucodon* (Wales), *Megazostrodon* (South Africa)

3. Not clear if reptile-mammal boundary crossed just once or a few times, at least 4 groups of early (stem) mammals recognized; one of most common lineages, Morganucodontids, is good example

4. Early Jurassic characterized by a series of splits and experimentation over time, but within a fairly narrow morphological range

5. Conservative in size and form for over 100 million years, about 2/3 of the entire history of mammals so far
Docodonta

- Mid-Jurassic-Late Jurassic
- Broader molars with cusps separated by squarish basin
- Upper and lower molar interdigitate, appear to used for crushing or mashing
- First example of crushing type molars, maybe mixing plant and animal food types?
Triconocodonta

- Mid-Jurassic-Mid-Cretaceous
- Cusps on molars in linear arrangement
- 3 cusps, slicing-shearing teeth
- Small insectivores and carnivores, but 1 got up to size of smallish cat (huge for Mesozoic!)
Multituberculata

- Mid-Jurassic-early Eocene, >100 MY, outlasted dinosaurs

- Mostly mouse-sized, but 1 in late Cretaceous as big as woodchuck, 1 in Paleocene as big as beaver

- Radiation after extinction of dinosaurs

- Resembled rodents in some ways: pair of incisors separated from cheek teeth by diastema; no canines; crushing and grinding molars; but distinctive blade-like lower premolar

- Widespread and common, range of locomotory adaptations, disappeared after appearance of modern rodents

Both multituberculates and therian mammals showed radiations in late Cretaceous, when flowering plants and insects diversifying.
Monotremata

1 of 3 Subclasses that persist today

- Origins and relationships uncertain; no fossils from before late Cretaceous; early fossils still have molar teeth.

- Traditional view: monotremes part of "prototherian" clade; modern view: probably therians, but relationship not clear – some genetic data suggest distinct group with early separation (mid-Jurassic), other genetic data suggest closer relationship to marsupials than placentals. Jury still out.

- Now occur in Australia and New Guinea, but Paleocene fossils from southern South America.
Symmetrodonta

- Mid-Jurassic – Late Cretaceous

- More closely related to therians than other Mesozoic groups

- Molars with 3 cusps arranged in triangle, better functional design

- Cochlea of inner ear not coiled as in therian mammals, separate lineage
Therians

Another group closely related to therians called Dryolestoidea: small insectivores with modified triangular molars, approaching form that defined true therians.

- Therians are the clade that includes modern mammals.

- Appearance of tribosphenic molars, 1st bi-functional tooth (both shearing and crushing), basic molar form from which all modern mammal molar teeth derived (still present in opossums).

- Clade diverged around 125 MYA to form 2 major lineages that persist today (Metatheria = marsupials and Eutheria = placentals); 3rd group Deltatherians extinct at end of Cretaceous.
Teeth are so important to understanding the ecology, evolution, taxonomy, and success of mammals that we will spend today’s lab on them!

Major advances in therian clade included:

1) Cusps arranged in triangle in upper molar
2) Talonid (heel and basin) added to lower molar

Same type of tooth still seen in modern opossums
Tribosphenic molars, along with masseter muscles, allowed complex chewing movements:

1) Initially puncture and crush using cusps and basins
2) Followed by slicing using paired shearing surfaces

Modifications for all sorts of other feeding modes (that you will see in lab!) came later
Bye-bye dinos!
Hello mammalian radiation!

Monotremes

Marsupials

Eutherians
(placental mammals)

Eomaia

Sinodelphys
Is it really that simple?

Did mammals really just wait around until the dinosaurs went extinct, then rapidly radiate to fill all those vacant niches?

Fossils versus molecules:

When did mammalian diversity originate?

Fig. 1.2. Models of the eutherian mammalian radiation: (A) explosive; (B) long fuse; (C) short fuse. Key: E, Eutheria; e, eutherian stem taxon; io, stem taxon to more than one ordinal crown group; o, ordinal stem taxon; P, Placentalia; X,Y,Z, placental orders. (From Archibald and Deutschman, 2001).
a) Orders and families of mammals originated rapidly after the extinction of dinos. Early view, supported by fossil record (fossils related to modern orders appear after K-T boundary; most modern families appear in Eocene).

b) Intraordinal divergences (e.g., modern and extinct families) after K-T. But molecular evidence (clocks) indicate interordinal divergences of many groups precede K-T boundary. Lineages leading to orders diverge well back in Cretaceous.

c) Lineages diverged even earlier in Cretaceous, some shortly after appearance of eutherians in fossil record (100 mya). Even some intraordinal diverges precede K-T boundary.
Fossil record getting better, molecular techniques and analyses keep improving, differences slowly being resolved. Closest to Long Fuse Model, although some intraordinal divergences likely occurred before K-T (but only by 10-15 my), and a few ordinal divergences occurred after.

(Springer et al., PNAS 2003)
Take home

• Not a simple, linear progression from earliest to modern mammals
• Many experiments, branches, dead ends
• Catastrophes often clear the stage for emergence and radiation of new taxa
• Mammals stayed small, insignificant, not very variable over 100+ MY while Mesozoic world dominated by dinosaurs
• Can only guess at what held mammals back evolutionarily, but perhaps being small, endothermic, and nocturnal helped them survive
Next time: Mammalian diversity during the Cenozoic!

Study questions:

1) Study “Ed’s Simplified History of the Mammals” (or the fancier figure, if you prefer) and become familiar with the order and timing of the major events indicated by numbers 1-7.

2) What were some of the major groups of mammals during the Mesozoic? What were their main characteristics and when did they persist?