Lab Objectives
1. To learn the components of the head skeleton of the shark and mammal.
2. To see how components of the head skeleton are modified in different vertebrates.
3. To learn how the components of the head skeleton are distributed between chondrocranium, dermatocranium, and splanchnocranium.
4. To see how the contribution of the three crania to the head skeleton changes through evolution.
5. To consider how tooth morphology has evolved and how it has been modified for different diets.

Material to Learn
1. Shark head skeleton
   - Figures 3.2, 3.3, 3.4
2. Cat head skeleton
   - Figures 7.2, 7.3, 7.4, 7.6
   - OMIT: Figure 7.5
3. Human head skeleton: Human bone names
4. Other head skeletons
   - Other head skeletons will be on display and the following figures may be helpful for reference: Figures 4.2 (perch), 7.S1 & 7.S3 (sheep), 7.S2 & 7.S4 (beaver), 8.1 & 8.3 (turtle), 8.7 & 8.8 (lizard), 8.12 & 8.13 (snake), 8.16 & 8.18 (alligator), 9.1 (bird).
   - You do not need to know unique bones in these skulls, but should be able to identify the ones in common with the cat by studying their position.
5. Material on teeth (below, and figures above)

Term List

**Shark**
- Adductor mandibulae
- Antorbital process
- Basal plate
- Basibranchial
- Basihyal
- Branchial arches
- Ceratobranchial
- Ceratohyal
- Endolymphatic fossa
- Epibranchial
- Epiphyseal foramen
- Foramen magnum
- Gill raker
- Gill ray
- Hyomandibular
- Hypobranchial
- Meckel's cartilage
- Naris
- Nasal capsule
- Optic pedicle
- Orbit
- Otic capsule
- Palatoquadrat cartilage
- Pharyngobranchial
- Postorbital process
- Rostrum
- Supraorbital crest

**Cat**
- Alisphenoid
- Basioccipital
- Basisphenoid
- Dentary
- Canine
Background & Instructions
During today’s lab, you will be studying prepared skeletal material. Handle the skulls that are out extensively to learn the bones that compose them. Handle all of this material gently so as not to damage it – some of it is old, rare, and fragile. Pay particular attention to the head skeleton of the shark, cat, and human. Although your lab manual deals thoroughly with the cat but not human, many of the bones are directly homologous. On lab exams you will be given both cat and human material, allowing you to focus on whichever species you feel will benefit you the most. However, do not neglect the cat! Also examine the rich collection of skulls on display to compare how the bones have changed through evolution. Finally, consider how the shape of the teeth of the head skeletons available to you is influenced by the animals’ diets.

1. Dividing up the head skeleton
The term head skeleton refers to all skeletal elements associated with the head. It includes the skull, mandible, and hyoid apparatus in most vertebrates. These are functional subdivisions. In addition, the head skeleton can be partitioned developmentally into the chondrocranium, dermatocranium, and splanchnocranium. The shark has a chondrocranium and splanchnocranium but no dermatocranium. Its skeleton is also cartilaginous as opposed to being made of bone. The chondrocranium is a single piece in the shark. The splanchnocranium is multiple elements that form and support the jaws and gill arches. Examine the shark head skeleton, learning the anatomy and the divisions. You have various wet and plastic-embedded preparations available to you, as well as freeze-dried chondrocrania. Handle the freeze-dried material with extreme caution - it allows you close access to the anatomy, but is very fragile. Also, do not use pencils or pens to point to the freeze-dried material because you will mark it up.

In most vertebrates, there are also parts of the skeleton that belong to the dermatocranium. These are bones that form as ossifications in the dermis as opposed to being derived from cartilaginous
precursors. Since the shark lacks bone, it cannot have a dermatoocranium. In the bowfin fish (*Amia*) that is on display, the dermatoocranium plays a much more important role. You actually cannot see much of the chondrocranium because it is covered by dermal bones. The splanchnocranium is also still present, but covered by dermatoocranium. It is easier to see than the chondrocranium because it still supports the gills. **Examine the *Amia* head skeleton and consider what subdivisions the bones that you see belong to.**

In most terrestrial vertebrates, including mammals (e.g., the cat and humans), the chondrocranium is reduced to the base and ventral portion of the skull and is largely replaced by the dermatoocranium. The dermatoocranium now forms the brain case laterally and dorsally, forming the **temporals, parietals, frontals, nasals**, etc. (see diagram in the lab – Figure 7.26 in your textbook). The splanchnocranium also has changed dramatically. It contributes small cartilages to the mandible, but also forms the inner ear bones (not visible in lab), and the hyoid apparatus, which is associated with tongue function and the larynx. **Examine the cat and human skulls on display and identify the bones that belong to each subdivision of the head skeleton.** Also examine the other tetrapod skulls on display and identify some of the major bones that you see in the focal taxa (cat & human). These bones are in similar positions between skulls because of their homology.

**Which elements of the head skeleton in the shark belong to the splanchnocranium?**

**The dermatoocranium?**

**Use anatomical terms to describe the position of the elements of the second and third visceral arches of the splanchnocranium relative to one another in the shark.**
Which bones in the cat head skeleton belong to the dermatocranium? The chondrocranium? The splanchnocranium?

Examine the human skulls on display. Which of the bones belong to the chondrocranium and dermatocranium? How does this compare to what you saw in the cat? Why?

2. Human cranial evolution
On display we have model and real crania of a number of extant and extinct hominids: Gorilla gorilla; Australopithecus afarensis, A. africanus, and A. boisei; and Homo habilis, H. erectus, H. neanderthalensis, and H. sapiens. These species serve as good intermediates of what our ancestors looked like and give us an idea of how we evolved. Our evolution included many changes: from quadrupedal, like the gorilla, to bipedal; our face and snout became foreshortened, while our braincase expanded in size; our teeth became more multi-purpose and smaller; and our cranial musculature, particularly that associated with jaw function became reduced. We see evidence of all of these changes in the series of crania on display today. Examine the head skeletons of the hominids on display and consider how the characteristics of the Homo sapiens head skeleton may have evolved.

Does the position of the foramen magnum differ among these species? If so, how and why?

Describe how the teeth differ among these species. Read the next section to give you guidance as to what the different teeth are called and used for.
How has the size and shape of the brain case and face changed? Why do you think this is?

The jaw musculature of modern humans has been reduced relative to our ancestors, partly to accommodate the larger brain case. What osteological clues can you see of this muscular reduction?

3. Vertebrate teeth
Examine the skulls on display and pay close attention to the shapes and types of teeth that they have and how they differ. Well differentiated teeth are the hallmark of mammals. Having different types of teeth in your mouth is called a heterodont condition. Start with the human skull. Although humans are highly specialized in many ways, their teeth are a good starting point because of a generalized, omnivorous diet. Examine the top jaw. There are four types of teeth, from medial to lateral: incisors, canines, premolars, and molars. Each of these tooth types have different functions:

- Incisors cut: They have a sharp cutting edge that is used to slice through food.
- Canines impale: They have a point that is used to penetrate flesh and grasp prey.
- Premolars chew: They have a flat surface that is used to break down the food. In humans they are also called bicuspids.
- Molars grind: They also have a flat surface, but it is much larger than that of the premolars. Molars are used for the final break down of food prior to swallowing.

Identify these teeth in the human skull. Then move on to the other skulls on display.

Identify these teeth in the human skull. Then move on to the other skulls on display. Consider the shape and size of the different types of teeth in each of the skulls. Also consider how many there are of each type (or if they are there at all). Some mammals have highly specialized teeth that help process specialized foods. For example, carnivores such as the cat have the lateral-most upper premolar and the medial-most lower molar modified into carnassials. Carnassials are longitudinally elongate but, similar to incisors, have a blade-like surface. In addition, upper and lower carnassials fit closely together to help cut flesh in a scissor-like manner. Rodents have incisors that are large and grow continuously because they are constantly dulled against hard surfaces, such as wood. Horses have elaborated molars that help them to process large quantities of plant matter.

Non-mammalian vertebrates often are considered homodont, lacking different types of teeth. However, their teeth are also often specialized for certain foods. Examine the skulls of the non-mammals on display: the viper, bird, turtle, gar, and perch. Consider if they have teeth, and how they are used to procure food.
Comparing the teeth of the cat and the human, what are three differences that you see? How do you think each difference allows the cat to be a specialized carnivore?

How does each of the following vertebrates use its teeth to procure food? Is each homodont or heterodont?

Viper:

Bird:

Turtle:

Gar:

Perch:

Seal: