Name____________________
Section___________________

Anatomy

The Vertebrate Skeleton

Vertebrate paleontologists get most of their knowledge about past organisms from skeletal remains. Skeletons are useful for gleaning information about an organism such as its mode of locomotion, posture, relative athletic ability, certain aspects of behavior, sensory capabilities, and diet. Because bone and teeth are usually the only parts that vertebrate paleontologists have to work with, it is important to be very familiar with them if one wants to study vertebrate paleontology. For all of the diversity of lifestyles and forms within Vertebrata, the vertebrate skeleton remains remarkably conservative. This is especially true of tetrapods.

This week you are responsible for learning the basic layout and regions of the vertebrate skeleton. In this lab you will primarily be looking at the skeleton of a common mammalian tetrapod, *Felis domestica*. You should be able to identify isolated bone as well as pieces of an assembled skeleton. These concepts are important to become comfortable with, because they serve as the basis for much of the course, and much of our understanding of the Natural History of Dinosaurs.

The vertebrate skeleton can be broadly divided into two major parts. The **axial skeleton** consists of the skull, jaws, vertebral column, and ribs. The **appendicular skeleton** is made up of the limb girdles and the limbs (appendages) themselves.

The Axial Skeleton

SKULL

The skull (or cranium) is a complex structure that houses the brain and sensory organs, provides articulation surfaces for the jaw (also called the mandible), and houses the muscles that operate the jaw. In primitive vertebrates such as fishes, the skull can be composed of many dozens of individual bones. A general trend in vertebrate evoluation is a reduction in the number of skull bones, through either outright loss or fusion with other bones. You are responsible for identifying only a few of the bones of the skull (nasal, maxilla, and occipital), as well as the holes (fenestrae) in the skull (described below).

Openings for the nervous and/or sensory system

Foramen magnum: This is the circular opening in the back of the skull that allows passages of the spinal chord through the skull to the brain.
Nares: the opening for the external nostril.
Choana: This is the opening in the palate (roof of the mouth) that communicates with the naris. There are right and left choana.
Orbit: The eye socket, which houses the eye and the muscles that control its movements. In many vertebrates (especially “reptiles”) a small ring of bony plates (sclerotic ossicles) lies within the tissue of the eyeball itself.

Openings for the jaw musculature.

The temporal region of the skull is the portion of the skull behind the orbits. It includes the braincase and attachments for the muscles of the jaw. In most vertebrates the braincase is surprisingly small and obscured from view by overlying bones of the skull. Most of the space in the temporal regions is filled by the jaw muscles.

There are problems associated with having one’s jaw muscles insert inside one’s head. When a muscle contracts it gets shorter, pulling the two ends of the muscle together. However, the volume taken up by the muscle cannot change. So as it gets shorter, it also bulges, getting wider. If the muscle is encased in a solid box, like the rear of the skull, the pulling power of the muscle is limited by the amount of space there is into which it can bulge. The earliest terrestrial vertebrates faced this dilemma, because the temporal regions of the skull were totally roofed over with bone. There were two less-than ideal ways of getting around this problem. Thor organisms could forfeit some of its biting power by possessing smaller and weaker jaw muscles. Or, it could possess large, strong muscles and run the risk of damaging its skull bones or braincase.

A third solution evolved that was quite successful. This was to open fenestrae (sing. fenestra) or windows in the temporal region of the skull. The openings provide the spaces into which the jaw muscles can safely bulge. At this point, terrestrial vertebrates (tetrapods) could evolve larger jaw muscles to gain a more powerful bite, but avoided the possibility of damaging themselves. Several types of fenestra evolved in different tetrapod lineates. You are responsible for knowning them and their distribution among tetrapod taxa, and you should be able it identify them in skull.

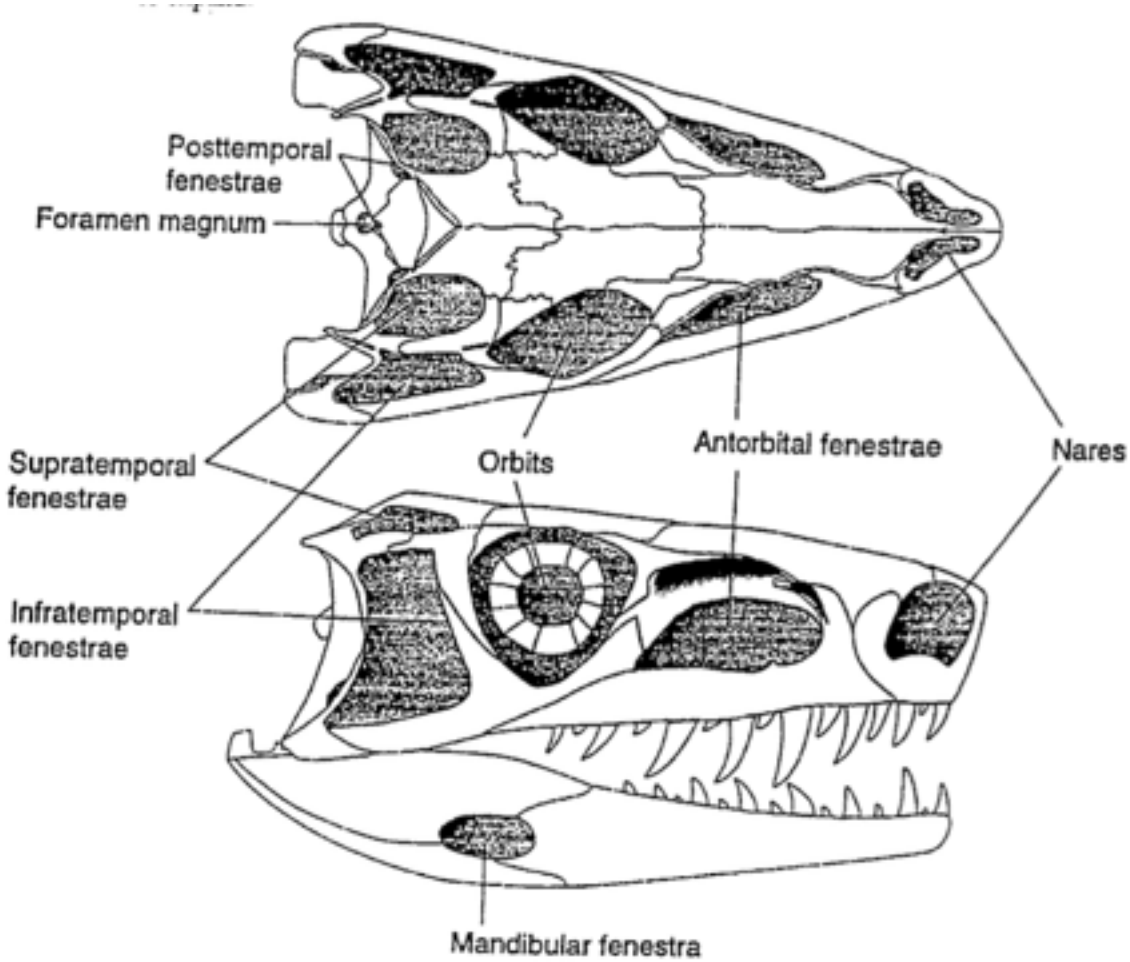
Post-temporal fenstrae: Tetrapods ancestrally possess this pair of openings in the rear of the skull. They may be secondarily closed in many lineages. Most “reptiles” retain them to some degree, and they are very large in turtles.

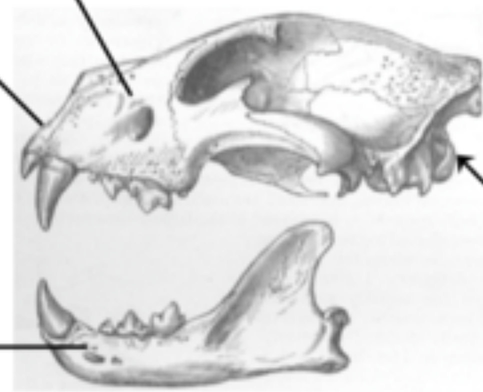
Infra- (lower) temporal fenestrae: Paired openings on the sides of the temporal region of the skull. They have evolved independently in synapsids and more derived “reptiles". Some reptilian groups (for example lizards and snakes) have removed the lower strut of bone from the border of the infratemporal, creating a more open temporal region of the skull.

Supra- (upper) temporal fenestrae: These paired openings are located in the upper part of the temporal region. May or may not be visible in the lateral view of a skull. They are not present in synapsids or turtles, but are present in diapsid reptiles (for example lizards tuatara, Crocodilians, pterosaurs, and dinosaurs including birds).

Antorbital fenestrae: The antorbital fenestrae are found only in archosaurs (for example crocodilians, pterosaurs, several extinct lineages, and dinosaurs). The paired openings are located on the sides of the skull between the naris and orbit. Modern crocodilians have secondarily covered these fenestrae, but they are present in numerous extinct crocodilians. Recent studies suggest the antorbital fenestrae house pneumatic sinuses in the skull.

Mandibular fenestrae: openings were also present in archosaurs. As the name implies, they are openings in the lower jaw, which probably provides room for job muscles to expand.

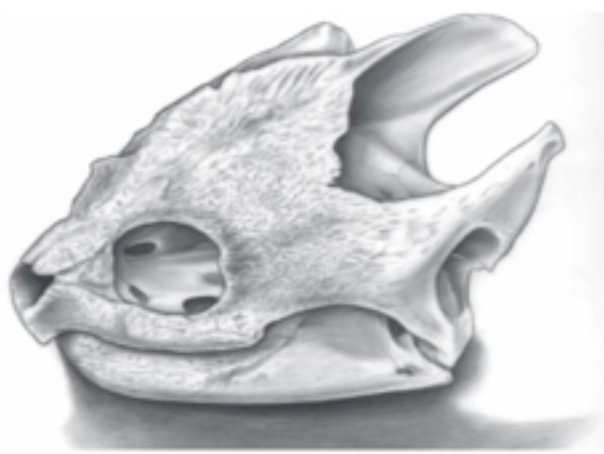

Posttemporal fenestrae
Foramen magnum
Supratemporal fenestrae
Orbits
Antorbital fenestrae
Nares
Infratemporal fenestrae
Mandibular fenestra



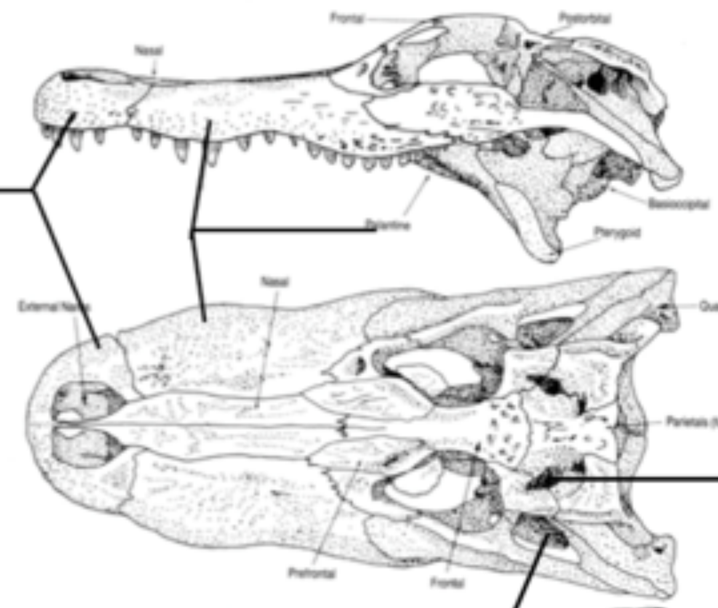
Is this skull anapsid, synapsid, or diapsid?

Is this skull anapsid, synapsid, or diapsid?

What key archosaur trait is this archosaur lacking?



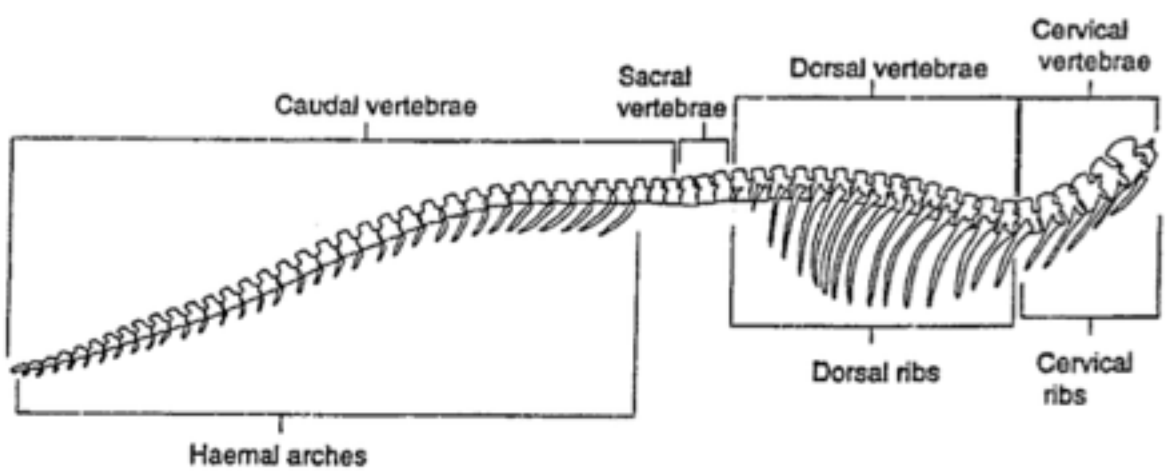
Is this skull anapsid, synapsid, or diapsid?



Vertebral column

The vertebrae are structures that stiffin the back and protect the spinal column, which runs along the dorsal midline of the vertebrate. Each vertebra is made up of a cylindrical centrum below and the neural arch above. The spinal cord passes through a space between these two pieces called the neural canal. In very primitive or very young vertebrates these two pieces maybe separate. In more advanced vertebrates or old individuals the two elements fuse together. The tetrapod vertebral column can be divided into four distinct functional units.

Cervical vertebrae: These are the vertebrae of the neck.
Dorsal vertebrae: these vertebrae extend from the base of the neck to the pelvis, but do not connect the pelvic bones. The dorsal vertebrae have the dorsal ribs attached to them.
Sacral vertebrae: these vertebrae attach the pelvic girdle. In tetrapods there may be anywhere from 1 to 12 sacral vertebrae. They often fuse to one another to some degree, creating solid, strong structure called the sacrum.
Caudal vertebrae: These are the vertebrae of the tail
Ribs: There are ribs associated with most of the vertebrae. Depending upon the vertebra to which they are attached they are called cervical ribs, sacral ribs, or caudal ribs.

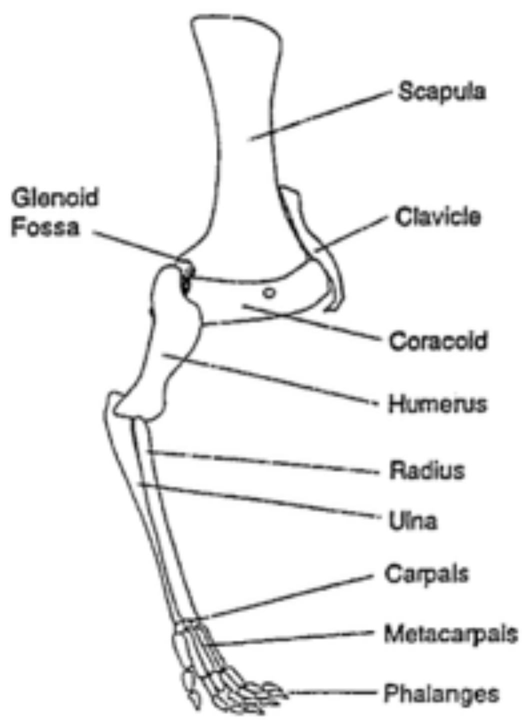


The Appendicular Skeleton

The pectoral girdle: the bones of the pectoral(shoulder girdle) evolved to provide an articulation for the forelimbs and their muscles, while keeping a flexible muscular connection to the axial skeleton. In the earliest vertebrates, the pectoral girdle was composed of several bones. In tetrapods it is made up of only three

Scapula: This is the shoulder blade, and is the largest one in the tetrapod pectoral girdle. It often informs a long blade with large areas for attachment of muscles.
Coracoid: this bone abuts the edge of the scapula and extends towards the midline of the organism. In mammals, the coracoid is greatly reduced and fused to the scapula.
Cavicle: this is the collarbone. It forms a bony connection between the pectoral girdle and axial skeleton. The clavicle was independently lost in many lineages throughout time, including the coyote.

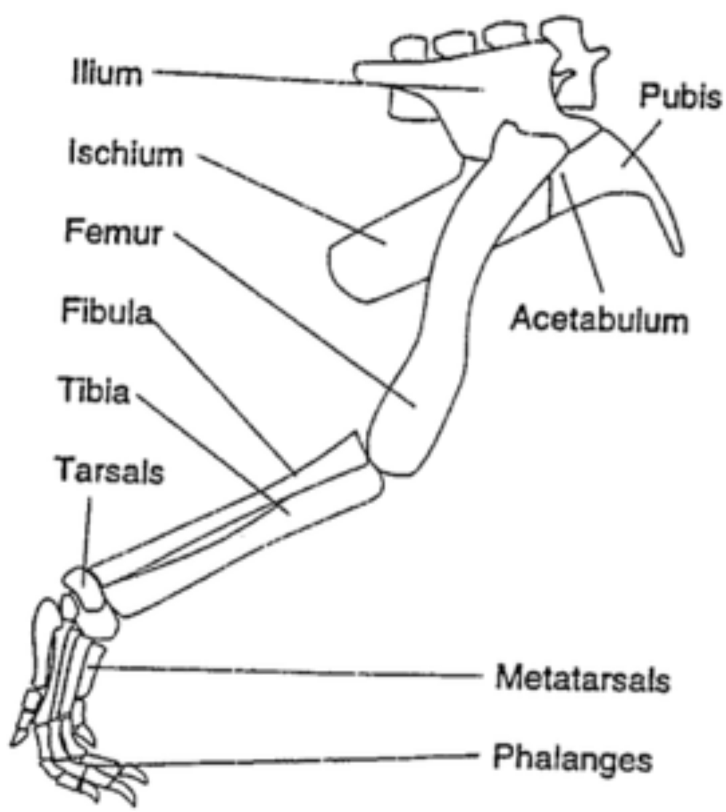
Forelimb
Humerus: Upper arm bone
Ulna: Lower arm bone that articulates directly with the humerus.
Radius: Lower arm bone that articulates loosely with the humerus

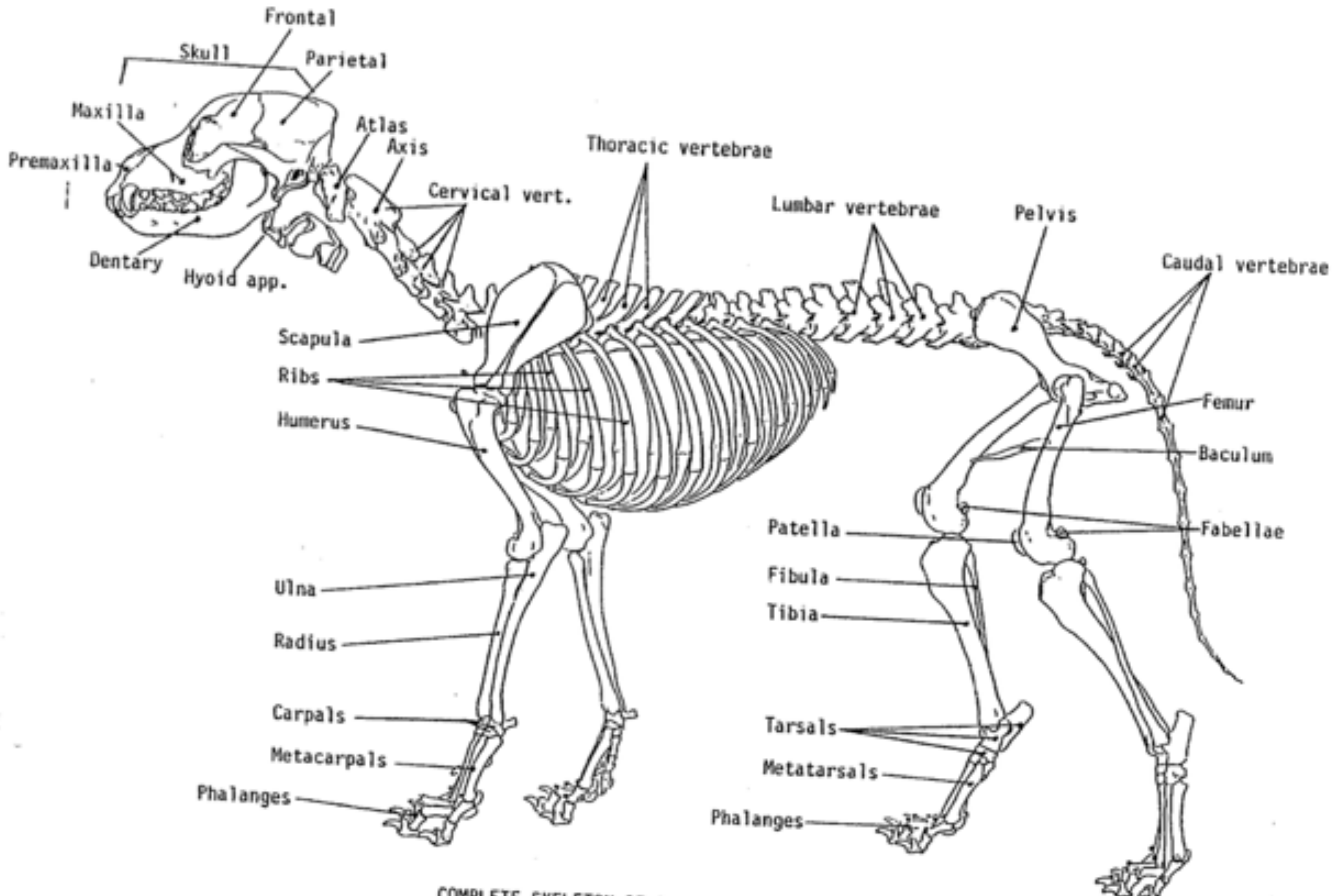


The pelvic girdle: the bones of the pelvic(hip) girdle make a solid connection between hindlimbs in the axial skeleton. Known collectively as the pelvis, is made up of three bones that form and articulation for attachment of the femur, the acetabulum. The three bones of the pelvic girdle listed below.

Ilium: The ilium connects the pelvis to the axial skeleton.
Ischium: The ischium projects some distance behind and below the acetabulum.
Pubis: The pubis extends downward and forward from the region of the acetabulum.

Hindlimb:
Femur: The upper leg bone.
Tibia: The lower leg bone that articulates with the femur
Fibula: The lower leg bone that is smaller and located to the side of the tibia.





COMPLETE SKELETON OF A MALE DOG (<u>Canis</u>)