Name:_____

GEOL 104 Dinosaurs: A Natural History

Smithsonian Assignment

DUE: November 2

"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/Penn Quarter: 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 available on ELMS. 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.

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

Name:_____

This package works as sort of a self-guided tour. It will start in the Osteology ("Hall of Bones") exhibit on the 2nd floor, then move to the 1st Floor Conquest of the Land exhibit, then into the Dinosaur Hall, following over to the Hall of Tertiary Mammals, then the Hall of Ice Age Mammals, then to the Hall of Life in the Ancient Seas, and finally out to the main Rotunda and over to the Sant Ocean Hall.

Some things to keep in mind:

- Remember proper handwritten taxonomic grammar:
    - **Genera** have one-word, capitalized, and underlined names:
        - Examples: Giganotosaurus Brachiosaurus
    - **Species** have ***two-word***, underlined names; the first part of the name (which is the same as the genus name) is capitalized, but the second part of the name is not:
        - Examples: Giganotosaurus carolinii Brachiosaurus altithorax
- When given a choice of items in bracket, **circle** the appropriate answer.

PART I – OSTEOLOGY

For this exercise, you will probably find the anatomy sheets available on ELMS and the website a useful guide in identifying the homologous bones in these different animals.

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.

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, but you should back up from there into the chamber with reptile skeletons.

Name:_____

As you recall, one of the first dinosaurs to be named—*Iguanodon*—was initially thought to be an immense iguana-like lizard. Find the skeleton of the modern rhinoceros iguana (*Cyclura cornuata*).

1) Examine the orientation of the femur of *Cyclura*. In animals (like dinosaurs) with a **parasagittal** (upright) **stance** the femur is oriented **vertically**; in animals with a **sprawling stance** it is oriented **horizontally**. In *Cyclura* the femur is oriented [vertically | horizonally].

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

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

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

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

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

Compare the skulls of *Melanosuchus* and *Gavialis*.

5) Which genus has a slender narrow snout and needle-like teeth? [*Melanosuchus* | *Gavialis*]

6) Which genus has a broader snout and stouter conical teeth? [*Melanosuchus* | *Gavialis*]

7) One of these crocodilians is better adapted for catching small-bodied fish; the other for catching bigger fish, turtles, and mammals. Which is which, and what attributes make them better for this mode of feeding?

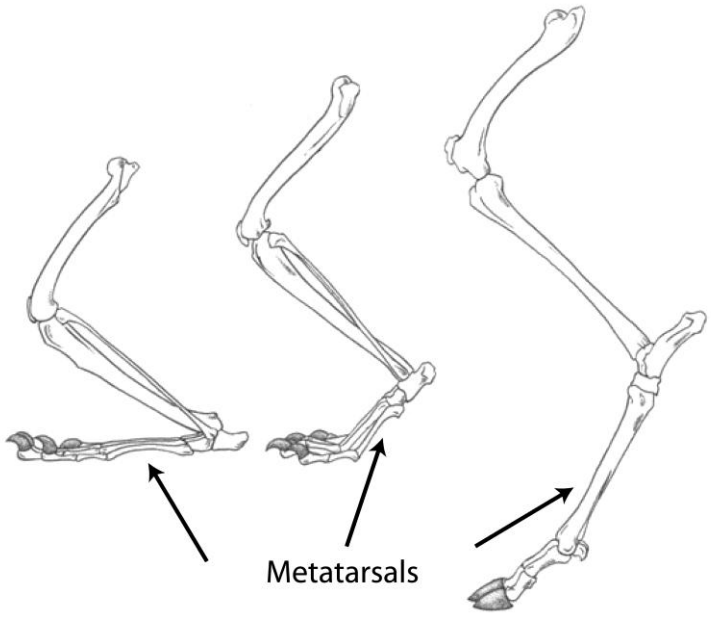
8) The *Melanosuchus* specimen shows well-preserved osteoderms (bones in the skin). Looking at the pattern of osteoderms, what function do you think the osteoderms would serve for a crocodilian?

Name:_____

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

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

Here is a graphic showing these foot postures, showing (from left to right) plantigrade, digitigrade, and unguligrade:



9) Nearly all modern lizards and crocodilians share the same foot posture. Take a look at the pes of *Gavialis*. 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 pair of splint-like bones oriented anteroposteriorly along its sides. (**DON'T** confuse these with the ribs or chevrons! Ribs and chevrons are oriented basically up-and-down (that is, dorsoventrally)). These anterioposteriorly oriented splint-like bones are actually the pelves (hips) of the snake, very much reduced from the condition in their lizard ancestors.

Name:_____

10) 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].

Before leaving the reptiles, go back and look at the teeth of *Gavialis gangeticus* and *Cyclura cornuata* (or pretty much most all the other toothed reptiles in the halls).

11) 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 African penguin (also called the black-footed or jackass penguin) species *Spheniscus demersus* and the common 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 opening) is the long slit-like opening on the beak.

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

Both loons and penguins are excellent swimmers, but they swim in different fashions. Use the anatomy of these two species to identify which is a **wing-propelled diver** (that pushes the water along with its wings) and which is a **foot-propelled diver** (that gets most of its propulsion from kicking with its feet).

13) Wing-propelled diver: shorter but strong wing bones; relatively short hindlimbs; feet not necessarily broad:

14) Foot-propelled diver: relatively long hindlimbs; toes long to spread out to form a broad paddling surface:

Name:_____

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.

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

16) The unguals are [slender and highly curved | wide and relatively uncurved].

17) 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.

18) Pedal digit I is [much shorter than | about the same length as | much longer than] the other digits.

Find the skeleton of *Rhea americana* in the same case.

19) The pedal unguals are [slender and highly curved | wide and relatively uncurved].

20) The pedal 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 through the round chamber beyond, to the Mammal exhibit. As you enter turn right and find the skeleton of the Indian rhino *Rhinoceros unicornis*.

21) How many cervical (neck) vertebrae does *Rhinoceros* have (**note**: cervicals do not have ribs)? _____

Now go opposite side of the passage and find the skeleton of the giraffe *Giraffa camelopardalis*.

22) How many cervical (neck) vertebrae does *Giraffa* have? _____

Extra Credit) List at least two features that would allow *Giraffa* to feed higher in the trees than *Rhinoceros*:

Name:_____

Different animals have different locomotory (moving) habits. Some are fast running specialists (**cursorial**), some are slow plodders (**graviportal**), and many are intermediate. The common zebra (*Equus burchelli*) is a cursor, while its close relative the tapir (*Tapirus bairdi*) is slower, even though both animals are about as long from the back of the neck to the end of the hips (i.e., the butt).

Compare *Equus* to *Tapirus*.

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

24) The pes of *Equus* is [more slender | much broader] than its less cursorial relative *Tapirus*.

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

25) 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 musk-ox (*Ovibos moschatus*).

26) How many teeth does it have in the ***premaxilla***? (Do not consider the maxilla) _____

27) The grinding teeth in the ***lower jaw*** are [directly behind the teeth in the front of the dentary | concentrated towards the back of the jaw, with a toothless gap in between].

28) Like most of the bigger mammals in this exhibit (those a quarter your size or larger), the limbs of *Ovibos* are oriented [parasagittally | sprawling out to the sides].

Name:_____

Review the different types of foot posture listed on p. 4, and indicate if the following mammals are **plantigrade**, **digitigrade**, or **unguligrade**. We will only look at the **pes** and ignore the manus for this.

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

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

31) Coatimundi (*Nasua nasua*) [plantigrade | digitigrade | unguligrade]

32) Beaver (*Castor canadensis*) (in the "Rodents" case) [plantigrade | digitigrade | unguligrade]

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

PART II – LIFE ON LAND BEFORE THE DINOSAURS

Go to the first floor; find 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).

Move down towards the end of the hall and find the case labeled "The Double Life of Ancient Amphibians". Find the mounted skeleton of *Eryops*, a large stegocephalian.

34) Refer back to your observations on modern crocodilians (p. 3). Of which of the two modern crocodilians do the jaws of *Eryops* most resemble? [*Melanosuchus* | *Gavialis*]

35) Based on this, what type of prey do you consider *Eryops* better adapted to eating?

[only small fish | small, medium, and larger prey, including terrestrial animals]

36) Look at the skeleton of *Pelosaurus laticeps*. What stage of the amphibian life cycle does it represent?

Head for the early "reptiles" (really "early amniotes") exhibits: go past "The Egg" exhibit in the glass cylinder and beyond the Fossil Café to find your way.

Name:_____

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.

37) Which of these animals adaptations for feeding on large prey?

[*Dimetrodon* | *Edaphosaurus* | *Cotylorhynchus*]

Extra Credit) What features of the anatomy of the animal in 37 led you to this conclusion?

The ancestral state for limb postures in tetrapods is **sprawling** (limbs oriented out to the sides); the derived state is **parasagittal** (limbs oriented downward).

38) *Dimetrodon*, *Edaphosaurus*, and *Cotylorhynchus* all have which limb posture?

[Sprawling | Parasagittal]

Around the corner of that display is one labeled "Cynodont Flesh-Eaters". On display are the skull of the large *Cynognathus crateronotus* and the much smaller skeleton of *Thrinaxodon liorhinus*.

The primitive condition for tetrapod teeth is **undifferentiated** (the same shaped teeth from the front of the snout to the back); the derived state is **differentiated** (specialized teeth in different parts of the jaws).

39) The jaws of the cynodonts show [undifferentiated | differentiated] teeth.

PART III – THE DINOSAURS

Turn right, and walk towards the Dinosaur Hall proper. You'll find the right pelves of *Stegosaurus* and *Allosaurus* on display on the right wall.

40) In these two dinosaurs, the acetabulum (hip socket) is [covered by a medial sheet of bone | open].

41) In which of these two dinosaurs is the main shaft of the pubis pointing backwards?

[*Allosaurus* | *Stegosaurus* | both | neither]

42) These pelves are shown in [left lateral | right lateral | dorsal | ventral] view.

Name:_____

Let's take a look at the complete skeletons. Walk down the hall and find the complete skeleton of *Allosaurus fragilis*.

43) The jaws of *Allosaurus* show [undifferentiated | differentiated] teeth

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

45) The hindlimbs of *Allosaurus* are [sprawling | parasagittal].

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

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

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

48) The hindlimbs of *Stegosaurus* are [sprawling | parasagittal].

49) *Stegosaurus* has a [unguligrade | digitigrade | plantigrade] stance in its pes.

We'll return to these two skeletons shortly. But for now, go to the skeleton of *Tyrannosaurus rex* (shouldn't be too hard to find…).

50) Which are larger? [Its largest manual unguals | Its longest teeth]

51) How many digits does it have per manus? _____

Find the metatarsus (the long bones of the foot between the ankle and the toes). Compare the length of the metatarsus as a whole to the length of the femur.

52) The metatarsus is [less than ¼ the femur length | about ½ the femur length | as long as the femur].

The *Tyrannosaurus* is facing its contemporary, the ceratopsid *Triceratops*. The *Triceratops* exhibit has been greatly expanded and updated in recent years. Go back down the steps into the alcove of the *Triceratops* exhibit. Find the original skull of *Triceratops horridus* on display.

53) In *Triceratops*, which horn is larger? [The nasal horn | The postorbital ("brow") horns]

Name:_____

Now go up the steps and look at "Hatcher", the Smithsonian's new *Triceratops* mount.

54) In *Triceratops* the metatarsus is

[less than ¼ the femur length | about ½ the femur length | as long as the femur].

Continue on through the ceratopsian and pachycephalosaur exhibits.

55) There are specimens of a couple of centrosaurines represented by fossils here. In *Centrosaurus*, which horn is larger? [The nasal horn | The postorbital horns]

56) Examine the juvenile specimen labeled "*Styracosaurus*" (formerly considered its own genus and species, "*Brachyceratops montanensis"*, and since August 2011 recognized as the juvenile of yet another centrosaurine: *Rubeosaurus ovatus*). Adults of *Rubeosaurus* (and *Styracosaurus*) have nasal horns as long or longer than the length of the snout in front of the eyes. What is the horn condition in this juvenile?

[Similar to adults: horn as long or longer than the snout in front of the eyes | a small cone | there is no nasal horn]

Several pachycephalosaurs are also on display here.

57) Which of the pachycephalosaurs on display here has prominent knobby osteoderms on its snout?

58) Where was the original fossil of the specimen you described in question 57 discovered?

Thescelosaurus neglectus and *Heterodontosaurus tucki* are two ornithischian dinosaurs. Both mounted on the wall near the Marginocephalia exhibit.

59) These two dinosaurs are [bipedal | quadrupedal].

60) [*Thescelosaurus* | *Heterodontosaurus*] has proportionately larger manus.

61) [*Thescelosaurus* | *Heterodontosaurus*] has ossified tendons in the posterior part of the tail.

Name:_____

Move along to the hadrosaurids, much larger ornithopods. The hind end of *Corythosaurus casuarius* is displayed. Note that there are impressions of patches of scaled skin preserved, and also many epaxial ossified tendons.

62) The ossified tendons are present [only in the distal part of the tail | run all the way up to the pelves].

Further down, find the skull of the saurolophine *Edmontosaurus annectens*, one of the "duckbill-iest" of the duckbills. (This dinosaur was once called "*Anatosaurus*", and there are some paleontologists who want to restore that name.)

63) The naris of *Edmontosaurus* is [about as large or slightly larger | very much smaller than] the orbit.

(Make sure you don't mistake the damage to the raised lip at the front of the premaxilla for the nares!)

64) Consider the modern herbivorous mammals you examined earlier. Which pattern of teeth that you examined there more closely resembled that you find in *Edmontosaurus*:

a. specialized browsers grazers such as *Ovibos* (musk ox): toothless in the front of the snout, followed by a gap between that surface and the many very similar teeth packed together further posterior in the jaws
b. generalized browsers such as *Paipio* (mandrill): nipping teeth up front, followed immediately by either biting teeth or general grinding teeth

Turn around, and find the recently remounted skeleton of the iguanodontian ornithopod *Camptosaurus dispar*.

65) Which of the following best describes the condition of the manus?

a. It was a grasping organ only, and had no weight-bearing function.
b. Digits II, III, and possibly IV were weight bearing, but I and V were not.
c. All five digits were weight-bearing: the entire hand had basically become a front foot.

Move further down the main "island". With a few exceptions, all the dinosaurs in this central island (other than the eggs and baby fossils) are from the Late Jurassic Morrison Formation of western North America. In front of you, on the floor of that display, is a dinosaur mounted in "death position" (i.e., the way it looked when it was found in the rocks), rather than "life position" (standing upright).

66) What dinosaur species is shown in death position at this point?

Name:_____

Continue on to the brand-new (2010) wall displays "Local Fossils on a Global Stage". These highlight discoveries made in the Washington, D.C. region (most especially northern Prince Georges County, MD!) Take a look at these panels, and concentrate on the actual fossils and casts.

67-69) List at least 3 ***non-dinosaur species*** or ***genera*** (animal or plant) found in this region, and describe what sort of organism they are:

67)

68)

69)

70-72) List at least 3 distinct groups of dinosaurs represented by fossils in this display.

70)

71)

72)

Extra Credit) What is the mode of preservation of the fossil of the juvenile specimen of the nodosaur *Propanoplosaurus marylandicus* found in Maryland?

Turn back around into the main gallery. The central island is dominated by *Diplodocus longus*, a very long sauropod.

73) Find the **posteriormost** caudals (the tip of the tail) of *Diplodocus*. Circle whichever of the following is a better description of the anatomy of these bones:

A. Very complex, with large transverse processes and tall neural spines

B. Very simple cylinders, with no transverse processes and no neural spines

74) The fore- and hindlimb bones of this dinosaur are very straight (not very flexed at the joints). Why might sauropods have very straight limbs?

75) How many cervical vertebrae are present on *Diplodocus*? Is this more or less than in *Giraffa*? (see p. 6)

Name:_____

76) Based on your answer above, the neck of *Diplodocus* was most likely [less | just as | more] flexible than the neck of *Giraffa*.

77) Move to the front end of the animal, and look up at the *Diplodocus* head. Even without rearing, it is still pretty tall! If you thought that it couldn't rise up any higher than shown, what **range** of plants might it be able to eat?

A. Herbs (less than 30 cm (1 foot) high) only.

B. Herbs and Bushes (about 1 m (3 feet) high) only.

C. Herbs, Bushes, and Trees.

D. Trees only: incapable of lowering its head.

Continue along the central island. Move down the rail, and find a pair of sauropod skulls.

78) Which genus has a dorsoventrally deep skull with a huge naris and thicker teeth?

79) Which genus has a longer skull with a smaller naris on the top of the skull and narrower teeth?

80) The *Camarasaurus lentus* skeleton directly beneath the two sauropod skulls from the previous question is in [life | death] position.

From this position you can see skeletons of four of the most common herbivorous dinosaurs of the Morrison Formation: *Camarasaurus*, *Diplodocus*, *Camptosaurus* (across the island), and (down the path) *Stegosaurus.* In nature, animals with similar diets divide up the ecosystem so that they reduce direct competition with each other (that is, they show **niche partitioning**). One way of doing this is by feeding at different heights.

Assuming that ***all of these could rear up on their hind legs***, indicate the relative height at which each could feed:

81) Tallest feeder:

82) Second tallest feeder:

83) Third tallest feeder:

84) Lowest feeder:

Name:_____

Continue along, and find the recently remounted skeleton of *Stegosaurus*.

85) How many ***pairs*** of **spikes** in the *Stegosaurus* **thagomizer**? _____

Extra Credit) The many **little osteoderms** (not the plates or spikes) protect which part of this dinosaur?

Continue along, and stop at the *Allosaurus fragilis* skeleton.

86) Which are larger? [Its largest manual unguals | Its longest teeth].

87) How many digits per manus does it have? _____

Incidentally, this particular individual had a tough life. Its left scapula was broken and rehealed improperly. The real ribs of this specimen (which are in the collections rather than on display; what are on display are plaster ones) are damaged along the left side, and the left dentary was so damaged and rehealed in such an unusual way that it was thought to be from a whole new dinosaur (named "*Labrosaurus*"). All this points to the *Allosaurus* having suffered a massive blow along one side that broke bones from the jaw tip through the torso. Because the scapula has healed (improperly), we know that the *Allosaurus* survived the blow.

88) The blow that damaged the *Allosaurus* was more likely from *Diplodocus* than from *Stegosaurus*. How can you tell? What would the damage from a *Stegosaurus* thagomizer look like?

Behind you are the stairs to the upper deck of the Dinosaur Hall. Before walking up the stairs, examine the small display of Mesozoic mammals and insects.

89) The Mesozoic mammal fossils here represent animals closest in size to [a mouse | a big dog | a horse].

Name:_____

PART IV – LIFE ON LAND AFTER THE AGE OF DINOSAURS

Now you'll be heading to the fossil mammal halls. Continue on, past the *Allosaurus* and *Stegosaurus* pelves and the dicynodonts and cynodonts. You should be facing the entrance to the Hall of Fossil Mammals, with a sign labeled "Mammals in the Limelight".

Find the wonderful mounted skeleton of *Hyracotherium vasacciensis*.

90) *Hyracotherium vasacciensis* is a member of what modern family of mammals? (You may have to find the proper label to tell).

91) Given that this is a fully-grown animal, how does it compare in size to the modern members of this family?

Now head over to the start of the hall, past the "Plants in the Age of Mammals" display, past the (covered over) glass case displays of Mesozoic mammals and Paleocene mammals. In general, as you follow the Hall of Fossil Mammals along you proceed upwards in time, tracing the history of North American mammals, other animals, and their environments through the Cenozoic Era. Each exhibit is organized by Epochs. Cenozoic Epoch names are different from those in the rest of geologic time: instead of being in the form "Late Jurassic Epoch" or "Early Permian Epoch", each is given a unique name. From oldest to youngest, they are the Paleocene, Eocene, Oligocene, Miocene, Pliocene, Pleistocene, and Holocene (or Recent). The last two Epochs are part of the Quaternary Period, and have a hall of their own (the Hall of Ice Age Mammals). The rest are the old "Tertiary Period," (now broken into the Paleogene and Neogene Periods) and represent the exhibits in the main Hall of Fossil Mammals.

Most of the Tertiary Hall is organized with a series of paintings in the back and the actual fossils and casts of fossils arrayed in front. Start with the Eocene exhibit.

Name:_____

In the glass cases are many specimens from the Green River Shale, a famous fossil locality. Many types of organisms have been recovered from these rocks. Indicate the group of organism represented Green River Shale fossils listed below:

92) *Primobucco mcgrewi* [plant | fish | bird]

93) *Mioplasus labracoides* [plant | fish | bird]

94) *Platanus wyomingensis* [plant | fish | bird]

95) From the types of fossils and the descriptions provided, how was the **non-living** environment of Eocene Wyoming different from the current arid mountainous environment of the "Cowboy State"?

96) The biggest animal in the main Eocene display is *Uintatherium robustum*, a horned quadrupedal herbivorous mammal. What feature of the dentition (teeth) of *Uintatherium* appears to be unusual for a typical plant-eater?

Continue along the Eocene display. Rank the following animals in size (by "Largest", "Medium", and "Smallest"):

97) *Diatryma* (a bird) [largest | medium | smallest]

98) *Smilodectes* (a primate) [largest | medium | smallest]

99) *Helalestes* (a tapir) [largest | medium | smallest]

Move on to the "Oligocene" Epoch exhibits (which are actually mostly latest Eocene Epoch animals, by more recent geologic time studies).

100) *Brontotherium hatcheri* is the largest animal on display here. It was a

[bipedal carnivore | quadrupedal carnivore | bipedal herbivore | quadrupedal herbivore].

Name:_____

Find the following "Oligocene" species and indicate the group to which it belongs. The options include:

dog **cat** **rhino** **horse** **tortoise** **lizard** **bird** **oreodont** (extinct herbivorous mammal)

101) *Merycoidodon culbertsoni* _____

102) *Hesperocyon gregarius* _____

103) *Trigonius osborni* _____

Turn around, and find the vertical burrow with the skeleton at the end. The burrower is the rodent *Paleocastor fossor*.

104) To what group of rodents does *Paleocastor fossor* belong? _____

Head on over to the Miocene Epoch exhibit. Find the following Miocene species and indicate the group to which it belongs. The options include:

rhino **horse** **camel** **chalicothere** (extinct herbivorus mammal) **oreodont** (extinct herbivorous mammal)

105) *Moropus elatus* _____

106) *Parahippus tyleri* _____

107) *Promerycochoerus superbus* _____

108) *Stenomylus hitchcocki* _____

Extra Credit) Which of the above four species shows the most adaptations for cursoriality?

Turn around and find out about the evolution of the horse at the exhibit "Evolution: Browsers to Grazers". (Incidentally, the Smithsonian has an excellent collection of fossil horses). Over the history of equids (horses) many aspects of their anatomy change. They represent one of our best records of **correlated progression**. Indicate how each of the following attributes of horses changed over time.

109) Overall size [increased | remained the same | decreased]

110) Number of toes [increased | remained the same | decreased]

111) Complexity of grinding surface of tooth crowns [increased | remained the same | decreased]

Name:_____

Look at the Late Miocene-Early Pliocene Epoch display. The largest mammal here is *Stegomastodon arizonae*.

112) To what **living** animal group is *Stegomastodon* most closely related?

[rhinos | horses | elephants | humans | hippos]

113) What evidence can you see that the rhinoceratoid *Teleoceras fossiger* was not a fast running animal?

Move into the Hall of Ice Age Mammals. As you enter, there is an exhibit of some odd mammals off to your left. Find the pair of skeletons of the giant ground sloth *Eremotherium rusconii*.

114) Could this animal have eaten leaves off of tall tree branches as well as plants on the ground? If so, how?

Just as the dinosaurs produced the ankylosaurs, the mammals produced their own heavily armored forms: the glyptodonts. On display is the glyptodont *Glyptotherium arizonae*. Like the ankylosaurs, glyptodonts were herbivores.

115) Why might heavily armored animals like ankylosaurs and glyptodonts not make effective predators?

116) Could the shell of *Glyptotherium* and other glyptodonts fold up into a ball the way a modern armadillo's shell (also on display) can? If so, how can you tell? If not, why not?

Turn around, and look at the fossils from Rancho La Brea (the famous La Brea Tar Pits) in the exhibit "Fossils and Tar Pits". There are two species of carnivorous mammal here, threatening the ground sloth *Paramylodon harlani*. Give the ***species name*** for the carnivorous mammals on display:

117) Dire wolf:

118) Sabre-toothed cat:

Name:_____

119) These Ice Age predators are [much smaller | about the same size as | much larger than] *Tyrannosaurus rex*.

120) The large bird *Teratornis merriami* was a(n) [herbivore | carnivore].

Further down in the Ice Age Mammal Hall are fossils of northern mammals. The largest of these is *Mammuthus primigenius* (the wooly mammoth).

121) Where was this particular composite skeleton of *Mammuthus primigenius* found?

Go to the skeleton of *Mammut americanum* (the mastodon). In front of it are the teeth of *Mammut* and *Mammuthus* that you can touch.

122) The teeth of [the mastodon *Mammut* | the mammoth *Mammuthus*] were better adapted for chewing leaves and twigs, while the other one was better adapted for grazing and grinding grass.

Consider that the animals in the main section of this hall were living in North America when humans first entered the continent 13,000 years ago (in some cases, they actually arrived at the same time). Just a short time ago (geologically speaking), America's wildlife was at least as spectacular as that of the modern Serengeti Plain.

There are some non-American fossil animals on display in this room, in a rotunda. Find these, and indicate what genus represents each of the following groups

123) Bird: _____

124) Marsupial: _____

125) Deer: _____

Extra Credit) Which of those three was a dinosaur?

Name:_____

PART V – MESOZOIC MARINE LIFE

Double back through the Halls of Ice Age Mammals. Before you get to the Hall of Tertiary Mammals, take a right and head into the Hall of Ancient Life in the Seas. You'll be moving backwards through time: your first encounters will be with Cenozoic marine life. Go through these, and reach the chamber with Mesozoic marine life. This hall as a whole documents marine vertebrate, invertebrate, and plant life throughout the last 542 million years with fossils, a great mural, and some life restoration models hanging about.

Find the Mesozoic marine reptiles. These are mounted in front of or directly below the mural (and a few are in glass cases along the rail). In particular, find two of the larger species: *Dolichorynchops osborni* and *Tylosaurus proriger*.

124) In which are all four limbs paddle shaped and about equal size, and the tail is short?

[*Dolichorhynchops* | *Tylosaurus*]

125) In which are the forelimbs considerably larger than the hindlimbs, and the tail quite long and powerful?

[*Dolichorhynchops* | *Tylosaurus*]

Look at the snouts of these two reptiles.

126) Which has a shorter, broader snout with very large conical teeth (and thus probably a predator of fairly large prey)? [*Dolichorhynchops* | *Tylosaurus*]

127) Which has a relatively long narrow snout with smaller, more needle-like teeth (and thus probably a predator of smaller fish)? [*Dolichorhynchops* | *Tylosaurus*]

Find the fossil of the primitive bird *Hesperornis regalis*.

128) Which was *Hesperornis*, a wing-propelled diver or a foot-propelled diver? (See p. 5 for details.) What evidence did you use to determine this?

Name:_____

The seas of the Mesozoic, like those of today, had diverse types of "shellfish" (invertebrates). Many examples are on display: some along the wall with the main mural, others in the center "island", and still others on their own display labeled "Taking Cover" on the wall opposite from the main mural.

In the center island, facing the marine reptiles, is an exhibit about ammonites (extinct relatives of the modern octopi, squids, and nautili.) Some ammonites have **straight** shells, many have shells coiled in a **disc** (like a Frisbee or donut), still others have more **complex coiled** patterns (i.e., not simply circular or along a single plane).

129) *Sphenodiscus lenticularis* had a [straight | disc-shaped | complex coiled] shell.

130) *Baculites compressus* had a [straight | disc-shaped | complex coiled] shell.

131) *Cirroceraus stevensoni* had a [straight | disc-shaped | complex coiled] shell.

Find the display labeled "Taking Cover". On the top of this section are many excellent fossils, such as several enormous ammonites and a specimen of the scallop-relative *Inoceramus*.

132) The *Inoceramus* shown here is approximately the size of [a quarter | a dinner plate | a welcome mat].

PART V – SANT OCEAN HALL

One of the newer major halls at the Smithsonian is the Sant Ocean Hall. It is directly opposite the main entrance to the museum—beyond the elephant—on the first floor. The Ocean Hall has a big central concourse that concentrates on ocean life, a right hand path that focuses on environments and human interactions, and a left hand path about fossil marine life. Head over to that left hand path, and we'll explore some issues about Mesozoic and Cenozoic marine life and the Cretaceous/Paleogene extinction event.

Down the middle of the fossil marine life section are a set of free-standing displays. Find the one of these labeled "A Reef Built by Clams". This exhibit concentrates on rudists, a group of extinct clams that were the major reef-builders in the Cretaceous seas. There are two major groups of rudists described, characterized by the different way they grow: **uprights** and **recliners**.

133) Which mode of growth does *Titanosarcolites* sp. show? [upright | recliner]

134) Which mode of growth does *Parastroma sanchezi* show? [upright | recliner]

Name:_____

The long wall of the fossil section, labeled "Global Vanishing Acts", discusses two great mass extinctions: the Permo-Triassic extinction and the Cretaceous-Paleogene extinction. We will focus on the Cretaceous-Paleogene extinction: find the section labeled "The Sky is Falling!", and specifically the part that says "How Do We Know?" On display are models of two deep sea cores that sample sediments from before, during, and after the Cretaceous-Paleogene extinction.

135) Where in the world was the ODP Site 1049 core drilled? _____

136) Where in the world was the ODP Site 1259 core drilled? _____

The exhibit describes the changes in the foraminiferans (armored amoeba-like single-celled organisms) over the event.

137) The average size of foraminiferans just after the extinction were [smaller | the same size | larger] than those before.

138) The number of species of foraminferans just after the extinction was [fewer | the same | greater] than those before the extinction.

The core also contains ***non-fossil*** geological materials that record the impact of the asteroid in the Yucatán. Two types of materials are present in these cores (one is found in both cores, on only shown in ODP 1049).

139) List one of these non-fossil geologic records of the impact:

Extra Credit) List the other of these non-fossil geologic records of the impact:

Find the section labeled "Survivors".

140) What ecological types (that is, ways of life, ***NOT*** clades) does it say were among the better survivors in the sea?

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