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 ~ 5,700 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 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 Reeder et al. (2007. Occas. Pap. Mus. Texas Tech, 269:2).

In fact, in the last couple years, dozens of new mammal species have been described. Most were small mammals such as rodents, bats or shrews; however, just last summer a potentially new beaked whale has been (in the genus Berardius). On a local front, a new species of flying squirrel was described this summer from the Pacific Northwest (Glaucomys oregonensis).

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

For example, if we just look at size, among 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 represent 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 beautifully documented fossil intermediates. Relatively recent discoveries (Simmons et al. 2008. Nature, 451:818) have even
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.

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** - exception are monotremes, which we’ll discuss later.

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* - sweat glands - evaporative cooling
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.

3. *Tympanic bone* is present; it supports the tympanum or eardrum. This is derived from an ancestral lower jaw bone 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
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 naress).

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. *Calkaneum* – There is a heel bone where 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 intercalvicle. The exception is monotremes.

   **pelvic girdle** - ilium, ishcium, pubis fused into the **inominate** 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 now address how these changes evolved, that is, we’ll address the origin of mammals.