

Mammalogy Lecture 1 - Introduction to Mammals

I. In terms of the number of living species, mammals are not a particularly diverse group; there are only ~ 6,600 or so described species listed in revisions of the most recent taxonomic checklist. For perspective, this is just over half the number of bird species, and this sometimes leads to the perspective that we've discovered all extant mammals. This is not the case though, as there are lots still being discovered; for example, see the analysis by Burgin et al. (2018. J. Mamm., 99:1-14; pdf on course website).

In fact, in the last couple years, dozens of new mammal species have been described. Just this year, a new species of insectivoran (*Podogymnura intermedia*) was described from islands the Philippines. On a local front, two new species of chipmunk were described last summer ago from central Idaho (*Tamias cratericus* in central Idaho and *Tamias grisescens* in central Washington; Herrera et al. 2022). Most recent discoveries have been small mammals such as rodents, bats, or insectivorans; however, in 2016 a new beaked whale was discovered (in the genus *Berardius*).

Still, though, Mammalia is not very diverse with respect to species richness; however, if we look at morphology, mammalian diversity really is quite remarkable.

For example, if we just look at size, one of the smallest of mammals is *Craseonycteris thonglongyai*, sometimes called the bumble-bee bat (or Kitt's hog-nosed bat). It weighs just under 2 grams: basically, the weight of a couple of paper clips. The largest, *Balaenoptera musculus*, the blue whale can weigh up to 200,000 Kg, that is 200 Million g. This represents a size range spanning 8 orders of magnitude.

In addition, these two species represent both flying forms, where the front limbs have evolved into wings, and fully marine forms, in which hind limbs have been lost evolutionarily. In one of

these major transitions, the evolution back to the sea, we have well-preserved fossil intermediates that beautifully document gradual evolution of fully aquatic forms from terrestrial ancestors. The discovery of *Onychonycteris* (Simmons et al. 2008. Nature, 451:818) has provided evidence for intermediate bats, although this transition is not nearly as well-documented as is the case for whales.

There are also **gliding forms**, **saltatorial** (hopping) forms, **fossorial** (burrowing) forms, **arboreal** forms, and **myrmecophagous** forms that specialize on a diet of ants. Each of these lifestyles usually has a suite of associated adaptations, and we'll learn about these throughout the semester.

This diversity is especially remarkable when we recognize that all mammals originated from a single common ancestor, that is, a single ancestral species that probably lived around ~220 million years ago. Furthermore, the biology of mammals is remarkably different than that of the MRCA (most recent common ancestor) we share with other amniote tetrapods.

II. So, we'll spend the semester exploring both the nature and the origin of this diversity, but before we move on. I think it's a good idea to try to come up with a definition for mammals.

Short definition: hairy, milk producing, endotherm that gives birth to live young.

Like most short answers, **this one has some problems**; there are exceptions to some of the terms in the definition. Furthermore, it's useless for fossils known from skeletal remains.

We'll explore mammalian characters (or characteristics), and contrast each either with other tetrapods or, where we can, with the condition seen in early ancestors of all mammals.

A. Soft Anatomy Characters – Eleven characters – Asterisks denote characters unique to mammals.

1. ***Lactation** - nourish young by producing milk with **mammary glands**.
2. **Vivipary** - only monotremes lay eggs; other mammals bear live young.

3. ***Hair** - Hair is a uniquely derived feature of mammals not found in any other group.

Structure is suited to serve as an insulator; there are three layers: Cuticular scales, cortex, medulla.

4. ***Sweat** and ***Sebaceous glands** in skin - sweat glands - evaporative cooling

- sebaceous glands - associated with hair.

5. ***Endothermy** - Mammals produce their own heat through metabolic processes.

6. ***Four-chambered heart** - with complete separation of pulmonary and systemic circulation.

7. ***Annucleate Red Blood Cells** – This provides more space for hemoglobin and greater capacity for carrying oxygen.

8. ***Separate renal artery** and vein rather than a renal portal system.

9. ***Muscular Diaphragm** - used in respiration. (Skirt steak is the diaphragm muscle).

10. ***Facial muscles**. This allows for facial expression and is important in communication.

These facial muscles are derived from ancestral *constrictor coli*, which itself evolved from *interhyoideus* of ancestral fish (and which is still present in larval frogs).

11. Expanded cerebral portion of brain, in particular, a portion called ***dorsal pallium**

B. Hard Anatomy (Skeletal) Characters.

— Cranial — Eight cranial characters

1. ***Double occipital condyle**, the point of articulation between skull and vertebral column. The ancestral condition is a single condyle, similar to that seen in a modern alligator skull.

2. ***Atlas/Axis Complex** - modifications of the first two cervical or neck vertebrae

When mammals rotate head, atlas rotates on shaft of axis (called the dens).

3. ***Tympanic bone** is present; it supports the tympanum or eardrum. This is derived from a bone in ancestral lower jaws called the **angular**. In many mammals, this forms an auditory bulla.

4. *Three ear ossicles – transmit sound waves from the eardrum, or tympanum, to inner ear.

malleus --- articular -- ancestral jaw joint

incus --- quadrate -- ancestral jaw joint

stapes --- stapes, or columella

5. *Single pair of bones in lower jaw or mandible, the **dentary**. Since it's the only bone, it **participates in the jaw joint**. This is a key paleontological character, as we'll see later.

6. Single opening into nasal cavity (we have two nostrils, but one bony opening). **External Naris** (ancestrally, there were two nares).

7. **Secondary Palate** – A solid shield of bone separating nasal and oral cavities.

- Ancestrally, external nares opened into oral cavity.

Ventral and medial extensions of palatine bones, maxillae, and premaxillae separate the nasal cavity from oral cavity.

This allows mammals to breathe while processing food.

8. **Respiratory turbinates** – These convoluted bones in the nasal cavity are thought to be *critical for endothermy*, and we'll talk about their role in mitigating respiratory water loss.

— Teeth — Five dental characters.

1. Lack palatal teeth; teeth are **marginal**, that is, restricted to jaw margins.

2. ***Diphyodont** - At most, there are two generations of teeth. This contrasts with monophyodont and polyphyodont.

3. **Thecodont** – Teeth are rooted in a socket, as opposed to acrodont or pleurodont.

4. **Heterodont** - Different teeth have different shapes and different functions, as opposed to homodont (seen in alligator)

5. **Multicuspate** – Teeth have lots of cusps or bumps; contrast with unicuspate.

– Axial Skeleton – 2 axial characters

1. *Extreme **regionalization of vertebral column.**

cervical region- neck vertebrae - almost always 7; some groups with 9

thoracic region - chest region - 12 or 13

lumbar region - lower back - variable number

sacral region - associated with the pelvis

caudal region - associated with the tail

2. **Ribs** are restricted to **thoracic** vertebrae

– Appendicular Skeleton – Four characters associate with the limbs

1. *Limb bones have **epiphyses** - Bony caps at either end that are separated from the shaft by cartilage (epiphyseal plate) that ossifies during ontogeny. This permits a great deal of stress at joints.

2.* **Calcaneum** – There is a heel bone where the Achilles tendon inserts. This provides a great deal of leverage for extension of the foot.

3. Reduction in the elements of limb girdles, the point of attachment of limbs to axial skeleton

pectoral girdle - scapula plus clavicle - lack anterior and posterior coracoids as well as an interclavicle. The exception is monotremes.

pelvic girdle - ilium, ischium, pubis fused into the **inominiate** bone.

4. Limbs rotate under body to **parasagittal posture**; contrast with lizards for example which exhibit a condition similar to the ancestral condition.

C. The presence of these characters in mammals represents a very sweeping set of changes relative to those present in ancestors. We'll next address how these changes evolved, that is, we'll address the origin of mammals.