Name:_____

GEOL 104 Dinosaurs: A Natural History

Smithsonian Assignment I: Osteology and Life on Land before the Dinosaurs

DUE: October 9

"Every man is a valuable member of society who by his observations, researches, and experiments procures knowledge for men."

-James Smithson (1765-1829), a British natural historian whose legacy of over $500,000 was given to the government of the United States of America for the creation of "an Establishment for the increase and diffusion of knowledge": the Smithsonian Institution.

The Smithsonian Institution's National Museum of Natural History (NMNH) has one of the largest collections of dinosaur and other fossils in the world. The Smithsonian museums are free; hours for the NMNH are 10 am to 5:30 pm 7 days a week. You can take the Metro from the College Park Station to any of a number of stations near the Museum. The quickest route is the Green Line from the UMd-College Park Station to Archives/Navy Memorial: you don't have to change trains, and the NMNH is just on the other side of the Archives Building.

For this exercise you may wish to bring along the anatomy sheets handed out in class. You may work in teams and discuss your answers; however **ALL WORK YOU TURN IN MUST BE YOUR OWN**. (I have caught and reported a number of students in the past you have cheated by copying each other's work: please don't make me do that again…). To comply with University Senate regulations, please sign the following so that you may receive credit for this assignment.

I pledge on my honor that I have not given or received any unauthorized assistance on this assignment

_____

Signature UID Date

NOTE: Use your OWN OBSERVATIONS in order to answer the questions.

This package works as sort of a self-guided tour. It will start in the Osteology Hall, and then move downstairs to the Conquest of the Land exhibit, and end up in the Dinosaur Hall.

Name:_____

PART I - OSTEOLOGY

In order to better understand the dinosaurs, we first have to understand the anatomy, behavior, and ecology of modern vertebrates. The Smithsonian's Osteology ("Bones") Hall gives us an excellent opportunity for comparison. We do know a lot more about modern animals (their complete anatomy, including soft tissue; their behavior; their physiology; etc.) than we do about extinct creatures, so that way we can better tell when a particular skeletal structure matches a particular behavior or function. We can then take this information and apply it to extinct creatures, like the dinosaurs of the Mesozoic.

For this part of the exercise, you will probably find the anatomy sheets handed out in class (also available on the website) a useful guide in identifying the homologous bones in these different animals.

Throughout, when given a set of choices in brackets "[ ]", circle the **single best** possible answer.

Go to the second floor of the museum, and enter into the hall labeled "Bones/Reptiles/Insect Zoo". This is one of the older halls, but it contains a lot of useful specimens and information. The end of the osteology exhibit proper is a chamber with the skeletons of various fish (if you get to the exhibit with stuffed reptiles or the Orkin Insect Zoo, you've gone to far).

Find the case labeled "Perciform Fish", and identify the swordfish *Xiphias gladius*. (It is easy to identify, because it is the biggest one in the room!) Look at its front fins.

1) The front (pectoral) fin is organized as:

[a single long bone, followed by a pair of long bones distally, followed by a series of long bones |
a single plate-like bone, with a larger number of elongate bones coming off of it like the tines of a comb].

Look for the case labeled "Flying Fish". Find the skeleton of the flying fish *Danichthys*.

2) The "wings" of the flying fish are actually pectoral fins. Compared to *Xiphias*, the fins are:

[of a totally different structure | the same underlying skeleton, but of different relative size].

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The next hall combines the skeletons of the reptiles and amphibians. We'll start with the skeletons of salamanders (the major group of four-legged, tailed amphibians), in the table in the middle of the room.

Find the skeleton of giant Asian salamander *Megalobatrachus japonicus* (actually called "*Andrias japonicus*" in current taxonomy).

3) How many bones are in the proximal part of the arm? _____

4) How many bones are in the forearm (distal to the elbow, proximal to the wrist)? _____

5) How many sacral vertebrae (hip vertebrae which connect to the ilia) are present? _____

Now, on to the reptiles. We'll start with the lizards. As you recall, the first dinosaurs to be named (*Megalosaurus* and *Iguanodon*) were thought to be immense monitor lizards and iguanas, respectively. Representatives of both groups can be found in this hall. Check out the skeletons of the monitor lizard (*Veranus* [a typo: the correct name is *Varanus*] *bengalensis*) and the rhinoceros iguana (*Cyclura cornuata*).

Now find the specimen of the black tegu (*Tupainambis negropunctatus*).

6) How many digits (fingers) per manus (hand) does it have? _____

7) How many digits per pes (foot) does it have? _____

8) How many sacral vertebrae (hip vertebrae which connect to the ilia) are present? _____

When Owen named the Dinosauria, he said one of the distinguishing features of this group was their **upright stance**: that is, their limbs were oriented directly underneath the body. Look at the black tegu again.

9) The limbs of the black tegu are [directly underneath the body | sprawl out to the sides].

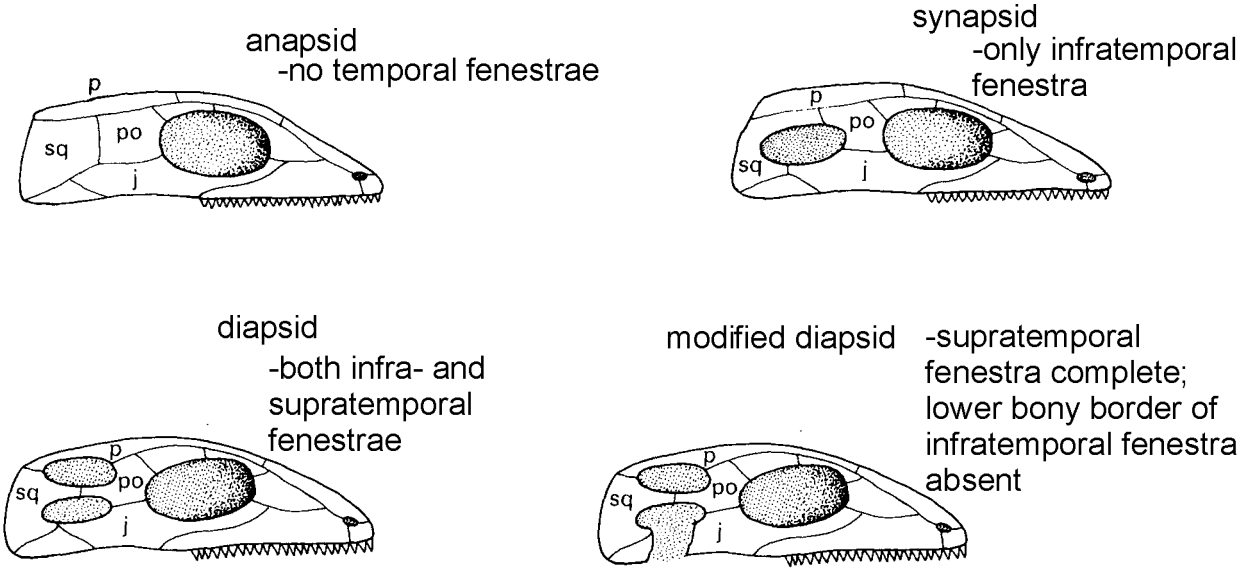
Find the skeletons of *Varanus* (misspelled "*Veranus*") *bengalensis* and of the Gila monster (*Heloderma suspectum*). Note that these two lizards are about the same length from their shoulders to their hips. Compare the relative length of their limbs to the size of their torso.

Name:_____

10) Based on the relative limb length, [*Varanus* | *Heloderma*] is likely the faster lizard.

11) Justify your answer to 10.

Below are cartoons of four major skull types found in amniotes. They differ by the patterns of the **temporal fenestrae** (the openings for jaw muscle attachments).



Find the skeleton of the chameleon (*Chamaeleo chamaeleo*).

12) Which of the skull types above does *Chamaeleo* show?

[anapsid | synapsid | diapsid | modified diapsid] (Circle the correct answer)

Turn left to find the crocodilian skeletons. Shown are the American alligator (*Alligator mississippiensis*), the American crocodile (*Crocodylus acutus*), the gavial (*Gavialis gangeticus*), and the black caiman (*Caiman niger*).

13) Which of the skull types above do crocodylians show (easiest to see in *Gavialis* and *Alligator*)?

[anapsid | synapsid | diapsid | modified diapsid]

Name:_____

Compare the skulls of *Crocodylus* and *Gavialis*. *Gavialis* eats primarily small fish; *Crocodylus* eats larger fish, turtles, birds, and the occasional land mammal.

14) What features of the shape of the snout and the shape and size of the teeth would allow you to predict that *Gavialis* ate only small fish?

15) What features of the shape of the snout and the shape and size of the teeth would allow you to predict that *Crocodylus* which captured larger prey?

16) Look at the skeleton of *Alligator*. How many sacral vertebrae (hip vertebrae which connect to the ilia) are present? _____

17) Look at the pelvis of any of the crocodilians. The distal end of the pubis is positioned [anterior | posterior] to the acetabulum (hip socket).

(Incidentally, the pubes of crocodilians are specialized compared to other tetrapods in that they do not form part of the acetabulum, and are in fact mobile and part of a special breathing mechanism in crocs.)

18) The nares (nostrils) of crocodilians are placed [at the tip of the snout | right in front of the eye sockets].

19) The *Caiman* specimen shows well-preserved osteoderms (bones in the skin). Looking at the pattern of osteoderms, what function do you think the osteoderms would serve for a crocodilian?

Name:_____

Biologists use the following terms to describe the foot posture of different vertebrates:

- **Plantigrade**: The animal walks with the unguals, other digits, and metacarpals and metatarsals all touching the ground ("flat-footed")
- **Digitigrade**: The animal walks with the unguals and other digits touching the ground, but the metacarpals and metatarsals held up
- **Unguligrade**: The animal walks only on the unguals ("tip-toes"), and the other digits and metacarpals and metatarsals are held up

20) Nearly all modern lizards and crocodilians share the same foot posture. Take a look at the manus and pes of *Alligator*. Which posture does it show? [plantigrade | digitigrade | unguligrade]

Continue your counterclockwise turn, to find the snake cases. Locate the skeleton of the Indian python *Python molurus*, and find the splint-like bones along its sides. These are actually the pelves (hips) of the snake, much reduced.

21) The pelves indicate where the dorsal vertebrae (and therefore the trunk of the body) ends, and the caudal vertebrae (and thus the tail) begins. Based on what you see in *Python molurus*, snake tails:
[make up most of the length of the body | are about as long as the trunk | are much shorter than the trunk].

Extra Credit) Look at the skeletons of other snakes. Many groups lack pelves, but you could still recognize where the dorsal series ends and the caudal series begins. What features would you use to recognize this change?

Take another left turn, and see the enormous skeleton of the leatherback turtle *Dermochelys coriacea coriacea*).

22) How many digits (fingers) does it have in each manus? _____

23) How many digits (toes) does it have in each pes? _____

24) Based on the shape of its hands and feet, how would you be able to tell that *Dermochelys* was a swimmer?

Name:_____

Move past the frog skeletons, and find the skeleton of a young Galápagos tortoise *Geochelone elephantopus*.

25) What evidence on the skull is there that this animal has a horny beak rather than a toothy mouth?

26) Based on the shape of its hands and feet, how would you be able to tell that *Geochelone* was a land-dweller?

Before leaving the reptiles, go back and look at the teeth of *Alligator mississippiensis*, *Tupainambis negropunctatus*, and *Varanus bengalensis* (or pretty much most all the other toothed reptiles in the halls).

27) In general, the shape of the teeth

[stays the same from the front of the jaws to the back of the jaws, although the size might change | are very different in different parts of the jaws].

Move on to the bird skeleton hall. Next to the skeleton of the huge leatherback turtle (*Dermochelys coriacea coriacea*), in one of the first bird display cases you come across, is the skeleton of various "Aquatic birds". Take a look at these, including the penguin species *Spheniscus demersus* and the loon *Gavia immer*. The **sclerotic ring** is a series of small platy bones that wrap around the eyeball: this gives you a darn good idea of which opening is the orbit! The naris (nostril) is the long slit-like opening on the beak.

28) *Gavia* and *Spheniscus* [do | do not] have an antorbital fenestra (an opening on each side of the face between the orbit and the naris).

Move over to the skeleton of the ostrich (*Struthio camelus*). Look at its pelvis.

29) The distal end of the pubis is positioned [anterior | posterior] to the acetabulum (hip socket).

Extra Credit) Is this the same position as in crocodylians? [Yes | No]

Name:_____

Find the skeleton of the stork (*Leptoptilus dubius*).

30) Do the digits (fingers) of the manus (hand) of the stork have unguals (phalanges that supported claws or nails)?

[Yes | No]

31) How many digits (toes) are on the pes (foot) of the stork? _____

Find the display labeled "Arboreal Birds" (that is, tree-dwelling birds), and locate the skeleton of the oropendola *Gymnostinops montezuma* (now called *Psarocolius montezuma*). This has the foot of a typical perching bird, in which digit I (the homologue to our "big toe") faces backwards and grasps the back of the branch, while digits II-IV grasp the front.

32) Digit I is [much shorter than | about the same length as | much longer than] the other digits.

33) The unguals are [long, slender, and slightly curved | short, wide, and relatively flat].

34) The phalanges immediately proximal to the unguals are [much shorter than | as long or longer than] the proximal-most phalanges.

Find the case labeled "Running Birds". Find the skeleton of the cariama *Cariama cristata*, and look at its feet.

35) Digit I is [much shorter than | about the same length as | much longer than] the other digits.

36) The unguals are [long, slender, and slightly curved | short, wide, and relatively flat].

37) The phalanges immediately proximal to the unguals are [much shorter than | as long or longer than] the proximal-most phalanges.

Pass through the bird room, and the round chamber beyond. Unlike the rest of these exhibits, these aren't centered on particular subgroups of vertebrates. Instead, they each discuss some major general aspects of vertebrate osteology. Find the case labeled "Skeleton in Support".

38) Based on this display, what aspects of the internal structure of bone allow them to be both lightweight and strong? (List one aspect, with extra credit for a second).

Name:_____

39) In the case describing the function and motion of joints, list at least three different types of articulations (with extra credit for a fourth):

Now head on onto the big mammal skeleton hall.

The ancestral condition for mammals (and for tetrapods in general) are five digits on the manus, and five on the pes. However, different forms have modified this condition to various degrees. For each of the following species of mammal (scattered throughout this main hall), indicate the number of manual digits per manus, and pedal digits per pes.

	Manus	Pes
40) Proboscis monkey (*Nasalis larvatus*)	_____	_____
41) Tapir (*Tapirus bairdi*)	_____	_____
42) Giraffe (*Giraffa camelopardalis*)	_____	_____
43) Common zebra (*Equus burchelli*)	_____	_____
44) Gray whale (*Eschrichtius robustus*)	_____	_____

Find the display case for "Bats". As you can see, the basic bat body plan is very similar among all these species. We'll use the Samoan fruit bat (*Pteropus samoensis*) as our example, because it is one of the larger skeletons on display.

45) Which of the following descriptions best describes the wings of a bat:

a. It is made up mostly of a long arm and a very long fourth finger (ring finger)

b. It is made up of a long arm with a hand where most of the bones are fused together

c. It is made up of a long arm with very long fingers (especially fingers three, four, and five).

Name:_____

Different animals have different locomotory (moving) habits. Some are fast running specialists (**cursorial**), some are slow plodders (**graviportal**), and many are intermediate (**subcursorial** for faster, **mediportal** for slower. The pronghorn (*Antilocapra americana*) and the common zebra (*Equus burchelli*) are cursors, while their close relatives (such as the Borneo pig (*Sus cristatus*) and Tapir (*Tapirus bairdi*), respectively) are slower.

Compare *Antilocapra* to *Sus*, and *Equus* to *Tapirus*.

46) The limbs of cursors (*Antilocapra* and *Equus*) are [proportionately longer | proportionately shorter] than their less cursorial relatives (*Sus* and *Tapirus*).

47) The manus and pes of cursors are [more slender | wider] than their less cursorial relatives.

In the "Monkeys" case, find the mandrill (*Papio sphinx*), a rather impressive baboon in life and as a skeleton.

48) Which of the following statements best describes the shape of its teeth?

[stays the same from the front of the jaws to the back of the jaws, although the size might change |
are very different in different parts of the jaws].

You can compare across the room, and find that except for species with very specialized diets (like grazers), the condition you found in the mandrill is very similar to that in most other mammals, and distinguishes us as a group.

Now in the "Cloven-Hoofed Mammals" case, find the skeleton of the lightly-built pronghorn (*Antilocapra americana*).

49) How many teeth does it have in the premaxilla? _____

50) The grinding teeth are [directly behind the teeth in the front of the dentary |
concentrated closely together after a toothless portion of the jaw].

51) Most of the bigger mammals in this exhibit (those a quarter your size or larger) have limbs that are
[directly underneath the body | sprawl out to the sides].

Name:_____

Review the different types of foot posture listed on p. 6, and indicate if the following mammals are **plantigrade**, **digitigrade**, or **unguligrade**. For a set of "knowns", the Alaskan brown bear (*Ursus middendorfi*, now *Ursus arctos*) is plantigrade, the llama (*Lama glama*) is digitigrade, and the giraffe (*Giraffa camelopardalis*) is unguligrade.

52) Bison (*Bison bison*) [plantigrade | digitigrade | unguligrade]

53) Tiger (*Panthera tigris*) [plantigrade | digitigrade | unguligrade]

54) Red fox (*Vulpes vulpes*) [plantigrade | digitigrade | unguligrade]

55) Pronghorn (*Antilocapra americana*) [plantigrade | digitigrade | unguligrade]

56) Common zebra (*Equus burchelli*) [plantigrade | digitigrade | unguligrade]

57) Beaver (*Castor canadensis*) [plantigrade | digitigrade | unguligrade]

58) Aardvark (*Orycteropus afer*) (near the entry for the exhibit) [plantigrade | digitigrade | unguligrade]

59) Human (*Homo sapiens*) (pes only) (near the entry for the exhibit) [plantigrade | digitigrade | unguligrade]

PART II – LIFE ON LAND BEFORE THE DINOSAURS

Now, on to the fossils! Head to the first floor, and navigate around to the exhibit called "Conquest of the Land" (also labeled "Fossil Plants" on some maps). These exhibits discuss the colonization of land by plants and early stegocephalians ("amphibians" in the old sense).

Find the case labeled "Amphibians—The Vertebrates Take to Land", and locate the model of the crossopterygian fish *Eusthenopteron*.

60) The front (pectoral) fin is organized as:

[a single long bone, followed by a pair of long bones distally, followed by a series of long bones |
a single plate-like bone, with a larger number of elongate bones coming off of it like the tines of a comb].

Find the mounted skeleton of *Eryops*, a large stegocephalian.

61) Based on the shape of its teeth, speculate on what diet this animal had.

[Note also the skeleton of *Pelosaurus laticeps*, a possible "tadpole" of *Eryops*.]

Name:_____

In the center of this room is a set of fossils of the stegocephalian *Buettneria perfecta* that were found together.

62) Based on the text (hanging from the ceiling), what is the likely reason for the particular grouping and position of the bones?

Head for the early "reptiles" (really "early amniotes") exhibits: look for an *Allosaurus* foot in a glass cylinder to find your way.

Find the skeleton of *Diadectes* in the display case labeled '"Stem" Reptiles'. This creature is very close to the base of Amniota: some paleontologists think that it is a true amniote, while others think that it lies just outside that group.

63) What skull type (see back at p. 4) does *Diadectes* have? [anapsid | synapsid | diapsid | modified diapsid]

Extra Credit) Paleontologists agree that *Diadectes* wasn't a flesh-eater. What feature(s) of the teeth suggests a non-meaty diet for this animal?

Find the exhibit labeled "The First Wave of Reptilian Diversity", featuring the skeletons of *Dimetrodon grandis*, *Edaphosaurus boanerges*, and *Cotylorhynchus romeri*. In modern classifications, these animals would not be considered reptiles, although it is fair to say that they were part of the first wave of amniote diversity. *Dimetrodon*, with the largest skull, is probably the best one to look out for the next two questions.

64) These animals have the [anapsid | synapsid | diapsid | modified diapsid] skull type.

65) These animals [do | do not] have an antorbital fenestra.

Extra Credit) In which of these three animals are the teeth most differentiated in size and shape between the different parts of the jaws? [*Dimetrodon* | *Edaphosaurus* | *Cotylorhynchus*]

Name:_____

66) In comparison with similar sized mammals (which you saw in the Osteology Hall), would you predict that the early amniotes (like *Diadectes*, *Dimetrodon*, *Edaphosaurus*, and *Cotylorhynchus*) were as fast as modern mammals? Why or why not?

Find the exhibit labeled "Cynodont Flesh-Eaters". On display is the skull of the large *Cynognathus crateronotus* and the much smaller skeleton of *Thrinaxodon liorhinus*.

67) These taxa have a [anapsid | synapsid | diapsid | modified diapsid] skull type.

68) The shape of their teeth

[stays the same from the front of the jaws to the back of the jaws, although the size might change | are very different in different parts of the jaws].

69) These teeth are most like those of [typical lizards and crocodilians | typical mammals].

Find the case labeled "Early Reptilian Plant-Eaters" (again, these are actually synapsids, not true reptiles). The particular group here are dicynodonts. Find the large skull of *Aulacephalodon baini*.

70) How many teeth (total) are present in the skulls of these animals? _____

Move on to the exhibit un-creatively named "Non-Dinosaurs". Find the skeleton of the Triassic reptile *Trilophosaurus buettneri.*

71) The limbs of *Trilophosaurus* are [directly underneath the body | sprawl out to the sides].

Look behind you at the skeletons of dicynodonts, and back at *Edaphosaurus*, *Dimetrodon*, and *Cotylorhynchus*. Now look back at *Trilophosaurus*.

72) Out of all of these creatures, which would you suspect was the fastest? Why?

Name:_____

Look at the skulls of the two phytosaurs (sometimes called parasuchians) behind glass. During the Late Triassic Epoch, these creatures were the ecological equivalents to modern crocodilians.

73) These animals [do | do not] have antorbital fenestrae.

74) These animals have a(n) [anapsid | synapsid | diapsid | modified diapsid] skull type.

75) The nares (nostrils) of phytosaurs are placed [at the tip of the snout | right in front of the eye sockets].

Extra Credit) How does the last answer compare to the same question for crocodilians? [The same | the opposite] (see question 18).

Turn left, and walk (finally!) into the Dinosaur Hall. Look around for a bit: this hall will be the focus of the second Smithsonian assignment. However, we'll look at a few dinosaurs before we go.

You'll find the right pelves of *Stegosaurus* and *Allosaurus*.

76) In *Allosaurus* the main shaft of the pubis points forward, similar to those of [crocodilians and lizards | birds].

77) In *Stegosaurus* the main shaft of the pubis points forward, similar to those of [crocodilians and lizards | birds].

Let's take a look at the complete skeletons! Find the complete skeleton of *Allosaurus fragilis*.

78) The shape of its teeth

[stays the same from the front of the jaws to the back of the jaws, although the size might change | are very different in different parts of the jaws].

79) *Allosaurus* [does | does not] have an antorbital fenestra.

80) The hindlimbs of *Allosaurus* are [directly underneath the body | sprawl out to the sides].

81) *Allosaurus* is a [biped | quadruped].

82) *Allosaurus* had a [unguilgrade | digitigrade | plantigrade] stance.

Nearby is the recently restored skeleton of *Stegosaurus stenops*.

83) *Stegosaurus* is a [biped | quadruped].

84) *Allosaurus* has a(n) [anapsid | synapsid | diapsid | modified diapsid] skull type.

85) The limbs of *Stegosaurus* are [directly underneath the body | sprawl out to the sides].

Name:_____

86) *Stegosaurus* has a [unguligrade | digitigrade | plantigrade] stance in its hindlegs.

Extra Credit) Which of these two dinosaurs seems to have more cursorial adaptations? Explain.

That's it for the first Smithsonian Assignment! I hope you enjoyed this first Smithsonian project. If you have the time, feel free to examine the many other great exhibits in this museum.

NOTE: If you went on this project as a group, please list all the members of the group: